8TH LOWRAD

International Conference on the Effects of Low Doses and Very Low Doses of Ionizing Radiation on Human Health and Biotopes

28th – 30th September 2009, Rio de Janeiro, Brazil

Under the auspices of the Comissão Nacional de Energia Nuclear, the Instituto de Radioproteção e Dosimetria, the Associação Brasileira de Energia Nuclear, the Low Radiation International Network and the World Council of Nuclear Workers
Dear Colleagues,

On the behalf of the Organizing Committee, the International Journal of Low Radiation, the Institute of Radioprotection and Dosimetry, the Brazilian Nuclear Energy Association and WONU it is our great pleasure to welcome you to the 8th International Conference on The Effects of Low Doses and Very Low Doses of Ionizing Radiation on Human Health and Biotopes (LOWRAD 2009). During the conference many aspects of this theme such dose effect relationship, the effect of dose rate, DNA repair mechanisms, and new indirect effects such as genomic instability and bystander effects will be discussed. The purposes of the conference is also to assess the uncertainty of the various risk assessments and to analyse the scientific ways through which these uncertainties could be reduced, to present and discuss the latest research results concerning the health effects of exposure of humans and other living organisms to low and very low doses of ionizing radiation. The conference aims to present state-of-the-art scientific research from leading experts in the field and to make the findings accessible to specialists and non-specialists who work with or are otherwise concerned about low dose exposures. Main speakers from academic institutions will present basic scientific results and will be joined by regulators, clinicians and health physicists, whose job it is to interpret the basic science and formulate and implement protection policy for individuals exposed during their work, in their environment or as a result of medical treatments. So, we hope that you will enjoy all aspects of the conference and we wish you a pleasure stay in Rio de Janeiro.

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International Executive Chairman  
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Dr Carlos E. BONACOSSA DE ALMEIDA  
Scientific Committee Chairman  
Brazil

Ing Abel J. GONZALEZ  
Scientific Committee Chairman  
Argentina
8th International LOWRAD Conference is organized under the auspices of the Comissão Nacional de Energia Nuclear, Instituto de Radioproteção e Dosimetria, Associação Brasileira de Energia Nuclear, Low Radiation International Network, World Council of Nuclear Workers.

Conference Venue

Windsor Hotel
Av. Sernambetiba, 2630 - Barra da Tijuca
CEP 22620-170 - Rio de Janeiro
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AWARDS

Marie Curie Prize
Offered by International Journal of Low Radiation

Edward J. Calabrese
General Information

Badge

Participants are requested to wear their badge at all times during the conference. It must be used to attend the lectures and to take part at the Welcome Reception.

Insurance

The organizers do not accept liability for individual medical, travel or personal insurance and participants are strongly advised to take out their own personal insurances policies.

Language

The official language of the meeting is English. No simultaneous translations will be provided.

Oral Presentations

The authors have 20 minutes for presentation and few questions.

Poster presentations

It is expected that all participants prepare a poster presentation, even the ones that were selected to make an oral presentation.

Posters should be mounted by 9 AM on the day of the presentation and should be removed by 17 PM. The poster section should be 0,80 x 1,50 cm. The organizers are not responsible for loss of posters.

Full Papers

At the end of the LOWRAD 2009 Conference, representatives of the Scientific Committee will select papers that will be submitted to the usual IJRL peer review process. The Editor of the Journal of Low Radiation will be directly in touch with the selected authors asking them to provide their paper by e-mail.

Projection facilities

Only Power Point facilities will be provided. Slides must be presented in the lecture room 15 minutes before the start of the corresponding section.

Social Events

The Welcome Reception will take place on September 27th, at 6 PM, at Windsor Hotel.
Monday, 28th September

Registration

8:30 – Opening session

Scientific Programme

Monday, 28th September

8:45-9:45 Keynote

Biological Significance of Synergistic Interaction between Ionizing Radiation and another Factor

Jin Kyu Kim
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Living organisms are never exposed to merely one harmful agent. Many physical, chemical, biological and social factors may simultaneously exert their deleterious influence to them. The combined exposure to two harmful agents could result in a higher effect than would be expected from the addition of the separate exposures to individual agents. An increase in the overall biological effect under the combined action of ionizing radiation with another harmful factor can be explained in two ways. One is the supposition that synergism may attribute to a reduced cellular capacity of damage repair after the combined action. The other is the hypothesis that synergism may be related to an additional lethal or potentially lethal damage that arises from the interaction of sublesions induced by both agents. These sublesions are considered to be ineffective when each agent is applied separately. Based on this hypothesis, a simple mathematical model has been elaborated, which is able to predict the greatest value of the synergistic effect, and the dependence of synergy on the intensity of agents applied, as well.

The most interesting results, obtained from the model study, are the conclusion that for a lower intensity of physical agents or a lower concentration of chemicals a lower temperature must be used to provide the greatest synergy. Actually, any decrease in the intensity of physical agents would result in an increase in the duration of thermoradiation action to achieve the same absorbed dose. Therefore, the number of thermal sublesions will also be increased resulting in the disruption of the condition at which the highest synergy should be observed. Hence, to preserve an optimal ratio of heat-induced damage to radiation-induced damage with any decrease in the dose rate (or the intensity of other agents), the exposure temperature should be decreased. It can be concluded on this basis that for a long duration of interaction, which is important for problems of radiation protection, low intensities of deleterious environmental factors can, in principle, synergistically interact with each other.

9:45

Coffee Break
Morning
Oral Presentations

Chairperson: Dr. Carlos Eduardo Bonacossa de Almeida

10:15-10:35 LWR08, S. Michelin
Down Regulation of Surface Hla-G Expression in a Melanoma Cell Line Exposed to Low Dose Rate Beta Irradiation

10:35-10:55 LWR08, T. Paunesku
Effect of Low Dose Radiation on Nuclear and Mitochondrial Genomes

10:55-11:15 LWR06, A. Osipov
Radiation-Induced Genomic Instability in Directly Irradiated Versus Bystander CHO-K1 Cells

11:15-11:35 LWR09, C. Bracalente
Assessment of γH2AX Nuclear Foci Number and Size in Normal and Repair-Deficient Cells Irradiated with Low and High Linear Energy Transfer (LET) Radiation

11:35-11:55 LWR08, A. Osipov
Exposure-time Dependent Development of Molecular and Cellular Responses to Low Dose-Rate Gamma-Radiation in Mammals

11:55-12:15 LWR08, D. Bazyka
Neuroimmune and Gene Expression Changes in Chronic Fatigue Syndrome after the Low Dose Radiation Exposure

12:15-12:35 LWR09, J. Kim
DNA Damage and Somatic Mutations in Tobacco Plants Exposed to Gamma Radiation

13:00 Lunch
Telomere Length after Low-Dose Radiation Exposure

**D. Bazyka, I. Ilyenko, O. Beliaev, O. Lyaskovska**
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Phone/fax: 380-44-451 8294, E-mail: bazyka@yahoo.com

**Objectives:** Experimental studies have demonstrated relationships between the telomere length and exposure to the ionizing radiation, radiogenic cytogenetic markers. The early effects of irradiation under the professional levels include cell activation and differentiation changes, low apoptosis, high expression of anti-apoptotic proteins and at higher doses - the elevated TCR-variant cell counts, apoptosis, cytogenetic stable and non-stable markers. Aim of the study was to estimate telomere length after the low dose exposure and reveal factors that might influence telomere changes.

**Methods:** A study was performed in 47 subjects (18 radiation workers of the Chernobyl 30-km exclusion zone, effective doses of external exposure: 3-28 mSv; $^{137}$Cs and $^{239}$Pu incorporation doses up to 0.6 mSv; 15 age-standardized controls and 14 Chornobyl clean-up workers twenty two years after the exposure). Cellular phenotype was studied by flow cytometry. Relative telomere length (RTL) was studied by Flow-FISH procedure with Telomere PNA Kit/FITC using K562 cell line as a standard.

**Results and discussion:** Our data demonstrate the lower RTL in radiation-exposed. In radiation workers exposed under the professional limits a tendency of mean RTL values decrease was shown (fig.1). A decrease was significant ($p < 0.02$) in clean-up workers at the late period after radiation exposure. Telomeres length variability depends on cells type and could be related with the individual functional characteristics. For lymphocytes several contributing mechanisms changing the telomere length have to be encountered under the low-dose ionizing radiation exposure, i.e. a changed radiosensitivity, an increased cell turnover, the selective cells elimination by apoptosis, and telomerase activity.

Molecular background of the variations in human individual radiosensitivity is not clear yet. The RCRM studies after Chornobyl have demonstrated correlations of the acute radiation effects with some HLA phenotypes but these data haven’t been reproduced later in studies of hibakusha. In telomerase-deficient mice and cell lines a correlation is demonstrated between the telomeres length and radiosensitivity but it’s not so clear for telomerase proficient cells. The human fibroblast clones immortalized by ectopic telomerase expression and varying by a telomere length show no difference in LD$_{50}$ and chromosome aberration counts after gamma-irradiation, supposing the stabilizing role of the high telomerase activity in radiosensitivity (Zongaro et al., 2008). In humans a recent evidence suggests a link between radiosensitivity and telomere length. A positive correlation between cellular radiosensitivity and telomere length in breast cancer and cancer-prone recessive syndromes, associated with radiosensitivity, such as ataxia-telangiectasia and Nijmegen breakage syndrome, patients has been reported (Sprung et al., 2008). In exposed to low-doses dependencies are more complicated. A study of the individual changes in RTL values before
entry and after finish of the activities inside the radiation area has demonstrated no differences.

Comparative analysis of the basic cellular immunity parameters and lymphocyte activation revealed none of the statistical differences between groups of exposed except of the higher cytotoxic CD8+ cell counts in clean-up workers (33.12±1.12 vs 27.00±1.76%). Both groups have shown increased variant TCR-negative cell counts (3.1 and 5.1x10^-4) and a high bel-2 fraction.

The studies performed in Chornobyl staff showed relationship of RTL with genotoxic effects. Negative correlations were shown between the RTL and the total number of aberrant cells (table 1) and positive with the number of single acentric fragments. Shortest telomeres have been revealed in staff with the highest numbers of the cells containing micronuclei. Correlations with the radiogenic mutations rates (dicentrics) were not revealed due to the insufficient number of patients with such type of aberrations. T-cell receptor mutations and RTL seem to have negative relationship (fig. 2), bridging the telomeres length and radiation-induced impairment of immunity.

Table 1. Correlations between the relative telomere length and different types of chromosome aberrations

<table>
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<tr>
<th>Cytogenetic markers</th>
<th>Spearman’s correlations with 3 RTL (r)</th>
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<tbody>
<tr>
<td>Aberrant cells, (%)</td>
<td>-0.61</td>
</tr>
<tr>
<td>Total aberrations number/100 metaphases</td>
<td>-0.48</td>
</tr>
<tr>
<td>Single acentric fragments, (%)</td>
<td>-0.98</td>
</tr>
<tr>
<td>Pair acentric fragments, (%)</td>
<td>0.99</td>
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Mainly the telomere shortening is related to age and, possibly environmental factors. Data obtained at low dose show dependencies with parameters usually changed by the ionizing radiation. Of course the other factors could have influenced and have to be subject of analysis. Special attention has to be dealt to association of the telomere length and disease. Preliminary studies show such associations between the shorter telomeres and early risk of dementia (Grodstein, et al., 2008). However, our current evidence is not supportive for such influence in the studied Chornobyl radiation workers as this cohort is a selected one by the professional health restrictions criteria for nuclear workers.
Conclusions: This study shows that low-dose radiation may *in vivo* induce in humans the changes in the telomere regions that are detectable after twenty years. The nature of these changes remains not clear. No connection was shown with the cellular immunity parameters while some relationship could exist with chromosome damage. Possibility of the hTERT dependent or independent pathways down-regulation as well as the adoptive origin of telomere shortening should be evaluated due to the experimental data on the hTERT radioprotective effects in cells with shortened telomeres.

Chairperson: Dr. Carlos Eduardo Bonacossa de Almeida

15:30-15:50 LWR08, R. Vazifehmand
   Natural Radiation Effects on Human Mitochondrial DNA Mutations in Ramsar, Iran

15:50:16:10 LWR08, R. Amendola
   Low Level of ROS over-Production By Spermine Oxidase Activity and Low Dose Radiation Effects on DNA-Repair Deficient Cell Lines

16:30

*Coffee Break*

16:50-18:30 Poster Presentations
Tuesday, 29th September

8:45-9:45 Keynote
Radiation Effects on the Environment: implications for Radiological Protection

F. Bréchignac
Institute of Radioprotection and Nuclear Safety (IRSN), Scientific Direction (DS/Dir), Blg 229, Centre d'Etudes de Cadarache, 13115 St Paul-lez-Durance, France
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Environmental protection has become today an important issue that radiological protection needs to consider for several reasons. As sadly demonstrated by past nuclear explosions and several accidents, radiation is known to promote deleterious impacts on human beings as well as on the environment. Current civil nuclear activities therefore are prompting fears, questions and significant efforts of regulation to prevent the occurrence of unacceptable harm. Also, there is a wide societal concern about the effectiveness of mastering risk in a robust and transparent manner. This led the International Commission of Radiological Protection (ICRP) to reconsider its long standing paradigm, which subordinated environment protection to that of human beings, and to initiate the construction of a specific system framework for the radiological protection of the environment against ionizing radiation.

One basic foundation of this protection system is the ability to understand the effects of radiation on the environment components. Such radiation effects have been subjected to numerous studies in the past decades, but essentially focused on high levels and acute dose rates of external g irradiation. The resulting overall knowledge therefore still proves to be very fragmented, with poor understanding of the impact of chronic exposures to internal irradiation accumulated within living organisms in the long run, over several generations. Large gaps also remain with respect to the diversity of animal and plant species. Significant effort of research is needed to close these gaps. In particular, it is necessary to verify if the first guide values derived from research of the past decades, 1-10 mGy.d\(^{-1}\) as highest safe levels for populations of animals and plants, are still valid in a context of long term chronic exposure to low doses. Significant biological effects have indeed been observed at lower dose rates, on cellular and sub-cellular targets, but their propagation to higher levels of biological integration (population, communities, ecosystems) is not clear.

The developing system of radiological protection of the environment is dominated by operational goals. Driven by simplification, it emphasises conceptual and methodological approaches that are readily accessible today: reference organisms supported by individual-based traditional toxicological data. Whilst there are immediate advantages to this approach (pragmatism, consistency with other approaches in use for man and biota), there are also clear limitations which need to be acknowledged and further considered. One of them is to rely on effects data gathered almost exclusively for individual organisms to meet protection goals which are usually set at population and ecosystem levels. Such limitations have already been faced in other fields of environmental protection against other stressors, pushing a number of environment professionals to assign stronger emphasis on more systemic approaches. This leads in particular to advocating the need to boost scientific and methodological approaches featuring the ecosystem concept as a mean to access a unified goal of protection: preserving life sustainability through protection of ecosystem structure and functioning.

9:45 Coffee Break
Morning
Oral Presentations

Chairperson: Dr. José Marcus Godoy

10:15-10:35 LWR21, H. Date
Statistical Properties of Radiation Damage to Bio-Cells by X-ray Exposure

10:35-10:55 LWR20, H. Silva
Radiosensitivity Gamma on Cladonia Substellata Vainio (Lichen) and the Consequent Effect on Limestone Rocks

10:55-11:15 LWR20, G. Voloschak
Tissue and Database Archives on Dog And Mouse, Gamma-ray and Neutron, Acute and Protracted Whole Body Irradiation Experiments

11:15-11:35 LWR19, W. Pereira
Choice of Critical Radionuclide by Calculation of Absorbed Dose Rate in Biota, in Different Areas of High Natural Radioactivity in Brazil

11:35-11:55 LWR19, A. Monfared
Estimation of External Natural Background Gamma Rays Doses to the Population of Caspian Coastal Provinces in North of Iran

11:55-12:15 LWR15, A. Moskalev
Radioadaptive Response of Drosophila Melanogaster Larva Neuroblast

12:15-12:35 LWR15, S. Mortazavi
Radioadaptive Response Induced by Diagnostic Doses of Tc-99m in Wistar Rats after Receiving a Lethal Dose

12:35-12:55

13:00 Lunch
Keratin's Cluster Regenerative Profile is activated in Mouse Skin after Neutron Irradiation: In-Vitro vs In-Vivo Experimental Models

R. Amendola¹, M. Artibani¹, E. Fratini¹, T. Bellissimo¹, M. Trippanera¹, K. Kobos¹*, E. Pasquali¹, F. Chiani², V. Licursi², R. Negri²

¹ENEA, BAS BIOTEC MED, Roma, Italy; ²Università La Sapienza, Dip. Biologia Cellulare e dello Sviluppo, Roma, Italy

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Objective: This project aims to explore the different response of alternative experimental models to monitor the effects of ionizing radiation. Emerging data contributes to evaluate results coming up from in-vitro vs in-vivo experiments, paying more attention to conclusive remarks. In more details, in vivo mouse skin regeneration profile after exposure to different doses of 14 MeV neutron has been compared to human keratinocytes experiments after radiation exposure. Cellular and DNA damages have been analysed in vivo at 6 and 24 hours after irradiation on groups of at least 6 animals, both in the radio-resistant C57Bl/6 and the radio-sensitive CBA/J mouse strains.

Methods: 14 MeV neutron irradiation is performed at the ENEA Frascati, neutron generator facilities (FNG), specifically dedicated to biological samples. FNG is a linear electrostatic accelerator that produces up to 1.0x10¹¹ n/s 14 MeV neutrons via the D-T nuclear reaction. Regenerative profile has been related to apoptosis markers (TUNEL and Caspase-3 activation), proliferation (Ki67), and DNA damage (gH2AX and 8-oxodG) following 20 cGy and 1 Gy, 6 hours and 24 hours delayed time after exposure. Low doses (0.1 and 1 cGy) are under observation to determine hypothetical threshold of regenerative profile activation.

Conclusions: The co-regulation of a sub-class of keratin, keratin associated protein and S100 family of Ca-binding proteins, are transiently up-regulated at 6 hours from the 20 cGy dose delivered, and drastically down-regulated at 24 hour at the higher dose of 1 Gy. The differential modulation of these genes in the epidermis plays a key role in the skin self-renewal activation processes, with absence of apoptosis and cellular and DNA damage evidenced at 24 hours from the 20 cGy exposure in contrast with 1 Gy exposure. Interestingly, these repair processes are apparently in charge of three-dimensional skin architecture reconstitution more than DNA repair process and/or apoptosis, and it appears to be independently exerted from mouse strains. No overlapping results are detected accordingly to previous and alternative works done on keratinocytes cell line.

The project has been partially funded by Italian Space Agency (ASI), MOMA Contract, 2006-2009.
*K.K. is supported by an International Fellowship Program for young scientist by ENEA (2009)
Chairperson: Dr. José Marcus O. Godoy

15:30-15:50 LWR14, M. Toossi
Preliminary Results of Radiation-Induced Bystander Effects in Qu-DB Cell Line

15:50-16:10 LWR14, F. Faria
Three-state Stochastic Model for the Radiation-induced Bystander Effect in Vitro

16:30 Coffee Break

16:50-18:30 Poster Presentations
Wednesday, 30th September

Morning
Oral Presentations

8:45-9:45 keynote

**History and Evolution of the Radioprotection Standards in the European Union: Consequences on Medical Practice and Nuclear Energy**

*Nicole Colas-Linhart*
Department of Biophysics, University Paris Diderot-Paris7, France.

In 1994, the professor Constant Burg in a report to the First French Minister wrote this alarming text: “basic norms were recommended and their efficiency was proved. New norms, more strict, is underway to be proposed. They are based on scientific hypothesis non warrantable and their application in France will have catastrophic consequences”

One explanation of these new radiation protection recommendations, regulary ajusted to be lower, is the adoption by the ICPR in 1959 of the LNT model. This LNT hypothesis, called by Z. Jaworowski “the ossified LNT paradigm”, based on “precautionary principle” is always applied actually. So many people are convinced that radiation is harmful in any amount.

In 1990 the directive 60 of the ICPR recommends the decrease of dose limits for workers and the population. For example, the safe limits for the population in case of artificial exposition were modified from 5 mSv/year to 1 mSv/year, the threshold being lower than the average level of ionizing radiation in the world, about 2.4 mSv/year.

Examples of disastrous consequences induced by the lowering of radioprotection norms will be shown.

Furthermore, some radionuclides with a low radiotoxicity as technetium 99, tritium, potassium 40 and iodine 129 are actually put in the hot seat by French ecologist organizations.

Technetium 99 is produced by the fission of $^{235}$U and $^{239}$Pu in nuclear reactors and is also a radioactive daughter of technetium $^{99m}$Tc, which is used for medical purpose (80 % of nuclear medicine scans are performed with $^{99m}$Tc). Results of our previous work will be presented: after chronic $^{99}$Tc empoisoning in rat, observed thyroid abnormalities were induced by chemical toxicity rather than by radiotoxicity.

Tritium occurs naturally in the environment (natural production = 200 g per year) and is a radionuclide that will be used and produced in fusion reactors (environmental waste = 50 g per year). Although its very low radiotoxicity is well known (Wr = 1, ICPR n°60), some texts suggest to increase the Wr factor to 2. All electronuclear industry will be paralyzed if the Wr factor is reaching 2.

In France, the absence of nuclear doctor, radiobiologists and radiotoxicologists within regulation organizations, appears as a great inadequacy of radioprotection.
Chairperson: Dr. Lene Veiga

10:15-10:35 LWR01, A. Ismail
Relationship between Radon Concentration and Men Infertility: Case Study in Iraqi Kurdistan

10:35-10:55 LWR01, K. Loganovsky
National Mental Health Care System Following Radiation Accidents and Radiological Terroristic Attacks

10:55-11:15 LWR03, O. Laurent
Second Analysis of the Association between Exposure to Ionizing Radiation and Mortality in French Nuclear Power Plant Workers

11:15-11:35 LWR03, L. Veiga
Estimating Lifetime Cancer Risk due to Radiation Exposure using an Interactive Radioepidemiological Program: concepts, Adaptation to Brazilian Population and Application

11:35-11:55 LWR03, F. Bochicchio
Low Dose Risks and Effective Dose. The Case of Radon

11:55-12:15 LWR03, A. Babak
The Aging Factor Underlies the Phenomena of Long-Term Elevation of Chernobyl Clean-up Workers' Somatic Morbidity Level

12:15-12:35 LWR04, W. Ruegg
Ionizing Radiation: Risk Perception, Risk Communication

12:35-12:55 LWR05, I. Costa
Effect of Low Dose of Ionizing Radiation in Exposed Populations

13:00 Lunch

Afternoon
Oral Presentations
Poster Presentations

Chairperson: Dr. Lene Veiga

14:30-14:50 LWR21, M. Kozicki
A System for High Resolution 3D Radiation Dose Distribution Measurements

14:50-15:10 LWR07, J. Zielinski
Database of Radiogenic Cancer in Experimental Animals Exposed to Low Doses of Ionizing Radiation

15:10-16:30 Poster Presentations

17:00 Cocktail
18:30-19:30 Keynote

HORMESIS IS CENTRAL TO BIOLOGY AND MEDICINE

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This presentation summarizes numerous conceptual and experimental advances over the past two decades in the study of hormesis. Hormesis is now generally accepted as a real and reproducible biological phenomenon, being highly generalized and independent of biological model, endpoint measured and chemical class/physical stressor. The quantitative features of the hormetic dose response are generally highly consistent, regardless of the model and mechanism and represents a quantitative index of biological plasticity at multiple levels of biological organization. The hormetic dose response model has been demonstrated to make far more accurate predictions of responses in low dose zones than either the threshold or linear at low dose models. Numerous therapeutic agents widely used by humans are based on the hormetic dose response and its low dose stimulatory characteristics. It is expected that as low dose responses come to dominate toxicological research that risk assessment practices for chemicals and radiation will incorporate hormetic concepts in the standard setting process.

19:30-20:00  Marie Curie Prize and Concluding Remarks
# Preliminary Programme
LOWRAD 2009 – Rio de Janeiro

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<td><strong>Registration</strong></td>
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<td><strong>Keynote</strong></td>
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<td><strong>Keynote</strong></td>
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<tr>
<td>Dr. Jin Kyu Kim</td>
<td>Dr. François Brechignac</td>
<td>Dr. Nicole Colas-Linhart</td>
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**End Session**
**Marie Curie Prize**
### The Effects of Low Doses and Very Low Doses of Ionizing Radiation on Human Health and Biotopes

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Daily Urinary Excretion of Thorium and Uranium of Exposed and Unexposed Nigerian Subjects and Comparison with Biokinetic Model Prediction

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Objectives: Values of urinary excretion of uranium and thorium of occupationally exposed people in Africa were up to now not available. This work presents the results of measurements conducted in 12 subjects working in the tin mining sites in Nigeria, and, for comparison, in 7 adults living in normal areas exposed to background radiation.

Methods: Uranium and thorium determinations were made by means of High Resolution Sector Field Inductively Coupled Plasma Mass Spectrometry (HR-SF-ICP-MS).

Results: The mean daily urinary excretion of uranium is 24 ng and 7 ng for the exposed and unexposed subjects, respectively; and for thorium it is 15 ng and 4 ng, respectively. A significant difference (P < 0.01) was obtained between the exposed and the unexposed groups for thorium and that of uranium is highly significant (p < 0.001). The excretion values of uranium and thorium were however, for both groups, within the normal range published in literatures. The biokinetic models of thorium and uranium recommended by the International Commission on Radiological Protection (ICRP) were used to predict their excretion rates for comparison with the measured data.

Conclusions: Large discrepancy was observed between the measured data and the model prediction using the ICRP default f₁ value for uranium. However, no significant deviation was observed between the predictions of the ICRP thorium model and the measured values.
Influence of Tropical Environmental and Climatic Factors on the Daily Urinary Excretion in Nigeria

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Abstract

Objectives: The daily urinary volume excreted is very crucial in order to accurately determine the excretion rate of substance needed for bioassay monitoring purposes. The International Commission on Radiological Protection (ICRP) Publication 89 reported a worldwide reference value of daily urinary volume based on the data from the temperate environment. However, in order to gain global acceptance, it is necessary to incorporate data from all parts of the world. To the best of our knowledge the present value did not include contribution from the tropical Africa. Daily dietary habits and level of exercise are considered to contribute significantly to the daily urinary excretion in normal human subject. In addition, environmental factors such as air temperature, pressure and humidity seem to play a major contributing role in tropical environments as indicated in a preliminary work conducted with a limited number of volunteers.

Methods: In order to improve the statistical significance of the study, twenty four hours urine collection from large number (> 250) of subjects was conducted. The samples were collected from male and female adults, adolescence of ages 15 – 18 years, and children below 15 years.

Results: The results of the study, intra- and inter variability of urine excretion, the dependence on age, gender, working habits, and the possible influence of tropical environmental conditions on the daily urine volume were presented and discussed.

Conclusions: The daily urinary volume for adult male and female subjects in Nigeria is lower than that predicted by the ICRP values. Values of urinary volume for adolescence and infant, which were not given by the ICRP, have been presented. The results suggest that the prevailing environmental factors play significant role in the urinary excretion of the subjects in the area. Intra- and inter variability of urine excretion was observed among subjects and therefore suggest dependence on age and gender.
Estimation of External Natural Background Gamma Rays Doses to the Population of Caspian Coastal Provinces in North of Iran

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Objectives: The effect of natural background radiation on health is still challenging. However, it is cleared that it depends on dose received by population. The estimation of external natural background gamma rays doses to the population of Caspian coastal provinces in north of Iran was the main goal of study.

Methods: Gamma rays was measured using calibrated radiation survey meter in random 51 urban and rural health centers to estimate the exposure to population (Total population = 6888118 persons) in residential areas of Gilan, Mazandaran and Golestan (Total area 59240 Km²) as Caspian coastal provinces in north of Iran.

Results: Results showed that the average dose rate in the area under study is about 60.37±14.88 nSv/h or 0.53 mSv/yr (Range 30 to 90 nSv/h or 0.26 to 0.79 mSv/yr). The data from Ramsar is excluded from the estimation because of a very high natural background radiation found in that area (Max. 240 mSv/yr). No significant difference was found between the doses of the provinces (P=0.237).

Conclusion: The external natural background gamma rays doses to the population of Caspian coastal provinces in north of Iran was found to be nearly equal to the average value in the world (0.5 mSv/yr). Further national studies are suggested.

Keywords: Background radiation, Gamma rays, Caspian Sea, Iran
LevRad software as a tool to learn how to proceed with a shielding adequacy analysis

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ABSTRACT

Objectives: Diverse strategies have been realized in an attempt to reduce the worldwide collective effective dose. The objective of this study was to create the LevRad software for teaching how to proceed in an analysis of barriers shielding against X-rays, to minimize the contact of the professional or the student with X radiation, and, finally, to prevent the consuming of the X-rays equipment.

Methods: With the aid of Flash Macromedia package from Microsoft®, a computational program was designed to provide visual and numerical information regarding a standard General Radiographic room. The typical radiographic room contains one X-ray tube, one chest bucky (image receptor), one command panel and one X-ray table. The technical Brazilian guide from ANVISA (Agência Nacional de Vigilância Sanitária) describes the basic procedures to test the shielding of the primary and secondary barrier. It is necessary that the user follows this guide and knows, at least, the following information: workload of each type of radiological installation, equipment characteristics and the technical parameters of each test.

Results: The program randomly supplies the exposure rate through each of radiation protection barrier, average workload per patient, average number of patient per week, equipment characteristics and exposure factors in the test of primary or secondary barrier. With these data, the user can calculate and return to the program his results referring to environment equivalent dose rate in each analyzed barrier. Finally, the program indicates if the value is correct or not. Some tests of the software were made, and preliminary results indicate that LevRad is efficient as a complementary tool for upgrade of professionals related to diagnostic radiology. In the case of education, the advantage is perceived when using the software before the first contact of the beginner with the X-rays equipment.

Conclusions The software introduces a solid knowledge about shielding adequacy analysis, prevents the consummation of the X-rays tube recurrent of the shielding adequacy analyses teaching and reduces the collective effective dose by avoiding the possible unnecessary exposures.
Tissue and database archives on dog and mouse, gamma-ray and neutron, acute and protracted whole body irradiation experiments

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Objectives: During a period of nearly forty years several thousands of dogs and 49,000 mice were irradiated with different doses and dose rates of gamma ray or neutron irradiation at Argonne National Laboratory (Illinois, USA). This effort was executed in several dozens of studies including hundreds of animals; since 2006 paraffin tissues and data collected on these animals are housed by our laboratory.

Methods: We have posted the data on two World Wide Web portals and have begun to use new methods to analyze the data collected. These portals are at connected websites http://janus.northwestern.edu/janus2/index.php and http://janus.northwestern.edu/dog_tissues/.

Results: Archived data for a few studies were re-analyzed as follows: (1) We investigated the data obtained from mice treated with low-dose highly fractionated (60 weekly fractions) 2-40 cGy of Janus reactor fission spectrum neutrons or 100-600 cGy of cobalt 60 gamma rays. At the time of natural death, tissue toxicities found in these mice were recorded, and these records were now re-analyzed. We found that the effects of protracted exposures were highly tissue-type dependent and gender specific, showing the dose rate dependence. (2) We re-analyzed the data obtained from mice treated with Amifostine, WR-151327, saline or nothing injected intraperitoneally 30 minutes before irradiation. Radiation exposures were acute, total doses were 206 cGy or 417 cGy cobalt-60 gamma rays or 10 cGy or 40 cGy of fission-spectrum neutrons (average energy 0.85 MeV). Amifostine reduced the total number of toxicities per animal for males in the gamma ray exposed mice and for both genders in the neutron exposed mice. Effects of protracted exposures were highly tissue-type dependent and gender specific, showing the dose rate dependence. (3) We analyzed the dog database specifically for incidence of prostate cancer in 94 controls and 601 animals which received whole body cobalt-60 gamma rays. Total doses ranged from 17 to 14,745 cGy with dose delivered per day (over a period of 22h) ranging from 0.3 to 225 cGy. This work revealed that the animals whose exposures started earlier in life had a statistically significant increase in prostate cancer incidence. Without segregating the data into age-dependent quartiles, however, this result was obscured and remained unnoticed.

Conclusions: In conclusion, new analysis of the decades old data yields new findings about radiation induced cancer and non-cancer related pathological complications in mammalian model organisms; these data can be at least partially extrapolated to humans.
An Evaluation of the Equivalent Dose Due to Natural Radioactivity in the Soil Around the Consolidated Tin Mine in Bukuru-Jos, Plateau State of Nigeria.

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ABSTRACT

Objective
The equivalent dose in the human body due to the natural gamma-emitting radionuclides ($^{238}$U, $^{232}$Th and $^{40}$K) in the surface soil surrounding the Consolidated Tin Mine site in Bukuru-Jos, Nigeria has been determined in this study.

Method
Measurements of the soil natural radioactivity were made using a multi-channel pulse-height analyzer (Canberra Series 10 plus) coupled to a 76 mm x 76 mm NaI (TI) scintillation detector.

Result
The mean concentrations obtained for each of the radionuclides are 35.4$\pm$17.6 Bq kg$^{-1}$ for $^{40}$K; 776.0$\pm$158.0 Bq kg$^{-1}$ for $^{238}$U and 2.72$\pm$0.58 kBq kg$^{-1}$ for $^{232}$Th. The mean absorbed dose rate due to natural radioactivity calculated at a height of 1.0 m above the ground was 2.16 $\mu$Gy hr$^{-1}$ which converted to an equivalent dose of 3.0 mSv yr$^{-1}$.

Conclusion
This value is far above the world average equivalent dose of 0.41 mSv yr$^{-1}$ but lower than the annual limit of 20 mSv yr$^{-1}$ for radiation workers but still represents a health risk to workers on the site.
Interaction of radiative and non-radiative factors in the process of tumour formation

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Objectives

The foundation for carrying out current research is the additional information extracted about the peculiarities of the tumor development process, conditioned by combined action of radiation and chemical carcinogen, while assessing the "dose-effect" dependence in tumors induction when exposed to ionizing radiation and at different time intervals after the cease of radiation.

Materials and Methods

The research was carried on mice of Af line of breeding at the age of 12 weeks and of 22-25 g weight. Each experimental group consisted of 30 animals. The general exposition was made at standard experimental gamma installation (60Co). Depending on the type of irradiation, the experiment was held in 3 series: 1 - total single-act exposition to doses of: 0.035, 0.1, 0.35 and 1.0 Gy at the dose power 1.0 Gy/hr; 2 - 0.35 Gy dose fractionated exposition (0.07 Gy per day during 5 days) at the dose power 1.0 Gy/hr; 3 - total 0.35 Gy exposition (0.389 Gy per day during 9 days) at the dose power 0.008 Gy/hr. Animals were introduced urethane in the form of 10% solution (in amount of 1 mg / 1 g of animal's weight) 1 day after both single and the last exposition. Control animals were introduced the same amount of physiological solution. The slaughter of mice was made after 5 month from irradiation and urethane introduction.

For the 1st series the urethane was introduced after 1, 3, 7, 15 and 30 days of exposition. After slaughter animal's lungs were fixed in 10% solution of formalin. The number of induced adenomas and percentage of mice with adenomas where chosen to be the measure of carcinogenic efficiency. Coefficient of interaction is determined as the ratio of observed effect at combined action to the sum of effects of separate impacts of irradiation and urethane, with correction to spontaneous level. Reliability of differences was determined by t-statistics.

Discussion of Results

Dose 0.035 Gy didn't increase the frequency of tumor growth. The increase of dose in 10 times from 0.1 to 1.0 Gy increases tumors' frequency by only 14%. Percentage of mice with adenomas in groups, exposed at 0.1 and 1.0 Gy, barely differ. The obtained results are not confined to the linear dose-effect dependence, but are of more complex type: at doses, greater than 1.0 Gy the curve conforms to quadratic dependence of dose; at 0.3 Gy dose the number of transformed cells is linearly proportional to dose; in the dose interval (0.3; 1.0) Gy the frequency of transformed cells formation doesn't change with the increase of dose. This can be explained by dominance of single-track effects at low doses, while inter-track effects become significant at high doses. That's why quadratic term appears and its influence increases with the increase of dose.

Biological effects of combined action were mathematically modeled for 0.35 Gy dose. The role of fractionating and dose power was researched.
Objective: The main objective of this work is to measure the environmental outdoor gamma radiation levels in several sites of São Paulo city, with the goal of estimating the dose values from natural radiation sources and comparing them with annual dose limits for the general public as proposed by the radiological protection standards. Method: Monitoring stations were placed in 12 different regions of the town including both urban (where building materials are present) and outskirts areas. Dosimetric methodology was based on CaSO₄:Dy thermoluminescence dosimeters and the measurements were carried out quarterly observing the four seasons of the year. Results: The average annual effective dose was calculated according to the ICRP-60 procedures, through the gamma radiation levels determined with the thermoluminescence dosimeters obtaining a value of 1.25 ± 0.15 mSv.y⁻¹. Conclusions: The result is of the same order of magnitude as the average annual background effective dose of 1.0 mSv.y⁻¹ obtained from the Environmental Monitoring Programme followed by the Instituto de Pesquisas Energéticas e Nucleares, IPEN – CNEN/SP, the largest institute in the nuclear research field in Brazil, with a large number of nuclear and radioactive facilities. This environmental outdoor average annual effective dose is also compared with the 0.9 mSv/y¹ value, estimated by UNSCEAR 2000 as the world average contribution from terrestrial and cosmic gamma rays.

Key Words: Thermoluminescent dosimetry, background radiation dose, natural radiation, radiological protection standards, environmental outdoor gamma radiation.

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Exposure to Radon in Cuban Tourist Caves

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ABSTRACT

Objectives

With the objective of estimating for first time the dose, due to Radon-222, received by tour guides and other people who work inside some of the most important tourist caves in the Republic of Cuba, measurements of radon concentrations were carried out in four of these caves: Santo Tomás Cave, Tapiada Cave, Del Indio Cave and José Miguel Cave. All these caves are located in the Viñales Valley (Pinar del Río City), a very important tourist area in the country.

Methods

The relationship among radon concentration, the concentration of natural radionuclides inside the caves and the geologic characteristics of the specific locations was analyzed. In order to select the most appropriates measurement places, different criteria were taken into account: representatives points of the geology of the caves, level of gamma radiation, exchange of air, places of work inside the caves (cafeterias, restaurants and shops) and places more frequently visited by tour guides. The measurement of gamma dose rate inside the caves was carried out with a scintillation detector type Scintrex BGS-3 previously calibrated at SSI, Sweden. The radon concentrations were measured with the equipment Alpha Guard PQ2000/MC50 and SARAD RM2000, both also calibrated at SSI, Sweden.

Results

The maximum radon concentration was found in José Miguel Cave with a value of 220 Bq/m³. The obtained results indicated that, in the studied caves, the annual dose is not greater than 1 mSv considering a work year of 2000 hours.

Conclusions

It was carried out the first estimation of doses received by tour guides and other people who work inside some of the most important tourist caves in Cuba. The obtained results indicate that in the studied caves it should not be necessary to implement any measures to control radon or to monitor individual tour guide exposure. However, it is necessary to point out that the concentration level of radon can be higher in other caves, specially in those where the uranium content be superior, exist major affluence of underground waters or the exchange of air be lower.

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Assessment of patient doses in X-ray diagnostics

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OBJECTIVES: A convenient and flexible tool for assessment of adsorbed, effective
doses and dose-equivalents in X-ray diagnostics was created. A Monte Carlo simulation of
absorbed dose in patient’s tissues in the dosimetry of various X-ray examinations was carried
out. X-ray spectra generated by the empirical TASMIP model were verified on X-ray units.
The further simulations are based on an anthropomorphic tissue-equivalent phantom, which
corresponds to an adult 173 cm tall with the mass of 73 kg and consists of a torso and a head
made of tissue-equivalent plastics which model bone, lung, and soft tissues. The phantom
consists of 39 layers (each layer 2.5 cm thick), 10 of which represent head and neck, 16 -
chest and 13 - pelvis. METHODS: Special sub-program was created to develop the digital
model of the phantom from its CT-scan images taken with a step of 4 mm (pixel size is
0.88×0.88 mm). First the absorbed doses in voxels in various diagnostic X-ray examinations
were calculated using Monte-Carlo method. The result of calculations was an array of x-ray
flux through the surface of every voxel, summation of doses on voxels over organ and tissue
volumes. Absorbed doses on organs and tissues of the phantom were determined by further
division by the mass of the organ to get the absorbed dose. Doses in 22 standard organs of
the adult phantom for various standard X-ray examinations were computed from the
absorbed dose distributions by another sub-program. RESULTS: The doses obtained from
Monte Carlo simulations were compared with the absorbed doses measured directly in the
phantom using thermo-luminescent dosimeter. The measurements were carried out in
specified locations of different layers in heart, lungs, liver, pancreas, and stomach. The
assessment of doses during X-ray radiography for younger patients is also possible.
CONCLUSIONS: A comparison was made with the doses calculated by several similar
programs for calculating patients’ organ doses and effective dose in medical X-ray
examinations. The results of the comparison are discussed in the report.
A system for high resolution 3D radiation dose distribution measurements

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Objectives
It is of our concern to construct a powerful system able to measure low-range doses of radiation in three-dimensions with high resolution. Such system may find several applications: for environmental and occupational protection, for CT of patients with cranial bone defect or in radiotherapy dosimetry for measurements of dose distribution. The latter is of interest since radiotherapy techniques require tissue-equivalent dosimeters for measurements of 3D dose distributions. Presently, a system comprising of tissue-equivalent dosimeters, the protocols of their applications, the procedures of their measurements and dedicated GeVero® software have been developed. Consequently, the state-of-the-art on the system is to be presented paying particular attention to the characteristics of the detectors and the scheme of their application in medical dosimetry.

Methods
PABIG⁹⁸ and VIPAR⁹⁹ dosimeters consisting of either poly(ethylene glycol) diacrylate or N-vinylpyrrolidone, respectively, and N,N'-methylenebisacrylamide, gelatin, ascorbic acid, copper sulfate and water, were prepared. In this work, the effect of the irradiation of the detectors with ⁶⁰⁴⁰Co (BK-10000, Poland) and medical linear accelerators (Clinac, Palo Alto, CA) is discussed. In case of the latter device, the irradiation scheme was calculated with Eclipse External Beam Planning System. Afterwards, the detectors were measured with NMR minispectrometer (Bruker, Germany) and MRI (Picker Edge). The data was processed with the aid of GeVero® software.

Results
The irradiation of the gel dosimeters leads to the polymerisation and crosslinking of their components. Consequently, the physical-chemical changes could be measured and the characteristics of the dosimeters were calculated. It occurred that the newly developed PABIG⁹⁸ dosimeter responds to the doses of up to ~25 Gy. Therefore, both gel detectors are of significance for the medical applications. In fact, the radiotherapy dosimetry studies revealed a possibility of verification of the theoretical radiation dose distribution with the gel dosimeters coupled with GeVero®.

Conclusions
Based on the results it is supposed that the worked out dosimetric system can be significantly helpful in medical dosimetry.

Acknowledgements
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The biological effects of Ayurvedic topical medicaments for Solar UV Radiation

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Abstract: The major acute effects of UV irradiation (~ 295 – 400 nm) on normal human skin comprise sunburn inflammation, erythema, tanning, and local or systemic immunosuppression (Matsumura and Ananthaswamy, 2004). Ultraviolet (UV) irradiated epidermal cells at high altitude developed Solar keratosis or Keratosis atinic characterizes with the horny keratotic, pre-malignant lesion which may progress to even squamous cell carcinoma. Geography, temperature, light, and wind contribute to the development of the ozone layer (Triatomic oxygen, O₃), During cold winters in the Siachen Glacier, winds moving in a circular pattern create a vortex and causes the production of polar stratospheric clouds, allows a surface for reactions and result in the release of reactive chlorine and bromine which is further triggered by the UV radiation triggers a reaction which destroys the ozone. The preventive measure for such solar ionization is effective by maintaining appropriate distance from the source and limiting the time and amount of exposures. However, in general the use of available chemical drugs to protect against solar radiation is not practical because of their toxicity. But due to the holistic friendly approaches of ayurveda system of medicine (WHO), an attempt was made to explore the biological effects of ayurvedic topical medicaments for solar UV radiation. The ancient medicine reveals that any ayurvedic topical resources having favourable biological effects for solar ionization radiation. Curd for its antiphoto ageing properties, Aloe vera for its elastosis protection against different broad-spectrum UVR emission spectra, honey’s antibacterial activity including hydrogen-peroxide activity with their clinical responses towards basal layer of human epidermis of Keratosis atinic from Siachen Glacier will certainly provide a new vista to global health program of solar UV ionization radiation.

Key Words: Biological effects, Ayurveda, Topical medicaments, Keratosis atinic (Solar UV Radiation), curd, honey, Aloe vera, clinical response.
Second Analysis of the Association between Exposure to Ionizing Radiation and Mortality in French Nuclear Power Plant Workers

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Objectives
To investigate whether chronic external exposure to low doses of ionizing radiation can induce health risks, epidemiological studies in populations exposed this way are needed. Nuclear industry workers match this definition and are consistently monitored for exposure to radiation. As part of a previous analysis, the relations between occupational exposure to ionizing radiation and mortality were studied in nuclear power plant workers from the French Electricity Company (EDF), followed-up until year 1994. The present work aims at updating this study, based on a follow-up extended until year 2003.

Methods
Permanent staff who had worked for at least one year at EDF during period 1961-1994 and who had been monitored for exposure to ionising radiation was included. Radiation doses to specific organs were estimated. Trend tests for mortality according to cumulative dose and relative risks at 100 mSv (RR\textsubscript{100mSv}) were estimated using Poisson regression. Cumulative dose were lagged by 2 years for leukaemia and by 10 years for other causes of death. Analyses were adjusted for age, sex, calendar time and educational level.

Results
The 22,393 workers included cumulated 449,984 person-years of follow-up. Mean career cumulative dose was 21.5 mSv, with a very skewed distribution. A total of 874 deaths occurred (307 due to cancer, 16 to leukaemia) and 66 workers (0.3%) were lost to follow-up. Mean age at end of follow-up was 49. Mortality did not tend to increase significantly according to radiation dose (for all cancers excluding leukaemia, RR\textsubscript{100mSv} = 0.71 (90% CI: 0.44, 1.06); for leukaemia, RR\textsubscript{100mSv} = 0.28 (90% CI: 0.01, 1.82)), except for cerebrovascular mortality (22 cases, p value for trend = 0.01, RR\textsubscript{100mSv} = 2.74, 90% CI: 1.02, 5.39). A trend approaching statistical significance was also observed for kidney cancer mortality (16 cases, p value for trend = 0.08, RR\textsubscript{100mSv} = 2.22, 90% CI: 0.68, 4.86).

Conclusions
This extremely stable population permitted an effective follow-up. Although the precision of relative risks estimates has improved since the previous analysis, associated confidence intervals are still wide. The results therefore remain sensitive to statistical fluctuations and must be interpreted with caution. However, they are statistically compatible with those issued from comparable studies (e.g., IARC 15 Country study). Although this cohort must be
further followed-up, it presents a good potential for joint analyses with other cohorts and could thereby already contribute to improving our knowledge of the potential health effects of low doses of ionizing radiation.
Measurements of $^{226}$Ra, $^{232}$Th and $^{40}$K using gamma spectrometry to assess a first order exposure risk for the persons residing in Western Haryana, India

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Abstract

The measurements of $^{226}$Ra, $^{232}$Th and $^{40}$K using gamma spectrometry is used to assess a first order exposure risk for the persons residing in Fatehbad and Hissar districts of Western Haryana, India. The concentration of Radium, Thorium and Potassium in the soil samples varies from 13.37 Bq m$^{-3}$ to 24.67 Bq m$^{-3}$, 34.67 Bq m$^{-3}$ to 67.34 Bq m$^{-3}$ and 298.78 Bq m$^{-3}$ to 405.67 Bq m$^{-3}$ respectively with average values of 18.78, 47.35 and 361.57 Bq m$^{-3}$ respectively. The radium equivalent activity ($Ra_{eq}$) calculated for the same soil samples varies from 92.72 Bq m$^{-3}$ to 140.6 Bq m$^{-3}$ with an average value of 111.80 Bq m$^{-3}$. The values of absorbed dose and annual effective dose (indoors and outdoors) are found to vary from 44.18 nGy h$^{-1}$ to 65.23 nGy h$^{-1}$, 0.22 mSv y$^{-1}$ to 0.32 mSv y$^{-1}$ and 0.05 mSv y$^{-1}$ to 0.08 mSv y$^{-1}$ respectively. The radon concentration and exhalation rates have also been reported. The radium equivalent activities in all the soil samples were found to be lower than the limit (370 Bq kg$^{-1}$) set in the Organization for Economic Cooperation and Development (OECD) report and the value of $Hex$ in all the samples is less than unity.

Keywords: Gamma ray spectrometry; dose; radon; exhalation rate.

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Radioprotective effects of Daflon against genotoxicity induced by gamma irradiation in human cultured lymphocytes

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Abstract

Objectives: Concerning side effects induced by ionizing irradiation, the radioprotective effect of daflon (as natural originated drug) has been investigated against genotoxicity induced by gamma irradiation with in vivo/in vitro method in cultured blood lymphocytes from human volunteers.

Methods: Peripheral blood samples were collected from human volunteers at 0 (10 min before), and at 1, 2 and 3 h after a single oral ingestion of 1000 mg daflon. At each time point, the whole blood was exposed in vitro to 150 cGy of cobalt-60 gamma ray, and then the lymphocytes were cultured with mitogenic stimulation to determine the micronuclei in cytokinesis blocked binucleated cell.

Results: For each volunteer, the results showed a significant increase in the incidence of micronuclei after exposed to gamma irradiation as compared to control samples. The lymphocytes in the blood samples collected at 1 h after daflon ingestion and exposed in vitro to gamma rays exhibited a significant decrease in the incidence of micronuclei, as compared with similarly irradiated lymphocytes from the blood sample collected at 0 h.

Conclusion: The maximum protection and decrease in frequency of micronuclei was observed at 1 h after ingestion of daflon with 40%. This data have important application for the protection of human lymphocyte from the genetic damage and side effects induced by gamma irradiation.
Radioprotective effects of hesperidin against genotoxicity induced by gamma irradiation in human lymphocytes

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Abstract

Objectives: The radioprotective effect of hesperidin against genotoxicity induced by gamma irradiation has been investigated in vivo/ in vitro in cultured blood lymphocytes from human volunteers.

Methods: Peripheral blood samples were collected from human volunteers at 0 (10min before), and at 1, 2 and 3 h after a single oral ingestion of 250 mg hesperidin. At each time point, the whole blood was exposed in vitro to 150 cGy of cobalt-60 gamma irradiation, and then the lymphocytes were cultured with mitogenic stimulation to determine the micronuclei in cytokinesis blocked binucleated cell.

Results: For each volunteer, the results showed a significant increase in the incidence of micronuclei after exposed to gamma irradiation as compared to control samples. The lymphocytes in the blood samples collected at 1 h after hesperidin ingestion and exposed in vitro to gamma rays exhibited a significant decrease in the incidence of micronuclei, as compared with similarly irradiated lymphocytes from the blood sample collected at 0 h. The maximum protection and decrease in frequency of micronuclei was observed at 1 h after ingestion of hesperidin with 33%.

Conclusion: This data have important application for the protection of human lymphocyte from the genetic damage and side effects induced by gamma irradiation in patients undergoing radiotherapy.
Genotoxicity effects of $^{99m}$Tc-MIBI in human peripheral blood lymphocytes

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ABSTRACT

Objectives: Tc-99m methoxyisobutyl isonitrile ($^{99m}$Tc-MIBI) has been widely used as a radiotracer for myocardial blood flow imaging. The purpose of this study was to investigate genotoxic effects of $^{99m}$Tc-MIBI in cultured human lymphocytes with adjusted radioactivity in same concentration in patients.

Methods: Firstly, the radioactivity doses were determined in whole blood at five minutes post injection of 20 mCi of $^{99m}$Tc-MIBI in patients. Secondly, the whole blood of human volunteers was incubated with 1, 2.3, 4 and 8 µCi of $^{99m}$Tc-MIBI. After thirty minutes incubation, the lymphocytes were cultured with mitogenic stimulation to determine the micronuclei in cytokinesis blocked binucleated cell. Results: Incubation of lymphocytes with $^{99m}$Tc-MIBI dose not induces any additional genotoxicity. The increasing of frequency of micronuclei was not more than samples treated with radiopharmaceutical up to two folders (8 µCi) than that concentration of $^{99m}$Tc-MIBI in blood in compare to control blood.

Conclusion: Our results showed that there is not any increasing in induction of micronuclei in lymphocytes that incubated with $^{99m}$Tc-MIBI at these levels of radioactivity doses.
ABSTRACT

Objective: Many studies have demonstrated the beneficial adaptive response of low dose $\gamma$-irradiation. Low dose $\gamma$-irradiation (LDR) might be effective for the prevention of various reactive oxygen species-related diseases. Ferric nitrilotriacetate (Fe-NTA) is a strong oxidant, which generates highly reactive hydroxyl radical and causes injuries of various organs including the kidney and liver. This study was designed to investigate the ability of low dose $\gamma$-irradiation to restrain Fe-NTA induced oxidative stress.

Methods: Sprague Dawley male albino rats were subjected to low dose $\gamma$-irradiation (50 cGy). Animals were challenged with Fe-NTA (9 mg Fe/kg body weight, intraperitoneally). Results showed that Fe-NTA enhances lipid peroxidation (LPx) accompanied with reduction in glutathione (GSH) content, antioxidant enzymes, viz., glutathione peroxidase (GPX), glutathione reductase (GR), superoxide dismutase (SOD), catalase (CAT) and phase-II metabolizing enzyme glutathione-S-transferase (GST). Fe-NTA also enhances the concentration of blood urea nitrogen (BUN) and serum creatinine as well as alanine aminotransferase (ALT), aspartate aminotransferase (AST) and $\gamma$-glutamyl transpeptidase (GGT) activities.

Results: Exposure to low dose $\gamma$-irradiation (3 h after Fe-NTA administration) resulted in a significant decrease in LPx, BUN, serum creatinine contents as well as ALT, AST and GGT enzyme activities. GSH content; GST and antioxidant enzymes were also recovered to significant level.

Conclusion: Thus, our data suggest that exposure to LDR might be a useful antioxidant mediator to suppress the Fe-NTA induced-oxidative damage in rats.

Key words: Ferric nitrilotriacetate, oxidative stress, low dose $\gamma$-irradiation, adaptive response, liver, kidney, lipid peroxidation and antioxidant enzymes.
Effect of the Radiation Gamma of a Source of Cs-137 on a System Bioindicador: *Tradescantia Pallida.*

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**Abstrat**

Objectives: In this work, the used bioindicador is the *Tradescantia pallida,* to verify its sensitivity the radiation gamma come from a source of Cs$^{137},$ and to monitor places of low doses of ionizing radiation in tropical climates.

Methods: For such, vases of the bioindicador had been distributed of form to remain displayed for a period 24-hour this source.

Results and Conclusions: The gotten results had shown that the biological system offers to an excellent alternative for biomonitoring of the radiation gamma to the low doses, being an excellent mechanism for acquisition of data of form fast and simple, capable to anticipate abnormality produced for genotoxic agents, favoring to the monitoring in nuclear installations.

Key Works: *Tradescantia pallida,* radiation gamma, the low doses
Protective effect of *Gingko biloba* against radiation-induced cellular damage in human peripheral lymphocytes: Antioxidant and radical scavenger activity

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Abstract

**Objectives:** The present study was designed to determine the possible protective effects of *Gingko biloba* extract (EGb) against oxidative cell damage induced by irradiation (IR) in human peripheral blood lymphocytes.

**Methods:** Human peripheral lymphocytes were exposed to IR after pretreatment with either saline or EGb, and treatments were repeated immediately after irradiation. Human peripheral lymphocytes were obtained for the determination of the frequencies of apoptotic cells. All samples were also examined microscopically and assayed for the frequencies of apoptotic cells.

**Results and Conclusions:** The frequencies of apoptotic cells in human peripheral lymphocytes were increased significantly in the saline-treated irradiation groups, while decreased significantly in the EGb treated-IR groups. In conclusion, the present data demonstrate that EGb, through its free radical scavenging and antioxidant properties, attenuates irradiation-induced apoptosis in radiosensitive cells, suggesting that EGb may have a potential benefit in enhancing the radioprotective effects.
Occupational exposure in radiopharmaceuticals production and transport of radioactive materials

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Abstract
Objectives: To evaluate the occupational exposure in the Centre of Isotopes (CENTIS) of Cuba.

Methods: The trends are analyzed and presented, over the 13 y period from 1996 to 2008. Percentage distributions of the annual effective dose (E), hand equivalent dose (Hp (0.07)) and lens equivalent dose (Hp(3)) in relation with the number of monitored workers are presented, taking into account the annual limits of exposure and dose constrains. Mean values of these dosimetric magnitudes are calculated and plotted. Bioassay results are also processed. For carrying out the analysis of the most exposed groups of individuals, the mean values of E, Hp(0.07) and Hp(3) and annual collective dose (S) are determined for the seven related occupational exposure departments. Annual handling activities for $^{131}$I and $^{99}$Mo, which have the highest contribution to occupational exposure at CENTIS, are also evaluated. Both of their maximum values and relationship with S are assessed. The percentage contributions to S are calculated for the related transport operations. ALARA principle is implemented and maintained considering qualitative and quantitative analysis. The use of electronic direct reading personal dosimeter for new practices and the most important operations is implemented with a credited dosimetry (TLD).

Results and Conclusions: In the studied period an annual average of 42 workers and a total of 504 individuals are controlled. There is 63-98% of the monitored workers for E, 80-100% for Hp(0.07) and 100% for Hp(3) that received 10% of the annual exposure limits. The highest annual committed effective dose represents 1-55% of their respective values of E. The staff belonging to departments of Radiopharmacy and Quality Control is the most exposed. The maximum value registered for S is 29.1 man-mSv and this occurs in 2003. In spite of this, the maximum handling activity of $^{99}$Mo was in 2005 and two years later for $^{131}$I. The annual contribution to S for the related transport operations only has represented 4-20%. There are identified as the most useful tools from the point of view of the optimization of protection, the use of electronic dosimeters and additional shielding for the collection of radwastes and the internal shielding components in hot cells and glove boxes. It is obtained a dose reduction between 10-28%. Our analysis shows occupational exposure in radiopharmaceuticals production and transport of radioactive materials is acceptably low in Cuba.
Estimating lifetime cancer risk due to radiation exposure using an Interactive RadioEpidemiological Program: concepts, adaptation to Brazilian population and application

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Background: Although ionizing radiation exposure accounts for only a small part of total cancer risk in any general population, there are a number of heavily exposed populations, such as the survivors of the atomic bombings of Hiroshima and Nagasaki, Japan that have been extensively studied for possible health effects of radiation. As a result, radiation epidemiologists and statisticians have developed models to estimate cancer risk as a function of radiation dose (IREP) and to use this information as a guide for radiation protection policy, as well as for adjudication of compensation claims made by workers who have developed cancer following a history of occupational radiation exposure.

Objectives: The aim of this paper is to present the concept of IREP and to discuss how the program might be adapted for use in Brazil, taking into account the site-specific cancer incidence and mortality rate of the Brazilian population.

Methods: The computer program IREP (Interactive Radioepidemiological Program) was developed by a working group of the National Cancer Institute (NCI) and the Centers for Disease Control and Prevention (CDC) to estimate the likelihood that a given diagnosed cancer can be attributed to a given prior history of radiation exposure, and the uncertainty of that estimate. The information provided by IREP can also be used to project lifetime cancer risk associated with a given exposure history.

Results: It will be presented potential applications in specific Brazilian situations of radiation exposure which include in particular the Goiania radiological accident, high natural radiation areas, and exposure from medical diagnostic procedures including computed tomography scans, as well as providing an information basis for adjudication of compensation claims for radiation-related cancers.

Conclusions: A Brazilian version of IREP may constitute an important radiation protection tool to project lifetime risk in radiation exposed population and also to be used in evaluating claims for cancer related to radiation exposure.
Lung cancer mortality among the miners in Bayun Obo Rare-earth Iron Mine

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Abstract

Objective: To investigate the lung cancer mortality among the miners in Bayun Obo Rare-earth Iron Mine. Methods: An epidemiology study on lung cancer mortality of the dust-exposed miners and dust-unexposed miners (controls) was performed in 2001 at Bayun Obo Rare-earth Iron Mine. Results: It was found that during the period from 1977 to March 2001, 27 cases of lung cancers were observed in the dust-exposed miners, while 8 cases of lung cancers were found in controls. The SMRs of them were 6.13 and 1.90 respectively. The SMR of the dust-exposed miners was much higher than that of the controls. The difference between the two SMRs is very significant ($X^2 = 9.488$, $P < 0.005$) The probability that 27 or more lung cancers would occur in the dust-exposed group, given the expected numbers and that a total of 35 occurred is $0.0015$. Conclusions: The high SMR for lung cancers among dust-exposed miners likely resulted from the inhaled thorium-containing dusts (carcinogens are $\text{ThO}_2$ and $\text{SiO}_2$) and its short lived thoron progeny. This is the first evidence in humans of the carcinogenicity after long-term inhalation of thorium-containing dusts and thoron progeny. An average latent period of 38.5 years after beginning exposure to the $\text{ThO}_2$-containing dusts and thoron progeny in this rare-earth iron mine was found. The total person-years of observation of the dust exposed miners and the unexposed miners were 62712 and 34672 respectively.
An Investigation on the Relationship Between
the Thorium Lung Burden and the Hepatic Function of the Miners at
the Bayun Obo Rare-earth Iron Mine

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Abstract

Objective: The paper is to present the dose effect relationship between the thorium lung
burden and the hepatic function of the miners at the Bayun Obo Rare-earth Iron Mine.
Methods: The exhaled thoron activity of 751 dust-exposed miners were measured by using
high sensitive negative voltage exhaled thoron progeny collection and measurement system
and the thorium lung burdens were obtained. The four hepatic functions (thymol turbidity
test, glutamic pyruvic transminase, thymol flocculation test and alkaline phosphatase) were
observed in the same time in those miners in Bayun Obo Rare-earth Iron Mine. Results
showed that during the period 1983-2001, 1270 measurements of thorium lung burden
estimates and 1270 measurements of every four hepatic functions (altogether 5080
measurements) were performed on 751 dust-exposed miners. Conclusion The results showed
that when the thorium lung burden of any miner was not higher than 11.11 Bq, the above-
mentioned four indices of hepatic function would not be affected.
Evaluation of Melatonin for Prevention of Radiation Myelopathy in Irradiated Cervical Spinal Cord

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Abstract

Objective: Radiation myelopathy (RM) is known as a serious complication of head and neck radiation therapy. Furthermore, the radioprotective roles of melatonin have been investigated on different tissues. The aim of this study was to assess the radio protective effects of melatonin on biochemical, histopathological and clinical manifestations of RM in the rat cervical spinal cord.

Methods: Four groups of rats were investigated as follows: The control group was treated with vehicle. The second group (melatonin only) was intraperitoneally injected with 100 mg/kg melatonin. The third group's (radiation) cervical spinal cord area was irradiated with 22 Gy cobalt-60 gamma-rays. The fourth group (melatonin plus irradiation) received 100 mg/kg melatonin intraperitoneally, and after 30 minutes their spinal cord area was irradiated with 22 Gy gamma radiation. Five animals from each group were randomly selected. 72 hours, 8 and 22 weeks after irradiation for analysis of malondialdehyde (MDA) and glutathione (GSH) levels, and underwent histopathological studies.

Results: The MDA levels in the irradiation group were significantly higher than in the control group (p<0.001). Furthermore, the GSH levels in this group were significantly lower than that of those in the control group (p<0.001). Administration of melatonin markedly reduced MDA (p<0.001) and increased GSH (p<0.05) levels in this group. Demyelination and clinical signs of myelopathy were decreased in the melatonin plus irradiation group in comparison to the irradiated group.

Conclusion: Our study confirms the radioprotective effects of melatonin at early stages of biochemical, as well as late histological and clinical changes in the spinal cord.

Keywords: Melatonin, Myelopathy, Radiation, Spinal Cord
Ingestion Dose due to Uranium through Potable Water

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Objectives

Uranium is a naturally occurring element found in low levels in all rocks, soil and water. Phosphate, igneous, and granite rocks generally contain a higher amount of uranium, while in sedimentary rocks such as limestone the concentration is low. Due to weathering and subsequent transport, these rocks were carried away by rivers, which are the major source of dissolved uranium in the oceans. Uranium if present in large amount in drinking water, may lead to harmful biological effects in human beings. It is also toxic to the kidneys and an exposure of about 0.1 mg/Kg of body weight of soluble uranium leads to chemical damage of the kidneys. In view of this the concentration of the uranium in river waters of Kali, Sharavathi and Netravathi, the three major rivers of coastal Karnataka were analysed as river water is the major source of potable water in the region.

Methods

The sampling locations were identified along the rivers keeping in view of the local geology. The water samples were collected during pre-monsoon, monsoon and post-monsoon period. The uranium concentration in water was measured by Laser Fluorimeter.

Results and Conclusions

The highest uranium concentration was observed in Kali river compared to Sharavathi and Netravathi. The seasonal variation of uranium concentration in river waters indicate higher concentration of uranium in the estuarine environment of all the rivers. The uranium content of a river depends upon the uranium concentration and its mineralogical form in the catchment area and the chemistry of the water bodies as a whole, particularly regarding the presence of ligands with which uranium may form soluble complexes under the prevailing Eh-pH conditions. The river water was found to be basic in nature in all the rivers from origin to estuary and the variation in pH was rather narrow. A moderate negative correlation was observed between uranium concentration and pH, which indicates that the uranium concentration in water decreases with increase of pH. Uranium concentration was found to vary considerably in river water, both spatially and temporally. The temporal variation may be seasonal, representing the changes in rainfall and run-off, evaporation and transpiration. From the measured concentration of uranium in river water, ingestion dose to the population of the region were computed. These dose levels were compared with the internationally recommended values. The ingestion dose due to uranium was found to be within the recommended level.
Down Regulation of Surface Hla-G Expression in a Melanoma Cell Line Exposed to Low Dose Rate Beta Irradiation

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Introduction and objectives

Beta-emitting radiopharmaceuticals are finding wider applications in cancer treatment, such as radio immunotherapy, bone-seeking radiopharmaceutical therapy, and in brachytherapy applications, but in each situation, non-uniform dose deposition exists.

The HLA-G molecule is a non classical HLA class I antigen and contribute to tolerance of fetus by inhibiting maternal immune response, and its expression in tumor cells may favor their escape from host immune surveillance. The objective of this work was to analyze HLA-G expression in a human melanoma cell line after external inhomogeneous beta irradiation at different dose and dose rate.

Materials and methods

Melanoma cell line (FSN), HLA-G+, was continuously irradiated by an external 32P source at 37°C until the programmed total dose was obtained. The absorbed dose was calculated applying MCNPX 2.5f Monte Carlo code for the 25 cm² tissue culture flasks.

Membrane HLA-G detection was performed by flow cytometry with specific antibodies at the end of irradiation.

Results

The final dose ranges from 100% in the center of the flasks to the 67% at the external limit. The value of dose and dose rate shown represent the average value calculated by the Monte Carlo code.

The cells were irradiated at 30 and 10 Gy with initial dose rate of 250 ± 30 mGy/hour.

The median fluorescence index (MFI) for HLA-G expression was 0.60 and 0.78 with respect to controls. For cells irradiated at 10 Gy with 45 mGy/hour the MFI was 0.82 and with doses ranging from 1 to 3 Gy at 25±5 mGy/hour the MFI was 0.85%. There was not induction of down regulation with 1 Gy at 4 mGy/hour.

Conclusions

For high doses (10-30 Gy) the down regulation of HLA-G at the same dose rate is dose dependent.

At relatively low doses (1-3 Gy) and low dose rate (25 mGy/h), HLA-G down regulation is still induced. The data suggest that dose rate about 4 mGy/hour could indicate a threshold for this effect.

This synergism between HLA-G down regulation expression and the killer activity of beta particles could increase neoplastic cells rejection by immune system.
Estimation the probability of cancer from occupational radiation exposure among workers in nuclear industry in Bulgaria

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Abstract: Today the radiation exposures almost are (except radiation accidents) in the rage of low doses. This is referring to the exposure in the professional sphere. According to exposure assessment of Bulgarian population with the individual doses from occupational exposure are low. In cases of radiation with relatively low doses, only stochastic effects are probable. Individuals, working in nuclear industry are exposed to continuous radiation with low doses and low dose rate.

Objectives: To estimate the probability of causation of cancer and go before occupational radiation exposure among workers in nuclear industry in Bulgaria.

Method: The assessment method of the Probability of Causation (PC) provides possibility to determine the causative connection between the occupational exposure and the consequent radiation-dependant cancer. The probability for such a connection depends on the duration of the employment period in an ionizing radiation environment, as well as on the cumulative dose for that period, age and sex of the employee and the latent period for the corresponding localization. Data has been processed with a software product “Survrad”.

Results: An analysis of the probability for a causative connection with the radiation was carried out on 77 workers in Nuclear Power Plant who have individual dosimetric card in the period 1986 - 2008. Cases with cancer of the digestive tract (21%), breast cancer (15%) and lung cancer (10%) are prevailing. Out of all analyzed workers 66% are male and 34% female. With 69 out of 77 workers the probability for their occupational radiation to be the reason for the cancer is zero. There is a probability that the additional exposure to radiation could be the reason for carcinogenic illnesses in 8 employees. The probability of occupational exposure to be the cause for the cancer is between 1% and 6%.

Conclusion: The present study does not find out a causative connection between cancer and a previous occupational radiation received through normal work.

Key words: Nuclear Power Plant, cancer, employees, probability of causation.
Three-state stochastic model for the radiation-induced bystander effect in vitro

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Objectives
This work aims to show that a simple Markovian model with three-state is able to reproduce experimental observations on bystander cell survival in a Conditionally Irradiated Medium (ICM) as a function of rescue time and radiation dose.

Methods
The stochastic model attributes three possible states to the cells: healthy (state 2); genetically transformed (state 1); and dead (state 0) with n₀ cells initially in the system.

The master equation is,

\[
\frac{dP(n,m,t)}{dt} = (n + 1)\mu_1(t)P(n + 1, m - 1,t) + (m + 1)\mu_2(t)P(n,m + 1,t)  
- (n\mu_1(t) + m\mu_2(t))P(n,m,t)
\]

(1)

where P(n,m,t) is the probability of having n healthy cells and m transformed cells at time t. The transition rates are given by,

\[
\mu_i(t) = \mu_{i0}e^{-\lambda t}
\]

(2)

For the case of signal release at time zero only, the expected values of n and m are given by,

\[
\langle n \rangle = \sum_{n,m} n P_{n,m}(t) = n_0 \times \exp\left(-\frac{\mu_{10}}{\lambda} \left(1 - e^{-\lambda x_t}\right)\right)
\]

(3)
\[
\langle m \rangle = \sum_{n,m} m P_{n,m}(t) = \frac{n_0 \mu_{10}}{\mu_{20} - \mu_{10}} \left[ \exp\left( -\frac{\mu_{10}}{\lambda} (1 - e^{-\lambda t}) \right) - \exp\left( -\frac{\mu_{20}}{\lambda} (1 - e^{-\lambda t}) \right) \right]
\]

(4)

The survival fraction (SF) is then given by,

\[
SF = \frac{n_0}{n_0} \exp\left( -\frac{\mu_{10}}{\lambda} (1 - e^{-\lambda t}) \right)
\]

(5)

This model uses the limiting \( t \to \infty \) to evaluate \( SF \) as a function of the dose.

**Results**

Figure (1) shows the adjust produced for the clonogenic survival fraction in an experiment of ICM and Figure (2) shows the survival fraction as a function of the alpha particle number when 10% of cells were directly irradiated. In Figure (1) the solid curve was obtained with \( \mu_{10} = (3.3 \pm 0.15) \times 10^{-4} \) and \( \lambda = (6.6 \pm 0.79) \times 10^{-4} \). In Figure (2) a linear dependence with dose was supposed for \( \mu_{10} \), i.e., \( \mu_{10} = (k/\lambda)N \), where \( (k/\lambda) = k_0 \) and \( N \) is the number of alpha particles.

![Figure 1 - Adjust of the clonogenic survival for unirradiated cultures of human keratinocytes in the experiment of Mothersill](image-url)

Figure 1 - Adjust of the clonogenic survival for unirradiated cultures of human keratinocytes in the experiment of Mothersill
Figure 2 - Survival fraction of C3H10T^1/2 cells irradiated with alpha particles of LET = 90 KeV·μm^{-1}.

Conclusions

It was shown that a simple stochastic model with three states is capable to describe the cell survival fraction as a function of time and dose. The hypothesis that the parameter $\mu_{10}$ possesses a linear dependence with dose allows a good reproduction of the survival fraction in function of the alpha particle number.
Effect of low dose of ionizing radiation in exposed populations

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Objectives: The present study aimed to investigate nucleotide alterations in exon 4 of gene TP53 in three populations of the Amazon region (Monte Alegre, Prainha and Alenquer populations, all of them in the state of Pará - Brazil), exposed to low radioactivity of the uranium reserves.

Methods: Blood samples of 151 individuals (25.8% male and 74.2% female) were collected. They had answered to a questionnaire, which approached partner-physician-ambient risk factors for mutagenesis and/or carcinogenesis. DNA of samples was extracted by phenol-chloroform method. The target genetic region was amplified by PCR, and the amplicon (199pb) was sequenced by chain-terminating inhibitors method. The sequences were created in genetic analyzer ABI Prism 3130 (Applied Biosystems, CA, USA).

Results: It was found an alteration, the nucleotide G→C in the codon 72 (TP53*72 C=0.345), which produces a change of AA arginine for proline (Arg72Pro). The found allelic frequency does not differ of global frequency (0.352) presented in the genetic database (GenBank/NCBI). The statistical analyze showed that codon 72 polymorphism, in homozygosis (TP53*72 C/C), is an important risk factor for cancer development (p=0.023; OR=6.52; IC: 1.29 - 32.94), adjusting for age and smoking.

Conclusion: This association indicates an increased susceptibility to genotoxics agents, as low dose of ionizing radiation. This provides some evidences that low doses of ionizing radiation can be harmful to susceptible people.
Comparison of Equivalent Doses in the Excretory Urography and Renal Dynamic Scintigraphy Procedures


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Abstract

Objectives. The excretory urography and renal dynamic scintigrapy are diagnostic procedures that provide adequate information for evaluation of renal function. The objective of this paper is to produce a comparative study between the equivalent doses of radiation received by the main organs of the abdominal region in each procedure mentioned assuring the choice of the best diagnostic method with less exposure of the patient to ionizing radiation.

Methodology. The methodology consisted of a comparison of doses in various organs during the excretory urography and renal dynamic scintigraphy procedures. For this, a literature review was conducted in which it was possible to identify the doses for the patients exposed during the X-rays examinations and to calculate the doses in the renal dynamic scintigraphy using the “software” “cFAE” for the mathematical model of the Brazilian male reference and the mathematical model of the Brazilian female reference. The “software” results gives the FAE- “absorbed fractions specific” for each organ and, on the basis of these fractions were calculated the dose equivalent of twelve organs from the abdominal region.

Results. The results show that the doses of radiation in dynamic renal scintigraphy are lower for all organs evaluated when compared with excretory urography, excepting for the kidneys that received doses 0.56 higher in renal dynamic scintigraphy when was used the model "reference male" and 0.60 times higher when was used to the" reference female".

Conclusion. Considering the uncertainties associated with the method adopted, the results obtained in this paper suggest that the renal dynamic scintigraphy offers lower risks to the patients because there are no adverse effects inherent to the practice and, that the radiation doses are lower in this procedure.

Key words: Patient Dosimetry, “cFAE”, Renal Dynamic Scintigraphy, Excretory Urography
Effect of low dose radiation on nuclear and mitochondrial genomes

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Abstract

Objectives
A growing body of literature points to the changes in mitochondria as one of the major components of a general stress response following radiation. We hypothesized that chronic stress from low dose radiation should lead to an increase in the number of mitochondrial genomes per cell.

Methods
In order to test this hypothesis, we have decided to develop a new type of quantitative PCR assay, where genes for mitochondrial proteins encoded by mitochondria and nucleus are compared for copy numbers. We have begun to apply this assay on DNA isolated from paraffin tissue blocks preserved in an archive of mouse tissues. To evaluate changes in numbers of mitochondrial genomes in different tissues from different mice we did quantitative PCRs for mitochondrially encoded mitochondrial genes COX1 and ND1 and for nuclear-encoded mitochondrial genes COX4 and NDUFV1.

Results
During 1960-1992 more than 49,000 B6CF1 mice (F1 hybrid of C57BL/6J females and Balb/cJ males) were exposed to different doses and dose rates of gamma rays or fission-spectrum neutrons as whole body irradiation. Several hundreds of these mice were irradiated for 60 weeks with one fraction per week, receiving a total of 0, 2 or 6 Gy of gamma rays. Tissue from these animals were harvested at the time of their natural death and paraffin embedded. For our analysis we selected heart (high ratio of mitochondrial: nuclear genomes), kidney and spleen (medium ratio). To be assured that the changes observed are not a result of neoplastic changes, we interrogated both healthy spleens and spleen tumors by Q-PCR. This initial analysis showed that in irradiated mice spleen tumors and healthy spleens alike mitochondrial genes showed higher copy numbers than in spleen tissues of non-irradiated mice.

Conclusions
We are developing a new technique for DNA from archived tissues to evaluate changes in mitochondrial genome numbers in mice exposed to low dose radiation over a period of 60 weeks. Preliminary data on spleen DNA suggests that irradiation has caused an increase in mitochondrial copy numbers. We will continue these studies using “healthy” kidney and heart tissues, moreover, we will expand this study to include additional doses and fractionation regimens.
Change of chlorophyll fluorescence transients in Arabidopsis leaves irradiated with low dose gamma rays using gamma phytotron

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Objectives: Ionizing radiation is a potent cytotoxic and genotoxic agent that induces physiological aberrations and genetic mutations in plants. However, it is generally accepted that plants are much more tolerant to ionizing radiation than animals. In the present study, we aimed to analyze chlorophyll fluorescence transients and to evaluate various chlorophyll fluorescence parameters for application to the ecological biomonitoring of radiation-exposed environments and to the biodosimetry and high-throughput screening for plant mutation breeding.

Methods: Arabidopsis seedlings were grown on the MS medium in tissue culture vessels (Magenta, Chicago, IL) for 17 d with a photocycle of 16 h and a temperature regime of 18/22°C (D/N). The seedlings were consecutively exposed to gamma rays at a dose rate of 80 mGy h⁻¹ for 10 h per day during the whole irradiation period of 7.5 d. Chlorophyll fluorescence analysis was carried out after 15-min dark incubation of detached leaves using a fluorimeter, HandyPEA (Hansatech, Norfolk, UK).

Results: The phenotypic trait of the irradiated seedlings discernible from the control ones was reddish color on the abaxial side of rosette leaves. The reddish color seems to be due to the accumulation of anthocyanins. Otherwise, substantial phenotypic alterations were not observable with the naked eye. Moreover, since the Fm was only slightly decreased with no significant change in the Fo after exposure to gamma rays, the maximum photochemical efficiency, Fv/Fm, was almost the same between the control and irradiated leaves. In contrast, the details of the Kautsky fluorescence induction (J-I-P) were substantially affected by the consecutive 8-d irradiation of gamma rays up to the accumulated dose of 6 Gy. The photosynthesis performance index, PI, which is based on the details of the JIP induction, could discriminate between the control and irradiated leaves, being about 40% lower in the latter.

Conclusions: The obtained results suggest that the kinetics of the Kautsky induction curve can be utilized to monitor irradiated plants for environmental assay or mutation breeding. Especially, the PI is expected to be a sensitive and reliable parameter for evaluation of the irradiated plants.
The possible increase of some cancer rates on the area with fuel-like hot particles deposition from Chernobyl fallout in Poland

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The tiny particles of spent nuclear fuel, so called „fuel-like hot particles” were present in the radioactive cloud from initial phase of Chernobyl accident in April 1986. Since those particles were relatively large they precipitated from the plume rather fast and they are present in the fallout on a not very remote sites from damaged NPP. The Polish border is about 400 km far from Chernobyl and in the northeastern Poland relatively massive precipitation of “fuel-like hot particles” were identified [1,2,3]. Such hot particles contain many radioisotopes of non-volatile elements among them plutonium. Since in remote sites the ratio between $^{137}$Cs and Pu isotopes was on the level of 1000 the enhanced activity of Pu of specific Chernobyl isotopic ratio can be treated as a signature of hot particles fallout in the environment. The Chernobyl plutonium deposition in Poland was found to be as high as 30 Bq/m² in the maximum [4]. The geographic pattern of this deposition was a subject of our recent study.

The external dose from Chernobyl fallout was estimated to be below 0.3 mSv in 1986 [5] so one cannot expect any increase of cancer rate from external radiation. Although the inhaled hot particles may increase the dose to critical organs in the not well-recognized way. Many of radionuclides (Pu, Am, Cm, Sr radioisotopes) present in the fuel-like hot particles can accumulate in bones or liver. The main exposure was due to inhalation. In our study we examined the cancer rates in the most exposed counts (Polish name „powiat” – it is form of up to tens commons) for cancer of liver, bones and lungs as well as the red-marrow leukemia against their mean ratio in scale of whole Poland. The cancer rates were normalized for the age profile. The statistics on cancer cases were obtained from local Białystok Cancer Register.

In case of lung cancer no increase was found although for liver cancers, bone cancers and red-marrow leukemia the increase can be observed. Moreover, the time profile suggests also the relationship with Chernobyl accident. The maximum rate is about 1995, so about 10 years after the accident. The difference between mean values for appropriate cancer ratios for whole Poland and three powiats can be consider significant in terms of Mann - Whitney tests.

References
Estimation of Internal Exposure To $^{99}$m in Nuclear Medicine Patients


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ABSTRACT

Introduction: $^{99m}$Tc is the most widely used radionuclide in nuclear medicine. It is obtained by elution of $^{99}$Mo-$^{99m}$Tc generators. Depending on the quality of the generator and its integrity, $^{99}$Mo might be extracted from the column during the elution process, becoming a radionuclidic impurity in the $^{99m}$Tc eluate. This fact would impart an undesired dose to the patients submitted to diagnostic procedures.

Objectives: The aim of this work is to evaluate $^{99}$Mo incorporation and internal effective doses in nuclear medicine patients through bioassay techniques, providing information on the metabolism of molybdenum in humans.

Methods: A methodology based on in vivo and in vitro measurements was developed. In vivo measurements were performed with a NaI detector installed in the IRD WBC. Urine samples were analysed with a HPGe at the IRD bioassay laboratory.

Results and Conclusions: Patients showed detectable activities of $^{99}$Mo in whole body and urine. Results were interpreted with AIDE software. Estimated incorporation was compared to predicted values based on ICRP model. The committed effective doses of the patients varied between 0.03 and 2.6 $\mu$Sv using the real intake values as a basis, i.e, determined from the eluate measurement. Biological half-life calculated through the model (60.3 days) is 3.8 times longer than the one obtained through in vivo monitoring (15.7 days). Average real $^{99}$Mo intake by the patients, determined through the measurement of $^{99}$Mo in eluates samples collected in the Nuclear Medicine Services was 3599 Bq. The incorporation of such activity would deliver an effective dose of 0.82 $\mu$Sv to the patient. Such dose does not represent a significant contribution if compared to the dose received due to the administration of $^{99}$Tc for the examination. Biological half-life of molybdenum calculated through the model (60.3 days) is 3.8 times longer than the one obtained through in vivo monitoring (15.7 days). This means that, according to ICRP model, $^{99}$Mo is retained in the human body much time than observed in the experimental data obtained in this study. These data are in agreement with the values of about 20 days, suggested by Giussani et al.
Evaluation of the Internal Exposure in a $^{123}$I Production Plant through In Vivo Monitoring

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ABSTRACT

Introduction: $^{123}$I is a photon emitter radionuclide (159 keV) used in nuclear medicine for image diagnosis of a variety of diseases. It has been produced at the Institute for Nuclear Energy (IEN) since 1998 and supplied to nuclear medicine centres located in the State of Rio de Janeiro. The IEN has increased its production in about 500% in the first five years in order to respond to the increasing demand from the clinics for Meta-iodine-benzyl-guanidine (MIBG). The production of the radiopharmaceutical MIBG as well as the annual maintenance of the cyclotron can lead to internal exposures of the workers by $^{123}$I and $^{65}$Zn.

Objectives: This work presents the techniques performed at the IRD whole body counter for the identification and quantification of $^{123}$I and $^{65}$Zn. It is also discusses the methodology adopted for data interpretation in terms of committed effective doses as well as an evaluation of the results of the in vivo measurements.

Methods: Workers have been monitored routinely at the IRD Whole Body Counter. Monitoring is based on in vivo measurements of the thyroid and whole body for the determination of $^{123}$I and $^{65}$Zn respectively.

Results and Conclusions: It is concluded that (i) the measurement techniques are suitable for routine monitoring of occupationally exposed workers and (ii) the radiopharmaceutical production plant is safe in terms of radiation protection conditions since all incorporations detected so far represent only a small fraction of the annual dose limits.
In Vivo and In Vitro Bioassay Methods to Evaluate Occupational Internal Exposure to $^{18}$F

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ABSTRACT

Introduction: $^{18}$F is currently produced in Brasil in São Paulo, Rio de Janeiro and in Belo Horizonte. A new production plant in Recife is to be started in a near future. Other plants should be installed in the Southern and Center-West regions of Brazil. The increasing use of $^{18}$F in nuclear medicine through PET technology leads to the growth in the number of occupationally exposed workers. External and internal exposures may occur both in the production of fluordeoxyglucose (FDG) and during its clinical use in nuclear medicine. Workers involved in such activities are routinely monitored for external exposure. However internal monitoring should be promptly available in a suspicion of accidental incorporation.

Objectives: The aim of this work is to provide procedures for internal monitoring of $^{18}$F to be applied in cases of possible incorporation of fluoride and FDG, using In Vivo and In Vitro methods.

Methods: In Vivo techniques were developed at the IRD-Whole Body Counter. The NaI(Tl)8x4 detector was calibrated with a whole-body phantom, simulating homogeneous distribution of $^{18}$F within the body. The NaI(Tl)3x3 was calibrated with a brain phantom inserted in an artificial skull, simulating FDG incorporation. The HPGe detection system of the IRD-Bioassay Laboratory was calibrated for In Vitro measurements of urine samples with 1 liter plastic bottles containing a standard liquid source. A methodology for bioassay data interpretation, based on standard ICRP models edited with the software AIDE-version 6, was also established.

Results and Conclusions: In Vivo measurements in whole body and brain geometries are suitable to evaluate $^{18}$F incorporation in the form of fluoride and FDG, respectively. The techniques present enough sensitivity to detect and quantify activities as low as 32 Bq in the whole body and 7.5 Bq in brain, resulting in minimum detectable effective doses of $4.4 \times 10^{-6}$ and $1.55 \times 10^{-5}$ mSv, respectively, for fluoride and FDG incorporations. In Vitro bioassay showed insufficient sensitivity for the evaluation of fluoride incorporation. However, the technique is able to detect doses below 1 mSv in the case of FDG incorporation. In this case it is possible to detect incorporations that would deliver an effective dose of $3.0 \times 10^{-6}$ mSv, which is far below the recording level of 1 mSv.
Optimization of $^{131}$I Doses for the Treatment of Hyperthyroidism

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ABSTRACT

Introduction: Several methods can be used to determine the activity of $^{131}$I in the treatment of hyperthyroidism. However, many of them do not consider all the parameters necessary for optimum dose calculation. The relationship between the dose absorbed by the thyroid and the activity administered depends basically on three parameters: organ mass, iodine uptake and effective half-life of iodine in the thyroid. Such parameters should be individually determined for each patient in order to optimize the administered activity.

Objectives: The objective of this work is to develop a methodology for individualized treatment with $^{131}$I in patients with hyperthyroidism of the Grave's Disease.

Methods: A neck-thyroid phantom developed at the IRD was used to calibrate a scintillation camera and a uptake probe SCT-13004 at the Nuclear Medicine Center of the University Hospital of Rio de Janeiro and a uptake probe SCT-13002, available at the Nuclear Medicine Institute in Goiânia. The biokinetic parameters were determined based on measurements performed in eight voluntary patients.

Results and Conclusions: For the iodine uptake test using the scintillation camera, the distance of 45.8 cm, between source and detector was the one which presented the best count rate output, since it presents a view angle compatible with the thyroid size of approximately 6 cm in patients with Graves’ corresponding to a calibration factor of $(4.3 \pm 0.2)$ cpm/kBq. For the uptake probe SCT-13004 at 25 cm it was obtained a calibration factor of $(39.3 \pm 0.8)$ cpm/kBq. The value obtained for the uptake probe SCT-13002 was $(16.3 \pm 0.26)$ cpm/kBq. The values of effective half-life of the eighth patients studied (Table1) are in accordance to the value found in literature for patients with hyperthyroidism of the Graves’ disease $(4.9 \pm 0.1)$. With the SCT-13004 system was obtained at distances of 25 cm. The values of iodine uptake (%) of in the thyroid in two hours and the volume (cm$^3$) found are also within the average values expected for this type of patient. It is concluded that the use of the equipment available at the hospital (scintillation camera and uptake probe) has shown to be a suitable and feasible procedure for dose optimization in terms of effectiveness, simplicity and cost. This procedure can be applied for the individualized optimization of $^{131}$I dose to be administered to each patient.
Exposure to 900-MHz mobile phones and blood cell count and serum levels

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Objectives: The world-wide and rapidly growing use of mobile phones has raised serious concerns about the biological and health-related effects of radio frequency (RF) radiation. A major concern of the adverse effects of exposure to non-ionizing electromagnetic field (EMF) is cancer induction. The aim of this study is to investigate the potential hazardous effects of 900 MHz Global System for Mobile Communications (GSM), RF exposure on function and digital read-out of CELL COUNTER blood surveyor.

Material and methods: The device were exposed at a dose of 0.5, 0.78, 1 W/kg (locally in the head SAR) at 900 MHz mobile phones electromagnetic field during read out of a blood sample. After each expose, reading was repeated at the non-existence of EMF. The outcome was assessed by changes in the serum levels and blood cells count (BCC) of the sample (RBC, WBC, etc).

Results: Results showed that EMF exposure caused a significant decrease of RBC, WBC count of the blood sample at the dose of 1 W/Kg of the 900 MHz EMF. Dose of 0.78, 0.5 W/Kg mobile phones has the second and third highest BCC read-out, and 1 W/Kg mobile phone has lower BCC than those for 0.5 and 0.78 W/Kg. The average BCC concentration for WBC, RBC during the expose with 1 W/Kg mobile phone were 3010±5.4, 9.87±0.4# and for 0.78 and 0.5 ones were 3030.25±3.6, 3072.5±4.7 and 7.73±0.3, 8.14±0.28# respectively.

Conclusion: Blood counting at 900 MHz mobile phones electromagnetic field showed statistically significant decrease in the serum levels and BCC, while(p = 0.02). These results may encourage researchers to evaluate the effects of EMF’s on the biological systems.

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The effect of Electro Magnetic Field exposure Produced by Mobile phones on Elisa Surveyor

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Objective: Along with the augmentation in the usage of mobile phone and exposure of people to Electro Magnetic Fields produced by them, there has been an increase in studying the biological effects of these fields. However the effects of these fields on other devices have not been studied yet. There have been clues about the malfunction and decrease in the accuracy of devices used in Medical centers and labs. Special regulation has been conducted to inhibit the use of these devices in such areas. The Effect of RF/MW on biological systems is based on the Rate at which Radiofrequency Energy is absorbed by body (SAR) when exposed to radio-frequency electromagnetic field but whether this mechanism is involved in paralyzing other devises is not clear. The aim of this study is to investigate the potential hazardous effects of 900 MHz Global System for Mobile Communications (GSM) Radiofrequency (RF) exposure on the on function and digital read-out of Eliza surveyor.

Material and methods: The Eliza surveyor were exposed to dose of 0.5, 0.78, 1.1 W/kg(locally in the head) of mobile phone electromagnetic field working at 900 MHZ frequency, during read out of samples of human serums with five different concentrations 50, 100, 150, 200, 250, 300 λ in vials numerically labeled 1, 2, 3, 4, 5, 6 respectively.

Results: Results showed that the exposure to EMF caused a significant decrease in the read out of the device at all there Doses. The read-outs of the samples in vials 1, 2, 3, 4, 5, 6 during the exposure to 1.1 W/Kg were 0.22, 0.33, 0.42, 1.85, 2.17, 2.69 λ, and for 0.5 W/Kg it were 0.21, 0.33, 0.42, 1.80, 2.65, 2.73 λ, respectively. The read-out of the samples at the non-existence of EMF was 0.21, 0.34, 0.41, 1.84, 2.70, 2.75, respectively.

Conclusion: The results clearly shows that exposure of the Elisa Surveyor to Electro magnetic Field has significantly altered the accuracy of the device and its' effect is proportional to EMF strength. This study suggests that new regulations should be conducted to restrain using of mobile phones by lab technicians while running these devices.

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Telomere Length after Low-Dose Radiation Exposure

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Objectives: Experimental studies have demonstrated relationships between the telomere length and exposure to the ionizing radiation, radiogenic cytogenetic markers. The early effects of irradiation under the professional levels include cell activation and differentiation changes, low apoptosis, high expression of anti-apoptotic proteins and at higher doses - the elevated TCR-variant cell counts, apoptosis, cytogenetic stable and non-stable markers. Aim of the study was to estimate telomere length after the low dose exposure and reveal factors that might influence telomere changes.

Methods: A study was performed in 47 subjects (18 radiation workers of the Chornobyl 30-km exclusion zone, effective doses of external exposure: 3-28 mSv; \(^{137}\)Cs and \(^{239}\)Pu incorporation doses up to 0.6 mSv; 15 age-standardized controls and 14 Chornobyl clean-up workers twenty two years after the exposure). Cellular phenotype was studied by flow cytometry. Relative telomere length (RTL) was studied by Flow-FISH procedure with Telomere PNA Kit/FITC using K562 cell line as a standard.

Results: Our data demonstrate the lower RTL in radiation-exposed. In radiation workers exposed under the professional limits a tendency of mean RTL values decrease was shown (fig.1). A decrease was significant (p < 0.02) in clean-up workers at the late period after radiation exposure. Comparative analysis of the basic cellular immunity parameters and lymphocyte activation revealed none of the statistical differences between groups of exposed except of the higher cytotoxic CD8\(^+\) cell counts in clean-up workers (33.12±1.12 vs 27.00±1.76%). Both groups have shown increased variant TCR-negative cell counts (3.1 and 5.1x10\(^{-4}\)) and a high bcl-2 fraction. The positive correlations were shown between the RTL and the total number of aberrant cells and negative – with the number of single acentric fragments, no correlation – with radiogenic aberrations (dicentrics).

Conclusions: This study shows that low-dose radiation may in vivo induce in humans the changes in the telomere regions that are detectable after twenty years. The nature of these changes remains not clear. No connection was shown with the cellular immunity parameters while some relationship could exist with chromosome damage. Possibility of the hTERT dependent or independent pathways down-regulation as well as the adoptive origin of telomere shortening should be evaluated due to the experimental data on the hTERT radioprotective effects in cells with shortened telomeres.

Fig.1.
Experimental model in rats irradiated with 10 Gy for the analysis of radiation injury of skin

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Introduction: Radiotherapy is one of the most used therapeutic modalities, aimed at the destruction of cancer cells, from the use of ionizing radiation. The irradiation of the skin can elicit a series of injuries in fibrosis, culminating in necrosis which results in functional alteration of the body. The morphological evaluation of the effects associated with irradiation of the skin becomes essential to establish more effective strategies of irradiation and decreased morbidity. The objective this study is to evaluate the radiation skin changes using a model in Wistar rats.

Methodology: Male Wistar rats, 3 months age, were anesthetized with thiopental, immobilized on support of Styrofoam in prone position and irradiated with single dose of 10 Gy, with a 4 MeV electron beams. The skin was irradiated using field of 3cm\textsuperscript{2}, and a 0.5cm tissue equivalent bolus to obtain a homogeneous dose distribution of dose. After irradiation, the animals remain under constant evaluation, and the lesions were photographed. The animals were divided in groups and were sacrificed on days 1, 5, 10 and 25 after irradiation. For morphologic, the skin samples were fixed in formaldehyde at 10%, dehydrated, cleared, and then paraffin-embedded. The thick sections (5μm), stained with sirius red-Picro, hematoxylin-eosin and toluidine blue, and for immunohistochemistry to the expression of cytokine TGF-beta.

Results and conclusions: Erythema was predominantly observed followed by dry desquamation of the skin of some animals. Normal growth of hair was observed after 25 days. However, when observed by optical microscopy that there was a slight inflammatory infiltrate in all groups. Collagen fibers parallel to epidermis in the group were seen 10 days starting a fibrotic process. Collagen fibers were found out in group of 25 days the - normal remodeling of the fibers. The immunohistochemistry showed that there is an increased expression of cytokine TGF-beta in the group of 5 days and a subsequent decrease in the other groups - the acute phase of inflammation with subsequent recovery.

The observations indicate that the irradiation triggered an inflammatory response with release of the cytokine TGF-beta, induces fibrosis. This appears to suggest that the effect evolves until the tenth day, with subsequent reorganization of the tissue as observed in animal group sacrificed 25 days after irradiation.
Estimating Lung Cancer Risk due to Radon Exposure in the Radon-Prone Areas of Belgium

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Radon exposure in Belgium is particularly pronounced in the southern part of the country, characterized by a sub-surface composed of highly deformed and fractured (black) shale, schist and sandstones of the Ardenne massif. A national indoor radon measurement campaign (1995-2000) showed that all of the high radon risk areas (where more than 5% of the measured buildings exceed the Belgian action-level of 400 Bq/m³) were situated within the Ardenne massif, affecting a population of 380,000. For this reason, detailed information, measurement and prevention campaigns have been organized for the local population and municipal authorities.

Whereas the national average radon concentration is about 50 Bq/m³, this average increases to 170 Bq/m³ in the high risk areas. Here, 13% of the houses exceed the action level, affecting more than 50,000 people, and 4% of the houses exceed 800 Bq/m³, affecting more than 15,000 people. In 33% of the dwellings, the design level for new buildings (200 Bq/m³) is exceeded. According to the risk estimates from international epidemiological studies, about 24% of the occurring lung-cancers (49 cases on 201 per year) would be due to radon exposure in the high risk areas. About 40% of the radon-induced lung-cancers (LC) would occur in the population exposed to more than 400 Bq/m³ (about 20 lung-cancers per year). Comparison of these theoretical values with actual LC statistics of the Belgian Cancer Registry shows a good match between the total number of annual LC in the high risk areas (201 calculated to 203 observed). The correlation between LC occurrence and average radon concentration however is obscured by the high number of influencing factors (migration, age-distribution, life-habits,...) and the relatively limited population. Radon campaigns aim at stimulating house owners and building responsible to mitigate the radon affected buildings and to apply preventive measures in new buildings. In the high risk areas, preventive reduction of radon exposure should lead to a reduction of the LC occurrence with 7%.
Development and Application of In Vivo Measurement Of $^{210}\text{Pb}$ as an Indicator for $^{222}\text{Rn}$ Internal Exposure

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ABSTRACT

Introduction: Radon and its decay products are present in the atmosphere and are the most important contributors for the internal exposure of humans to natural radiation. The execution of in vivo measurements of $^{210}\text{Pb}$ in the population and in individuals occupationally exposed in underground mines has been studied and recommended as one of the procedures for the estimation of $^{222}\text{Rn}$ exposure. The metabolism of $^{210}\text{Pb}$ and its distribution within the human body, mainly deposited in bone tissue, suggests the regions of skull and knee as the most suitable for in vivo monitoring of such radionuclide. A previous radiological survey in non-uranium mines in Brazil indicated that an underground coal mine in the State of Paraná, in the south of Brazil, presented high radon concentration.

Objectives: The aim of this work were: (1) To investigate whether underground coal miners may also have elevated $^{210}\text{Pb}$ in the skeleton as a result of occupational exposure to radon in the coal mine; (2) To estimate the committed equivalent dose and the committed effective dose in different incorporation scenarios using a computer code.

Methods: In vivo measurements of underground coal miners were performed in the IRD-CNEN Whole Body Counter using an array of four high resolution germanium detectors installed in a shielded room. The detection system was positioned at the head and knee geometries and the positive results were verified using a mathematical method that applies a moving median smoothing function to the total spectrum for each measurement. The relative contribution from the incorporation of $^{222}\text{Rn}$, $^{214}\text{Pb}$ and $^{210}\text{Pb}$ present in the mine environment and from $^{210}\text{Pb}$ in the diet were evaluated in some plausible scenario.

Results and Conclusions: The minimum detectable quantity of $^{210}\text{Pb}$ in the skeleton using this methodology was 50 Bq. In vivo measurements of $^{210}\text{Pb}$ in 6 out of the 32 underground coal miners ranged between 83 and 164 Bq suggesting that these workers received significant occupational cumulative exposure to $^{222}\text{Rn}$. The simulation of some exposure patterns of $^{222}\text{Rn}$ progeny and $^{210}\text{Pb}$ incorporation showed that the most important contribution for $^{210}\text{Pb}$ skeleton deposition was the intake of $^{214}\text{Pb}$ and $^{210}\text{Pb}$. These radionuclides were present in the underground mine as $^{222}\text{Rn}$ progeny.
Method of the Recovery of the Health of the Populations Exposed to the Radiostresogen Factors using "Pacovirina-Plus"

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Objectives. The improvement of the treatment of the persons exposed to ionizing radiation using the product of vegetable origin "Pacovirina-plus" have been performed on the aim of optimization of the immunocorection.

Methods. Study of the efficiency of "Pacovirina-plus" on the recovery of the health of the populations exposed to the radiostresogen factors (participants in the diminution of the Chernobyl NPP consequences) have been performed on the base of clinic and paraclinic investigations.

Results and discussion. The scientific results of the optimization of treatment of the ionizing radiation exposed patients using product of vegetable origin "Pacovirina-plus" are related in this paper. Administration of the "Pacovirina-plus" at the patients exposed to the radiostresogen factors demonstrate the improvement of the health indices, manifested through the significant diminution of the astenic, depressive syndromes and digestive disturb, restoration of the CD4/CD8 rapport and the antioxidant activity with the normalization of ALAT, ASAT and diminution of the peroxide oxidation activity of the lipids.

Table. The influence of the product of vegetable origin "Pacovirina-plus" on the biochemical indices of the participants in the diminution of the Chernobyl NPP consequences

<table>
<thead>
<tr>
<th>Nr</th>
<th>Indices</th>
<th>$X \pm m_x$</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ALAT</td>
<td>47,9±21,6</td>
<td>0 - 41,0 un/l</td>
</tr>
<tr>
<td>2</td>
<td>ALAT</td>
<td>41,1±17,4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASAT</td>
<td>58,3±28,9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ASAT</td>
<td>36,8±19,1</td>
<td>0 - 37,0 un/l</td>
</tr>
<tr>
<td>3</td>
<td>Bilirubin</td>
<td>10,6±3,0</td>
<td>8,0 - 23,0</td>
</tr>
<tr>
<td></td>
<td>Bilirubin</td>
<td>12,3±3,3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Glucose</td>
<td>4,9±0,6</td>
<td>3,3 - 6,5 mmol/l</td>
</tr>
<tr>
<td></td>
<td>Glucose</td>
<td>4,7±1,2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Tymol</td>
<td>1,7±0,7</td>
<td>1,5 - 5,0 mmol/l</td>
</tr>
<tr>
<td></td>
<td>Tymol</td>
<td>1,7±0,7</td>
<td></td>
</tr>
</tbody>
</table>

Note: $^1$ – the results before the administration of the product of vegetable origin "Pacovirina-plus", $^2$ - the results after the administration of the product of vegetable origin "Pacovirina-plus".
Investigating Roles of Dual Tyrosine Phosphatases in DNA Damage Responses

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Objectives: This project investigates putative targets of the atypical dual tyrosine phosphatase 3 (DUSP3 or VHR) in ionizing radiation induced foci (IRIF) of HeLa cells following damage caused by gamma and ultraviolet C radiation aiming to identify possible involvements of this enzyme in DNA repair and genomic instability.

Methods: From literature database experimental approaches were based in: 1) Western Blots to VHR, Actin and Cyclin proteins for checking expression and stability; 2) Fluorescence Confocal Microscopy to VHR, pJNK e pH2AX proteins for determination of expression and (co-)localization, and 3) theoretical investigation of structural features of proteins known to be involved in DNA damage and repair and comparison with known VHR substrates by using bioinformatic tools.

Results and Conclusions: VHR is highly expressed along cell cycle and very stable to degradation, which quickly migrates to nucleus in HeLa cells after low (0.5Gy) to high (15Gy) doses of gamma ray. On the IRIFs, VHR co-localizes with pH2AX and pATF2. Furthermore, after UVC radiation of these cells, VHR co-localizes with p-JNK and also pATF2. Theoretical approaches raised a list of more than 30 putative substrates for DUSP3, one of those (Mre11) being confirmed by posterior Confocal Microscopy analysis and that co-localized with VHR in IRIF. In addition to those results, different human cell lines (normal or tumorigenic) and other VHR substrates are under investigation by other techniques and also by large-scale approach as proteomic analysis.

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Low dose risks and effective dose. The case of radon.

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Abstract

Objectives. The objective of this paper is to review the evidence of health effects of low dose of ionizing radiation arising from exposure to radon and its decay products and to discuss if effective dose can be considered a good proxy of the associated risks.

Introduction. Radiation protection policies and regulations are based on the concept of effective dose, a (non measurable) quantity that should be proportional to the risk due to the exposure to ionizing radiation that produced that value of effective dose. A single risk coefficient is used by ICRP, and such coefficient is an average over population characteristics, gender, age. When applied to a single person, it does not take into account the interaction between ionizing radiation and other risk factors.

Methods. A review of recent and on-going activities is carried out as regards: i) epidemiological studies on the health effects of radon exposure in dwellings and mines, ii) reports and recommendations on radon from international organizations, iii) international regulations on radioprotection.

Results. A strong interaction between ionizing radiation and other risk factors actually occurs, as in the case of radon and cigarette smoking for the lung cancer. Recent pooled analyses of epidemiological studies in Europe, North-America and China have shown consistent statistically significant increases of lung cancer risk due to continuous exposure to radon in dwellings. The observed relative risk is similar for current smokers, ex-smokers, and never smokers. This implies a multiplicative interaction between radon and smoking, so that the absolute risk due to radon for a smoker is much higher (about 25 times for a male used to smoke about one package of cigarette per day) that for a never smoker exposed to the same level of radon. There is no such a difference between effective doses calculated for smokers and non-smokers. This strong interaction should be taken into account, but it is difficult due to the present approach of regulations, mainly based on the effective dose only.

Conclusions. The effects of low doses of radiation from exposure to radon have been shown by more and more convincing epidemiological studies. However, the quite different absolute risk for smokers and non smokers is not reflected in similar differences in effective dose. Therefore, effective dose should be used with much care to estimate individual risks. Moreover, a coordination between policies to reduce radon levels and policies to reduce smoking habits would be appropriate and useful.

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Guarapari: Singular Opportunity for Coherent Insights into the Nature of Radiation Effects at Man Physiology Frontier: Need for International Interdisciplinary Research Project

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Objectives: Ionizing radiation (IR) has been primordial terrestrial and extraterrestrial background, archetypal environment-biotope for the life origin and evolution, and natural milieu of human physiology/pathophysiology reactivity and selectivity.

Methods & Results: Physiological norm/pathology dichotomy and borderline states, and the nature of organism’s systems disorders and diseases with respect to IR effects is a matter of boundaries-thresholds-adaptation-optimization phenomena and perturbations of organism systems homeodynamic responses, where central nervous and cardiovascular system are evolutionary immanently most sensitive and vulnerable to deviations induced by IR, having at low-dose range predominantly free-radical, charge transfer and redox character.

Guarapari, Espirito Santo, Brazil, inhabited from 1585, with population ~105,000 (2005), representing Earth rare coastal natural high background radiation area with wide diapason of exposure levels (3-35, up to 175 mSv/year) that results from monazite sand deposits with Th, could give unique opportunity for investigation of radiation effects on man in his natural setting during centuries to understand their conceptual difference from influence of relatively short term accidental manmade radiation and searching for possible novel phenomena at molecular, cellular, tissues, systems, and organism level, from genotype to phenotype.

Possible “Guarapari Project” could offer unparallel opportunities for experimental and theoretical insights into ambivalent nature of physiologic and pathophysiologic frontier systems reacting to primordial IR effects within a natural, dynamic spatial-temporal scale at various hierarchical levels of complexity, from molecular to epidemiologic, on the base of contemporary “omics”- genomics, metabolomics, proteomics, connected with “redoxomics”, and modern methods (MRI, qEEG, etc) for investigation of organism systems (especially, brain/CNS, CVS, immune) states and disorders, revealing adaptation phenomena, CNS-CVS “synchronicity”, nature of cognitive effects, vaccination- radiation dependence, development of novel biomarkers, “omics” biodosimetry, new protection standards, etc.

Conclusions: This Challenge addressing fundamental scientific, global health, safety, and security matter, demands cooperative international efforts and effective interdisciplinary collaboration.
Environmental radioactivity monitoring around the ARTI

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Objectives: The objective of this investigation is to guarantee the health and safety of local residence by detecting a prior radiological effect due to an operation of the Jeongeup Advanced Radiation Technology Institute (ARTI) in Korea, providing the basic data that can estimate environmental effect of radiation, and also to establish a stable research mood by acquiring confidence on analysis results from local dwellers through an scientific and a continuous inspection.

Results: The range of all-beta-radioactivity analyzed for the rain samples was from 4.66 to 81.8 mBq/L, and that in the Yeonggwang province also was included within the range presented above. The range of all-beta-radioactivity of rain which exists in all over the country were from 0 to 344 mBq/L. For the rain samples, an analysis on the §H radioactivity was performed. §H concentrations in all of rain samples were detected below minimum detectable activity (MDA). By the gamma analysis result of the samples such as soil, pine, cabbage, rice, rain, honey etc, §Cs concentration detected in other regions - namely, in and around the Jeongeup ARTI - was below 2 Bq/kg-dry The range detected in the soils of the whole country was <0.565-43.5 Bq/kg-dry. §Cs concentration in honey samples collected around the Jeongeup ARTI was 0.128 Bq/kg-fresh. However, no data was available for comparison with the results presented by this investigation, and also because §Cs concentration might be varied according to the factors such as the altitude, soil characteristic, topography etc, it was judged that further research on these factors should be followed. By the §Sr analysis results on soil samples, the range of §Sr concentration detected in and around the Jeongeup ARTI was 0.093 Bq/kg-dry to 0.112 Bq/kg-dry. However, the range that was, 0.240 - 1.16 Bq/kg-dry, presented through this investigation was within that detected around nuclear facility for the recent five years.

Conclusions:
In this investigation, after the pre-treatments of the samples, measurements of the samples by using instruments were carried out. Also, these measurement results were analyzed and compared with the range of the radioactivity concentration of the whole country. By the analysis results, there was no trend of a diffusion or an accumulation of the radioactivity materials.

Keywords: Jeongeup ARTI, Environmental monitoring, Radioisotope, radioactivity
Response of Haploid and Diploid Yeast Cells to Low Intensity of Ionizing Radiation

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Background: The dose rate of ionizing radiation constitutes a significant parameter in radiation research. While it is generally accepted that lowering the dose rate leads to a decrease in the cell-killing efficiency per unit dose, the matter is less clear for low-level ionizing radiation. The long-term exposure of living objects to low-levels of ionizing radiation is especially important in relation with possible synergistic interaction of harmful environmental agents with radiation as well as with radiation hormesis sometimes observed at low intensities of radiation. However, an assessment of the regularities of both synergism and hormesis display at low level of dose rate is still an intriguing and unresolved problem.

Objectives: In this paper, we present new experimental data evidencing quite opposite response of haploid and diploid yeast cells storing in water (37°C) during chronic (15-35 days) exposure to low dose rates of ionizing radiation. Possible mechanisms are discussed.

Results and Conclusions: Quite opposite response of haploid and diploid yeast cells storing in water (37°C) during chronic (15-35 days) exposure to low dose rates of ionizing radiation (1, 10 and 100 folds of natural background) was demonstrated. Cell death was shown to be significantly delayed for diploid yeast cells exposed to 10 and 100 folds of natural radiation background in comparison with that exposed to the only natural background. On the contrary, cell death was accelerated for haploid yeast cells exposed to 10 folds of natural background in comparison with that exposed to natural background. This means that the effect of low dose rate was positive for diploid yeast cell and negative for haploid ones. It may be related with some reparation systems activated in diploid yeast cells by low dose rates of ionizing radiation while haploid cells are defective in these systems. The existence of such kind of reparation in diploid cells may be caused by two sets of homologous chromosomes, i.e. diploid-specific recovery.

Keywords: yeast cells, diploid, haploid, ionizing radiation, synergism, hormesis
Photoreactivation Parameters of Bacterial Cells after Exposure to UV Light and Ionizing Radiations

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Objectives: The purpose was to estimate photoreactivation parameters of bacterial cells irradiated with UV light and ionizing radiation, and to evaluate the influence of the different physico-chemical factors on the parameters of the photoreactivation kinetics.

Materials and Methods: Escherichia coli strain Bs-1 hypersensitive to UV light was used in this study. Survival curves and kinetics of the photoreactivation were measured in E. coli cells exposed to UV light (254 nm) and ionizing radiations (β-rays of 137Cs, β-rays of 60Co and 25 MeV pulsed X-rays). A mathematical model was applied to evaluate the probability of photoreactivation and the irreversible component of the radiation damage.

Results: Both the rate and extent of photoreactivation decreased in the following order of inactivating agents: UV light, pulsed X-rays, β-rays of 60Co and of 137Cs. The irreversible component of radiation damage increased with the same order of radiations whereas the probability of photoreactivation per unit time was independent of the kind of radiation. After exposure to 6 MeV photons, the parameters of photoreactivation were changed in the presence of caffeine or after irradiation in the presence of dithiothreitol.

Conclusions: The independence of the probability of photoreactivation on the quality of radiation indicates the cells have the same ability to photoreactivate damage produced by different kinds of radiations. The decrease in the extent and the rate of photoreactivation with radiation quality is explained by the formation of irreversible damage rather than by the impairment of the photorecovery process itself. Chemical and physical factors influencing the relative contribution of ionization and excitation on the ionizing radiation effect could modify both the extent of the photoreactivation and the probability of the recovery per unit time. It is concluded that the mathematical approach used here may be useful to reveal some new relationships between the parameters of photoreactivation.

Keywords: Photoreactivation; bacterial cells, UV light, ionizing radiations
Estimation of the UV Dose after Irradiation with Ionizing Radiation of Different Energy

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**Backgrounds:** Charged particles emit Čerenkov light when their velocity exceeds the phase velocity of light in the medium. This light includes wide spectra of visible and UV light, and their biological significance was demonstrated by the photoreactivation of UV-hypersensitive bacterial and yeast cells irradiated with ionizing radiation. The biological effect of ionizing radiation was not totally due to ionization of molecules, and thus their excitation may be important for some cases.

**Objectives:** The purposes were to estimate the dose of the equivalent UV light accompanied with sparsely ionizing radiation of various energy, to confirm the biological importance of Čerenkov light emitted by charged particles when their velocity exceeds the phase velocity of light in the medium, and to discuss the significance of the data for some biological effects (adaptive response, radiation hormesis) produced by low dose of ionizing radiation.

**Materials and Methods:** A simple mathematical model was suggested to estimate the UV dose after irradiation with sparsely ionizing radiation, assuming that excitation and ionization events act stochastically and independently from each other.

**Results and Conclusions:** A mathematical approach was suggested and applied for calculation the dose of the equivalent UV light accompanying sparsely ionizing radiation of different energy. The value of the UV dose for the same dose of ionizing radiation (100 Gy) greatly increased with the energy of ionizing radiation. The biological importance of Čerenkov light emitted by charged particles when their velocity exceeds the phase velocity of light in the medium was confirmed.

**Keywords:** UV dose, ionizing radiation, radiation energy, contribution of excitations
DNA Damage and Somatic Mutations in Tobacco Plants Exposed to Gamma Radiation

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Backgrounds: The lesions produced by interaction between ionizing radiation and DNA can be detected by the single cell gel electrophoresis (SCGE) assay. Somatic mutations can be visually measured in Nicotiana tabaccum var. xanthii (NTX) plants.

Objectives: The objectives of this study were to generate dose-response curves for SCGE analysis using nuclei isolated from leaf and root tissues of intact tobacco plants irradiated with gamma-rays, to study the kinetics of repair of DNA damage induced by radiation as measured by the SCGE assay, and to compare the DNA damage as measured by the SCGE assay in plant leaves up to 24 hour after gamma irradiation.

Materials and Methods: NTX seedlings were used for this study. On the same plant under identical treatment conditions, both acute DNA damage in somatic cells were measured by the Comet assay and leaf somatic mutations were visually counted. Irradiation was carried out using ⁶⁰Co source (Gamma Cell 220, AECL, 0.47 Gy/min)

Results and Conclusions: Gamma-irradiation of tobacco seedlings induced a dose-dependent increase in DNA damage and somatic mutations, as well. The DNA damage induced by gamma rays was repaired by 50% within an hour while 80% of the induced DNA damage was repaired within four hours after irradiation. This process of DNA repair and misrepair is one mechanism of converting gamma ray-induced lesions into heritable somatic mutations. These data indicate that DNA strand breaks are rapidly repaired, however, other lesions such as oxidized bases may persist longer and be misrepaired to somatic mutations. The increased yield of somatic mutations was highly correlated with the increased DNA damage measured by the SCGE assay immediately after irradiation. The reported data indicate that the standard alkaline SCGE protocol using nuclei from plant leaves may not be suitable alone for biomonitoring late effects of acute ionizing radiation, as the DNA damage is readily repaired. Other endpoints like somatic mutations should be done together for the purpose.

Keywords: gamma radiation, tobacco, DNA damage, somatic mutations
Analysis of common mitochondrial DNA deletion (mtDNA 4834) in heart and blood in a radiobiological model in Wistar rats (*Rattus novergicus*)

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Objectives: In the radiotherapy for tumors located in the thoracic region, part of the heart may be located close to the treatment field and to receive significant doses of ionizing radiation. This can cause severe cardiac complications. Irradiation of cardiac muscle may lead to cellular modification as result of reactive oxygen species accumulation and mutations on DNA. The cardiac muscle is completely dependent of the aerobic metabolism involved in the synthesis of ATP that occurs in mitochondrias. Those organelles contain their own DNA which codes for components of the respiratory chain. For the absence of protein like histones and the inefficient repair system, mitochondrial DNA is a potential target of ionizing radiation and reactive oxygen species. The deletion mtDNA 4834 in rats, equivalent to the mtDNA 4977 in human has been associated to the ionizing radiation and oxidative stress. The objective of this study was to evaluate the presence and the levels of this deletion in cardiac and blood tissues of irradiated Wistar rats.

Methods: The assays were developed with samples of cardiac and blood tissues of animals irradiated with doses of 5, 10 and 15 Gy in a field of 3 cm² centered in the heart, using a linear accelerator with a beam of fotons with nominal energy of 6 MV. The animals were sacrificed at 3, 15 and 120 days after irradiation. After that, extraction of DNA, PCR, sequencing and quantification through of real time PCR was developed using primers to generate fragments of the mtDNA deletion.

Results: In blood tissue the levels of the deletion oscillate and do not present proportionality to the ionizing radiation. However in cardiac tissue occurred an immediate reply, showing that the deletions levels suffer gradual decrease observed on the 3\textsuperscript{rd} day through 15\textsuperscript{th} day after irradiation, increasing after that. Additionally, an inversely proportional relation between the doses and the levels of the deletion was observed for all the analysis times. It was verified, through sequencing, that on the 15\textsuperscript{th} day the cardiac tissue accumulated high levels points mutations in the deletion region.

Conclusions: The study showed that the variation of deletion levels in cardiac tissue can be used as a bioindicator for radioinduced mitochondrial DNA damages. In addition, the accumulation of radioinduced injuries to this molecule can reduce the ATP supply and contribute for the energy deficit in the cardiac muscle.
Effect of irradiation on the removal of undesirable color from *Schizandra chinensis* Baillon extracts

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Objective

The fruit of the *Schizandra chinensis* Baillon is a well-known traditional herbal medicine in Korea, China and Japan. *Schizandra chinensis* extracts were used to investigate the improvement of color and the changes of physiological activities for the better application to food, cosmetics or pharmaceuticals by removing undesirable color.

Methods

Materials - *Schizandra chinensis* fruits samples were grinded with a blender containing methanol, and the extracts was left to stand under agitation for 24 h. Subsequently, the solution was filtered using filter paper. The extract was stored in glass vials, at 4°C in the dark for further analyses.

Irradiation - Gamma-ray and electron beam irradiations were carried out at ambient temperature using a high-level 60Co source (Nordion Inc, Canada) at the Korea Atomic Energy Research Institute (Jeongeup, Korea).

DPPH radical scavenging assay - The hydrogen atom or electron donation ability of the corresponding extracts and some pure compounds was measured from the bleaching of purple colored methanol solution of diphenylpicrylhydrazyl (DPPH). Electron donating ability (EDA) was calculated in the following way: $\text{EDA} (%) = \frac{(1 - (A_{\text{sample}}/A_{\text{blank}})) \times 100}{1}$, where $A_{\text{blank}}$ is the absorbance of the control reaction, and $A_{\text{sample}}$ is the absorbance of the *Schizandra chinensis* sample. All tests were carried out in triplicate.

Result

A gamma and electron beam irradiation technique was applied to remove an undesirable color of *Schizandra chinensis* extracts. The samples were exposed to 1 to 10 kGy of a gamma-ray or electron beam. Interestingly, the colorant of the *Schizandra chinensis* extracts was effectively removed at 2 kGy of gamma-ray and electron beam. The major colorant of *Schizandra chinensis* extracts was cyanidin-3-O-xylosylrutinoside (Cya-3-O-xylrut), and the content of Cya-3-O-xylrut had a tendency to decrease with the increase of the irradiation dose. However, electron donating ability (EDA) and the contents of major lignans, such as schizandrin, gomisin A and gomisin N, of *Schizandra chinensis* extracts were not changed by irradiation treatment.

Conclusion

In this study, gamma-ray and electron beam irradiation technology can be applied to various functional products to remove color without changing physiological activities.
Effect of gamma-ray irradiation on chlorogenic acid levels among different age group of centipedegrass

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Objective
Centipedegrass is a warm season turfgrass in the world. Chlorogenic acid (CA) is one of the important compounds present in the leaf of centipedegrass. A study has been made to enhance the level of CA upon gamma irradiation in centipedegrass.

Methods
One and three month old seedlings grown in plastic pots under glasshouse conditions at 24°C ± 2°C, relative humidity 90% were used for the study. The pots with one month and three month old seedlings were subjected to gamma irradiation (ARTI, KAERI).

HPLC analysis was performed using a Beckman Coulter C18 ODS column, 25cm x 4.6mm ID using an Agilent HPLC system. The solvent gradient was: linear from methanol-water (20:80) to methanol in 50 min, with a flow-rate of 1ml/min and a 5-min recycle time. Both solvents contained 0.1% orthophosphoric acid. The column effluent was monitored at 340 nm. From each sample, the peak related to the CA was calibrated with standard CA and values are recorded in terms of mg/ml.

Result
Each single pot containing approximately 100 seedlings were exposed to gamma irradiation at 25 Gy, 50 Gy and 100 Gy for 4 h. Irradiated plants were brought to the glasshouse conditions and watered regularly. After two days of irradiation, leaf samples weighing 0.25 g were randomly collected from each pot including control sample (non-irradiated) on 3rd, 6th, 9th, 12th and 15th day interval. Leaf samples were extracted using 10 ml of methanol for 2 days under shaking and filter-sterilized sample of 10 μl were subjected to HPLC. The HPLC data analysis showed a variation in the CA levels among control and irradiated samples. However, plants irradiated at 100 Gy showed a constant increase in the CA level (0.0060 to 0.0123 mg/ml and 0.0236 to 0.1440 mg/ml, respectively) from 3rd to 15th day among one and three month irradiated plants compared to control.

Conclusion
In the present study, increase in the level of CA was observed upon gamma irradiation in one and three month old seedlings of centipedegrass. So, the increase in the CA level obtained with this procedure can be considered as beneficial, since this is one of the important compounds in this plant.
Kinetic Evaluation of the Repair of Dna in Peripheral Blood as an Indicator of the Individual Radiosensitivity

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Objectives: In recent years the role of radiotherapy in the management of cancer has become very important. Approximately half of patients who develop this condition require treatment radiant. However, 5% of individuals develop side effects in normal tissue within the treated field, including acute effect, delayed effect and cancer. An estimated 80% of the variation in the response of healthy tissues to radiotherapeutic treatment is not attributable to external causes and respond to an inherited phenotype, which depends on the interaction of multiple genes and products.

If you could find a relationship between the level of genomic damage and radiosensitivity individual, patients might benefit from identifying their biological treatment. While various experimental alternatives have been evaluated to estimate the radiosensitivity individual they are controversial and need to be validated. Consequently, and given the impossibility of addressing all the factors operating, it is proposed that the comet assay in peripheral blood could be a useful alternative generic. Would be evaluating its effectiveness in estimating the ability to repair radiation damage in healthy individuals, with the aim of knowing the normal response and then compared with patients undergoing radiotherapy.

Methods: We analyzed 40 samples from the Blood Bank of the city of La Plata, of young and potentially healthy female. The same was implemented on the comet assay in its alkaline version, at different times post-irradiation (0, 45 and 120 minutes). The data were evaluated from the parameters percentage of cells with damage, categorization of damage and the damage index. The samples were irradiated with an electron linear accelerator with a nominal potential of 4 MeV. The doses used were 4 and 6 Gy.

Results: While the evaluation of the kinetics of repair for both doses showed a good fit (R² = 0.98) decreasing exponentially better performance of the relevant mechanisms, with a percentage of damage near the end of controls, indicating that the dose 6 Gy would be more appropriate for the purposes of the study.

Conclusions: The high repeatability of results in the individuals tested to suggest that the greatest percentage of damage under the operating conditions, are repaired within 45 minutes post-irradiation reaching greater structural restoration in a matter of 2 hours after irradiation.
Radiosensitivity Gamma on *Cladonia Substellata* Vainio (Lichen) and the Consequent Effect on Limestone Rocks

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OBJECTIVES: In this paper we wanted to determine the influence of the gamma ray on usnic acid production by *Cladonia substellata* and also the effects of the increased content of this compound on chelation formation in limestone rocks nearby this specimen.

METHODS: Samples of *C. substellata* were put on paper envelopes for radiation exposure on gamma ray with Co-60 source, receiving different doses (5, 7, 10, 15, 20, 30, 40, 50, 60 and 80 Gy) on gamma irradiator (Co-60 – irradiator, Radionies Laboratory, dose tax: 9.06 Gy. h⁻¹). After irradiation, the lichen were packed over shredded limestone. For 90 days the lichen samples were sprayed with deionized water, three times a week, then collected and analyzed by Thin Layer Chromatography (TLC) and High Performance Liquid Chromatography (HPLC). The control samples (rocks that were not exposed to the lichen) and the ones that were exposed to the 5, 10 and 80 Gy irradiated *C. substellata* were analyzed by X-Ray Diffratometry.

RESULTS: It was observed an increased production of the usnic acid until the 10 Gy dose. Beyond this, there was a drop in the production, reaching a very low biosynthesis at 80 Gy. It was shown with the diffratograms that the 10 Gy irradiated *C. substellata* samples were easily transformed. The rocks that were submitted to the 80 Gy irradiated lichen stayed similar to the ones on the control group.

CONCLUSIONS: We realized that *C. substellata* increments the usnic acid biosynthesis while gamma radiation doses is increased, but there is a limit for it. The degrading effect of the usnic acid on limestone was proportional to the produced amount of the substance, which could be extrapolated for natural conditions, where excessive radiation may have influence on pedogenesis and ecological succession.

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EU Normative Framework and Standards of Radiological Protection in Medicine

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ABSTRACT

Objectives
This paper deals with standardisation of medical exposure understood as a complex of norms, standard-setting procedures, and actors involved. We address three aspects of standardisation regarding: 1) the idea and the character of normative regulation; 2) the objectives of legislation; 3) the practical consequences of standards and norms in radiological protection. The study of regulatory aspects of standardisation in medical exposure, from the ex ante perspective, is necessary with the view to their legal implications for patients' health protection, taken from the ex post perspective, such as definition of the liable party, apportioning of liability, and formulation of the legal standard of care.

Methods
We begin by outlining the development of norms and standards of radiological protection elaborated by the international organisations and national authorities, from the perspective of gradual recognition and adoption of the preventive approach to radiological risk taking, keeping in mind the uncertainties about the effects of exposure at low doses. Then, we examine the EU and Member States’ normative framework in radioprotection in medical exposure, in light of harmonisation of national legislations on the basis of the Euratom Directives. We discuss to what extent medical standards in radioprotection vary in Member States, and the underlying reasons of this situation.

Results
There are a number of factors determining differences in Member States’ laws and regulations on patients’ radioprotection, namely: 1) peculiarities of legislative and regulatory mechanisms, e.g., use of soft law tools, public/administrative law instruments within the private sphere, delegated regulation, participation of private actors in regulation; 2) the patterns of regulatory setting focused on both “performance” and “procedure” standards, and representing the mix of performance-based, technology-based and other regulatory approaches; 3) decentralisation of standard-setting of medical practices at the local level.

Conclusions
We would conclude as follows: 1) the EU legislation regarding radioprotection in medical exposure have some links to the precautionary principle; 2) the same (high) level of health protection could be guaranteed for the EU citizens undergoing medical exposure; 3) law can stimulate self-organisation within health care environment and induce the “operators on the floor” to self-reflective performance, in order to enhance quality of services and patients’ safety, taking into account increasing limitations of direct regulation.
Calculation of the radiation dose to premature infants undergoing diagnostic radiology using MCNP4C Monte Carlo code

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Abstract

Objective: Diagnostic radiology is used increasingly in diagnosing the different diseases of neonates in infant Intensive Care Units. Since the infants are more radiosensitive than the adults, the estimation of the dose received by the infants undergoing radiographic examinations is of great importance. In this investigation, the Entrance Skin Doses (ESD) of the infants was assessed using Monte Carlo code.

Methods: In this research, Monte Carlo N-particle transport code (MCNP4C) was used for dose estimation of infants in diagnostic radiology. Homogeneous cylindrical water phantoms with different weights and dimensions were used for simulation of infants inside the incubator. All components of the X-ray tube such as target, filters, insert and housing were simulated to obtain the x-ray spectrum produced. This energy spectrum of the X-ray was used to determine the ESD of the infants. To assess the entrance skin dose, a small spherical cell was simulated on the surface of the phantoms. The *F4 tally was used to score the energy flux, this value was then multiplied by an energy-dependent mass energy absorption coefficient to estimate the dose in the tally cells. All the components such as incubator, phantom and the tube were simulated in a 6*6*3 m³ room.

Results and conclusion: The effects of different parameters such as kv, mAs and patient size were investigated in this study. According to the results of the simulations, the entrance skin doses increase with increasing mAs and patient's size and decrease with the kilovoltage of the x-ray tube. The calculate ESDs for the infants in all cases were below 90μGy per radiograph. These results are in closed agreement with the previous measurements of other investigators.
Health State in Children Survived after the Chernobyl NPP Accident

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Objectives. Two decades has gone after the Chernobyl disaster, but it still remains in the human memory. Chernobyl nuclear accident represents the most catastrophic nuclear accident in the history of mankind, characteristic not only by a large number of emergency workers but an important part of population affected in nearby regions. The retrospective data analysis indicates that increased radiation level during the accident at the Chernobyl nuclear power plant (NPP) has spread far beyond the bound of territories known as affected, including the Republic of Moldova. About 3500 participants in diminution of consequences of Chernobyl accident (PDCCA) and 1679 of their children borne after the catastrophe live currently in Moldova. Problem of health state occurred for the last years in children of PDCCA. Differentiation of health disorder reasons in children is important task here.

Methods. Children of PDCCA have been investigated using clinical, immunological (on the base of monoclonal antibody) and cytogenetic analysis.

Results and Conclusions. Using multilateral approach our study confirms scientifically, both installed immunologic pathologies and cytogenetic complication in Chernobyl nuclear accident worker’s children. Special attention was granted to immune status evaluation – key subject in organism’s immune reactivity. Personally obtained data were analyzed in view of contemporary existing scientific information from other sources. The dynamics analysis of the medical investigation results during 1996-2007 years of the health of the about 400 children (107 girls, 115 boys, 5-17 years old), which parents took part in liquidation of CNPP accident have been performed. Clinical, immunological disturbance and increased chromosome mutagenesis intensity in somatic cells of the investigated children gave reason to classify them among those with the increased risk of probability of the pathology with genetic component. This conclusion may be considerate as fundament for elaboration of separated registry of the children born in families of liquidators. The immunological disturbance of Children probably reflects the disturbance of the differential processes and maturity of thymus cells and can be the consequences of the factors influence related with the clinic pathologies. The results permitted to select the group for feature cytogenesis and clinic investigations.
Bioremediation of Land Contaminated by Radioactive Material

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Objectives. Radionuclide pollution arises as a result of many activities, largely industrial, such as mining and the provision of nuclear energy. These pollutants are discharged into the atmosphere and aquatic and terrestrial environments and may reach high concentrations, especially near the site of entry for point source emissions, and/or be transported between different environmental compartments. Metallic radionuclide has also entered the environment as a result of weapons-testing and accidents such as Chernobyl. The effects of radionuclide in ecosystems are not well understood, although a degree of understanding exists over their fate; it is primarily concerns over transfer along aquatic and terrestrial food chains that are of current economic and public-health significance. Microbial biotransformations of metallic radionuclides are of great importance in the biosphere and several have additional applications for bioremediation. Reactions mediated by microorganisms include solubilization from organic and inorganic complexes, compounds and minerals by the production of acids or chelating agents.

The aim of our study consisted in elaboration of the new biotechnological method for environmental pollution risk reducing.

Methods. Screening the importance of soil micro-organisms (Penicillium sp., Mucor sp. Aspergillium sp.) on radionuclides mobility have been performed.

Results and Conclusions. The influence of microorganisms on the environmental fate of radionuclides was elucidated, using some nonpathogenic strains of Penicillium sp. and Mucor sp., active producers of extra cellular pectolitic enzymes. Higher degree of radio nuclide’s insoluble compounds solubilization, especially cobalt’s compounds, was observed under the influence of investigated strains in vitro (Invention nr. 3657 MD). Such mechanisms are important components of radionuclide biogeochemical cycles and should be considered in any monitoring analyses of environmental radionuclide contamination. Elaborated biotechnologies present a high interest as a potential method for treatment of the radiotoxic compounds from rocks, ores, waste depositary and other contaminated places. The strains have been deposed at the National Collection of Nonpathogenic Microorganisms of the Republic of Moldova.
Ionizing Radiation: Risk Perception, Risk Communication

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Objectives
In surveys about risk perception, nuclear power often ranks highest. The obvious reason for such a perception is fear from radioactivity. In order to quantify this fear, a survey has been executed using scenarios with easy to calculate risk.

Methods
These scenarios included internal and external exposure to radiation. A scenario with an extremely low dose was a decaying Pu-238-atom in the lung, one with a very high dose was the direct exposure to the content of a CASTOR container with 12 tons of extremely radioactive waste in 10 m distance without screening. The survey has been executed with highly educated adults from several European countries, mainly students of scientific/technical faculties and scientists or engineers. We asked to estimate either the time to a lethal dose or the risk (in %) of getting cancer. The answers were compared with risk estimations using ICRP risk models (linear extrapolation from high dose, LNT).

Results and Conclusions
The survey revealed an extremely undue risk perception. Most people overestimated the risk by a factor of a million or more, especially in the case of low doses. The answers also showed an extreme range of perceptions, in most scenarios over 10 orders of magnitude. A surprisingly large fraction of the people thought that even a very low dose leads always to cancer, overestimating the risk billion-fold or more.

In case of ionizing radiation, risks communication is obviously very difficult, in particular for low and very low doses. For the general public, units like Bq, Sv, Gy are meaningless. Comparisons with legal limits are not very helpful either. Absolute risk values are better suited, but also difficult to interpret for non-experts. The best way is probably to compare with other, well accepted or at least tolerated risks. Such risks may be: smoking one single cigarette, being killed by a meteorite, crossing a street, walking just one step and many others. One may also compare the risk of e.g. an exposure of 1 mSv to the beneficial effect of eating 1 kg of fruits/vegetables or exercising for one hour. All such estimations are based on rather well known risks or benefits of high “doses” and using LNT (extrapolation to small doses).
The Significance of Thyroid Cancer in Reactor Safety Assessment

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Abstract:

Objective
The risk of thyroid cancer from reactor accidents has long been a salient factor in the analysis of nuclear reactor safety. The objective of this paper is to place this risk into its proper perspective.

Method
Published predictions of the consequences of reactor accidents, and the observed consequences of such accidents, are considered. The most significant evidence is that provided by the Chernobyl accident, which released about $1.5 \times 10^{18}$ Bq of iodine-131. An increase in the incidence of thyroid cancer was the only public health effect of radiation that was expected to be statistically significant.

Results
The risk has been found to arise largely, though not exclusively, from the abundance of iodine-131 in the fission product inventory of an operating nuclear reactor. Iodine is volatile and forms volatile and gaseous compounds, so that it disperses widely in the atmosphere if released in an accident. It can thus be inhaled. Volatile forms deposit on grass and vegetation, thus entering the human food-chain, particularly through consumption of contaminated cows’ milk. Iodine which enters the human body concentrates naturally in the thyroid gland. With iodine-131 having an 8-day half life, the thyroid becomes the most highly irradiated organ or tissue in the body. On the other hand, thyroid cancer is a relatively treatable form of cancer and is rarely fatal even when it is not diagnosed and treated. Therefore, although it is likely to be the greatest risk of radiation induced cancer, it may not constitute the greatest risk of death due to a reactor accident.

Conclusions
The Chernobyl accident caused a statistically significant increase in the incidence of thyroid cancer in children, which occurred more rapidly than expected. As with any form of cancer, no individual case can be attributed with certainty to radiation exposure but several hundred identified cases of thyroid cancer are more likely to have been caused by radiation from Chernobyl than from any other cause. No other physical effect of radiation exposure on public health is likely to be discernible from this accident or from any other reactor accident that might occur. Estimates of the expected number of cancer cases due to a reactor accident should not be based on collective doses involving trivial exposures to large populations.
A computational tool for evaluating the at risk staff absorbed dose in nuclear medicine treatments

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Objectives: The main objective is to develop a dedicated program, based on Monte Carlo simulations techniques, in order to perform absorbed dose calculations for the evaluation of exposure risks during nuclear medicine practices.

Methods: A dedicated Monte Carlo program has been adapted from the main code PENELOPE in order to perform suitable absorbed dose computation due to radioisotope exposure. The develop program allows to define a desired irradiation set up, which involves geometry and materials. Dedicated routines are incorporated to 3D dose distribution calculation. In addition, adapted software (MatLab supported) allows to assess a suitable visualization of 2D “hot-points”. Furthermore, once the program is already validated, it becomes possible to introduce attenuators for radiation protection purposes. The effectiveness performances of different shieldings are investigated as a function of different parameters, like relative distance and radioisotope properties.

Results: The first step regarding the preliminary validation of the developed program establishes its feasibility and reliability. After that, dedicated simulations are performed in order to evaluate the dose distribution according to different relative positions of exposed person to the patient. Different radioisotopes, which emission spectra were already suitably characterized, are considered as radiation sources. The dedicated visualization program provides a comfortable, easy and user-friendly graphical interpretation of obtained dose distribution, which emphasize relative higher risk zones. The protection insertions are successfully taken into account, which show the expected relative radiation risk reduction.

Conclusions: The main goal of developing an original subroutine for the calculation of absorbed dose during nuclear medicine treatments is successfully achieved. Actually, this program, based on the evaluation of absorbed doses, could be considered as a helpful tool in order to establish optimal daily radiological protection criteria, even according the actual radioisotope source.

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Mammography image quality optimization delivering minimal dose by means of Monte Carlo simulations

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**Objectives:** The main goal of this work is to evaluate irradiation configuration, according to typical mammography facilities, in order to improve X-ray image quality. In addition, total absorbed doses are calculated with the aim of determining the optimal irradiation setup with the minimal dose delivering.

**Methods:** X-ray imaging process is suitably studied by means of dedicated Monte Carlo program, based on the main code PENELOPE, which allows to define the main physical and geometrical parameters affecting the absorption contrast X-ray image. Several relevant quantities, like sample properties (chemical composition, thickness and shape) and incident beam features (energy spectrum composition, source size and angular divergence) can be introduced to the program in order to evaluate their effect on image quality. Furthermore, detector resolution and inserted collimators (pin-hole grid) can be also carefully modelled. Dedicated routines are incorporated for 3D dose distribution calculation, which can be suitably visualized by means of adapted software (MatLab supported).

**Results:** A commercially available mammography system is possible to model by means of the developed program. Therefore, on the base of this modelling, different setup configurations are studied in order to characterize the effect of relevant irradiation parameters on the image quality. The insertion of a dedicated parallel collimator shows a significant quality improvement. The calculation of absorbed dose for different configurations allows to establish the optimal quality-dose compromise.

**Conclusions:** The developed Monte Carlo program seems to be a useful tool for X-ray imaging process modelling. Actually, image quality improvement is performed according irradiation parameter configurations. Furthermore, absorbed dose calculation allows to decide optimal irradiation setup corresponding to minimal dose delivery. Finally, it should be emphasized that this model can be straightforwardly applied for other X-ray imaging techniques.

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Radiation-Induced non (Targeted) Effects of Radiation – What, Why and How?

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Objectives: Ever since the grudging acceptance that non-targeted effects (NTE) can be measured in unirradiated cells or distant progeny of irradiated cells, the discussion has raged about the relevance of these effects. For the purposes of this presentation, NTE are defined as effects not associated with DNA lesions in the cell showing the effect and so include genomic instability and bystander effects. Obviously, it is important to consider relevance for practical applications such as radiation protection and radiotherapy. To this end this paper will review data from in vivo experiments, which address questions about risk after medical and environmental exposures. However a major area of interest is the intrinsic relevance of these mechanisms in biology.

Discussion: Arguments will be made in this paper, that non-targeted effects (NTE) may call into question not only radiation effects paradigms but may also have relevance to wider mechanisms in cancer biology, population ecology and evolutionary biology concerning process of selection, the transmission of heritable traits, the relevance of “social” interactions between cells, organisms and populations and the mechanism by which cells/organisms respond rapidly to environmental stress. This paper will also argue that a key consequence of findings in NTE biology is that at any given level of organization, from gene to ecosystem – communication of stress signals and heritability of stress adaptations provide the bridges linking one hierarchical level to the next and enable the rapid propagation of change triggered by stress at one level, resulting in change at a higher (or lower?) level. This addresses a major problem in evolutionary biology because while the molecular mechanisms of natural selection are fairly well understood a major knowledge gap exists in translating mutational drift at the level of the individual cell to natural selection at the ecological level where sociobiological factors are so important. The existence of the mechanism discovered in the NTE field provides a glimpse of a major way that evolution could be regulated through communicated signals between cells, individuals, and populations. These control and optimize responses at the level of the population and coordinate the emergence of exquisitely tuned systems which can adapt rapidly to micro or macro environmental change. It is likely that consideration of these mechanisms could also be of benefit in cancer biology providing new insights into the regulation of cancer cell social groups and how these interact with the host.
Development of an online system for the evaluation of fetal radiation dose to patients and staff in diagnostic radiology

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Objectives: Development of an online system, named “Dose Fetal Web”, for the evaluation of the dose to the fetus from both medical and occupational exposures of the pregnant woman.

Methods: The methodology used in this system estimates the fetal dose from data related to radiologic diagnostic examinations of a pregnant patient, or from the routine individual monitoring dosimetry of a pregnant worker. The input data of this program are associated to the conversion-coefficients tables of uterine to fetal dose, normalized uterine dose (NUD), generated by means of Monte Carlo simulations.

Results: The fetal doses from both medical and occupational exposures of the pregnant woman, as well as the risks associated with these exposures, were evaluated by means of simulated case studies using the online system. E.g., supposed the 22 weeks pregnant patient had to undergo a single AP Abdomen procedure (70 kVp peak tube voltage and total filtration 3 mmAl), the fetal dose calculated by the “Dose Fetal Web” was 1.54 mGy. The risks calculated by the online program were 5.0×10⁻⁴ and 1.384×10⁻⁴ to the induction of mental retardation and decline in IQ score, respectively. E.g., considering that the staff member can be pregnant, and assuming that she wore 0.25 mm lead equivalent apron during every procedure, with an equivalent dose of 0.8 mSv/month measured with the TLDs outside the apron, the fetal dose calculated by the online software was 0.036 mSv/month.

Conclusions: The online program will be a useful tool for the medical and paramedical personnel who are involved with fetal dose (and hence risks) calculations and counseling of pregnant women who may be concerned about in-uterus exposure of their fetuses. It was designed to be used by the quality assurance (QA) costumers from public and private imaging facilities.
Database of Radiogenic Cancer in Experimental Animals Exposed to Low Doses of Ionizing Radiation.

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Objectives: To address the question of whether or not the dose-response curve for radiation carcinogens is linear at low doses.

Methods: A comprehensive database (hereafter referred to as Database) of animal carcinogenesis experiments involving exposure to different types of ionizing radiation was created. The experiments were identified through the International Radiobiology Archives of Long-Term Animal Studies (1996) and a MEDLINE search using the keywords: rat, mouse, dog, ionizing radiation, alpha, beta, gamma, X-rays, neutrons, cancer, and neoplasms. Paper copies of identified publications appearing in peer-reviewed journals, annual reports of research institutions, and conference proceedings were obtained. Each of these articles was reviewed to ascertain its relevance to radiation carcinogenesis in animals. Publications pertaining to a same experiment, but published at different times, sometimes with different first author names and in different journals, or reports to illustrate different aspects of radiation effects in mammals, were identified and set apart in order to avoid duplicate entries. Papers containing all of the information necessary for inclusion in the Database (species and strain of experimental animal, type of radiation, mode of administration, body or organ doses, dose rate, and type of cancer of interest) were selected as appropriate sources of data.

Results: The Database on radiogenic cancer in animals consists of 800 datasets drawn from 262 experiments. The Database includes 87,982 exposed and 37,111 unexposed (control) animals. This represents the largest Database on experiments on radiation carcinogenesis in animals assembled to date. Based on visual examination of the data six major patterns of dose-response were observed: four patterns (U-shape, J-shape, no apparent effect, no cancers in exposed and control animals) showed no evidence of effect or a decrease in cancer incidence at low doses and two patterns (dose-related increase in cancer incidence inverse U-shaped) showed some evidence of a radiation effect at low doses. Based on visual examination, there were more datasets with no evidence of an effect or a decrease in cancer incidence at low doses than datasets with a positive dose-effect relationship. Subsequently, we conducted a rigorous statistical analysis to determine the meaning of frequently observed crude negative dose-response slopes at low doses.

Conclusions: A descriptive overview of the experiments included in the Database, along with a qualitative assessment of the shape of the dose-response relationship for radiation carcinogenesis at low doses in experimental animals is presented. Results of the formal
statistical analysis of this large Database, which provides at most limited evidence of hormesis, will be discussed.

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Working towards Residential Radon Survey in South America

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Objectives: This project was inspired by the World Health Organization’s International Radon Project launched in Geneva in January 2005. The objective is to create a detailed map of residential radon levels in South America. To collect the data for the map a comprehensive survey of radon levels in dwellings throughout the ten countries of South America is proposed. In this presentation we estimate the cost of such a survey.

Methods: We propose to conduct a survey using the distribution and analysis of passive alpha tracking detectors. Long term (one year) measurements of radon will be done in houses selected at random (at 0.5% rate) in pre-selected cities in each country.

Results: We estimated the budget for the survey at 6 millions US dollars over four years.

Conclusions: The results of the proposed survey will allow to conduct assessment of the exposure to residential radon in the populations of South American countries and to model the health impact of this exposure. They will also help national health authorities in developing national residential radon action levels and regulations, as well as to provide public health guidance for radon awareness and mitigation.

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Mapping of Residential Radon in The World

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Objectives: Create a global database of national residential radon levels. Review the information to identify countries with reliable estimates of Average Population Radon Level (APRL).

Methods: Information for the database was derived from the surveys conducted by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) from 2001 through 2007 for its 2006 Annex E on radon, the UNSCEAR 2000 Report, and "An Overview of Radon Surveys in Europe". The following sources were also searched for keywords (indoor and radon): MEDLINE, tables of content of Radiation Protection Dosimetry, tables of content of Radiation Measurements, and the WEB. We have conducted a systematic review of all original documents contributing information to the database. Initially for the purpose of data quality objectives (DQO) we used the following valuation order to classify the reliability of the references: journal publication, conference proceedings, internal report, UNSCEAR Surveys, WHO 2006 Survey, personal communication. However, we realized that for the purpose of assessing the reliability of the national indoor radon levels the above classification did not work well given that most of the information had been published in 'gray literature' and that some of this literature was of very high quality. Therefore we treated journal publications, conference proceedings, and internal reports equally as long as they were publicly and relatively easily available (on the web for example).

Results: We evaluated each reference in terms of level of evidence for using national Average Radon Level reported in the reference (sufficient evidence, limited evidence, and inadequate evidence). Currently the database contains information on national indoor levels from 67 countries (out of 193 recognized by WHO). These 67 countries represent 76% of the world's population and 71% of its land mass. Radon information varies by continent with only three African countries (out of 53) and 34 European countries (out of 46) with data. Consequently, we have created a map of national levels of residential radon around the world. In addition to static map, we have also implemented a preliminary web version and Google Earth version of the map.

Conclusions: The current maps have many deficiencies, but after improvements and extensions, it might provide a useful means for United Nations Scientific Committee on the Effects Of Atomic Radiation (UNSCEAR) to review and communicate information about the very important radon data it collects, and to facilitate electronic updates of the database and subsequently mapping of the data. Such a tool could be extended over time to other sources of exposure.
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Radioactivity in some Sachet Drinking Water Samples produced in Nigeria

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Objectives
This paper presents the report of measured activity concentrations of naturally occurring radionuclides of $^{40}$K, $^{226}$Ra (Uranium series) and $^{228}$Ra (Thorium series) in some sachet drinking water samples being produced and consumed in Nigeria; and an estimations of consequent annual effective dose rates to the consumers of the water samples.

Methods.
Samples of 15 brands of sachet water were bought from stores randomly chosen in Nigeria and prepared using standard procedure for gamma spectroscopy measurement. The measurement was done by using vertical high-purity germanium (HPGe) co-axial detectors (Canberra Industries Inc.) coupled to Canberra Multichannel Analyzer computer system. The measured activity concentrations for $^{226}$Ra and $^{228}$Ra were used with their ingested dose conversion factors to estimate annual effective dose rates for the International Commission on Radiological Protection (ICRP) age groups 0 – 1 y, 1 – 2 y, 2 – 7 y, 7 – 12 y, 12 – 17 y and ≥ 17 y from consumption of the water samples. The pH and other physico-chemical parameters of the samples were also measured.

Results.
Measured activity concentration values varied from 0.57±0.21 to 34.08±5.61 Bq l$^{-1}$, 2.22±0.97 to 15.50±4.51 Bq l$^{-1}$ and 0.04±0.01 to 7.04±1.16 Bq l$^{-1}$ for the radionuclides respectively. Estimated total effective dose rates varied from 4.73 to 49.13 mSv y$^{-1}$, 1.21 to 12.26 mSv y$^{-1}$, 0.86 to 8.54 mSv y$^{-1}$, 1.22 to 11.66 mSv y$^{-1}$, 3.40 to 28.98 mSv y$^{-1}$ and 0.68 to 5.04 mSv y$^{-1}$ for the different age groups respectively. The pH of the samples varied from 7.1 to 7.6.

Conclusions.
The highest total annual effective dose was found in Tisco sample while the lowest was found in Focar sample. The total annual effective dose in all samples considerably exceeded the average worldwide ingestion exposure dose value of 0.12 mSv y$^{-1}$ from uranium and thorium series reported by the United Nations Scientific Committee on Effects of Atomic Radiations (UNSCEAR). Therefore the Nigeria populace is advised to consume less of these water samples. The producers are also advice to treat their water in order to reduce the radium content.
Exposure-time Dependent Development of Molecular And Cellular Responses to Low Dose-Rate Gamma-Radiation in Mammals

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Objectives: Give a review of the five-year studies of molecular and cellular effects in mice chronically exposed to low dose-rate gamma-radiation.

Methods: Changes in the levels of DNA single-strand breaks (SSB), DNA-protein cross-links (DPC), apoptosis, cytogenetic disturbances and reactive oxygen species (ROS) production rate were analyzed in blood system cells (lymphocytes, leucocytes, spleen and bone marrow cells) of CBA male-mice chronically exposed (up to 1 year) to gamma-radiation at a dose-rate of 61-62.5 cGy/year (Cs-137 gamma-radiation course) using a comet assay, DNA alkaline unwinding assay, DNA halo assay, routine cytogenetic tests and cellular oxidative status markers, respectively.

Results: The results showed that the molecular and cellular responses to chronic low dose-rate ionizing radiation exposure developing with an increase in the exposure time (dose) of irradiation in a few stages. During exposure time up to 120 days (doses up to 20 cGy), there was found statistically significant changes in the DPC level only. It is possible that changes in the DPC level under low dose irradiation is non-specific and reflects the structural rearrangements of chromatin in entire cell population. Beginning from 120th day of exposure, statistically significant increase in the SSB level, apoptotic cells frequency and ROS production rate was observed. Need to note that further prolongation of exposure time to 1 year and, hence, increase of a total dose did not, lead to further increase in the yields of these indices. No significant increase in the cytogenetic disturbance frequencies was found until exposure time at 300-365 days (50-62.5 cGy). Take in account that the exposure time is compared with a life span of mice the effect could be attributed by exhausting cell defense systems during the aging process and disturbance of the balance between the DNA damage formation and their repair

Conclusions: To summarize, the obtained results strongly support the hypothesis of non-linear threshold nature of chronic low dose-rate gamma-radiation genotoxic action. A three stage exposure-time dependent mechanism of molecular and cellular effects formation in mammals long-term exposed to low dose-rate low-LET radiation was proposed on the data base.
Assessment of the dose and risk to patients undergoing scoliosis radiography

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Abstract

Objective: The purpose of this work is to investigate how effective doses and absorbed doses to organs in AP, PA and Lateral projections vary in female and male patients, using the same operating voltage commonly applied in routine expositions of scoliotic patients.

Methods: The Monte Carlo code MCNPX and the FAX (Female Adult voXel) and MAX (Male Adult voXel) phantoms were combined in order to calculate effective doses, absorbed doses to organs and risk of cancer incidence. The risk of cancer incidence attributable to scoliosis exams were estimated using the Biological Effects of Ionizing Radiations (BEIR) VII Committee Report.

Results and Conclusions: The results show that the effective dose and risk of developing cancer due to radiation tends to be higher in AP projections for both sexes. The results also showed that the absorbed doses to organs vary considerably with the geometric projection. The thyroid, bladder and breast doses are significantly higher in AP projections, while the bone and skin doses are higher in Lateral projections. On the whole, the feminine patients undergoing scoliosis radiography received lower effective and absorbed doses than masculine patients. Additionally, the results have confirmed that the combined use of MCNP code and FAX and MAX Phantoms is very helpful for dosimetric studies involving scoliosis' x-ray exams.
Assessment of the Dose and Image Quality in Digital Chest Radiography using Computer Modeling

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Abstract

Objective: The purpose of this work is to use the Monte Carlo code MCNPX and the Female Adult voxel (FAX) and Male Adult voxel (MAX) phantoms to investigate how the dose and image quality in digital chest radiography vary with tube voltage (70-150 kV), anti-scatter methods (grid and air gap) and gender of the patient.

Methods: The effective dose was calculated by ICRP60 and image quality was quantified by calculating the signal-difference-to-noise ratio for pathological details (calcifications) positioned at different locations in the anatomy. Calculated quantities were normalized to a fixed value of air kerma (5 μGy) at the automatic exposure control chambers.

Results and Conclusions: The results obtained in this work suggest that the air gap technique and lower tube voltages provide an increase in the digital image quality. Furthermore, this study has also shown that the detection of pathological details vary with the gender of the patient.
Incidence breast cancer of the women of the Gomel area after influence of ionizing radiation owing to Chernobyl accident

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Objectives - to reveal features of frequency and dynamics of incidence by a breast cancer of the women of the Gomel area received various doses of an irradiation owing to Chernobyl accident and living in territories with various density of pollution $^{137}$Cs.

Methods - were applied the comparative analysis of parameters incidence, the regression analysis, the cluster analysis, account of relative risk, dosimetry, mathematical modeling.

Results - maximum level of incidence, statistically significant the exceeding similar parameter in control group (the women living in Vitebsk area) and in territories with density of pollution radioactive cesium 37–185 kBq/m$^2$ and 185–555 kBq/m$^2$, was registered among the women living in territories with density of pollution > 555 kBq/m$^2$. The peak of incidence of the women by a breast cancer in territories with density of pollution 37–185 kBq/m$^2$ and more than 555 kBq/m$^2$ is reached for 15 years earlier, than in control group and corresponded to age group 55–59 years. Among the women living in territories with density of pollution $^{137}$Cs more 555 kBq/m$^2$ growth rates incidence authentic higher, than among the women of control group. The cluster analysis at a level of the separate occupied items has shown, that in 18 of 799 Gomel areas, occupied items, «congestion» of incidence by a breast cancer among the women was marked. Pays on itself attention, that «congestion» of number of cases of a breast cancer was marked in the occupied items with by the average- group cumulative dose of an irradiation more than 25 mSv (in the age of is more senior 17 years on the moment of Chernobyl accident), in 5 of them the cumulative dose of an irradiation has exceeded 70 mSv. Among the women who have received cumulative dose more 50 mSv, it was marked statistically significant excess of relative risk, that allows to attribute them in group of high risk.

Conclusions - the received results testify to the adverse tendencies in dynamics of incidence by a breast cancer among the women, injureds owing to Chernobyl accident, that dictates the further realization of analytical epidemiological researches.
Results of long-term monitoring of incidence by malignant tumor among adult population of Belarus, undergone to influence of radiation owing to Chernobyl accident

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Objectives: The analysis of levels and dynamics of incidence malignant tumor (MT) among adult population of Belarus, undergone to influence of radiation owing to Chernobyl accident (ChA).

Methods: Persons were investigated who were taking part in liquidation of consequences of ChA (1GPA); the evacuations evacuated from a zone (2GPA); the persons living in territories with density of pollution by caesium-137 > 555 kBq/m² (3GPA) and 37 kBq/m² - 555 kBq/m² (5GPA). As control group the population living in least injured from ChA Vitebsk area is chosen.

The analysis of incidence is lead only for adult population for the period of 1993-1996 and 1997-2006 years. Included in research are all localizations of a cancer (ALC), MT: stomach (C16), colon (C18), lung (C34), skin (C44), kidney (C64-65), urinary bladder (C67) and thyroid gland (C73).

In the analysis were applied only truncated age-standardized rate.

Results: In 1993-1996 years statistically significant distinctions between average standardized parameters of incidence a cancer of investigated localizations among the injured population in comparison with control group were absent. In 1997-2006 years among person’s 1GPA authentic excess of parameters of incidence by a cancer of all investigated localizations, behind exception C44, among persons 2GPA and 3GPA - only C73, among persons 5GPA - ALC, C18 and C44 was marked. In 1997-2006 years in comparison with 1993-1996 years the average standardized parameter of incidence a cancer of ALC among persons 1GPA has grown on 41,7%, among the population of control group - on 11,9%, incidence C16 has grown among persons 1GPA on 57,2%, C34 - on 84,5%, among the population of control group decrease in incidence on 14,9% and 6,2% accordingly was marked. The average standardized parameter of incidence C18 among persons 5GPA has grown on 38,8%, C44 - on 94,0%, C67 - on 24,5%, in control group on 12,7%, 39,8% and 17,4% accordingly.

Conclusions: The lead research has revealed statistically significant distinctions of incidence C34, C16, C18, C44, C67 among various categories of the population in comparison with control group. The greatest distinctions were in 1GPA. Among all observable groups of the population significant excess of incidence C73 is revealed.
Estimation of radiation risk of development of cancer and noncancer diseases among the population of Belarus, injured of Chernobyl accident

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Objectives - quantitatively to estimate radiation risk (RR) of development cancer (breast cancer) and noncancer (cataract, myocardial infarction, cerebrovascular illness) diseases among the population of Belarus, injured of Chernobyl accident (ChA).

Methods - the research is organized for a type matched case – control study. In research are included the persons who were taking part in liquidation of ChA and woman in the age of 10-35 years on the moment of ChA. At account of sample size the following conditions were observed: power \(1-\beta=80\%\); \(Z_\beta=0,842\) (tabulared meaning); a significance value \(\alpha=0,05\); \(Z_\alpha=1,96\) (tabulared meaning); a share exposure in group of the control \(p_0=40\%\) (for noncancer diseases) and 5% (for a breast cancer). «Controls» were considered exposure at the cumulative dose of an irradiation more than 50 mGy. Number of «controls», picked up to each case - \(k=2\). The odds ratio - \(OR=1,5\) (for noncancer diseases) and 2 (for a breast cancer).

Results – were developed clinical-epidemiological and dosimetric questionnaires for an estimation of RR of breast cancer, cataract, myocardial infarction and cerebrovascular diseases. All subjects of research were interrogated prepared by a trained interviewer under the developed questionnaire. Before realization questionnaires it is offered to all subjects of research to fill in the form of the informed consent. Sample size for an estimation of RR of development of noncancer diseases among the liquidators has made 1734 men (578 "cases", 1156 "controls"), including of risk of development of cataract and illnesses of system circulation - 867 men (289 "cases", 578 "controls"), sample size of risk of development of a breast cancer has made 1122 women, of them 374 "cases" and 748 "controls". 319 women, patients by a breast cancer, and 400 liquidators now have passed clinical examination, from which 217 surveyed had in case history of a myocardial infarction and cerebrovascular illness, 183 - cataract.

Conclusions - thus, information now is assembled and the clinical examination 85,3% of «cases» necessary for an estimation of RR of development of a breast cancer, 75% - for an estimation of RR of development of illnesses of system circulation and 49,5% - for an estimation of RR of development cataract is carried out. The research proceeds.
Modeling of Low-Dose Radiation Effects

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Objectives: Low-dose radiation effects have attracted a great deal of attention lately, mainly because low doses are widespread in nature and they may potentially have long-term effects on human beings and biota (LOWRAD, 2007; Belyakov, 2008). The purpose of the present study is to develop a model with the intention of describing the set of low-dose radiation effects on organ tissue, including non-target effects such as the bystander effects and adaptive response.

Methods: This model is based on the assumption that any organ can be described as a complex structure of cells, influencing or supporting each other in different ways. Similar to (Little et al., 2005) it is assumed that cells can either be (A) non-damaged, (B) affected / damaged or (C) dead (groups A and B can be classified into subgroups, if necessary). It is also assumed that the cells from group (B) can potentially recover from radiation damages. Furthermore, it is assumed that the probabilities of the radiation effects and the recovering process are determined by both the radiation dose and the structure and function of the cell.

Results and conclusions: Results of the model simulations demonstrate different possibilities for the description of the bystander effect in comparison with the direct effects. The differences depend on the model parameters and the assumptions made about the cells which can potentially induce the bystander effects. It is also demonstrated that a model can describe simultaneously the experiments results including the bystander effects and adaptive response (Sawant et al., 2001).

References


Postradiation Cognitive Disorders

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Background. Hippocampal neurogenesis in the adult brain is very radiovulnerable, and its alterations seem to be the main cerebral basis of postradiation cognitive disorders following exposure to low doses of ionizing radiation.

Objectives. The goal was to detect the radiation-associated domain of cognitive disorders in the remote period of exposure to low doses of ionizing radiation as a result of the Chernobyl accident.

Methods. The cognitive functions were assessed in 167 clean up workers of the Chernobyl accident (doses 0.01–5.0 Gy, age at examination 39–65 years). Inclusion criteria consisted: current organic mental disorder; healthy before the accident; absence of stroke, neuroinfection, cerebral tumor, head injury, alcohol abuse, and any severe physical illness. Controls included non-exposed patients with multiple sclerosis (n=18), vascular dementia (n=28), and 20 healthy subjects. The neuropsychological battery (W AIS, TE4D, SKT, RAVLT) and brain mapping of quantitative electroencephalography (qEEG) were used.

Results. The characteristic dose-related cognitive dysfunction was found at exposure >0.3–5.0 Gy considered to be the domain of postradiation cognitive disorders: 1) verbal IQ decrement in comparison with pre-morbid IQ assessment (WAIS); 2) impairment of cognition (TE4D); 3) memory and attention worsening (SKT); 4) verbal short-term memory declining, proactive and retroactive interference of verbal information deterioration (RAVLT). The postradiation cognitive domain was accompanied with decreasing of the relative theta-power (>4–7 Hz) of qEEG at the left frontal area and the decreasing of the ratio of summary relative theta-power (>4–7 Hz) to alpha-power (>7–12 Hz). The theta-activity of EEG is considered to be the hippocampal rhythm. These dose-related neuropsychological and neurophysiological abnormalities testify to disorders of the cortico-limbic system, mainly the hippocampus of the dominating (left) brain hemisphere.

Conclusion. Postradiation cognitive disorders following exposure to >0.3–5.0 Gy are distinguished with mild to moderate impairment of cognition, memory and attention worsening, and verbal learning deterioration that could be attributed to the postradiation alteration of hippocampal neurogenesis, especially in the dominating hemisphere.
Relationship between Radon Concentration and Men Infertility; Case Study in Iraqi Kurdistan

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Abstract

Objective: The aim of this study was to make sure for relashtioship between annual effective dose and the ratio of men infertility in some selecte locations in Iraqi Kurdistan region.

Methods: Solid state nuclear track detectors type CR-39 used in this project.

Results and Conclusions: The results show that there is exponential relation between annual effective dose and the ratio of men infertility, and radon concentration in most locations which have high ratio of men infertility are increased, especially in those whose their defect on concentration of sperm (sperm/ml), and this is due to the ventilation rate, type of their works, structure of homes, variation of geological formation and variations in grades of uranium at different locations.

Finally, we concluded that there are clear indicates of risks of radon concentration on men sterility, and especially on the sperm’s activity.

Key words: CR-39 NTDs, Radon concentration, effective dose and men infertility
Natural radiation effects on human mitochondrial DNA mutations in Ramsar, Iran

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Key words: Mutation, Human mitochondrial DNA, Radiation dose, Ramsar

Introduction
Natural radiation varies geographically, but it is never absent and has been irradiating all forms of life since the beginning of evolution. Chromosome lesions and cancer are well known macroscopic effects of ionizing radiation. Ramsar has an inhabited area with highest level of known natural radiation in the world (226 Rn and its decay products).

Material and Methods:
Saliva samples were obtained with informed consent of a number of healthy individuals living in the high radiation area (Talesh mahalleh) and also similar numbers of healthy individuals from Tehran city about 360Km south of Ramsar. mt DNAs were extracted from all saliva samples by cinnagen kit and then a non coding mt DNA control region (15961-00421 np) was amplified by following primers. After electrophoresis, all the PCR products were direct sequenced and analyzed by applied bio system prism 310 genetic analyzer.

Results:
In our study, we found a total of 65 mutations from the first group of healthy individuals in Ramsar while the results of similar healthy control from Tehran were normal. From the total of these 65 mutations, 50 mutations (76.92%) had already been seen in the similar study in kerala (India) whereas 15 new mutations (23.07%) were found in our study; that contains; 16145(G/A), 16519(T/C), 16214(C/T), 16217(T/C), 16184(C/T), 362(A del), 262(A/G), 60(T ins), 64(T/C), 16219(C/T), 324(C/G), 16069(C/T), 16222(C/T), 16297(T/C), 273 (A/G) and one ic; 263 (A/G) was a polymorphism.

Conclusion:
Annual exposure levels of natural radiation in Ramsar (Talesh mahalleh) are up to 260 mGy/y. Our results are in agreement with kerala findings but the existence of higher radiation dose in Ramsar, could be responsible for inducing more mt DNA mutations. Our research is at its beginning stage and our continuing works may further elucidate complexity of radiation induced mutation.

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Choice of Critical Radionuclide by Calculation of Absorbed Dose Rate in Biota, in Different Areas of High Natural Radioactivity in Brazil

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Objectives
This study aims to assess the Radiological Environmental Impact on Biota (RElb), through the calculation of the absorbed dose rate in fish from three dams suffering influence of uranium mining in Brazil: in the state of Ceará (CE) where Phosphate with uranium by product mining plant is being commissioned, in the state of Bahia (BA) where the uranium mining facility is in activity, and in the state of Minas Gerais (MG) where the uranium mining unit is undergoing decommissioning.

Methods
The bioindicators were: tilapia fish (Tilapia nilotica, Linnaeus, 1758) for the states of Ceará and Bahia, and cara fish (Geophagus brasiliensis Quoy & Gaimard, 1824) for the state of Minas Gerais. The analyzed radionuclides were: U-238, Ra-226 and Pb-210 from the uranium family, and Th-232 and Ra-228 from the thorium family. A model of calculation of absorbed dose rate has been used that defined a coefficient to transform activity concentration (Bq kg⁻¹) into absorbed dose rate (Gy y⁻¹); it also proposed a boundary situation to assess the radiological impact on biota and a limit to the absorbed dose rate (3.65 Gy y⁻¹). The internal dose rate was the unique one considered, and the sum of the contribution of alpha, beta and gamma radiations were considered.

Results
For tilapia fish, the estimated dose was 2.76 μGy y⁻¹ in Ceará, and 2.51 μGy y⁻¹ in Bahia. For the cara fish (MG), the estimated value was 1.09 μGy y⁻¹. For all studied cases the value of the absorbed dose was six orders of magnitude lower than the limit. Uranium contributed with over 99% to the absorbed dose rate estimated for Ceará and Minas Gerais. On the other hand, Ra-226 was the critical radionuclide in Bahia, with 56% of the absorbed dose rate.

Conclusions
These results allow to conclude that the RElb due to natural radionuclides analyzed in these three localities is negligible and that the critical radionuclide to be analyzed is either U-238 (CE and MG) or Ra-226 (BA). This shows the lack of correlation between species and...
critical radionuclide. Therefore, a case by case analysis, for each plant and each biomonitor should be done to carry out an assessment of the radiological impact on the biota (REIₖ) of analyzed radionuclides. Although being in distinct operational phases, the fact that the three mining plants have similar impacts reinforces the irrelevance of the impact of these ventures.
Isotopes of Uranium and Thorium and their Contribution to the Absorbed Dose Rate in Fish from the Sepetiba Bay

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Objectives

The present study aims to determine the activities of the isotopes U-238, U-235, U-234, Th-232, Th-230 and Th-228, and to estimate the absorbed dose due to these radionuclides in fish from two different positions in the food chain in the Sepetiba Bay (the mullet, *Mugil liza*, Valenciennes, 1836, phytophagous fish and the croaker, *Micropogonias furnieri*, Desmarest, 1823, bottom feeder fish), and to use these criteria to infer the radioecological importance of these isotopes.

Methods

The isotopes were analyzed by radiochemical methods followed by alpha spectrometry. Five specimens of mullet and the nine specimens of croaker were analyzed. Statistical analysis was performed as an analysis of variance among the mean activity concentrations of the isotopes in fish. Equality among the mean activities was the null hypothesis (H₀), and a difference among the mean activities was the alternative hypothesis (H₁). The internal dose rate was calculated in µGy.y⁻¹, from the activity of the radionuclides, obtained in Bq.kg⁻¹ fresh weight, for each isotope as follows:

\[ D_a = DCF \cdot E_a \cdot N_a \cdot \Phi \cdot C_0 \]  
µGy.y⁻¹

where:

- DCF is the dose conversion factor \([\mu \text{Gy.y}^{-1} \cdot (\text{Bq.kg}^{-1})^{-1}]\), in this case equal to 5.05;
- \(E_a\) is the energies of the alpha (MeV);
- $N_0$ is the amount of transitions that produces an alpha particle (dimensionless);
- $\Phi$ is the amount of absorbed energy (dimensionless) and;
- $C_0$ is the activity concentration of the radionuclide in the organism (Bq.kg$^{-1}$).

Results

The mean activity concentrations ranged from 1.74 Bq.kg$^{-1}$ referred to U-235, to 13.48 Bq.kg$^{-1}$ referred to U-234, both values measured in the croaker. The isotopes of uranium studied contributed with 540 $\mu$Gy.y$^{-1}$ and 515 $\mu$Gy.y$^{-1}$ for mullet and croaker respectively. The isotopes of thorium, in turn, contributed with 298 $\mu$Gy.y$^{-1}$ for mullet and 319 $\mu$Gy.y$^{-1}$ for croaker. The calculated $f$ value was 0.69 and the tabulated one was 1.92. Thus, $H_0$ was accepted.

Conclusions

In conclusion there was no significant difference among the activities of studied isotopes and, hence, among the absorbed doses from these isotopes. Consequently, for these two fish from different trophic levels, the six isotopes have the same importance from a radioecological viewpoint.
Is there any Difference between Haemostatic Effects of Non-radioactive and Radioactive Lantern Mantle Powder?

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Abstract

Introduction: Some poorly educated people in different parts of Iran use burned mantles as a wound healing medicine. Mortazavi et al. have recently shown that topical application of radioactive lantern mantle powder on wounds cause a progressive surface reduction (2009). Also their histological study showed a significant statistically difference in some basic parameters concerning healing. In this paper the haemostatic effect of burned radioactive lantern mantles powder is presented.

Materials and Methods: In this experimental study, 41 male Wistar rats were divided randomly into 3 groups. Following anesthesia, animals' tails were cut off at a thickness of 5 mm by using a pair of surgical scissors. No intervention was made on the animals of the control group. The 2nd and the 3rd groups received topical non-radioactive lantern mantle powder or radioactive lantern mantle powder respectively. After treatment, the volume of blood loss was measured using a scaled test-tube. The bleeding time and clotting time were also measured using a chronometer.

Results: The volume of blood loss, bleeding and clotting time in control animals were 4.07 ± 1.69 cc, 127.73 ± 44.98 sec and 107.27 ± 51.11 sec, respectively. In the 2nd group, in which the animals were treated with a non-radioactive lantern mantle, the volume of blood loss, bleeding and clotting time were 2.34 ± 0.70 cc, 54.50 ± 8.75 sec and 22.9 ± 15.34 sec, respectively. In the 3rd group, in which the animals were treated with a radioactive lantern mantle, the volume of blood loss, bleeding and clotting time were 1.54 ± 1.69 cc, 39.54 ± 44.98 sec and 36.62 ± 51.11 sec, respectively.

Discussion: To our knowledge, this is the 1st study to investigate the alterations of bleeding and clotting time as well as the volume of blood loss following the use of radioactive lantern mantle powder. The results obtained in this study clearly show the significant alterations in the above mentioned parameters following the topical use of the non-radioactive or radioactive lantern mantle powder. Although the magnitude of the difference between haemostatic effects of non-radioactive and radioactive lantern mantle powder was small, radioactive powder appeared to be more effective.

Keywords: Lantern mantle, haemostasis, bleeding, hemorrhage, radioactive, thorium

Reference:
Radioadaptive Response Induced by Diagnostic Doses of Tc-99m in Wistar Rats after Receiving a Lethal Dose

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INTRODUCTION: Substantial laboratory data indicate that adaptive response can occur, in which low doses of ionizing radiation can induce mechanisms whereby cells become fitter to cope with subsequent exposures. However, doubt still persists concerning whether it is possible to detect decreased or increased morbidity and mortality due to low-level radiation exposure in the presence of other effects. The aim of this study was to investigate the effect of diagnostic doses of radioisotopes on induction of adaptive response to a subsequent receipt of a lethal dose. MATERIALS AND METHODS: 40 male adult Wistar rats (200-250 g) were randomly divided into two groups of 20 animals. The animals were kept in special cages with controlled temperature, humidity, and lighting. The animals in the 1st group received a diagnostic dose of Tc-99m (0.9 mCi, i.p. injection). The second group (controls) were treated in the same manner but received sterile normal saline instead of technetium. After 48 hours, all of the animals were whole-body irradiated with a previously reported LD50/30 dose of 6.7 Gy of cobalt-60 gamma radiation. Then, the animals were returned to their cages and monitored for 30 days. During this interval, the general clinical state of the living animals as well as death events were controlled/recorded daily by an expert group.

RESULTS: No death event was observed during days 1-14 in either group. At day 20, the survival fractions for the control and radioisotope groups were 65.0 and 60.0%, respectively. The same pattern was observed until day 24. Finally, thirty days after gamma irradiation, the survival fractions for the control and radioisotope groups were 25.0% and 55.0%, respectively (a statistically significant difference; P<0.05).

CONCLUSION: These data clearly show that diagnostic doses of radioisotopes may induce an adaptive response. This phenomenon may interfere with the outcome of any subsequent therapeutic application of photons or radioisotopes. In this light, further studies are needed to clarify the extent of this effect and its persistence.

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Natural Radioactivity in Lucrecia City, Northeastern Brazil: Gross Gamma Ray and Indoor Radon

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Objectives

This research aims to provide the Lucrecia city actions in the area of environmental and public health (prevention, mitigation and management) as regards the distribution of the carcinogenic agent radon and decay products in urban and rural areas. Domestic radon has been identified as the most important environmental risk factor for lung cancer. The Lucrecia city (Rio Grande do Norte-Brazil) has presented an unusually high incidence of different cancer types in contrast to other neighboring municipalities. This region is formed by metamorphosed rocks of granitic composition.

Methods

The Indoor radon measurement was making with Long-term electrets passive radon detectors E-PERM® System (RADELEC INC.). Gross gamma radiation with RS-125 Handheld Super-Spectrometer with large NaI Detector (103 cm³) (TERRAPLUS) and gross alpha-beta radiation were analyzed by liquid scintillation counting (SAC-4 (alpha) e FHT - 770T (beta) from Eberline)

Results

We present the results from 110 Long-term passive radon detectors installed in 100 dwellings (mainly bedrooms) in Lucrecia city. The survey was performed during two periods of three months on the dry season (December -February). All dwelling are without ceilings and have ceramic roofs, while the floor is tiled or cemented. The choice of different dwellings was random. For the two periods, the GM for Indoor-Radon were determined as 220 Bq/m³ (SD: 957; range 40-7679; MED: 237). In the first measured period all dwellings exceed the EPA-USA action levei of 148 Bq/m³ (range: 170-6538; MED: 307; GM: 370; SD: 956) but in the second measured period, the data are more scattered (range: 42-7679; MED: 115; GM: 135; SD: 919) due to occurrence of an abnormal early onset of rain season. The gamma radiation level was also checked in each dwelling and range 913-5625 cpm (MED: 3539; GM: 3505; SD: 567). Ten water samples from Lucrecia dam show gross alpha/beta radiation ranging between 0.17/0.47 Bq/l (dry period) and 1.35/ 2.05 Bq/l (rain period) and exceed the MCL for gross alpha of 0.56 Bq/l (EPA-USA).

Conclusions

Our results show that for the Lucrecia city the indoor-radon and gross alpha/beta in water are high and further and more extensive research is needed.
Effects of prolong exposure to low frequency electro magnetic field (LEMF) on vascular alpha adrenergic receptor response of rat

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Objectives:
Studies show that exposure to electromagnetic field (EMF) affects cardiovascular parameters especially blood pressure yet the results have paradoxical nature. The mechanism by which these effects take place is unclear; we conducted this study to investigate whether the change of blood pressure is due to the effect of LEMF on alpha adrenoreceptors of the blood vessel.

Methods:
Twenty adult male Wistar rats weighing 150-200 g were divided into three groups: group one included 8 male rats exposed to 500 μT and 50 Hz for seven months. Group 2 was included 8 rats that exposed to 100 μT and 50 Hz for 7 months. Control group included 4 rats and were kept in normal condition. All groups were kept under 12hr light/dark condition and water and food were equally provided for all groups. After 7 months rats were anesthetized by IP injection of sodium pentobarbital (30 mg/kg). The thoracic aorta was immediately isolated and placed in 4 °C Krebs Solution. Then the thoracic aorta dissected free of adherent connective tissue. The aortic segment was cut into rings of 3–4 mm in length, taking special care to avoid stretching or touching the luminal surface of the rings. The isolated aorta strips was connected to a power lab force transducer that inserted to organ bath containing Krebs solution. The mechanical response of the strips to phenyephrin (as α1 adrenoceptor agonist) and parzosin (as α1 adrenoceptor antagonist) were recorded by AD bridge amplifier.

Results:
The data was analyzed using ANOVA and Duncan test at p<0.05 as significance level. The results showed no significance differences between responses of strips that isolated from LEMF exposed rats and control groups.

Conclusions:
It can be concluded that prolong exposure to Low Frequency EMF with intensities less than 500μT may not affect the alpha adrenoceptor responsiveness.

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Statistical properties of radiation damage to bio-cells by X-rays exposure

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Objectives:
To quantify the probability of cell killing by a photon irradiation associated with electron interactions, the number of lethal lesions induced by electron tracks in the cell nucleus exposed to X-rays is evaluated from a statistical point of view.

Methods:
We perform a Monte Carlo track simulation of electrons in the cell nucleus after the irradiation of MeV-order photons, where the electrons produced by the photoelectric effect and the Compton interaction start with initial energies in a certain distribution. Then, by taking account of clustering events of ionization and excitation along the electron tracks, the relative numbers of lethal and potentially lethal lesions are estimated based on the scheme of the MK (Microdosimetric-Kinetic) model.

Results and Conclusions:
The number of the tracks passing through a cell nucleus was found to be just a few (0-2 on average) per Gy on the assumption that a linac 6 MV-Xray is irradiated to the cell in a deep location of human body and the nucleus is spherical in diameter of about 5\(\mu\)m. The expected energy transfer of electrons per unit length (i.e., LET) is not constant along the track and a large portion of the energy is imparted at around the endpoint of the track. Therefore, it could be plausibly regarded that the number of passing events in the nucleus inducing cell death follows the Poisson statistics. With this postulation, we deduced a new relationship between the dose and the survival fraction of cells alternative to the conventional LQ (Linear-Quadratic) relation, in which the repair process of lesions in the nucleus is essential to form a bending characteristic of the survival curve at low doses. It was found that the new relation describes well the tendency of the curve to become straight again at higher doses.
Studying the Double Action of Cadmium (2⁺) to Classification and Frequencies of Chromosome Aberrations induced in Human Lymphocytes Exposed to Gamma Rays

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ABSTRACT

Objects
- Chromosome aberrations induced in Human lymphocytes treated with Cadmium and Gamma rays.
- Cadmium standard solution Cd(NO₃)₂ in HNO₃ 0.1M, pH 5.5 (Cd: 1000 µg/ml) (Wako Pure Chemical Industries, Ltd, Japan)
- Gamma ray source with dose rate: 0.0514 Gy/s. Thermal Light Dosimeter.

Methods
- Using origin Cadmium standard solution (Cd: 1000 µg/ml). Contributed in concentrations per each tube and in stage per each combination.
- Using Co⁶⁰ source, phantom 1 hole and TLD for irradiation and dosimeter.
- 4 combinations were conducted: Cd; Gamma; Cd/gamma (pre) and Gamma/Cd (post). Cadmium in concentrations 0; 0.05 μg/ml and 0.10 μg/ml were combined with gamma rays in doses 0; 0.75 Gy; 1.0 Gy and 1.5 Gy in two combinations: combination 1 for pre-treatment with Cd (Cd before irradiation 3 hours), combination 2 for post-treatment with Cd (Cd after irradiation 3 hours).
- Culture in full medium with colchimid 48 hours.
- Analyse mitotic index, dicentric, ring, fragment, chromatid breaks per each point.

Results
Different with Arsenic, the observed results presented that Cadmium in the single concentrations 0.05 μg/ml and 0.10 μg/ml were not aspect to mitotic index and chromosome aberrations also. In the combined treatments, the difference on frequencies of Dicentric and Fragment in lymphocytes treated with variable Cadmium concentrations in the same group of gamma rays dose was clearly. Following the increasing of Cd concentrations in the combinations exposed to the same radiation dose, the frequencies of Dicentrics were decreasing but the frequencies of Fragments were increasing. The difference on frequencies of chromosome aberrations was not detected in the Cadmium concentrations 0.05 μg/ml and 0.10 μg/ml of the combinations of post-treatment, it means that Cadmium do not aspect to the induction of chromosome aberrations after repair time.

Conclusions
1. Cadmi Cd(NO₃)₂ in range of concentration from 0.05 μg/ml to 0.10 μg/ml were not caused the decrease in mitotic index in Human lymphocytes.
2. Cadmium it self in concentrations limited to 0.10 μg/ml were not induced chromosome aberrations in the first cycle of human lymphocytes in vitro.
3. There were a changing of prediction, frequencies of dicentric aberrations were decreased with increasing of Cadmium concentrations in the combinations exposed to the same dose of
gamma rays, but frequencies of fragment aberrations were increased with increasing of Cadmium concentrations in these combinations.

4. There was weak difference of aberration frequencies between single-irradiation combinations and pre-irradiation combinations. Those showed that 180 minutes after irradiation was full time to complete the DNA damage repair progress.

5. We suggest that Cadmium is not directly causing chromosome aberrations but aspect to the DNA damage repair progress of lymphocytes. The Cadmium action can be lead to the increasing fragments (unactive cohesive free ends) by bound the blunt free-end of DSB or create near site DSB (unblunt free-end) which lead to difficulty in joint together.

6. For biological dosimetry and for the dangerous level of radiations: Because dicentric was used as a biomarker for dose assessments, Cadmium will create an incorrect result on dosimetric value. The relinking prevention of fragments will increase the dangerous level of exposing to ionizing radiation.

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EvaIuate the Heath Aspecting LeveIs caused by Ir192 Radiation Source Risk at Vungtau 2007 and Dungquat 2008 by Biodosimetric Method used Technique of Chromosome Aberration Analysis

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Objects
Chromosome aberrations test and biodosimetry for the donors follow:
- 102 workers who were working in the area of the risk of IR192 industry radiation source (risk group).
- 60 workers who were breaking down of the area where the IR192 industry radiation source working (forbiddance group).
- 83 workers who were working in the area where the dosimetric alarm machine alarmed (suspected group).

Methods.
- Diagnosis of the clinical signs related to radiation risks.
- Taking 10 ml peripheral blood per donor, but using 0.5 ml for cell culture.
- Routine for cell culture was standard medium and chemicals (Gifco, Difco, Sigma) with 48 hours incubator time. Conventioning paint for slides.
- All chromosome aberrations were examined by genetic theory (Savage) which response to DNA damages to chromosome aberration type.
- Equivalent dose was counting for 10 mSv with 1 dicentric/1000 metaphase, 100 mSv with 2 dicentric/1000 metaphase. The application equation for dosimetry was the private calibration experimental with gamma rays source 125 mGy/h y=0,492D + 3,054D².

Results
- In the risk group, there were no evidence of chromosome aberrations in 35 donors, 11 donors were detected chromatid breaks, fragments were detected in 36 donors, dicentrics in range 1/1000 cells were detected in 16 donors, in range 2/1000 cells was detected in 1 donors, three donors got special cells with more than 2 dicentrics.
- In the forbiddance group, there were no evidence of chromosome aberrations in 29 donors, fragments were detected in 29 donors, only 2 donors were detected dicentrics in range 1/1000 cells.
- In the suspected group, there were no evidence of chromosome aberrations in 35 donors, 19 donors were detected chromatid breaks, fragments were detected in 29 donors.

Conclusions
- The data in the risk group showed that 11 donors were exposed to the dose level 10 mSv, 3 donors to the dose level 100 mSv and 3 donors to the special partial doses.
- The data in the forbiddance group showed that only 2 workers who were exposed to 10 mSv.
- No worker from suspected group was aspected to radiation.

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Study of the delayed effects induced by accelerated $^{12}$C ions with energy of 200 MeV/n and X-rays on mice in vivo


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In present work we investigated the delayed effects induced by accelerated $^{12}$C ions with energy of 200 MeV/n and X-rays on mice. Dose dependence, ability of the adaptive response (AR) induction and genetic instability (GI) in F₁ generation were studied by the micronucleus test in polychromatic erythrocytes (PCE) of bone marrow.

Two-month-old males of SHK mice were irradiated by $^{12}$C ions with energy of 200 MeV/n on “Nuclotron” in Joint Institute for Nuclear Research (Dubna) and by X-rays on RUM device with a voltage of 200 kV at a dose rate of 1 Gy/min.

The dose dependences of the frequency of PCE with micronucleus (MN) induced with doses of 10, 15, 50, 100 and 150 cGy of both types of radiation were studied. For AR detection mice were exposed to irradiation according to the following scheme: an adapting doses of 10 cGy of $^{12}$C ions or X-rays, followed after a day by a challenging dose of 1.5 Gy of X-rays.

To obtain generation F₁, 15 days after the irradiation, males from the irradiated and control groups were mated in separate cages with unirradiated females for two weeks. Descendants of irradiated and unirradiated parents were exposed to additional X-radiation with a dose of 1.5 Gy or by the scheme of AR (10 cGy+1.5 Gy) to reveal the genetic instability. Bone marrow specimens for calculating micronuclei were prepared by the conventional method.

The experiments demonstrated that: 1) at low doses (0-50 cGy) both dose dependences of cytogenetic damage induction can be fitted by a linear regression and almost coincide, i.e. RBE value is equal 1; at higher doses RBE value rises to 1.4; 2) irradiation of mice with dose of 10 cGy of accelerated $^{12}$C ions induces AR as X-radiation; 3) the levels of spontaneous and radiation-induced PCE with MN in mice born from both males irradiated with a dose of 10 cGy of accelerated $^{12}$C ions and X-rays and unirradiated animals are the same; and 4) the F₁ generation from irradiated males is unable to induce the AR, as distinct from their parents. The offsprings of unirradiated males reserve this ability. Obtained data indicate the genetic instability in F₁ generation born from $^{12}$C- and X-irradiated males.

These findings may be used to assess the delayed radiation effect from low-dose radiations and for developing basic foundation of adaptive medicine.
Radioadaptive Response of *Drosophila Melanogaster* Larva Neuroblast

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*Objectives.* The mechanisms of radiation adaptive response are low understood, especially on the whole organism level. *Drosophila melanogaster* is good model system for those investigations because of well-developed genetics techniques and availability of transgenic strains.

*Methods.* It was analyzed the level of DNA damage (comet assay) and apoptosis (diffusion assay) of *Drosophila melanogaster* larvae neuroblasts, developed in condition of low doze-rate chronic γ-irradiation (4 cGy), in response to high-dose irradiation (3, 6 Gy) immediately and after 30 and 90 minutes. It was used wild type strain Canton-S and Superoxide dismutase mutant strain.

*Results.* The adaptive response by the level of DNA damage was shown for both strain, but it was less expressive in Sod. The observed resistance is presumably connected to increase of DNA-damage repair efficiency in preirradiated objects, to free radical scavenging and promotion of sensitivity to apoptosis.

*Conclusions.* It is assumed, that observed changes may be result of selection of resistant cells during development in condition of a chronic irradiation.
Influence of PARP-1 Over-expression on Drosophila melanogaster Whole Organism Radiosensitivity

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Objectives
The objective of our research was to investigate the role of PARP-1 in the whole organism radiation response.

Methods
Effects of preliminary over-expression of PARP-1 on the subsequent radiosensitivity to 30 Gy of acute irradiation were studied with the \( y P{w^ + , UAST-PARP-I}/y w; P{ELAV-GeneSwitch} \) genotype. This genotype was generated from cross among the stock \( y P{w^ + , UAST-PARP-I} \) (kindly provided by Dr. Tulin, Carnegie Institution of Washington, Baltimore) and \( y w; P{ELAV-GeneSwitch} \) (kindly provided by Dr. Keshishian, Yale University, New Haven). Over-expression of PARP-1 was generated in nerve system of the third instar larvae or imago, 24 or 72 h before acute irradiation, by 25 \( \mu \text{g/ml} \) of mifepristone.

The effects of irradiation on the whole organism and cellular levels were investigated. The analysis of prolongation of the larval stage, pupa lethality, age dynamics of imago mortality, as well as DNA damages and apoptosis have been carried out.

Results and Conclusions
The obtained results will be presented and interpreted from a point of view of PARP-1 role in radioadaptive response.
National Mental Health Care System following Radiation Accidents and Radiological Terroristic Attacks

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Objectives are to specify the neuropsychiatric lessons of the Chernobyl accident and justify the countermeasures and main principles of a National mental health care system following radiation accidents and radiological terroristic attacks.

Methods are analysis and integration of own post-Chernobyl neuropsychiatric experience in an interaction with the international literature data.

Results. The main neuropsychiatric lessons of the Chernobyl accident are as follows: 1) Psychological consequences: radiation anxiety, panic reactions, psychosomatic disorders, and social disintegration; 2) Impact on society: victimization, "acquired helplessness", "panic flight to disease", social inactivity, work days lost, disability; 3) Radiological and psychological justification of evacuation and resettlement; 4) Postradiation post-traumatic stress disorder: "flashback for tomorrow" (cancer, congenital abnormalities etc.); 5) Developmental effects of irradiation on the brain; 6) Adverse long-term effect on mental health in adults; 7) Suicides; 8) Potential radiocerebral effects. Moreover, the “Shelter Object” of the Chernobyl NPP is a unique model of radiological dispersal device (RDD) or “dirty bomb”.

Conclusion. This is crucial to create the National system for mental health care for the survivors of radiation accidents and radiological terroristic attack. Its main principles and countermeasures have to include: 1) Comprehensive public information about accident (truthfully, professionally, timely) with mass media balanced and optimistic approach; 2) Public training; 3) Governmental readiness; 4) Reasonable interventions; 5) Psychological support; 6) Social-economic benefits to be a “survivor”, but not a “victim”; 7) Legislation (reasonable social and medical insurance; medicine for health, but not for sick benefits); 8) Professional re-training; 9) Reasonable employment; 10) Psychoprophylaxis, psychorehabilitation and treatment.
Neuroimmune and Gene Expression Changes in Chronic Fatigue Syndrome after the Low-Dose Radiation Exposure

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Background. The Chronic Fatigue Syndrome (CFS) is currently considered to be the conventional cluster of characteristic symptoms, resulted from the exposure to low levels of different exogenous hazards, including ionizing radiation, viral infections etc. The classical examples of “environmental CFS” were described following the Gulf War and the Chernobyl accident.

Objectives. The goal was to detect the changes of neurocognitive and immune functions and gene-expression following exposure to low levels of radiation and non-radiation industrial hazards as a result of the Object “Shelter” transformation to ecologically safe system.

Methods. Cognitive functions assessment (RAVLT), brain mapping of quantitative electroencephalography (qEEG), immunologic phenotype, carriage of blood infections (CMV, HSV, HCV, HBV, Toxoplasma gondii) and with individual external, internal, and total radiation doses assessment for 196 “Shelter” workers (males aged 20–52 years) at the baseline and after exposure were used. TP53, TP53 13, BIRC 5, DDB 2, NF-kappa B, TGFR, MKNK2, CDKN1B, CDKN2A, CCND1, CDKN1A, FASLG, MADD, BAX, MAPK14 gene expression was performed in 12 workers.

Results. The doses for 1–4-year period consisted of: externaI – 0-69.9 mSv (20.4±13.7), internal– 0-2.4 mSv (0.4±0.5), total – 0-70.6 mSv (19.4±13.9). Following the works the mild cognitive disorder and abnormal EEG increased; verbal short-term memory, verbal learning, and proactive interference of verbal information deteriorated; delta-, theta- and beta-power increased in the left fronto-temporal region together with alpha-power and dominating frequency of electrical brain activity decreasing. These data at a dose-related manner testified to low doses related overactivation of the cortical-limbic system mainly in the dominant (left) hemisphere. Gene studies have demonstrated increased BIRC5 (survivin) and MKNK2 expression possibly of protective origin together with the individual variation of the other genes expression, the moderate cellular-type immune system deficiency and absence of the viral blood infections reactivation.

Conclusion. Performed study shows some connection between the nervous and immune system changes and absence of relationship with the chronic viral infections carriage that is reported in CFS patients. Gene expression study revealed mainly the activation of protective systems and it was not possible to find out the “molecular signature” of the low doses of ionizing radiation possibly due to the influence of concomitant factors. Expansion of the study and organization of international collaboration on CFS following low dose exposure seems be promising.
Keratin's Cluster Regenerative Profile is activated in Mouse Skin after Neutron Irradiation

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Objective: This project aims to the identification of an in vivo mouse skin regeneration profile after exposure to different doses of 14 MeV neutron. Cellular and DNA damages have been analysed in vivo at 6 and 24 hours after irradiation on groups of at least 6 animals, both in the radio-resistant C57Bl/6 and the radio-sensitive CBA/J mouse strains.

Methods: 14 MeV neutron irradiation is performed at the ENEA Frascati, neutron generator facilities (FNG), specifically dedicated to biological samples. FNG is a linear electrostatic accelerator that produces up to $1.0 \times 10^{11}$ n/s 14 MeV neutrons via the D-T nuclear reaction. Regenerative profile has been related to apoptosis markers (TUNEL and Caspase-3 activation), proliferation (Ki67), and DNA damage (γH2AX and 8-oxodG) following 20 cGy and 1 Gy, 6 hours and 24 hours delayed time after exposure. Low doses (0.1 and 1 cGy) are under observation to determine hypothetical threshold of regenerative profile activation.

Conclusions: The co-regulation of a sub-class of keratin, keratin associated protein and S100 family of Ca-binding proteins, are transiently up-regulated at 6 hours from the 20 cGy dose delivered, and drastically down-regulated at 24 hour at the higher dose of 1 Gy. The differential modulation of these genes in the epidermis plays a key role in the skin self-renewal activation processes, with absence of apoptosis and cellular and DNA damage evidenced at 24 hours from the 20 cGy exposure in contrast with 1 Gy exposure. Interestingly, these repair processes are apparently in charge of three-dimensional skin architecture reconstitution more than DNA repair process and/or apoptosis, and it appears to be independently exerted from mouse strains.

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Low Level of Ros Over-Production by Spermine Oxidase Activity and Low Dose Radiation Effects on DNA-Repair Deficient Cell Lines

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Objective: The aim of the project is to determine the existence of a hypothetical DNA damage threshold, which could trigger the cellular decision for DNA repair or apoptosis. Low level of constitutive DNA damage is accomplished by ectopical expression of murine Spermine Oxidase enzyme (mSMO), a component of the polyamines metabolism pathway. Low level of X-irradiations deliver challenging dose of damage will be evaluated in proficient and both transcription-coupled-repair (TCR), a sub-class of a nucleotide-excision-repair (NER) and base-excision-repair (BER) deficient cell lines.

Methods: Chinese hamster ovary parental cell line (AA8), the NER deficient counterpart (UV61), and the BER deficient counterpart (EM9) were transfected with mSMO, by retroviral infection. Stable transfected colonies have been analysed for cell viability, apoptosis, gH2AX and ROS over-production. Identical end-points have been evaluated after 1 and 10 cGy of low let irradiation by X-Ray generator (Gilardoni, 250 KeV, 1.5 mA, dose-rate 0.1 Gy/min), performed at the ENEA Casaccia. End points were determined at 6 and 24 hours after exposure.

Conclusions: The priming dose of low level of ROS over exposure by mSMO did not provoke evaluable alteration on surviving capabilities on parental AA8, and, respectively, TCR (NER) and BER deficient UV61 and EM9 cell lines. Accordingly the mSMO over-expression increases the level of ROS, but below the threshold to induce DNA repair cellular commitment. Since mammals SMO is differentially activated in a tissue specific manner, it could be of interest to gain more knowledge in determine if very low dose exposure of X rays could start DNA repair processes, taking advantage also of the experimental upcoming evidences in both NER and BER deficient cell line models.

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Study of the 6-propyl-2-thiouracil (PTU) as a Radioprotector for the Thyroid Gland

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Introduction: Many epidemiologic studies have shown that the exposition to the external radiation increases thyroid neoplastic frequency, especially when given during childhood or adolescence. Radioprotectors are chemicals agents that decrease the radiation damage. The mechanisms of radioprotection are complex. The application of a radioprotector drugs could be useful to avoid the development of malignancies in the normal areas after radiation treatment.

Objective: Study of PTU as a radioprotector in the thyroid gland.

Methods: Rat thyroid epithelial cells (FRTL-5) and human colon cancer cells (HT-29) were exposed to γ-irradiation at different doses (1 to 8 Gy) in the presence or absence of PTU (1 mM). Cell surviving fractions (SF) were determined by the standard in vitro colony formation assay using the SF as an indicator of radiation effect on cells. Adenosine 3’,5’-cyclic-monophosphate (cAMP) levels were measured by radioimmunoassay (RIA). Catalase activity was measured as described by Aebi.

Results: The SF was increased, in the presence of PTU, with all the doses in both cell lines. The dose reduction factor (DRF) for 3 Gy equals 1.7 and 1.4 and 1.5 and 1.9 for 5 Gy in FRTL-5 and HT-29 cells respectively. Since it has been demonstrated that the increase of the radioresistence can be induced by the stimulation of the cAMP transduction signal pathway, cAMP levels were measured after incubating the cellular lines during 5, 24, 48 and 72 hours with different concentrations of PTU (0; 0.5 mM; 1 mM and 1.5 mM). PTU increased extra cellular levels of cAMP in all the treatments in a dose and time dependent manner for FRTL-5 cells. Meanwhile, a peak was observed at 24 hs in extra cellular levels incubated with PTU 1 mM (36.97 ± 6.74 fmol/µg prot vs control: 17.53 ± 3.9 fmol/µg prot, p<0.001) in HT-29 cells. Forskolin and dibutyril cAMP mimicked the effect of PTU on SF (0.469 ± 0.003 vs. 0.31 ± 0.01 and 0.31 ± 0.02 vs. 0.205 ± 0.03, at 3 and 5 Gy). One hour after the irradiation PTU increased catalase’s activity in both cell lines at 3 Gy and 5 Gy (p<0.05). Twenty four hours later, the activity was augmented at 3 and 5 Gy (p<0.05) for FRTL-5 cells.

Conclusion: PTU is a radioprotector for thyroid cells and exerts its effect through cAMP and the enhancement of antioxidant enzyme’s activity.
Radiation-Induced Genomic Instability in Directly Irradiated Versus Bystander Cho-K1 Cells

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Objectives: The aim of present study is to compare the radiation-induced genomic instability (RIGI) manifestations in the progenies of totally irradiated cells vs. the progenies of cells mixture containing 90% of non-irradiated cells and 10% of irradiated cells.

Methods: Chinese Hamster Ovary cells (CHO-K1 cell line) were used in this study. The cells were cultivated under standard conditions. The irradiation was performed using a γ-rays unit “Agat” (Russia) equipped by ⁶⁰Co source (dose rate of 1 Gy/min). The DNA breaks level, apoptotic cells percentage and intracellular reactive oxygen species (ROS) content were measured using a comet assay, DNA halo assay and DCF-DA test, accordingly.

Results: There was a significant increasing in the DNA breaks level, apoptotic cells percentage and intracellular ROS content in 9-32 cell generations after total acute irradiation of cells at a dose of 1 Gy as an evidence of the RIGI induction. The increased ROS content in the progeny of irradiated cells testifies in favor assumption of important role of mitochondrial dysfunction in perpetuating of RIGI. The ROS overproduction leads to elimination of cells that are sensitive to the oxidative stress. Earlier, we have demonstrated a selective pressure of RIGI processes leading to the radioresistant cell clones forming. The experimental results on cells mixture (co-culture containing 10% of cells irradiated at a dose of 1 Gy and 90% of non-irradiated cells) showed a statistically significant increase in the ROS content in 9(11) cell generations as well as in all tested end-points (DNA breaks, apoptosis and ROS) from 12(14) cell generations. It is necessary to note that the effects manifestation did not differ from the genomic instability expression in generations from totally irradiated cells.

Conclusions: These studies show that the secondary bystander effect via signals secreted by minor population of genome unstable cells has been involved in the forming of genomic instability.

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Occupational exposure to low radiation recorded before and after new radioprotection regulations

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Radiation protection regulations contained a lot of rules and rational explanations in order to protect occupational exposure workers, patients undergoing radioactive procedures and environment: plants, water and animals. From radiation harmful effect was discovered and to newdays, the radioprotection rules were changed and improved. New discoveries from nuclear field enforced a new legislation of radioprotection; it was taken into consideration and the radiation low dose effect on the human health, doses recorded acutely or during a prolonged period of exposure to ionizing radiations. In Roumania the new radioprotection legislation was issued in 2000 and implemented step by step in nuclear fields. In this way, occupational exposure workers had to change their manner of utilization of the radioactive sources in order to mitigate the doses of radiations, possible to be recorded by their duty.

This paper presents the new radioprotection legislation effect on the low doses recorded by the occupational workers. Thus, the individual and collective doses in occupational sectors where workers were employed over the period 1990 - 1999 were calculated and then compared with the existent radiological statistical data obtained over the period 2000 – 2008. On the other hand, presents the individual doses recorded during almost twenty years.

It was observed that the occupational exposed persons were frequently achieving doses before the new radioprotection regulation application in nuclear facilities.
Assessment of γH2AX nuclear foci number and size in normal and repair-deficient cells irradiated with low and high linear energy transfer (LET) radiation

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Purpose: When cells are exposed to radiation, DNA double-strand breaks (DSBs) triggers a signaling cascade that leads to the rapid formation of a repair complex at the break. Within minutes of DNA damage, histone γH2AX appears at discrete nuclear foci. In this study we investigated the characteristic of radiation induced foci formation in two related cell lines with different radiation sensitivity exposed to low and high LET radiation. For this purpose, the number and size of nuclear foci were evaluated as quantitative indicators of the extent of DSBs complex formation.

Materials and Methods: CHO-10B2 cells and irs-20 cells (defective in DNA-PKcs) were exposed to 0.5, 1, 2, 3 Gy of low LET gamma rays (137Cs) and high LET lithium beams (6Li, 14 MeV/n, 135 keV/μm, TANDAR accelerator, Buenos Aires, Argentina). DSBs were assessed by the detection of phosphorylated histone H2AX (γH2AX) by immunofluorescence and image analysis measurements.

Results: γH2AX labeling demonstrated that the number of foci (average size 0.5 μm² ± 0.1) increases as a function of dose 30 min after irradiation with gamma rays for CHO-10B2 as well as for irs-20 cells. However, the latter cells showed a higher number of foci than CHO-10B2 cells for all doses assayed. Regarding cells irradiated with high LET lithium ions, significantly larger foci were observed in the nuclei of both cell strains (1.2-1.6 μm² for all doses). The increase in the foci size could be attributed to the densely damaged DNA and probably represents clusters of DNA damage. Moreover, the number of lithium-induced larger foci per nucleus increases with dose and fits with the expected number of hits per nucleus, calculated from the fluence for each dose.

Conclusion: This work provides quantitative data on the induction of larger γH2AX foci by high LET irradiation in related cell strains in comparison with those observed after low LET radiation. A close relationship was detected between larger foci number and particle fluence for all dose assayed.

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Evaluation of the environmental effects on the Ciliates Protozoan Planktonic Community in aquatic environment influenced by mining activities (UTM - Caldas, MG - Brazil)

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Objectives: To date few studies have been conducted addressing diagnosis of the possible impact of Mineral Treatment Unit in Caldas – UTM, (MG) radioecology on biota in the surrounding bodies of water. In this context, this study was conducted to assess possible environmental impact caused by acid drainage from mines and processed liquid effluents from UTM on the ciliates protozoan community after treatment and release in Antas Reservoir (RA), i.e., point P41.

Methods: Sampling in the AR (Cab, P41, P14S and P14F) took place during the October/2008 and January/2009 months. For each sampling campaign were realized microbiological (identification and density estimative of the ciliates protozoan, Shannon-Weaver Diversity Index - SWDI), physical and chemical (water temperature, pH, conductivity, dissolved oxygen, sulphate, uranium e thorium) analyses.

Results: The highest values of electric conductivity obtained in water samples of the AR were registered in the oct/08 month in all the evaluated sampling points (Cab = 497.0 μS.cm$^{-2}$; P41 = 765.0 μS.cm$^{-2}$; P14S = 563.0 μS.cm$^{-2}$ and P14F = 604.0 μS.cm$^{-2}$), when compared to the values obtained for the jan/09 month. The sulphate values in water samples of the AR introduced to themselves above the limits established by the current legislation for Class II water in the P41 (386.7 mg. L$^{-1}$) and P14F (287.8 mg. L$^{-1}$) points. Only one uranium value (0.07 mg. L$^{-1}$) and one thorium value (0.07 mg. L$^{-1}$) showed were above the limits established by the Resolution 357 of the Conama and for the Trade n° 50/SLC of June of 1997 of the Brazilian Nuclear Energy Commission, respectively, both in the point P14F (oct/08). The P41 point, which receives the effluent treated derived liquids of the UTM, presented the least average total value of density of ciliates protozoan (2133 cel.L$^{-1}$), when compared to the average total values of density obtained for the Cab, P14S and P14F points. When the SWDI was applied, the point P41 (oct/08) presented the least diversity of types of ciliates protozoan ($H' = 0.447$).
Conclusions: The least average values of total density of the ciliates protozoan took place in the P41 and P14F points, where the highest values of concentration were verified for chemical parameters (sulphate, uranium and thorium). Being so, the low values of cellular density and DI registered in the P41 and P14F points, probably they were made a list to possible toxic effects of the chemical elements and radionuclides (uranium and thorium) due to the release of effluents by this mining company (UTM) on the AR (P41).

Topic: Radiation effects on non-human biota
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The aging factor underlies the phenomena of long-term elevation of Chernobyl clean-up workers' somatic morbidity level

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Objectives. There are many contradictory publications on the phenomenon of somatic morbidity increasing among clean-up workers (CUW) during more than two decades after the Chernobyl disaster.

Methods. The retrospective epidemiological analysis was performed for 14448 CUWs who have been under medical observation since 1986. The changes of morbidity composition for the main classes of diseases (according to ICD-10) have been monitored by annual periods of age growth. Comparison was drawn between two CUW groups: with registered equivalent doses more (n=12949) and less than 25 cSv (n=1499).

Results: The trends of CUWs' long-term somatic morbidity level in the main classes of diseases of ICD-10 after disaster were not monotonous. The first peak of morbidity was observed in the age ranged 40 to 50 years and then the second one appeared around 65 years. The late unfavorable after-effects of the CUWs' irradiation by doses over 25 cSv can be detected mainly in classes of diseases with the evident role of infectious factors in pathogenesis (respiratory system diseases, diseases of skin and subcutaneous tissue) and in the class of mental and behavioral disorders. There weren’t reliable differences in specified age period in CUWs' morbidity levels in other classes of diseases in both compared groups. Moreover, in the class of diseases of the musculoskeletal system and connective tissue in over-25-cSv-irradiation CUW group a lower morbidity level than in the other group was discovered.

Conclusion: Processes of age involution are the ones that lay in the basis of long-term dynamics of CUWs' somatic morbidity in the late period after the Chernobyl disaster. Over-irradiation of CUWs by doses over 25 cSv during the emergency clean-up works does not lead in the late period to clearly identifiable growth of morbidity in the majority of ICD-10 classes of diseases. Decrease of morbidity in class XIII by doses of irradiation over 25 cSv can be interpreted as a hormesis effect.

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The paper is original work of the above stated authors and has not been submitted elsewhere. For any queries, please contact us via phone or email (see above).
In vitro studies of radiobiological effects of boron neutron capture therapy (BNCT).


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BNCT is an experimental radiotherapeutic modality that uses the capacity of the isotope $^{10}$B to capture thermal neutrons leading to the production of $^4$He and $^7$Li, particles with high linear energy transfer (LET). The aim of these studies was to evaluate in vitro the mechanisms of response to the radiation arising of BNCT and conventional photon therapy (low LET). We measured the survival cell fraction as a function of the total physical dose and analyzed the expression of p27/Kip1 and p53 by Western blotting in a cell line of colon cancer (HT-29). Exponentially growing cells were distributed into the following groups: 1) BPA ($10$ ppm $^{10}$B) + neutrons; 2) BOPP (2,4-bis ($\alpha,\beta$-dihydroxyethyl)-deutero-porphyrin IX) ($10$ ppm $^{10}$B) + neutrons; 3) neutrons alone; 4) gamma-rays. A control group without irradiation for each treatment was added. The cells were irradiated in the thermal neutron beam of the RA-3 (flux= $7.5 \times 10^9$ n/cm$^2$ sec) or with $^{60}$Co (1Gy/min) during different times in order to obtain total physical dose between 1-5 Gy ($\pm 10\%$). A decrease in the survival fraction as a function of the physical dose was observed for all the treatments. We also observed that neutrons and neutrons + BOPP did not differ significantly and that BPA was the more effective boron compound. Protein extracts of irradiated cells (3Gy) were isolated at 24 h and 48 h post radiation exposure. The irradiation with neutrons in presence of $^{10}$BPA or $^{10}$BOPP produced an increase of p53 at 24 h maintained until 48 h compared to the control groups. On the contrary in the groups irradiated with neutrons alone or gamma the maximal increase of p53 was observed at 48 h. The level of expression of p27/Kip1 showed a reduction of this protein in all the irradiated groups, being more marked at 24 h and for the BNCT groups. These preliminary results suggest different radiobiological response for high and low LET radiation. The knowledge of mechanisms of damage and repair produced in tumor after treatment will allow to manipulate the response of cells to irradiation which will contribute to the therapeutic improvement.
Preliminary results of radiation-induced bystander effects in QU-DB cell line

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Introduction: It was believed for many years, that radiation traversal through the nucleus of a cell is a prerequisite for producing radiation effects. But over past few years deeper examination of post irradiation of events has revealed that exposure of cell populations to ionizing radiation results in biological effects occurring in both irradiated and non-irradiated cells. In other words cells recipient of growth medium from irradiated cultures also respond to the radiation exposure. This phenomenon is termed the "radiation induced bystander effects". The purpose of this study was to investigate whether bystander effects is manifested in a large cell, such as lung carcinoma cell line (QU-DB).

Methods: For induction bystander effect in non-irradiated cells "medium transfer" technique was employed, to observe the effect the cytokinesis-block micronucleus assay was applied. Flasks contain cultured cells were divided to two groups, target and bystander ones. Target cells were irradiated to 0, 50, 200 and 400 cGy of gamma rays. Irradiation was performed by a Co⁶₀ teletherapy unit delivering approximately 79 cGy/min. After 24 hours, medium were poured off the target flasks, filtered through 0.22 μm filters, to ensure that no cells were present in transferred medium, the filtered transferred to bystander flasks. At this stage cytochalasin B was added to the medium. 24 hours later, cells were harvested for preparation of microscopic slides for micronucleus (MN) detection.

Results: Irradiated cells demonstrated higher number of MN/1000 cells in comparison with control cells. The difference are dose dependent. The excess MN and corresponding doses in cGy are as follows: 50 & 70.25; 200 & 165.25; 400 & 247.25.

Excess MN was also observed among bystander cells in a dose dependent manner. The excess number of MN observed in 1000 by bystander cells and the corresponding dose (cGy) are as follows: 50 & 7.25; 200 & 35; 400 & 71.

Conclusion: These results show when radiation dose is equal or more than 200 cGy, QU-DB cell line can generate and transmit bystander signals. Further work is required to reveal by stander effect for doses below 200 cGy.
Phytoavailability of $^{210}$Pb, $^{226}$Ra and $^{228}$Ra In Ferralsol Receiving Biosolids

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ABSTRACT

OBJECTIVE
Biosolids are byproducts of the treatment and processing of sludge, generated from urban and industrial sewage. Their disposal is presently of great concern worldwide since it can impacts the environment when used as fertilizer to improve soil productivity in a sustainable way or it can receives other destinies like incineration or burial in landfills, whenever considered unsafe for agricultural purposes. Traditionally, the enrichment of the soil with radionuclides is connected with industrial and mining activities. However, the European Commission and the United States, detected that adding biosolids to soils as fertilizers may establish an important scenario for radiological contamination, due to presence of the $^{210}$Pb, $^{226}$Ra and $^{228}$Ra.

METHODS
In this work the impact of the application of biosolids in agricultural areas was evaluated by the study of geochemical partitioning of $^{210}$Pb, $^{226}$Ra and $^{228}$Ra in soils receiving different amounts of two kinds of biosolids: one derived from Barueri, a metropolitan region in São Paulo (industrial waste); and other derived from the city of Franca, São Paulo countryside (household waste).

RESULTS
The results showed larger potential bioavailability of these radionuclides in the soil samples that received biosolid. However the soil to plant transfer factor (TF) for $^{226}$Ra and $^{228}$Ra was not influenced by origin of biosolid or interaction between origin and dose according to variance analysis. The more elevated FT was observed to the $^{210}$Pb indicating larger bioavailability of this element. The medium values of FT for the corn, found in this study, they varied from 1.45E-04 to 4.56E-04 to the $^{226}$Ra and from 3.78E-04 to 9.33E-04 to the $^{228}$Ra and these values were similar to the existent values in the literature. The FT values of $^{210}$Pb (1.09 E-03 to 2.52 E-03) found to the corn were a little larger than the values cited in the literature.

CONCLUSION
The soil amendment with biosolid has not influenced the soil to plant transfer factor (TF) for $^{226}$Ra and $^{228}$Ra, although the soils that received biosolid showed larger potential bioavailability of these radionuclides than the original soil.

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Radiation dose to premature infants in neonatal Intensive Care Unit in Iran

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Abstract

Objective: Neonates in intensive care units (ICU) often suffer from a variety of respiratory and cardiovascular diseases. Radiographic examinations have an essential role in timely diagnosis of such diseases. The radiation exposure of the neonates should be minimized because of the more radiosensitivity and longer life expectancy of the newborn infants. In this study, the Entrance Skin Doses (ESD) of the infants in several hospitals of Iran were assessed for the first time.

Methods: This investigation was done in 4 hospitals in Shiraz city (Shahid Beheshti hospital, Namazi hospital, Hafez hospital and Dena hospital) and Al-Zahra hospital in Isfahan city. 30 infants with different weights and gestational ages were involved in this study. About 20\% of the infants were full-term and others were prematured. Most of these infants suffered from respiratory distress syndrome and pneumonia. The entrance skin doses (ESD) of these infants undergoing radiographic examinations were measured using TLD chips. TLD chips with dimensions of 3*3*1 mm\textsuperscript{3} were used for dosimetry purpose. Three TLD chips were put on the body of the infants at the center of the radiation field. The dosimeters were readout using a TLD reader model Harshaw 4500 after the irradiation. The calibration was done by a Cs-137 source.

Results and Conclusions: The mean ESD were measured for all infants. The values of ESD were in close agreement with previous works of other investigators in different countries. The mean, maximum and minimum measured values of ESDs were 60\mu Gy, 85 \mu Gy, and 40 \mu Gy per radiograph respectively. According to the results, the ESD values increase with the increase of the mAs and the patient size and decrease with increase of the tube kilovoltage.