Low dose effect data from STAR WP5 experiments

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Abstract

Within the framework of the Network of Excellence STAR (Strategy for Allied Radioecology), WP5 aims to enhance the scientific robustness of ecological protection criteria and their applicability as protection benchmarks. In this context, WP5 has conducted studies in order to acquire and link chronic radiation effects at low dose from the molecular to the population levels in plant and animals species. Four subtasks were defined for two radiation types (internal Am-241 α and external Cs-137 or Co-60 γ) and several biological models (zebrafish, nematodes, daphnids, plants): (i) to explore mechanisms of toxic actions at the sub-organismal level, using molecular markers; (ii) to study metabolic modes of action of ionizing radiation, based on "Dynamic Energy Budget (DEB)" concepts; .(iii) to investigate adverse consequences from the organismal to the population levels and identify different life history characteristics (e.g., age at first reproduction, number of offspring, longevity etc.) that might influence species radiosensitivity at the population level; and (iv) to consider the implications of acquired knowledge for radioprotection of wildlife.

As such, new experimental datasets were produced within WP5 through a series of experiments, performed to study effects of gamma or alpha irradiation at dose rates ranging from background levels to 350 $mGy.h^{-1}$. One objective was to understand the tissue sensitivity and radiation mechanisms of toxic actions at the sub-organismal level, using molecular markers. This approach was specifically applied to zebrafish exposed to Am-241 contamination or Co-60 external irradiation. Another objective was to understand how radiosensitivity at the molecular level could be linked to effects at the individual level, by studying organism responses targeted by ionizing radiations (e.g. DNA damage and repair, oxidizing stress, bystander effect) and the possible consequences on individuals in terms of reproduction and survival. This was performed on all biological models. In few species (nematodes, daphnids and duckweed), the DEB approach was applied to identify the metabolic modes of action of ionizing radiation, integrating molecular damage and transgenerational effects on growth and reproduction.

The applied approach focusing on studying molecular mechanisms of toxic actions through a variety of biomarkers, demonstrates quite clearly that the relative differences in biological effectiveness between alpha and gamma emitters will highly depend on the endpoint or biomarker analyzed, the time after irradiation, and the studied organism, tissue or organ.
DEB and modelling work has resulted in a methodology for estimating levels of response at which molecular markers can be considered as signals of deleterious effects on survival, growth and reproduction which are critical for population dynamics. To conclude, WP5 shows that biology-based mechanistic approaches can be powerful tools for understanding and linking mechanisms of radiotoxicity and increasing robustness in predictions of radiation effects at the individual and population levels.