

## Perspectives on Chernobyl and Fukushima Health Effects: What Can Be Learned From Eastern European Research?

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*This is part of the first half of the monograph: "A Critical Analysis of the Concept of an 'Effective Dose' of Radiation". The monograph in its entirety features two review papers from prominent Russian scientist Alexey Yablokov looking critically at the current standards of human radiation safety, accompanied by two editorials presenting a point/counterpoint perspective on Professor Yablokov's work. The second paper and editorial will be published in the next issue, due later this year.*

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It is now evident that much more is known concerning the health and ecological consequences of radioactive contaminants than is being acknowledged or appreciated by the mainstream scientific and regulatory communities. This became apparent following the 2005 publication of the influential Chernobyl Forum report, in which a large body of literature from Eastern Europe was ignored and an

attempt was made to downplay efforts to predict health outcomes for human populations living downwind from the Chernobyl disaster.<sup>1-5</sup> The Chernobyl Forum report suggested, largely in the absence of supporting data, that the disaster's net ecological consequences for flora and fauna was positive because of reduced anthropogenic influences (i.e. the so-called DMZ Effect, named after the phenomenon of wildlife proliferation in the demilitarized no-man's-land between North and South Korea) and that the reported diverse array of human morbidities in the region were largely the result of stress and environmental factors beyond radiation (e.g., smoking and alcoholism). Critical analysis of this report reveals that these statements were included, and perhaps tolerated by the majority of participants, because of a lack of Western peer-reviewed scientific literature to refute them. However, an evidence-based approach to public policy development cannot rely on ignorance as its foundation. If information necessary for informed public policy is absent or meager then an appropriate response is to acknowledge this deficiency and commission the needed research to meet societal needs.

One positive outcome of the bias exhibited by the Chernobyl Forum was that it inspired a call to action from many quarters, including those interested in conducting basic research. A diverse array of international stakeholders (e.g., the Chernobyl Research Initiative, led by the authors of this editorial; multiple research teams from the U.S.-based National Cancer Institute; the EU-sponsored Agenda for Research on

Chernobyl Health group led by Drs. Keith Baverstock and Elisabeth Cardis; and Dr. Nick Beresford's Centre for Ecology & Hydrobiology in Lancaster, England, among others) have been involved in this revived interest in Chernobyl. However, perhaps as a consequence of the policy impacts of the unsupported and optimistic outlook disseminated by the report, there has been very limited investment by any agency into basic research surrounding Chernobyl—and now also Fukushima. The research efforts precipitated by the Chernobyl Forum report are dwindling and certainly most of these efforts appear to be unsustainable due to a lack of funding. It is perhaps revealing to examine the funding priorities of the U.S. National Science Foundation where, during the past few years, more than \$1B has been directed towards research related to climate change while less than \$1.5M has been invested in research into the aftermath of Fukushima. Less than \$1.5M has been invested in all Chernobyl research since 1987, with essentially no new funding since 2008.<sup>6</sup> Given that most scientists are essentially tradesmen selling their research as wares, scientific investigation generally will not happen unless it is commissioned via a grant from a funding agency. This is especially true in the U.S. academic environment, where researchers are required to obtain grants to wholly or partially underwrite their own salaries and where indirect cost payments by granting agencies to research institutions are used to pay for discretionary programs. This is the fundamental reason for the lack of an extensive body of Western literature concerning the health

and environmental impacts of the Chernobyl disaster. Given predictions of further cuts to U.S. federal funding agencies, it seems unlikely that this trend will change in the near future.

Thus it is very fortunate that in recent years several scientists from Eastern Europe and elsewhere have made a concerted effort to survey, compile and synthesize the significant literature related to the effects of Chernobyl that was published during the post-Chernobyl Soviet Union (1986-1991) and post-Soviet Union eras (1991 and onwards), mostly in Russian or other non-English languages, in journals and proceedings that for the most part never made it past international borders. Perhaps due to lingering Cold War attitudes and/or perceived deficiencies in the methodology of Soviet-style science, the bulk of this literature was ignored and, despite the potentially relevant content, played little role in shaping the findings and implied policy recommendations of the Chernobyl Forum report.

Principal among the recent efforts is the New York Academy of Sciences (NYAS) published monograph written by Alexey Yablokov, Vassily Nesterenko and Alexey Nesterenko, and edited by Janette Sherman-Nevinger, entitled *Chernobyl: Consequences of the Catastrophe for the People and the Environment*.<sup>7</sup> This volume is currently the best available comprehensive compilation of the extensive literature from Eastern Europe regarding the effects of Chernobyl. When first published in 2009, it was met with acclaim by the anti-nuclear community and with derision by the pro-nuclear establishment. These positions were largely politically motivated without regard to the merit of this unique compilation. Sadly, pro-nuclear proponents prevailed in influencing the NYAS to post a

Abbreviations			
DMZ	De-militarized zone	NGO	Non-governmental organization
IAEA	International Atomic Energy Agency	NYAS	New York Academy of Sciences
ICRP	International Cancer Research Partnership	WHO	World Health Organization

disclaimer regarding the volume and to discontinue the print version (although an online version is freely available to NYAS members and institutional subscribers to the *Annals of the New York Academy of Sciences*). The monograph is not without shortcomings: the translation leaves room for improvement and it does not stylistically align with typical Western scientific monographs. For the most part, it is an abbreviated yet encyclopedic listing of the many hundreds of research reports generated on the various topics covered by the book with little or no statistical treatment or assessment of the quality

of individual reports. However, this in no way discounts the enormous value of the empirical content, most of which cannot be found in English anywhere else. The skeptical mind would and should question the perspective of any author when interpreting the thesis of a published work, but the overwhelming volume and content of research findings reported by Yablokov et al. should command serious attention despite any stylistic shortcomings or political biases. At a minimum, this book should be used as an important resource for more detailed analyses of Chernobyl consequences.



Figure 1 — Measuring radiation on the banks of a canal (formerly River Romashka), which empties into the River Tom, Chernilshchikovo, Tomsk, Russia.  
(Source: A. Toropov, 2008)



*Figure 2 — In the past, signs marked the place where radioactive waste entered the River Tom in Chernilshikovo, Tomsk, Russia. Dumping ceased in 2008, yet it is believed there are low levels of various radionuclides still present in the river bed. These migrate downstream over time. (Source: Siberian Ecological Agency, 2006)*



*Figure 3 — Cows grazing on the banks of the River Tom in Chernilshikovo, Tomsk, Russia, close to where radioactive waste was dumped until 2008. (Source: Siberian Ecological Agency, 2002)*

Some of the skepticism directed towards the NYAS volume stems from the disconnect between the diverse array of human health issues that are reported versus the conventional wisdom espoused by nuclear regulatory agencies and NGOs (e.g., IAEA and ICRP). Yablokov et al. suggest an eventual death toll in the hundreds of thousands while the official IAEA and WHO estimates are a few thousand in total. Similar discrepancies have been found between an array of recent reports concerning impacts to wildlife (e.g., Møller et al and the rosy picture portrayed by the Chernobyl Forum report).<sup>8-13</sup> Interestingly, many parallels have been found between effects on animal populations and morbidities observed in humans (e.g., increased rates of tumors, lower male fertility, elevated frequencies of cataracts) suggesting some support for the hypothesis that, since birds and insects

generally do not smoke, drink alcohol, nor become clinically depressed, at least some portion of the observed human health effects must be related to radioactive contaminants and not just stress related to relocation following the disaster or other environmental factors.<sup>14-17</sup> That said, the potential health implications of stress for human populations should not be minimized.<sup>18</sup> Ironically, the much larger impacts observed for field-based studies on animals may result from the significantly more stressful environment imposed by life “in the wild” as compared to the relatively benign conditions of the laboratory environment where most radiobiology studies have been conducted in the past.<sup>19</sup> Ultimately, from a health, environmental and economic perspective, the causes of injury—be they physiological or psychological—are irrelevant, although from a mitigation perspective, a better

mechanistic appreciation of cause-and-effect would certainly be important.

Given that the diametrically opposing predictions of the health and environmental impacts of the Chernobyl and Fukushima nuclear accidents are unlikely to both be true, the question of why there are such large differences begs to be answered. At present, apart from the general appreciation of the fact that biological systems, especially those involving humans, are much more complicated than previously understood, the answers remain largely unstated. In this and upcoming issues of the *Journal of Health & Pollution*, Dr. Yablokov will explore some of the likely sources of discrepancies among different groups concerning the health and environmental impacts of radiation. Principal among these possible sources of disagreement is the way in which “effective dose” is usually calculated for exposed populations.

Yablokov methodically explores the many assumptions, simplifications, and limitations of this concept and finds it greatly lacking in realism. The argument is made that the natural world is much more complicated than can be addressed by the current models used by regulatory agencies, which generally ignore the large heterogeneities that exist for exposure, effects on different biological tissues, and radio-sensitivities of individuals. Given the interactions, sometimes non-linear, among environment, radio-sensitivity, and population processes (e.g., evolutionary and ecological responses) that have been revealed from animal studies, it is clear that simple and static models for calculating dose are incapable of realistically capturing the range and distribution of dose and effects for most human populations and it seems likely that the concept of an "effective dose" will need a significant revamp in light of recent findings.<sup>20-21</sup> Yablokov is not alone in this assessment; others have made similar and repeated calls for modification of outdated ICRP approaches.<sup>22</sup>

In this paper, Yablokov also explores the need to reassess the expected biological consequences of low-dose radiation. Although it has been widely appreciated that naturally occurring low-dose radiation can be a significant contributor to human health issues, these have largely been ignored when it comes to addressing regulatory limits to non-natural sources. Curiously, regulators will sometimes cite the fact that since doses of radiation from anthropogenic sources (e.g., nuclear power plants) are expected to be on average lower than doses from natural sources, health consequences will not be measurable and hence not of significance from a policy standpoint. This perspective would only be defensible if there were no demonstrated consequences of low-dosage radiation and dose effects

were not additive and heterogeneously distributed. However, the most respected independent authority concerning low-dose effects (i.e. the National Academy of Sciences' Biological Effects of Ionizing Radiation [BEIR] VII report) strongly supports the linear no-threshold (LNT) model for biological effects of radiation based on a comprehensive review of the literature, and as documented in Yablokov's paper, there are now a large number of reviews of the effects of natural radiation sources that effectively demonstrate that even low doses can result in significant public health problems.<sup>23</sup> For example, it is well-known that natural radon sources in homes is a leading cause of lung cancer both in the U.S. and abroad, although interactions between radon and smoking can sometimes cloud this relationship.<sup>24,25</sup> Furthermore, a recent meta-analysis of natural radiation source effects (excluding radon) found that, overall, natural radiation sources, such as those found in Kerala (India), Ramsar (Iran), Guarapari (Brazil), and many other places, have significant and measurable negative consequences for the populations of humans, animals and plants living in these naturally "hot" places.<sup>26</sup> Thus, there is no *a priori* reason to expect that low doses, no matter the source, be inconsequential. To ignore these effects because of the statistical challenges of working with small effects in large populations should be considered inappropriate given that risk equals effect size multiplied by population. Given the large number of people exposed to radioactive contaminants, the affected population is likely to also be large.

Yablokov's final contribution to this series, to be published in the next issue of the *Journal of Health & Pollution*, draws extensively from his NYAS book. In it, he explores the wide range of morbidities that have been associated with radioactive contaminants in

Ukraine, Belarus and Russia. A key message from this piece is that it is important to investigate the full range of health effects, not just cancers. When taken collectively, there is a diverse array of studies that provide strong evidence of large biological and public health impacts associated with the Chernobyl disaster. These studies have largely been overlooked and not effectively considered when it comes to regulatory discussions of "safe" levels of exposure to radiation. Many of these non-cancer effects may not have yet been demonstrated to directly associate with human mortality (e.g., radiation damage to chromosomes). But where there is smoke, usually there is fire, and it is intuitively obvious to any biologist that genetic damage is often a prelude to larger consequences for the organism or its descendants. It is precisely for this reason that health surveillance programs of workers involved in the nuclear industry and nuclear medical fields utilize bio-dosimetric methods involving estimates of genetic damage that are presumed to serve as bio-indicators of longer-term health consequences for exposed individuals. Indeed, the very term "effective dose" was designed to capture all negative health outcomes from radiation exposure, not just cancers.<sup>22</sup>

In the end, it would seem prudent to seriously consider the potential role played by radioactive contaminants as a contributor to the array of human morbidities that Dr. Yablokov has uncovered within the previously hidden scientific literature of Eastern Europe. We should all be very grateful for this infusion of important information to discussions related to the health and environmental consequences of radiological events. Lessons learned from Chernobyl are particularly relevant now as society grapples with a prognosis for the impacts of the Fukushima disaster and its implications for the future of nuclear energy.

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