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CHERNOBYL: CONSEQUENCES OF THE CATASTROPHE FOR PEOPLE AND THE ENVIRONMENT

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In the few weeks before I was asked to review this book there was media coverage of two diametrically opposed views regarding the magnitude of health effects associated with the Chernobyl reactor accident. One is expressed in the book under review and the other came from Zbigniew Jaworowski (former chair of the United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR). The opposing positions are placed either side of the ‘middle ground’ as expressed by organisations such as International Atomic Energy Agency (IAEA), UNSCEAR and WHO.

In the context of the Chernobyl accident Jaworowski⁽¹⁾ criticises publications, which use a linear-no threshold (LNT) dose response to evaluate cancer risks at very low doses and contrasts predictions of thousands of late cancer deaths with deficits (compared with Russian national statistics) of solid cancers in Russian emergency workers and the populations of most contaminated areas. He claims that the application of LNT led to the unnecessary ‘sufferings and pauperisation’ of millions of inhabitants of contaminated areas. In contrast to the views of Jaworowski the current book under review by Yablokov *et al.*, considers that the excess cancer cases related to the Chernobyl accident have been grossly underestimated.

In the opinion of this reviewer, the wide range of estimates that can be found in the scientific literature is mainly due to different estimates of population dose, the use of different radiation risk figures and different interpretations of epidemiological data

(particularly the use of different control groups). Published estimates of excess deaths also frequently differ in terms of which countries and time periods they refer to. This often makes meaningful comparisons difficult or impossible although it often remains clear that there is a large disparity between different authors. With such a range of views, an already vast and increasing literature, and claims that there has been coercion on an international scale, how can professional scientists—such as most readers of this review—arrive at an informed opinion on the radiation-related adverse health effects from the Chernobyl accident? The answer is with great difficulty! I personally find it necessary to critically read at least selected contributions from the whole spectrum of views. For that purpose this book covers the high cancer mortality tail of the distribution of predictions of health effects from Chernobyl.

This book is a collection of papers translated from an earlier publication in 2007 in Russian. The book presents data which it claims have been inexplicably omitted or inadequately considered by various international bodies such as IAEA and United Nations Agencies. It concludes that previous assessments of adverse health effects arising from the Chernobyl accident have been grossly under-estimated. The foreword by Prof. Grodzinsky (Chairman of the Ukrainian National Commission on Radiation Protection) proposes an explanation for this omission in terms of the influence of a pro-nuclear lobby, which has inhibited the funding of medical studies, diverted human resources away from Chernobyl

studies and has ‘liquidated government bodies that were in charge of the affairs of Chernobyl’. The views of the authors are similarly expressed in their introduction and throughout the text. The introduction explains that the book has its origins in the two conflicting evaluations of Chernobyl health effects published in 2006 around the time of the 20th anniversary of the Chernobyl accident (26 April 1986). Some appreciation of this history is useful to understand the context of this book. One of the conflicting evaluations was by the Chernobyl Forum, an expert scientific panel that was created in 2001 by the Director of the IAEA to conduct an exhaustive assessment of the health, environmental and social impacts of the accident. The other evaluation was by Greenpeace, an international non-governmental organisation with a strong anti-nuclear stance.

The Chernobyl Forum summary report is available online at: <http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf> or http://hps.org/documents/chernobyl_legacy_booklet.pdf.

Technical background papers of the Chernobyl Forum were presented at an IAEA conference in 2006 and are available in the conference proceedings online at: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1312_web.pdf.

The report by Greenpeace, *The Chernobyl Catastrophe: Consequences on Human Health* (edited by A. Yablokov, I. Labunska and I. Blokoy) is available online at http://hps.org/documents/greenpeace_chernobyl_health_report.pdf.

In the Chernobyl Forum Cardis⁽²⁾ gives a figure of about 4200 for the lifetime excess cancer deaths in a 605 000 population of the highest contaminated areas in Russia, Ukraine and Belarus. With the inclusion of a further 6.8 million people in other contaminated areas of Eastern Europe (average doses ~ 7 mSv) the excess increased to about 9000. Background cancer deaths for comparison were given as 109 000 and 936 000, respectively. Greenpeace give numerous numbers for excess incidence and mortality of a wide range of diseases but in many cases it is not stated over what period the excess cancer risk is integrated. It is therefore not possible to easily compare on an equal basis the claims of the Greenpeace report with the predictions of the Chernobyl Forum but it is clear that Greenpeace’s predictions are significantly higher—probably by a factor of 3–10.

Greenpeace describes their report as involving ‘52 respected scientists and includes information never before published in English. It challenges the UN International Atomic Energy Agency Chernobyl Forum report as a gross simplification of the real breadth of human suffering’. The Greenpeace approach is primarily to link temporal changes in health statistics after 1986 in Belarus, the Ukraine and other countries with the Chernobyl accident.

That is, all increases in disease, regardless of type, are assumed to be the result of the Chernobyl accident. The Greenpeace report covers many non-cancer illnesses that have not been observed as radiation-induced diseases even in studies of highly exposed radiation populations but they claim that the Chernobyl accident is ‘unique’ and, therefore, illnesses for which there is no known association with radiation may be the result of the radiation exposure from Chernobyl. Such an approach is also confounded by temporal and regional changes in health statistics that pre-dated the Chernobyl accident. During the production of the reports from the Chernobyl Forum and Greenpeace, a vast body of previously unknown data began to emerge in the form of publications, reports, theses, etc. from Belarus, Ukraine and Russia, much of it in Slavic languages. Little of these data appears to have been incorporated into the international literature. The quality of these publications and whether they would sustain critical peer-review in the western scientific literature is unknown.

The book by Yablokov *et al.* is part of an attempt to summarise these new findings and include them to extend the findings of the Greenpeace report. About 1000 of these translated titles are referred to among the more than 1400 references included in the volume. The longest section 5 on non-malignant diseases has over 500 references and about 85% are in Russian or Ukrainian. It is said that these new references ‘reflect’ more than 5000 printed and internet publications. There are claimed to be more than 30,000 of these types of publications, mainly in Slavic languages, related to the consequences of Chernobyl—the majority presumably remaining inaccessible to the western reader. There is clearly a massive overload of information—which we are all becoming used to on the internet in everyday life. It is not at all clear how these many sources have been used by Yablokov *et al.* and how they have influenced the conclusions made. This is not an issue related to Chernobyl alone. When I first visited Russia in 1982 as part of a UK-USSR Health Ministry exchange I was made aware of a very valuable and extensive literature in the fields of hot particle and neutron radiobiology research. These were mainly in Russian and published in obscure journals. I offered to facilitate publication in the west of the most important papers but the political situation at the time prevented this. The literature remains largely unknown in the west.

The one thing that both the Chernobyl Forum and the Greenpeace reports agree on is the fact that trying to estimate the health consequences from Chernobyl is extremely uncertain and may not, in fact, be possible. The Chernobyl Forum states, ‘It is impossible to assess reliably, with any precision, numbers of fatal cancers caused by radiation

exposure due to the Chernobyl accident—or indeed the impact of the stress and anxiety induced by the accident and the response to it. Small differences in the assumptions concerning radiation risks can lead to large differences in the predicted health consequences, which are therefore highly uncertain'. Greenpeace notes, 'It is widely acknowledged that neither the available data nor current epidemiological methodology allows holistic and robust estimations of the death toll caused by the Chernobyl accident'. This is an important point. During my 40 year career in radiation protection I have observed fierce arguments (mainly related to differences of opinion on the magnitude of radiation risks) which have turned out in the fullness of time to be merely reflections of the large uncertainties inherent in the data. In recent years it has become an integral part of the deliberations of international organisations such as the ICRP to consider the impact of uncertainties in their evaluations.

The book by Yablokov (Volume 1181 of the *Annals of the New York Academy of Sciences*) is a 327-page volume and is an English translation of a 2007 publication in Russian by the same authors titled 'Chernobyl'. This previous publication and some apparent concerns about possible ensuing controversy were referred to in an interesting statement on the New York Academy of Sciences web site.

'The *Annals of the New York Academy of Sciences* issue Chernobyl: Consequences of the Catastrophe for People and the Environment', therefore, does not present new, unpublished work, nor is it a work commissioned by the New York Academy of Sciences. The expressed views of the authors, or by advocacy groups or individuals with specific opinions about the *Annals* Chernobyl volume, are their own. Although the New York Academy of Sciences believes it has a responsibility to provide open forums for discussion of scientific questions, the Academy has no intent to influence legislation by providing such forums. The Academy is committed to publishing content deemed scientifically valid by the general scientific community, from whom the Academy carefully monitors feedback'.

Having described the origins of this book and given some references to alternative opinions the interested reader will hopefully be able to draw a balanced view as far as is possible on this complex subject. So what information does the book provide?

The book contains 15 sections grouped into four chapters.

- (I) Chernobyl contamination: an overview
- (II) Consequences of the Chernobyl catastrophe for public health

- (III) Consequences of the Chernobyl catastrophe for the environment
- (IV) Radiation protection after the Chernobyl catastrophe

Alexey Yablokov is sole author of the six sections of chapters II and three of the four sections of chapter III. He shares most of the other sections with Alexey and Vassily Nesterenko. There is unfortunately no index to the book. An online index is said to be available but I presume this is limited to members of the New York Academy of Sciences.

The preface provides a useful summary of the Chernobyl literature. The introduction addresses the issue of why assessments of health effects from Chernobyl are so disparate. The authors disparage the approach favoured by the majority of the epidemiology community, which seeks a correlation of health effects with levels of contamination or dose. They believe this approach is 'impossible' due to lack of measurements in the first few days, lack of information on 'hot spots' and lack of information on all of the isotopes involved. They consider that the USSR authorities distorted links between health effects and radiation exposure and they prefer therefore to rely on what they consider are independent investigations of comparative health measures in various territories that they consider are identical in terms of ethnic, social and economic characteristics and differ only in the exposure to radiation. The authors believe it is unreasonable to attribute the increased occurrence of disease in the contaminated territories to screening or socioeconomic factors (as considered by UNSCEAR) because they consider the only variable properly significant for this purpose should be radioactive contamination. This methodology does not seem to account for differences between territories that predate the Chernobyl accident.

Chapter I has only one section, which covers an assessment of 'Chernobyl contamination through space and time'. Concern is expressed regarding lack of knowledge on doses incurred soon after the accident from short-lived emitters and the effects of lead contamination arising from its use in fire-fighting operations. The problem of 'hot particles' is raised—a topic which I have spent 30 years researching. The discussion is cursory and does not include a wide range of peer-reviewed research publications in this field relating to dosimetry and biological effects of hot particles—including important contributions from Eastern Europe and Russia. Population dose is considered but it is not obvious which value the authors favour. The authors rely heavily on a review published in 2006 by Fairlie and Sumner⁽³⁾ where the highest collective dose estimates are from the US Department of Energy and UNSCEAR (930 000 and 600 000 Person-Sv, respectively for the world up to 2056) rather than figures, which have included any

input from the new Eastern European literature that is supposedly influential in driving the authors' views.

Chapter II has six sections and 190 pages—60% of the whole book. The sections include public health consequences, general morbidity, accelerated aging, non-malignant disease, oncological diseases and mortality. Leukaemia, thyroid and other cancers are considered separately for Belarus, Ukraine and Russia. I found this a very difficult read. Numerous facts and figures are given with a range of references but with little explanation and little critical evaluation. Apparently related tables, figures and statements, which refer to particular publications often disagree with one another. The section on oncological diseases (cancer) was of most interest to me. A section abstract indicated that on the basis of doses from ^{131}I and ^{137}Cs ; a comparison of cancer mortality in the heavily and less contaminated territories; and pre- and post-Chernobyl cancer levels, the predicted radiation-related cancer deaths in Europe would be 212 000–245 000 and 19 000 in the remainder of the world. I could not however find any specific discussion within the section to support these numbers. The section ends with an endorsement of the work of Malko⁽⁴⁾ who has estimated 10 000–40 000 additional deaths from thyroid cancer, 40 000–120 000 deaths from the other malignant tumours and 5000–14 000 deaths from leukaemia—a total of 55 000–174 000 deaths from 1986 to 2056 in the whole of Europe, including Belarus, Ukraine and Russia. These numbers confusingly, do not agree with a table (6.21) from the same author. The final section on overall mortality contains a table (7.11), which includes an estimate of 212 000 additional deaths in highly contaminated regions of Russia, Belarus and Ukraine. This figure is for the period of 1990–2004, and is based on an assumption that 3.8–4.0% of all deaths in the contaminated territories being due to the Chernobyl accident. One is left unsure about the meaning of many of these numbers and which is preferred. Considerable effort would be required to consult a large number of the source documents to check the veracity of the numerical estimates and the conclusions drawn. I have for example tried to obtain ref. (4) of Malko without success. It is clear however that the thrust of the authors' arguments is that they believe the Chernobyl Forum numbers for excess cancer mortality are significantly underestimated.

Chapter III deals with consequences for the environment and is made up of four sections dealing with activity levels in water/soil/atmosphere, impact on flora, impact on fauna and impact on microbial biota. It is claimed that 'Chernobyl irradiation' has caused structural anomalies and tumour-like changes in many plant species. Unique pathologic complexes are also reported such as anomalous pollen grains and spores. Genetic disorders, sometimes continuing for many years, and 'awakened'

genes that have long been silent over evolutionary time are reported. Long-term observations of both wild and experimental animal populations in the heavily contaminated areas show significant increases in morbidity and mortality that are considered to resemble the changes in the health of humans in these areas.

Chapter IV deals with radiation protection after the accident and is made up of four sections dealing with contamination of food and people, reduction of levels of internal emitters (decorporation), protective measures and consequences for public health and the environment. The most useful discussions appear to be those describing decorporation experience such as the use of meat additives (ferrocyanides, zeolites and mineral salts) and claimed dramatic reductions of incorporated ^{137}Cs in children with the use of pectin-based food and drinks (using apples, currants, grapes, seaweed, etc.). It is not surprising that this chapter calls for extensive international help, especially in Belarus, in view of the evaluations it has made regarding the increased levels of health effects and environmental impact from ongoing radioactive contamination.

The subject is not yet closed. Later in 2010 UNSCEAR are due to publish an update of the health effects of Chernobyl. It will be interesting to see to what extent it can take on board any of the recent new data such as that referred to in this book.

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