EVALUATION OF COUNTERMEASURES TO BE TAKEN TO ASSURE SAFE LIVING CONDITIONS TO THE POPULATION AFFECTED BY THE CHERNOBYL ACCIDENT IN THE USSR

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This paper presents a first estimation, performed in 1990, of the cost and averted collective exposure of the potential relocation of the population from the affected territories of Russia, Byelorussia and Ukraine, to improve their living conditions following the Chernobyl accident. A general and simplified modelling approach was adopted in the evaluation. Results suggest that from a strict radiological protection viewpoint, it would have been very difficult to justify any allocation of resources to relocate the population living in areas with less than 40 Ci/km^2. The study has also indicated the need for further investigations on various points.

1. INTRODUCTION

Following the Chernobyl accident a variety of measures were taken to protect those affected from exposure to radiation. Once the immediate effects of the accident were dealt with, attention turned to longer term considerations, in particular how to ensure "safe" living conditions for those living beyond the evacuated zone. In 1989, criteria were proposed to restore "normal" living conditions. In those settlements where the criterion was exceeded people would be relocated; in the remaining settlements normal living conditions, with no restrictions on food nor people's habits, would resume. Considerable debate and argument arose over the appropriateness of this criterion. In an attempt to resolve some of these disagreements, the Soviet Government requested the International Atomic Energy Agency (IAEA) to organise an international group of experts to review and evaluate the measures being taken to assure "safe" living conditions for those people continuing to live in the affected areas. This paper presents a first estimate of the effectiveness of the measures adopted within the so-called "State All-Union and Republican Programme for Urgent Measures for Eliminating the Consequences of the Chernobyl Accident for 1990-1992" by the Soviet Supreme of the USSR in April 1990 [1]. This study has been performed under contract for the Commission of the European Communities within the framework of the IAEA International Chernobyl Project [2].

2. METHODOLOGY AND DATA

Based on dosimetric and economic data collected in USSR during summer 1990, a general and simplified modelling approach was adopted in the evaluation. The basic input to the model is the distribution of the population living in the affected areas as a function of the level of ground contamination expressed in Ci/km^2 of Cs-137 [3]. The corresponding total population was about 705,600 people for the three Republics (Russia, Ukraine, and Byelorussia), and was considered to be representative of those living in these areas at the beginning of 1990, for levels above 5 Ci/km^2.

The doses corresponding to a given contamination level have been derived from a generic dosimetric model developed at the Institute of Biophysics in Moscow. The model is based on simple expressions, which are used to derive the external and internal doses in a given year, as a function of the surface Cs-137 contamination, when no restrictions exist. The average relationships between the dose and contamination level are presented in Table 1.

Table 1: Average relationships between surface contamination, individual annual dose (for 1990) and individual lifetime dose (1990-2060)[a]

Surface contamination Cs-137 (Ci/km^2)	Annual effective dose equivalent in 1990 (mSv)	Lifetime effective dose equivalent (1990-2060) (mSv)
5	≈ 2	≈ 40
15	≈ 5	≈ 90
40	≈ 13	≈ 210
80	≈ 25	≈ 410

a) Doses were estimated in the absence of any protective measures

In the absence of any protective measures, the total collective dose for the 1990-2060 period, for people living in the zones with more than 5 Ci/km^2 (500,000 people between 5 to 15 Ci/km^2, 200,000 between 15 to 40 Ci/km^2, 15,000 between 40 to 80 Ci/km^2, 1,000 above 80 Ci/km^2), was estimated to be about: 54,000 man-Sv.

3. COST AND EFFECTIVENESS OF COUNTERMEASURES

In the absence of adequate data, the model only considered protective measures in two broad categories: relocation of the population, and improvement of living conditions. Of the many measures taken to improve living conditions, only a few have a significant effect on the doses received; the provision of clean food is perhaps the most important in this respect. Relocation was assumed to be totally effective, and the dose was considered to be zero as soon as the population has left the contaminated area. Two further aspects have been considered. First, for social and economic reasons, the relocation of a given settlement or a set of settlements, may necessitate the additional relocation of neighbouring settlements where these are economically dependent on those relocated. Secondly, there may be many people in each Republic who wish to be relocated, even when the level of contamination is below the criterion.

As far as costs are concerned, all costs used in the model were taken from the "State All-Union and Republican Programme" [1]. Two categories of costs have been distinguished: "one off" costs, and annual costs. Based on a detailed analysis of the resources allocation in the three Republics, the cost "per capita" of relocation and improvement of living conditions were estimated.

4. PROTECTION STRATEGIES

The current State All-Union and Republican Programme was based on the following criteria for the countermeasures:

- improvement of living conditions for the population living in

areas where the ground contamination was above 5 Ci/km^2;

- relocation for the population living in areas where the ground contamination was above 40 Ci/km^2.

These two basic protective measures have been combined into strategies fiting with the generic conceptual framework presented in Figure 1. The value of 5 Ci/km^2 has been adopted in the model for level A. Expressed in terms of annual dose in 1990 or lifetime dose, this contamination level was corresponding to:

. an average annual effective dose equivalent in 1990 = 2.2 mSv/y

. an average lifetime effective dose equivalent (1990-2060) = 37 mSv

assuming no protective measures were taken. Altogether, 11 strategies have been evaluated with the model in which different values have been assumed for level B, the level above which it was assumed that relocation was implemented.

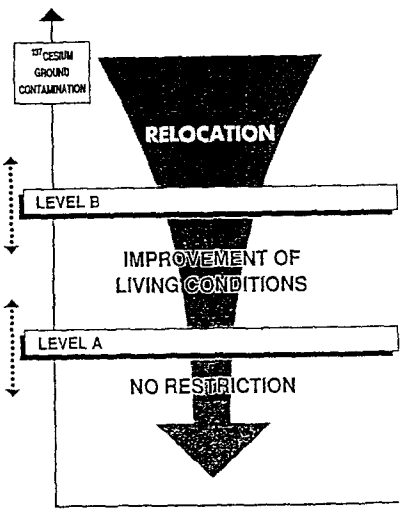

Figure 1: Basic scheme for the definition of "protective strategies"

5. COST-BENEFIT ANALYSIS

Strictly speaking, the evaluation of the various strategies was based on a differential cost-benefit analysis, here called cost-benefit analysis for simplification. To make judgements on the marginal costs per unit dose averted by the various strategies, it was necessary to introduce a reference value for the cost of the man-Sievert. The approach adopted in this study was to combine the use of a baseline monetary value of the man-sievert calculated according to the humam capital method with a risk aversion factor, increasing with the level of contamination, to reflect the general attitude of the population living in the contaminated areas. The final conclusion concerning the level above which relocation was justified, was clearly conditional upon the attitude towards aversion. Based on the most conservative assumptions only population above 40 Ci/km^2 should have been relocated. Figure 2 presents the range of level of ground contamination (40 to 80 Ci/km^2) for which the marginal cost of countermeasures and the marginal cost of the detriment are of the same order taking into account the sensitivity of the key parameters.

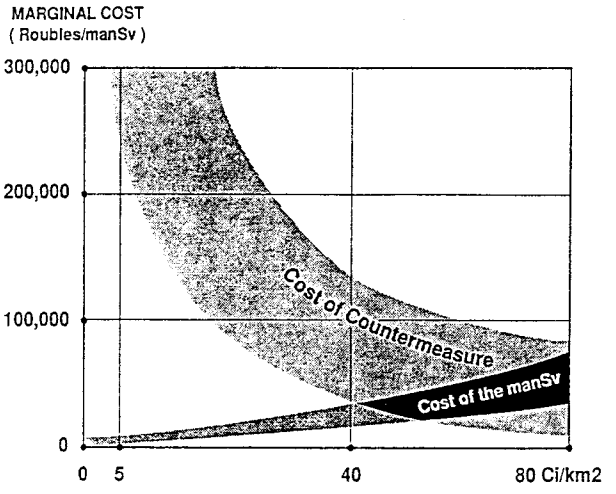

Figure 2: Cost-benefit analysis

6. CONCLUSION

This analysis was an attempt to provide a coherent framework for all the available data in 1990 concerning the cost and doses averted associated with various relocation strategies. Ideally the analysis should have been undertaken on a settlement by settlement basis, where proper account could have been taken of local variations in dosimetric and economic data. However, because of data limitations this was not possible. Using a baseline value of the man-Sievert, estimated on the basis of human capital considerations, the evaluation led to the conclusion that it was not justified to relocate anyone from the controlled zones. With some allowance for risk aversion, the results suggested that there were no strong arguments for the implementation of further measures other than those already envisaged, unless relocation costs would differ largely from the base case. Nevertheless, some other factors of a social or political nature could justify a more restrictive approach [4].

ACKNOWLEDGMENTS

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