1 INTRODUCTION

Studies on the quantification of health hazards to man due to exposure by small doses of ionizing radiation delivered at low dose rates belong to the most difficult problems in radiation research. Sometimes this field is even associated with "parascience" because of the difficulties encountered in searching for any significant effect in this region. Whereas the lectures 5 and 7 by Silini put more emphasis on a description of the types of biological radiation effects and on the risk estimates actually used in practical radiological protection work, this lecture will put more weight on an outline of the spectrum of problems and approaches used in work on the derivation of quantitative prognoses of late effects in man of low doses and dose rates. Because of the wide scope of such risk analytic investigations, in one lecture it will only be possible to give you some impression of the complexity of this topic and of concepts to cope with it, rather than a thorough discussion of our present knowledge. At this point, however, I would like to stress that most of these problems are of basic scientific nature, and that it is much easier to make sound recommendations for practical applications in radiological protection with the duty not to under-estimate possible effects for an average person.

Here, we will deal with
- the origins of some principal problems encountered in radiation risks assessments,
- some definitions and explanations of useful quantities,
- methods of deriving risk factors from biological data,
- methods of deriving risk factors from epidemiological data,
- concepts of risk evaluation and problems of acceptance.

2 SOME PRINCIPAL PROBLEMS ENCOUNTERED IN RADIATION RISK ASSESSMENT

There are several facts which cause severe problems in any investigation on the assessment of health hazards due to ionizing radiations. Among these facts we should mention as first order and insoluble problems:
- small doses of ionizing radiation can only lead to such types of health defects which occur also naturally,
- these types of health defects in addition occur naturally in human populations rather frequently compared to expected additional radiation induced frequencies,
- small doses (say below 10 rem), fortunately, lead with such small a probability only to serious health effects, that these radiation induced frequencies are small compared even to the natural variation of normal cases,
- we do not have methods at hand to discriminate a naturally occurring case, e.g. of leukemia or cancer, against a radiogenic one.

The second order problems are due to the pluridisciplinary nature of the field. To be able to deal properly with the task of analytic and prognostic radiation risk assessment, you have to try to be up-to-date in quite a number of scientific fields, namely e.g.
- radiation physics
- radiation chemistry
- radiation instruments and technologies
- biology
- medicine
- statistics and epidemiology,
- radioecology, systems analysis and operations research,
- agriculture, soil science, and forestry,
- dietics and food distribution pathways,
- aeronomy, hydrology and marine sciences.

With some simplification, one might say that knowledge in the first fields is needed to assess the probability of health effects from a given radiation exposure, whereas knowledge in the second group must be used to estimate in a prognostic way details of the radiation exposure of individuals and/or the whole population from information on the releases of radionuclides from technical facilities.