Multi-author Review

Microorganisms in nuclear waste disposal Part I

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Microorganisms in nuclear waste disposal. Introduction

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For a long time, deposition of radioactive waste as a means of preventing the reentry of harmful nuclides into the biosphere was considered only from the viewpoints of physics, chemistry, geology and hydrology. The role of living organisms was ignored. Investigations concerned with soil and groundwater pollution initiated research concerning the microbial flora and its activities in the rocks and soil of the subsurface, and it was found that microbes are widely present in the deep layers of the crust of the earth [1].

Materials such as bitumen or concrete, selected to be used as backfill or solidifying substrates in waste repositories, were thought to be resistant to microbial attack. Although there are structures of analogous materials from earlier times proving the supposed high stability of these materials, more recent investigations have provided clear evidence that degradation and deterioration of bitumen and concrete does occur. This gives rise to the question of whether microorganisms might have important effects on the necessary long-term stability of the nuclear waste repositories and whether any microbial activity might facilitate the release of nuclides into the groundwater and then into living organisms and the food chain of man.

Microbes are ubiquitous, and the following properties might enable microorganisms to play an important role not only in the biosphere, but also in the atmosphere, the hydrosphere and the lithosphere:

1) their small size allows for easy dispersal by water, air and other organisms;
2) they propagate rapidly under conditions which allow a short generation time;
3) they show a great metabolic versatility, which is a great flexibility in the regulation, coordination, induction and repression of metabolic pathways;
4) this allows them to colonize new habitats rapidly;
5) they are able to tolerate extreme environmental conditions;
6) they show a broad phenotypic variability as a response to the environment, through regulation of the genetic mechanisms;
7) they are able to associate with other organisms in synergistic symbiosis, which further enlarges the metabolic versatility of the single species and acts positively on properties 2 to 6 above.

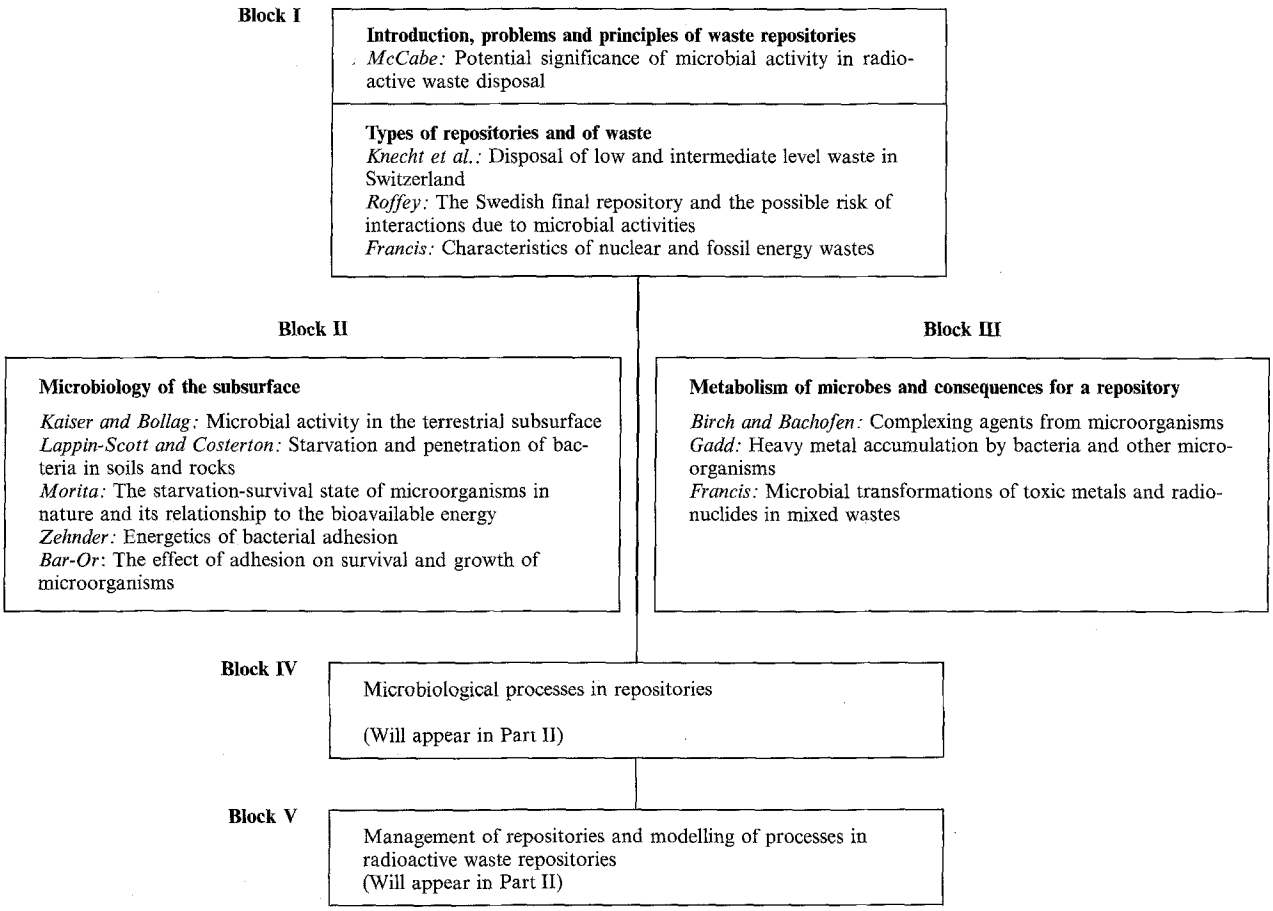
Most of the literature reviews on subjects concerning microorganisms in nuclear waste disposal, as well as the results of experimental studies, have been published as reports of the various national or international agencies dealing with the disposal of radioactive waste, and as such are not easily accessible. A group of microbiologists working on problems of the role of microorganisms in nuclear waste disposal in various European countries initiated the present Multi-author Review with the goal of information exchange between these groups of scientists and the public. It is a first attempt to summarize the basic information on the problems of microorganisms in nuclear waste disposal for a greater readership. In scientific journals, references are usually made only to publications which are readily available through libraries and bookshops. This was not possible for the present Multi-author Review, since as mentioned above most of the material is collected in more-or-less internal reports, mostly of governmental agencies, and thus can only be found in large libraries, possibly only those of the country in question.

The Multi-author Review has the following structure (fig.):

Block I contains a general introduction on the possible effects of microorganisms in nuclear waste disposal, a summary of basic information on how a repository is planned and constructed, and on the type and composition of waste deposited.

In block II some important *basic* topics of microbial ecology relevant to repository conditions are presented; subsoil microbiology, adhesion to surfaces, starvation and survival in oligotrophic environments, and bioenergetics.

Block III reviews some examples of general metabolic behaviour relevant to microorganisms in nuclear waste disposal such as tolerance to heavy metals, transformation of elements or gas formation.



Structure of the Multi-author Review.

In block IV experimental data are presented which have been obtained in applied research directed to specific questions emerging from safety assessments, such as examination of microbial populations in future repository sites, degradation of bitumen or sorption of nuclides.

In the final block V, an attempt is made via modelling and computer simulation to foresee the behaviour of a complex system 'repository' in the future, on the basis of our present knowledge.

As the reader will soon recognize, in spite of the enormous efforts made and the amount of work in progress there are a lot of open questions. One main problem concerns the extrapolation of laboratory experiments, and of monitoring over some years, to the time scale of some thousand years necessary in nuclear waste disposal. The various papers presented here should stimulate further research in the basic sciences as well as in the applied ones. The information collected here covers certain aspects of the problem of nuclear waste disposal and should be helpful to agencies concerned with such questions, and also to politicians. It may help to distribute scientific information more widely, and thus diminish biased speculation and emotional discussion.

1 Geomicrobiology J. 7 (1989) 1–130.

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