(c) Present gaps in knowledge on the radiation resistance of bacteria, viruses and parasites in their natural environment should be filled, especially with regard to dose rate effects. The character of radiation resistance in naturally occurring highly resistant microbes should be investigated.

(d) Experimental protocol for chemists and microbiologists working in radiation treatmen of sludge and waste water should be developed.

(e) Synergistic effects of radiation with chemicals (chlorine, ozone, air, etc.) and physical properties (heat, vibration, etc.) should be pursued.

(f) Exchange of information and experiences should be facilitated between pilot plants presently in operation or to be commissioned in the near future.

(g) Public health problems involved in the use of sludge (and solid waste) as fertilizer, soil conditioner or fodder should be evaluated by joint co-operative efforts of FAO, WHO and IAEA.

INTERNATIONAL SYMPOSIUM, STOCKHOLM, 2–5 JUNE

The meeting on "Combined Effects on the Environment of Radioactive, Chemical and Thermal Releases from the Nuclear Industry" was attended by 133 participants from 24 countries and representatives from 9 international organizations.

Environmental Effects from the Nuclear Industry

For many years extensive studies have been carried out on the effects on the environment of releases of radioactivity from the nuclear industry, particularly in regard to the impact on man. More recently, with the forecast rapid development of nuclear power, the environmental impacts of thermal releases from nuclear power stations and of chemical releases from the nuclear industry have also been examined individually. However, the possibility of synergistic and combination effects from interactions of these releases and their significance to man and his environment have received relatively little attention.

During the past few years a number of countries have taken a more active interest in studies of combined effects, not only in regard to releases to aquatic environments, particularly rivers and lakes, but also in respect to releases to the atmosphere. In order to provide a forum for exchange of information in this field, the IAEA in co-operation with the Nuclear Energy Agency of O.E.C.D. organized a symposium, held in Stockholm from 2–5 June, on the combined effects on the environment of radioactive, chemical and thermal releases from the nuclear industry.

Among the topics discussed at the symposium were:

- *Effects of temperature on radionuclide uptake by aquatic species;*
- *Synergistic and combination effects in aquatic systems;*
- *Effects of chemical releases on radionuclide uptake;*
- *Synergistic and combination effects from releases to the atmosphere.*

An introductory paper reviewed interaction mechanisms particularly in respect to radiation effects on biological systems, both with regard to substances that act as radioprotectors and those that act as radiosensitizers. Studies were described that related to the effects of temperature on the development of radiation damage to organisms, and also the sensitizing effects of certain chemicals. The author concluded from these studies that the dose modifying factors of these substances and of thermal effects are 2 or 3 under maximal conditions and that in almost all cases repair and recovery processes for radiation damage are impaired by the radiosensitizers and by temperature increase.

The effects of temperature on radionuclide uptake by aquatic species were described in a number of papers. One author discussed the effects of heated effluents on the bioaccumulation of radionuclides, taking into account the effect of temperature on feeding rates. The impact of thermal discharges on the uptake of cesium, cobalt, iodine and zinc radionuclides were studied by exposing bivalve populations in a one-kilometre-long discharge canal. Another paper described the effect of temperature on the uptake of cobalt-60 and zinc-65 directly from seawater by the common shrimp. Here it was shown that an increase in temperature will result in a higher rate of uptake of the radionuclides, and in a shorter biological half-life.

Another author discussed the combined effects of heat and chemicals in certain ecosystems, and considered this aspect in relation to power-plant siting. Three studies were exemplified in the paper in which the local physical and ecological aspects together with the interactions of thermal releases and the local ecosystem were described. Each example illustrated cases where cooling water discharges into areas of polluted water lead to adverse effects.

In respect to combination effects from releases to the atmosphere one author described synergistic effects of atmospheric releases of radioactive gases and sulphur dioxide which induced nucleation in the atmosphere. Extensive experiments had been carried out to study the effect of ionizing radiation dose on particle formation in an atmosphere containing low concentrations of sulphur dioxide. The mechanism of nucleus formation was described, and also the possible atmospheric effects of an increase in aerosol background. Interaction between the reactor stack plume and the cooling tower plume, and the aerodynamic effects of the cooling towers on the dispersion of reactor stack effluents were also discussed. A third paper dealt with cost effectiveness of release prevention controls for tritium and krypton-85. The author presented evidence indicating that projected levels of krypton-85 may pose a more serious health problem than those of tritium, while significantly more past effort had been devoted to tritium studies. It was suggested that application of cost-benefit analysis might result in a more efficient allocation of priorities.

The final session of the symposium was devoted to a panel discussion which was very well attended, and for which more than twenty written questions had been submitted by participants during the meeting. The topic for the panel discussion was the significance of synergistic and combination effects to the future development of nuclear power programmes and the need for further studies in this field. In general, it became apparent that studies on synergistic and combination effects that had been undertaken up to now indicated that this aspect of the environmental consequences of nuclear power programmes would not provide any serious detriment to the environment. However, it was also clear that continued research into synergistic and combination effects was necessary in order to provide further evidence in this field.