**I.N. Beckman**

# NUCLEAR WASTE AND ENERGY

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*Problem 1:* **NUCLEAR ENERGY**

**1.1 Safety of tradition nuclear installations**

- WWER-440/230; 440/213B; 1000
- RBMK

**1.2 New types of power reactors:**

- liquid metal fast reactor
- high temperature fast reactor
- thorium fuel reactor
-.fast breeder reactor for actinide transmutation, BR-10 its.
- gas-cooled reactor
- ship (ice-breaker, submarine) reactors: KLT-40, KN-3,
- Shelf-3, UNITERM ,ets.

**1.3 Development of new nuclear power**

- undeground and submarine nuclear electric station
- nuclear power - chemical-technology complex
- Nuclear electric-thermal power-dessalination plant

*Problem 2***:** **SEPARATION ON MIXED WASTERS**

**2.1 Use of polymeric membranes for cleaning gas rejects of atomic plants**

**2.2 Integrated systems of chemical technology for separation of radionuclides**

- Swing-adsorption techniques + membrane technology
- Absorption + membrane technology (Membrane absorber, selective membrane valve)
- Membrane extractor (permstractor)
- Membrane catalysis
- Membrane chemical and biochemical reactors
- Membrane separation of the gas mixtures under unsteady-state condition

The membrane gas-separation technique became important with the development of synthetic polymeric nonporous membranes, and for many years investigations have been made to develop convenient and reliable methods for separating radioactive gas mixtures by means of membranes. The entire history of membrane technology is a struggle for separation systems with high productivity, permselectivity, flexibility, and stability separation systems. Several approaches are possible; selection of materials with heterogeneous spatial structure; empoloyment of unsteady-state gas separation processes; use of mobile membranes; application of flowing liquid membranes.

One of the ways for increasing the selectivity of passive gas separation can be the generation of unsteady-state boundary conditions at the membrane inlet. Other approaches include the use of immobilized liquid membranes using carriers which can selectively bind certain permeant species. The combination of membrane separation with affinity interactions is classed as one of the so-called *Integrated Membrane Systems* (IMS). IMS is a collective term for various process configurations in which the high selectivity of affinity interactions and the high throughput of membrane separations are integrated into a hybrid separation technology. Recently, flowing liquid-membranes, in which a liquid-membrane solution flows along a non-porous membrane, have been proposed. This approach led to the creation of the term: *membrane permabsorber and selective membrane valve.* Application of moving membranes allows one to accomplish spatial separation of gas-mixture components. The following versions are possible in selecting the liquid;

- The flowing liquid can be nonspecific with respect to the separated gas mixture.

- The solubility constants of the gas-mixture components in the absorption medium differ considerably.
- The liquid is capable of chemical interaction with one or several components of the gas mixtures.

In the course of separation, the gases pass through the membrane, dissolve in the liquid absorbent, and are carried along into desorber. In the membrane module with flowing membrane, the productivity and selectivity obviously will depend on the transport parameters of the gases in the absorption liquid, on the time it takes for the liquid to pass from the diffusion cell to the desorber, as well as on the time of passage through the desorber.

The *membrane permabsorber* consists of two cells (absorption cell and desorption cell) and the liquid specifically selected as an agent for extraction that circulates between them. The gas mixture passes over the polymeric membrane in the absorption cell. The most permeable component of the gas mixture diffuses selectively through the nonporous polymeric membrane into the flowing liquid under it, is absorbed by this liquid, and transferred to the desorption cell. Degassing of the liquid occurs in the desorption membrane cell through the nonporous polymeric membrane, leading to highly concentrated gaseous products. There are two operating conditions of the membrane device: a flowing device, where the liquid is discharged out of the gas-separation device, and a circulated in the system.

A membrane valve consists of two modules: a permeator and desorber. The permeator is devided by two polymeric gas-separation membranes, between which a thin layer or the absorbent liquid is moving. The gas mixture and gas-carrier are passing under the surface of sandwich. The components of the gas mixture are dissolved in the liquid absorbent and are driven out of the permeator to the desorber. The selective membrane valve has one inlet for the initial gas mixture and three outlets for the product leaving the separation device. The SMV can be used to separate a three-component gas mixture: the component of the gas mixture passes through the composite membrane, and the third component, dissolving well in the absorbent, is entailed by the liquid into the desorder. There are four operating conditions of the SMV: a flowing mode without a desorber, a flowing mode with desorber, a circulator mode without a desorber, and a circulator mode with a desorber.

Mobile liquid membranes can be used to separate gas mixtures which are difficalt to separate by conventional methods even if the permeabilities of gases are practically the same.

**2.3 Active filter with planare adsorbent (Regular structures apparatus)**
- acids treatment basaltic fibres
- felt fibrous active coal

**2.4 Proton conductivity ceramic for tritium extraction, absorption and storage**
- Recovery and purification of tritium for thermonuclear energy installations

**2.5 Fibrous basaltic adsorbent for extraction and storage of heavy metals.**

*Problem 3:* **TRANSPORT MECHANISM OF RADIOISOTOPES THROUGH THE ECOCPHERE**

**3.1 Enviromental monitoring and nuclear safety**
-Mass-transfer of radionuclides and toxic pollutans in environment
- Marine radioactivity monitoring (Region of Black and Mediterranean seas)
- State and migration of radioactive rare gases in environment

**3.2 Plutonium in Environment and risks analisis of $\alpha$-emmited radioisotopes**

**3.3 Radionuclides and authowalve processes in ecosistems**

**3.4 Mathematics of transfer processes in environment**

**3.5 Diffusion diagnostics of structure and dinamics of atmosphere**

The investigation of radionuclides in rivers, seas and oceans has a long history. The quantitative and qualitative analyses of natural and artificial technologic radionuclides in sea regions, bottom deposits and in the lower marine atmosphere has been carried out for different regions. Radionuclide analysis of river and sea waters and air was carried out by our experiments in 1982-95 in the Black and Azov seas region. It was discovered that ecology situation in Black and Azov seas has become worse: the artificial radionuclides accumulate in rivers, sea currents and bottom deposits; air and beach pollution's are increased. This especially concerns the following river mouth regions: the Danube, the Dniester, the Dnieper, the Don and the Riony. The quantitative and qualitative changes of radioactivity pollution's of water and air can be caused by natural reasons: changes of sea waters salinity, hydrogen sulphide level raising, increase of submerged volcanic activity, etc. However, during recent years radioactivity increases of sea waters were caused by placement of Nuclear power plants in these regions. Chernobyl accident caused the considerable radioactivity increase of sea waters and air. In particular in sea-air appear the "hot" particles - stable and fast moving ones containing $\alpha$-emitting radionuclides. The Chernobyl fal-out is characterized by an unexpected feature. The nuclear fuel fractured into powder and escaped from the power plant in particles of different sizes. The largest lumps fell onto the power plant site and its surroundings. Smaller particles were carried by air over long distances. These "hot" particles could readily be found in the environment. An epidemiological follows-up study has been started to establish the potential health hazard caused by these particles.

Initially the impact of the Chernobyl accident was generally regarded to be of the most radiobiological importance for terrestrial environment. Counting discharges of artificial radionuclides in the marine environment are leading to a complex and changing overall source term and hence to increasing difficulties in verifying the respective contributions to the ultimate dose to man now and in the future.

In 1982 Moscow State University initiated expeditions to find out sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity guided by scientists of the Radiochemistry division, Chemical Department MSU. The programme is concerned with the increases number of source terms of artificial radioactivity in the oceans, their distribution and the contributions of these radionuclides to the overall hazard poses to man compared to radionuclides that occur naturally in the marine environment. The programme of work includes examination of the levels and path ways of key artificial and naturally occurring radionuclides on sea water, sediment and marine biota. In the Black sea region the major sources of these radionuclides are being identified and their contributions and future dangers in these contributions to human dose are being evaluated. Date on marine radionuclides required for the assessment of the dose to a man on a regional or global basis therefore are being obtained. There is much left to be done, however, in the Black and Azov regions to complete the picture. Increased experience must be achieved to permit more countries to decide what domestic actions are required in this area.

The investigation of radionuclides in sea water and air appears to be important for solving the following scientific and applied problems:

- Localization of the radioactivity sources in the marine environment and their relative contributions to overall dose assessment from marine radioactivity;
- Validation of models for radionuclides transfer in terrestrial, urban and equation environments and evaluation of radionuclide migration processes;
- Isotope variants of Krypton, Radon and other trace gases in the atmosphere;
- Radiological impact of the Chernobyl accident on countries neighbouring Russia;
- Discovering and investigation of 'hot' particles;
- Examination of the long-lived radionuclides behaviour from sea dumping activities and the behaviour of transuranics and other elements which are discharged from nuclear activities into the marine environment;
- Determination of existence form of radionuclides in sea environment;
- Estimation of contributions of Black and Azov seas radionuclides to the overall hazard poses to man compared to radionuclides that occur naturally in the marine environment.

The following methods and equipment was used:

- Direct radiometric methods;
- Rapid instrumental and separation methods for monitoring radionuclides in sea water and sediment samples;
- Membrane impactor for "hot" particles concentration and sampling;
- Precise analysis of waters, suspended matters and bottom sediments samples from different parts of Black and Azov Seas carried out in the stationary MSU laboratory.

On the whole, we hope, that the planned investigation will promote the creation of new field of Earth science-radiation and radionuclides ecology of see regions.

In this paper the methods of nuclear physics using high-energy $\alpha$-particles ($^{4}He$) are applied to the characterisation of thin surface layers, catalysts based on oxides of Th, Y, Al, and Ti, and polymers (polyethylene, polypropylene, poly-4-methylpentene-1). Heavy rare gas ($^{222}Rn$) is used as a radioacive diffusion gas probe.

A model describing gas transport and sorption of hazardous compounds was developed in order to characterise the planar sorbents. Two types of pores (macropores controlling the gas transport, and micropores controlling and micropores was determined experimentally by means of emanation thermal analysis (ETA) was used for the characterisation of morphology changes of the sorbents under “in-situ” conditions of their heat treatment in dry air in the temperature range 20-1300$^{o}$C.

The apparatus designated for the determination of selective transport parameters of radioactive gases in the polymer membranes with the use of the gas permeability method is described. Within the frame work of this study the gas permeability kinetics of radioactive gases, namely, tritium, radon, tritium water, $^{85}Kr$, $^{133}Xe$, $^{14}CH_4$, $^{14}C_6H_6$, etc., in polyethylene, polypropylene and polyviniltrimethylsilane (PVTMS) were measured. Diffusion coefficient, solubility constant and permeability coefficient of various gases in polymers as well as the productivity and permselectivity of membranes were calculated using the experimental results. The effect on these parameters of such factors as temperature, gas pressure, the gas mixture composition, membrane thickness, thermal, mechanical and radiation pre-history of the polymer has been studied. The prospects for the application of asymmetric membranes from PVTMS for the separation of heavy inert gases and for the removal of radioactive krypton, xenon and radon from their mixtures with air are demonstrated. The separation factor value for the gas pair Xe-Kr is 2.

Industrial glass producers are increasingly faced with the need to balance flass production and quality with environmental concerns. This paper summarizes the results of a study whose objective was exploration of several NOx reduction strategies proposed for use in industrial float flass furnaces. As a secondary investigation, the influence of …..operation was also explored. These strategies were compared by simulation numerically the turbulent reacting flow and heat transfer in the industrial environtment of furnace

From the results it can be concluded that waste glass can be used as a raw material for production of

We have been interesting in problems connected with action of glass industry on living environment for 10 years. There are two basic questions: what kinds of toxic compounds are emitted from glass factories; what are their risks for environmental pollution and heath. We try to give a concise answer for these questions in the first part of our lecture. From above mentioned parts of lecture we can make up “ecological picrure” of Czech glass industry. We cannot change toxicity of pollutanta but this “ecological picture” shows us the possibilities how to reduce quantity of pollutants.

## NUCLEAR WASTE RISK ASSESMENT AND MANAGEMENT

Lecture

The goal of any risk assessment is to estimate the likelihood of an adverse effect on humans, domestic animals, wildlife, or ecological systems from possible exposures to chemical or physical agents. The languages of mathematics and human speech must come together to facilitate discussion and decision-making if risk assessment and risk management are to achieve the success that society desires from them. The adoption of "sustainable development" as general environmental goal implies that economic development strategies should strive to simultaneously maximize both human welfare and environmental quality. An integrated risk assessment/risk management paradigm can facilitate achievement of this goal.

For radiation protection purposes the stochastic effects are expressed as a lifetime risk of early death by cancer or of a serious genetic effects. The safety of the disposal of nuclear waste should be judged in terms of the total health risk, defined as the product of the probability of occurrence, of the event by the probability of heath effect given the dose resulting from the event. For doses in the stochastic region, the risk associated with a release scenario is defined as product of three factors: 1. The occurrence probability of the scenario; 2. The effective dose equivalent due to the scenario; 3. The probability of a detrimental health effect per unit dose equivalent, which is equal to 0.0165 per Sv for stochastic effects. The primary consequence of this approach is that it is no longer sufficient to predict the most likely behavior of the repository; one has to consider the whole range of possible behaviors, given the uncertainties associated with their density of probability and quantify these uncertainties.

Taking into account the widespread use of nuclear energy for electricity generation and its potential for heat production, it is clear that sound, safe and efficient radioactive waste management is a necessary component of the nuclear industry. Most of the work in the sphere of nuclear power is devoted to construction of various new types of power reactor, safety and waste hanging. As in the field of nuclear waster, the activities in nuclear safety are geared both to information collection, analysis and exchange, expert assistance, advice and services in specific situations and work on establishing international norms. Activities included technical guidance to the countries of former Soviet Union on minimizing radioactive wastes from nuclear fuel cycle facilities; a development of quality assurance and control for radioactive waste packages and advanced technologies for processing radioactive wasters, and for siting, design, construction, operation, closure and post closure of radioactive waste disposal facilities.

## 1. RISK PARADIGM

**1.1 Risk assessment/management/communication fields**

-Human health and ecological risk *(Which is worse: cancer or development effects ?)*,
-Comparative risk (distinguishing between large risk and smaller risk)

**1.2 Steps in the integrated health/ecological risk assessment process:**

-Hazard identification
-Exposure assessment
-Exposure-response assessment
-Risk characterization

**1.3 Stages of the source-risk chain:**

SOURCE ⇒ DISPERSION ⇒ EXPOSURE ⇒ DOSE ⇒RISK

**1.4 Mathematical modeling (Monte Carlo simulation) for exposure routes, carcinogenicity date or noncarcinogenic effects**

-Absolute risk
-Relative risk)
-Submodels: a near field model; a far field model and a biosphere model

**1.5 Regional risk maps**

## 2. NUCLEAR ENERGY RISK ASSESSMENT

**2.1 Safety of tradition nuclear installations**

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**2.2 New types of power reactors**:

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**2.3 Development of new nuclear power**

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## 3. SEPARATION OF MIXED WASTES

**3.1 Use of polymeric membranes for cleaning gas rejects of atomic plants**

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-Acids treatment basaltic fibbers
-Felt fibrous active coal

**3.4 Proton conductivity ceramic for tritium extraction, absorption and storage:** Recovery and purification of tritium for thermonuclear energy installations

**3.5 Fibrous basaltic adsorbent for extraction and storage of heavy metals.**

## 4. SOLIDIFICATION OF NUCLEAR WASTE IN A STABLE SOLID MATRIX

**4.1 Waste form**: borosilicate and phosphate glasses, glass ceramics, a synthetic rock, supercalcine, concrete

**4.2 Radionuclides release from solid matrix** as influenced by various factors

**4.3 Radiometric emanation method** for characterization of the durability of solid matrix towards aggressive liquids

## 5. RISK ASSESSMENT OF HAZAROUS WASTE SITES

**5.1 Multibarrier concept**

-Waste form (glass, concrete or synthetic rock)
-Metallic canister
-Man-made barrier is a type of clay (“buffer”)
-Host rock and the geological environment

**5.2 Prescriptions a geologic repository.**

-Deep borehole disposal and a mine repository
-Criteria: a minimum canister life; a maximum radionuclide release rate from the engineered barriers; a maximum radionuclide arrival at the accessible environment; a minimum value of the groundwater travel time from the repository to the accessible environment; determined in natural conditions prior to the construction of the repository.

**5.3 A series of scenario**

-Present conditions possibly modified by the presence of the waste
-Most likely changes that will occur if the evolution of the system continues at the same rate as in the past
-Accident situation due to natural phenomena
-Accident situation due to human action

**5.4 Uranium- and thorium-series disequilibria in the safety assessment of radioactive waste disposal**

**5.5 Mechanisms of migrations radionuclides in geosphere**

-Advection with the flowing water, if any
-Diffusion, molecular or thermal
-Reaction/interaction with the fluid constituents or the medium
-In the near field and the far field

## 6. TRANSPORT MECHANISM OF RADIOISOTOPES THROUGH THE ECOSPHERE

**6.1 Safety analysis**

-Initial speciation of the radionuclides in the near field as well as their rate of production by the waste;
-Driving forces along the pathways;
-Driving forces along the pathway(s);
-Reactions occurring along the pathway(s)

**6.2 Screening of the important radionuclides for each site, each type of environment and for each evolution**

-Present conditions possibly modified by the presence of the waste
-Most likely changes that will occur if the evolution of the system continues at the same rate as in the past
-Accident situation due to natural phenomena

-Accident situation due to human action
-Calculation of biosphere conversion factor
**6.3 Radionuclides and autowave processes in ecosystems**
**6.4 Diffusion diagnostics of the structure and dynamics of the atmosphere.**

## NUCLEAR WASTE RISK ASSESSMENT AND MANAGEMENT

The growing demand for dependable electricity and the increasing concerns to reduce, or at least to limit the global level of fossil fuel combusion, points to the likelihood of an expanded use of nuclear power in the future. The continued and expanded reliance on nuclear power is a controvercial issue in most countries. Taking into account the widespread use of nuclear energy for electricity generation and its potential for heat production, it is clear that sound, safe and efficient radioactive waste management is a necessary component of the nuclear industry. Most of the work in the sphere of nuclear power is devoted to construction of various new types of power reactor, safety and waste hangling. As in the field of nuclear waster, the activities in nuclear safety are geared both to information collection, analysis and exchange, expert assistance, advice and servies in specific situations and work on establishing international norms. Activities included technical guidance to the countries of former Soviet Union on minimizing radioactive wastes from nuclear fuel cycle facilities; a development of quality assurance and control for radioactive waste packages and advanced technologies for processing radioactive wasters, and for siting, design, construction, operation, closure and post closure of radioactive waste disposal facilities. A new policy, regulation and planning for decomissioning large unclear faccilities was proposed. In addition, methods of the rehabilitation, decommisioning and disposal alternativies for nuclear reactor cleanup after a serious accident was created.

The bacik objective of radioactive waste menagement is the protecton of man and his environment. Those principles of how to active the permanent protection of the population as well as requirement for the radiological and environmental safety of the disposal of radioactive waste are the significant problem at present. Taking into account the widerspread use of nuclear energy for electricity generation and its potential for heat production, it is clear that sound, safe and efficient radioactive waste management at the and of the fuel cycle is a necessary component of the nuclear industry. Waste management is also an essential element in other industries stemming from the various applications of radioisotopes in medicine, industry and food and agriculture.

Today, after decades of research, development and idustrial applications, in can be stated confidently that safe technological solution for radioactive waste management exist. However, waste disposal as a part of the whole waste management system is no longer a matter for scientists and technocrats alone, but requires co-operation between them and politicans, licensing authorities, industry and, ultimately, the general public. The global is unique: the protection of human health and the global environment against possible short term and (very) long term effects of radioactive materials. Dialogue and co-operation among various parts of society may also give indications about the acceptability of solutions.

In the laboratory Ecoradiochemistry (MSU) and Membrane Research Centre of Institute of Petrochemical Synthesis RAS we are working in next fields: radiochemical aspects of the development of nuclear power, safety of nuclear installations, radioactive waste management, integrated systewms for separation of radionuclides, marine radioactivity monitoring, ets. Our efforts on the nuclear fuel cycle facilities while minimising their environmental and health impact. Radioactive waster management was soinsored through co-ordinated research programmes on the use of inorganic fibrous adsorbents and membrane extractors to cincentrate raionuclides in waste streams in to solid materials and on waste treatment and immobilisation technologies.

Most work in the sphere of nuclear power is devoted to construction of various new types of power reactors, safety and waste hangling. In the Moscow State University progress has been made in these research programs:

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3.2 Plutonium in environment and risks analysis of $\alpha$-emitted radioisotopes
3.3 Radionuclides and autowave processes in ecosystems
3.4 Mathematics of transfer processes in the environment
3.5 Diffusion diagnostics of the structure and dynamics of the atmosphere

Separation of mixed wasters

Transport mechanisms of radioisotopes through the ecosphere

Modeling radionuclide transport in marine environment

Risk analysis and biological effects and medium lived radioisotopes

Sources and effects of long lived radioisotopes

The rapid increase in the utilisation of risk assessment, since the presentation in 1983 of an analytical paradigm, has raised numerous and difficult scientific and policy issues. This paper describe insights as risk assesment has moved from relatively simple default approaches toward addressing the complexities of exposure scenarious and chemical toxicities. This move toward complexity and flexibility represents a natural progression for the field. Risk assessors often started by screening for those situations that might be of concern by using health-protective assumtions and simplifications. Realities are ineviably different than the simplified case, so additional information and methodologies to utilize it must be developed and implemented. Risk assesment must improve to assist in decision-making despite limitations of available information and human understanding. We adressed issue associated with mathematical modelling for exposure routes, carcinogenicity data, or noncarcinogenic effects. Risk assesment has thrived in this age of computerization. Early risk assessments used simplified assumption and approaches, in part, due to limitations of access to computational power. The paper show how risk assessment can gain from increasing modeling sophistication. But, mathematical methods can only move us a short way in the absence of ither concrete information or clear polici decisions. Mathematical modelling, Monte Carlo simulation, pharmacokinetics, mexanism of toxicity-these must be pathways to greater clarity and conciseness, not just complexity and tecnical sophistication. The public srena in which risk assesment exists is one of human concerns and desires for an improved life. It is this context that makes risk assesment such a challenging multidisciplinary field. The paper demonstrate that developing a flow from information-gathering to analysis to discussion to decision is still a challenge, even within the risk assesment/management/communication fields. The languages of mathematics and human speech must come together to facilitate discussion and decision-making if risk assessment and risk management are to achive the success that society desires from them.

In 1983, the National Academy of Science (USA) relased its risk assesment/risk management (RA/RM) “paradigm” that served to crystallize much of the early thinking about these concepts. By defining RA as a four-step process, operationally independent from RM, the paradigm has presented society with a scheme, or a conceptually common framework, for addressing many risky situation (e.g., carcinogens, noncarcinigens, and chemical mixtures). The procedure has facilitated decision-making in a wide variety of situations and has identified the most important reseadrch needs. The past decade, however, has revealed that additional progress is need. These areas include addressing the appropriate interaction (non isolation) berween RA and RM, improving the methods for assessing risks from mixtures, dealing with “adversity of effect”, deciding whether “hazard” should imply an exposure to environmental conditions or to laboratory conditions, and evolving the concept to include both health and ecological risk. Interest in and expectactations of risk assessment are increasing rapidly. The emerging concept of “comparative risk” (i.e.m distinguishing between large risks and smaller risks that may be qualitatively different) is at a level comparable to that held by the concept of “risk” just 10 years ago. Comparative risk stands in neen of a paradigm of its oen, expecially given the current economic limitations. “Times are tough; Brother, can you paradigm?

Figure 1 succinctly presents the risk assessment/risk management (RA/RM) paradigm set forth by the NAS in 1983. The four steps in the risk assessment process and the perhaps indelicately posed questions they adress are as follows.

1. Hazard Identification. Is this stuff toxic?
2. Dose-Responce Assessment. How toxic is it?
3. Exposure Assessment. Who is exposed to this stuff, how long, how often?
4. Risk Characterization. So what?

This risk information is one of several factors that the decision-maker must consider in answering the risk management question posed by an always intense, if not always admiring, public: So what are you going to do about it?

The paradigm has served to sort out the respective roles and responsibilities of risk assessorss and risk management. This has sheltered the risk assessor from some political pressures, while exposing risk managers to the need to make difficult decision and to communicate them in a comprehensible fashion to the public.

Which is worse: cancer or development effects? What are you going to do about these two risks?

A paradigm for eco-RA

In any event, there should be a single RA paradigm that is sufficiently broad to encompass both health and ecological concerns. Currently, there is the danger that eco-Raers and health-Raers will evolve in different-and possibly opposing-directions, to the detriment of both groups and the public.

The concept of relative risk analysis. These report demonstrated that it is possible-even with today’s limited data-to distinguish on a technical basis between high risk problems and lower risk problems.

Once again we stand in need of a defining paradigm that will structre our thought, our discourse, and our process.

During the last 10 years, the human health risk assessment paradigm has served to evaluate hazards poses by exposure to decelopmental and reproductive toxicants, mutagrns, carcinogents, and systemic toxicants. Most recently, the paradigm has been modified to evaluate potential impacts on fish, wildlife, endangered species, and selected flora due to chemicals or other stressors. **The goal of any risk assessment is to estimate the likehood of an adverse effect on humans, domestic animals, wildlife, or ecological systems from possible exposures to chemical or physical agents.**

*This papere discuss these scientific advances and presents a viewpoint on the way in which exposure assessments should be conducted from this point forth.*

Risk assessments of hazardous waste sites, of airborne emissions, of effluent discharges, or those conducted as a part of the process for permitting new facilities are often plagued by serious shortcomings in the exposure assessment phase of the analysis. There are a large number of factors to consider when estimating exposure, and the transport and distribution of a chemical that has been released into the invironment can be complex. Nonethelessm the avaiable data indicate that scientists cad do an adequate job of qualifying the concentration of chemicals in various media and the resulting uptake by exposed persons provided that they account for all of the important exposure factors.

Mathematical models for prediction of chemicals in the environment.

Ecological risk assessment defined as ‘characterization of the adverse ecological effects of environmental exposures to hazards imposed by human activies’. Adverse ecological affects include all biological and nonbiological environmental changes that society perceives as undersirable. Although ecological risk assessment and human health risk assesment differ substantially in terms of scientific disciplines and technical problems, the underlying decision process is same for both. A Committee on Risk Assessment Methodology (CRAM) defined an integrated health/ecological risk assessment framework consisting of the four component: Hazard Identification, Exposure Assessment, Exposure-Response Assessment, and Risk Characterization. The first three issues considered by CRAM were: (1) the use of the Maximum Tolerated Dose in animal bioassays. (2) the use of the two-stage model of carcinogenesis, and (3) the development of a conceptual framework for ecological risk assessment.

*The purpose of this paper is briefly describe the framework*

The past few years have seen a major increase in public interest in the environment. The adoption of “sustainable development” as general environmental goal implies that economic development strategies should strive to simultaneously maximize both human welfare and environmental quality. An integrated framework for risk assessment of the kind recommended by CRAM can facilitate achievement of this goal.

Ecological risk assessment was defined by CRAM as the characterization of the adverse ecological effects of environmental exposures to hazards imposed by human activities. Adverse ecolocical effects include all biological and nonbiological environmental changes that society perceives as undersirable. Hazards include both unintentional hazardd, such as pollution and soil erosion,and deliberate management activities, such as forestry and fishing, which are often hazardous either to the managed resoursce itself or to other components of the environment.

The method developed here provides a quantitative, objective measure of ecological risk for netural populations exposed to mixtures of chemical contaminants. It is founded on generally accepted risk assessment concepts: use of toxic units to assess the joint toxic effects of mixtures and expression of ecological risk as a relationship between toxicological end points and estimated environmental concentrations. Risk is the probability that a linear combination of toxic units exceeds 1, which expresses the probability that a measurent end point will occur. The method is applicable to many organism and toxicant mixtures.

Risk assessment was defined as "...the characterization of the potential adverse health effects of human exposures to environmental hazards".

For radiation protection purposes the stochastic effects are expressed as a lifetime risk of early death by cancer or of a serious genetic effects. To calculate the total risk of an exposed population it is necessary to use midels that extrapolate the information based on a limited period in the lives of individuals to the total lifetimes. In general, two different models are used: the absolute risk model and the relative risk model. In the relative model the age sensitivity has a large effect than in the absolute model. For a number of cancers it has been found that relative projection models describe the data better than absolute model.The effect per unit of dose is found to be high dose rates than at low dose rates (dueto more effective cell-repair mechanism), which means that a linear extrapolation from the high-dose levels to the low-dose levels overestimates the effect in the low-dose region.

Because radon migration tends to be dealt with more and more in the multidisciplinary context of pollution of the indoor environment, in this section we will outline how radon research in the future may fit into a fremework often used in investigations of substances that pollute the environmental. This framework is the source-risk chain, which consists of five stages:

source—dispersion—exposure—dose—risk

The main advantage at which a problrem may be controlled. (The item "risk" has been addressed in terms of the estimated mortality rate). The risk concepts used in the assessment of non-radioactive materials, however, are not always equivalent to the definition of "risk" used for radioactive substances. When comparing the risks of different pollutants of the indoor environment in a multidisciplinary effort, the premises for risk assessment are often discussed. It is worthwhile making an effort to bring the various approaches together. The question:"What can we do to decrease the risk due to radon?' may be answered by looking at all items and links in the source-risk chain.

## NUCLEAR WASTE RISK ASSESMENT AND MANAGEMENT

Taking into account the widespread use of nuclear energy for electricity generation and its potential for heat production, it is clear that sound, safe and efficient radioactive waste management is a necessary component of the nuclear industry. As in the field of nuclear waster, the activities in nuclear safety are geared both to information collection, analysis and exchange, expert assistance, advice and servies in specific situations and work on establishing international norms. Activities included technical guidance to the countries of former Soviet Union on minimizing radioactive wastes from nuclear fuel cycle facilities; a development of quality assurance and control for radioactive waste packages and advanced technologies for processing radioactive wasters, and for sitting, design, construction, operation, closure and post closure of radioactive waste disposal facilities. A new policy, regulation and planning for decomissioning large unclear facilities was proposed.

In the Moscow State University progress has been made in these research programs: radiochemical aspects of the development of nuclear power, safety of nuclear installations, radioactive waste management, integrated systems for separation of radionuclides, marine radioactivity monitoring, ets. Our efforts on the nuclear fuel cycle facilities while minimizing their environmental and health impact. Radioactive waster management was sponsored through co-ordinated research programmes on the use of inorganic fibrous adsorbents and membrane extractors to concentrate raionuclides in waste streams in to solid materials and on waste treatment and immobilization technologies.

This report describes the application of risk methodology to solve the problem of radioactive waste management. The most attention will be paid efforts that should be undertaken for the reduction of radiation sources. The work concentration mainly on the radon risk estimation and classification, requerements for limiting radiation exposure due to radionuclides from nuclear waste and the optimum radionuclide risk reduction processes.

The rapid increase in the utilisation of risk assessment, since the presentation in 1983 of an analytical paradigm, has raised numerous and difficult scientific and policy issues. This report describe insights as risk assessment has moved from relatively simple default approaches toward addressing the complexities of exposure scenarios and radiochemical toxicities. Risk assesment must improve to assist in decision-making despite limitations of available information and human understanding. Mathematical modelling, pharmacokinetics, mexanism of toxicity-these must be pathways to greater clarity and conciseness, not just complexity and technical sophistication. It is this context that makes risk assesment such a challenging multidisciplinary field. The report demonstrate that developing a flow from information-gathering to analysis to discussion to decision is still a challenge, even within the risk assessment/management/communication fields. The languages of mathematics and human speech must come together to facilitate discussion and decision-making if risk assessment and risk management are to achive the success that society desires from them.

In 1983 , the National Academy of Science (USA) released its risk assessment/risk management (RA/RM) “paradigm”. Risk assessment was defined as “...the characterization of the potential adverse health effects of human exposures to environmental hazards”. The item “risk” has been addressed in terms of the estimated mortality rate. The paradigm has presented society with a scheme, or a conceptually common framework, for addressing many risky situation. The human health risk assessment paradigm has served to evaluate hazards poses by exposure to developmental and reproductive toxicants, mutagens, carcinogents, and systemic toxicants. Most recently, this paradigm has been modified to evaluate potential impacts on fish, wildlife, endangered species, and selected flora due to chemicals or other stressors. The goal of any risk assessment is to estimate the like hood of an adverse effect on humans, domestic animals, wildlife, or ecological systems from possible exposures to chemical or physical agents. An integrated health/ecological risk assessment framework consist of the four component: Hazard Identification, Exposure Assessment, Exposure-Response Assessment, and Risk Characterization.

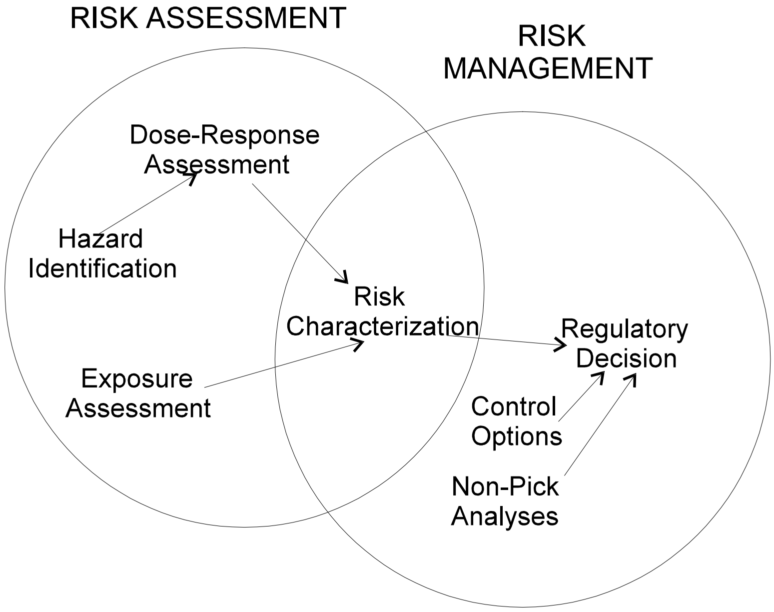
The method developed here provides a quantitative, objective measure of ecological risk for natural populations exposed to mixtures of chemical contaminants and radionuclides. It is founded on generally accepted risk assessment concepts: use of toxic units to assess the joint toxic effects of mixtures and expression of ecological risk as a relationship between toxicological end points and estimated environmental concentrations.

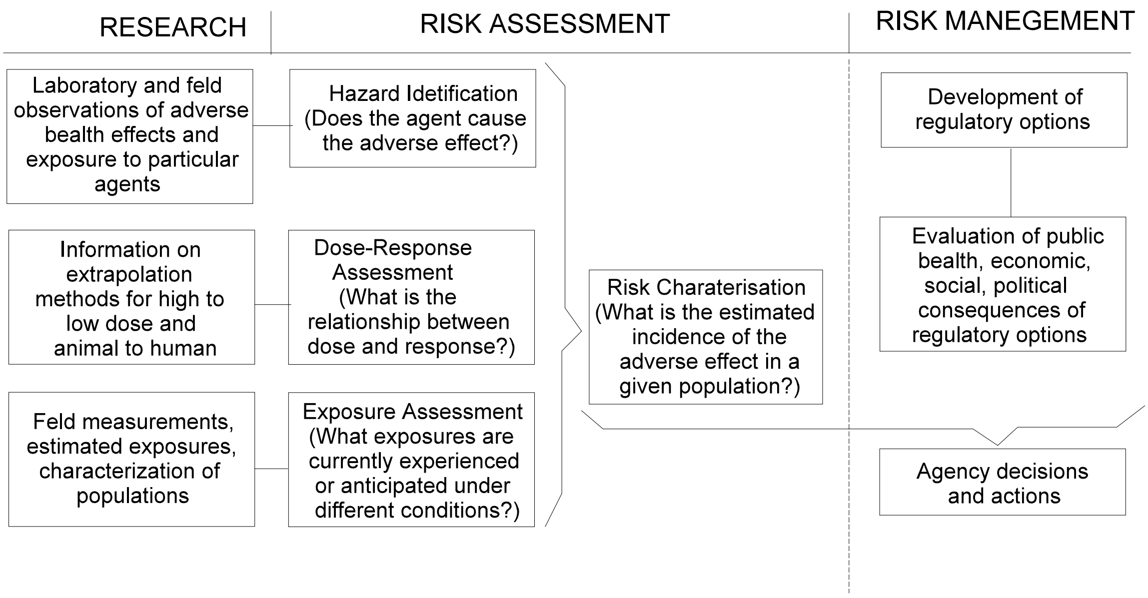
For radiation protection purposes the stochastic effects are expressed as a lifetime risk of early death by cancer or of a serious genetic effects. To calculate the total risk of an exposed population it is necessary to use models that extrapolate the information based on a limited period in the lives of individuals to the total lifetimes. In general, two different models are used: the absolute risk model and the relative risk model. In the relative model the age sensitivity has a large effect than in the absolute model. For a number of cancers it has been found that relative projection models describe the data better than absolute model.The effect per unit of dose is found to be high dose rates than at low dose rates, which means that a linear extrapolation from the high-dose levels to the low-dose levels overestimates the effect in the low-dose region.

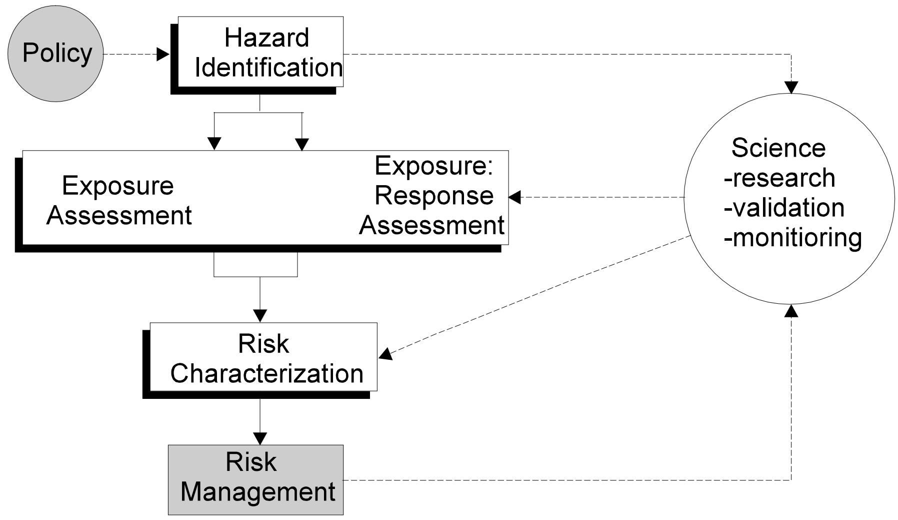
In this report we will outline how nuclear waste research in the future may fit into a framework often used in investigations of radioactive substances that pollute the environmental. This framework is the source-risk chain, which consists of five stages:

source—dispersion—exposure—dose—risk

Radionuclide migration in the geosphere is considered here in the framework of the disposal of nuclear waste in the ground. The safety of a repository should be judged in therms of the total health risk, defined as the product of the probability of occurrence of the event by the probability of tealth effect given the dose resulting from the event. Such a philosophy is perhaps acceptable for “minor” effects, not for “catastrophic” ones. The present regulatory prescriptions of a geologic repository are bases on four criteria: a minimum canister life; a maximum radionuclide release rate from the engineered barriers (also called the “near field”); a maximum radionuclide arrival at the accessible environment; a minimum value of the groundwater travel time from the repository to the accessible environment, determined in natural conditions prior to the construction of the repository. The migration of radionuclides in the geosphere is governed by three major mechanisms: advection with the flowing water, if any; diffusion, molecular or thermal; reaction/interaction with the fluid constituents or the medium. This report will review the relative role of each process both in the near field and the far field. A series of scenario will be defined, covering a broad spectrum of conditions: present conditions possibly modified by the presence of the waste; most likely changes that will occur if the evolution of the system continues at the same rate as in the past; accident situation due to natural phenomena; accidental situation due to human action. The potential and limitations of a decision theory framework to assess priorities in research, priorities in data collection, confidence in the validity of the performance assessment results will be discussed.




Policy
Hazard Identification
Exposure Assessment
Exposure: Response Assessment
Science
-research
-validation
-monitioring
Risk Characterization
Risk Management