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INTEGRATED MODEL DEVELOPMENTS FOR ASSESSING TOXIC ELEMENT TRANSPORT IN TERRESTRIAL, RIVER AND ESTUARINE ECOSYSTEMS

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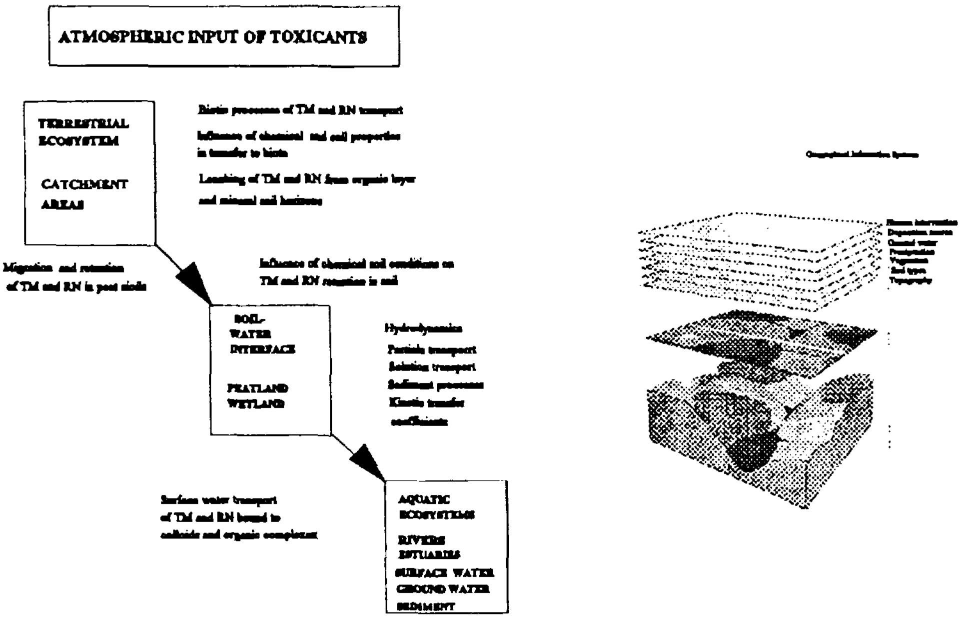
A systematic evaluation of the environmental distribution and fate of toxic metals and radionuclides in natural, semi-natural and estuarine ecosystems has been initiated. The goals are to develop, test and validate integrated models for use in establishing policies to limit excess dose to the exposed population. Multi-media modeling using GIS and the latest computer software can provide a technical foundation and lead to predictions in assessing global industrial effluents, their effects on the ecosystem and on man. Such predications must be validated by experimental measurements and error limits of the parameters assigned. The consequences resulting from remedial policy actions designed to limit dose in the event of another nuclear reactor accident, or from long-term exposure to an industrial chemical effluent, must be addressed by the models.

Radionuclides from nuclear weapons development and accidents at Kyshtym and Chernobyl are deposited on forests, agricultural lands, marshlands, rivers and lakes in regions utilized by the population for food, employment and recreation. In question is the length of time these areas will remain contaminated; thus, one requirement for a dynamic model is to predict the radiation or chemical dose in the future. Recent developments in the Geographic Information System (GIS) have provided a modeling framework where information can be collected and utilized. However, the application of GIS to ecological models is in its infancy. New mathematical tools of linked partial differential equations (PDE) and cellular automata (CA) can be used to great advantage in such complex ecosystems [1]. In addition, simple models are required which use the minimum number of variables, but which can explain the generic system. Recently developed software can provide generic models for ecologists to test concepts [2]. These models can then be employed for site-specific conditions. Different degrees of complexity can be incorporated into models by varying the compartment number and functional dependence of the rates of intercompartmental pollutant flows.

Deposition of toxic material on catchment basins requires an understanding of several ecological units. For example, the linkage of information on terrestrial, marshlands, rivers, lakes and estuaries and the material interactions among these environments can be described by models. Several compartments in contaminant flow are needed to describe the natural processes and cannot be restricted to considerations of only parts of the ecosystem. Interdisciplinary background is required for experimentalists and theorists to formulate the model development, use, testing and validation. Environmental and human risk assessments must include consideration of the most exposed individuals, ie., critical groups. An integrated system model is required to focus on planning and on predicting possible accident and health effects from the consumption of contaminated water and aquatic organisms. The model encompasses terrestrial, interface and aquatic components and the material flow between them, Figure 1.

Two hydrological processes must be considered in modeling, namely, transport by overland flow through the upper soil layers and infiltration where moisture provides the driving force for metals transport [3]. The net transport of each chemical element depends upon the resistance of moisture transport and the resistance caused by element soil-matrix bonding [4]. Thus, to describe the transport of toxic compounds to the ocean, we must consider three dimensional flow of material deposited on land from atmospheric sources. At any location, the driving forces are due to local hydrological conditions which can mobilize terrestrial material. The time required for such mobilization is important to the health of biological organisms in repositories of rivers, lakes, estuaries and oceans. To quantitate such processes, we must revert to multi-component models which can utilize the ever expanding data base for testing and validation purposes.

The integrated system model is focused on planning and on predicting possible accident and health effects from the consumption of contaminated water and aquatic organisms. In brief, the specific objectives of the study are to:



(a) (b)

Figure 1. Integrated model development showing (a) conceptual Terrestrial, Interface and Aquatic ecosystems and (b) Geographical Information System contaminant modeling for fate and transport in catchment basins.

a) Quantify the physical, chemical and biological processes influencing the behavior of ^{137}Cs, ^{90}Sr, other radionuclides and selected toxic trace elements deposited in river catchment basins leading to estuaries.

b) Provide scientific basis for predicting the impact of such contaminants on catchment areas and their consequent inputs into aquatic ecosystems.

c) Obtain detailed information on the factors influencing the concentration levels and transport of elements to define and incrementally improve on the reliability and accuracy of assessments of radioactive and toxic metal exposure of humans and other organisms.

d) Provide the basis for a practical model, or series of linked models, to be used by regulators and governments to yield an initial prediction of radiation and toxic chemical dose upon which formulation of public policy decisions would be based.

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