Environmental Exposure and Health

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Perspectives on environmental health management paradigms

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Abstract

Environmental health management paradigms have evolved over the past several decades through a "trial and error" approach, or sometimes through a "destroying and correcting" evolutionary approach. It is not clear whether, at this time, we have reached a final acceptable environmental health management model which may be satisfactory for all environmental concerns; one that addresses all potential adverse health outcomes or one that includes all stakeholders in the environmental health scientific community. This evolutionary, sometimes revolutionary development is still ongoing and maybe the goal of identifying an environmental health management model that answers all questions and concerns may not be achievable. In this study, we first review the historical development of environmental management models, provide some insight as to what the next step might be in this evolution and establish the necessary background to achieve that next step. We also provide an example of a study to demonstrate the potential outcome if one adopts the premise of the next step that is identified here. It is up to the next generation environmental health scientists and environmental health community to adopt this premise and take it further to the next level to address health concerns for the benefit of public.
Keywords: health, environment, management models.

1 Environmental management paradigms

Over several decades environmental scientists, economists, physicists, social scientists, health scientists and public health officials have been working on critical issues in environmental health management in order to find a feasible medium between limited resources, long term demands, environmental impacts, health effects and (always in conflict) interest groups. During the last decades,

in search of a solution to this multidimensional problem, our focus has shifted from one extreme to another. For example, decades ago the models we implemented first passed through the *Frontier Economics* period. During this stage, little attention was paid to the environment or the environmental impact. It was assumed that the environment would yield abundant resources and supplies, and scientists and engineers concentrated on developing these resources without regard to adverse environmental outcomes. During this phase, training, education and development of individuals in relevant sciences concentrated on resource-based activities, and significant advances were made in the area of resource-identification, resource-utilization and resource-exploitation.

After the realization of the environmental destruction caused by this approach, the pendulum shifted to the other extreme and we entered the period, which may be identified as *Radical Environmentalism*. In this philosophy the basic assumption is that environmental resources are limited and one should protect the environment without any regard to economic and other considerations. During this phase, scientific studies concentrated on the development of narrowly based natural sciences, and significant scientific advances were made in fundamental topics of compartmentalized basic sciences. In training and education the emphasis was placed on environmental preservation and naturalism.

When the economic burden of the *Radical Environmentalism* phase was realized, environmental policies shifted to the third phase, which may be identified as the *Resource Management* or *Resource Allocation* period. In this period, the environment was considered to be a subset of economics, in realization of the fact that, while we are developing our economic resources we should also consider the environment and pay attention to environmental issues. The development of concepts of environmental mitigation and assessment, and "those who pollute will pay" mentality belongs to this stage of environmental management. The regulatory environmental laws such as RECRA, CERCLA, SARA and others in US are the outcome of the policies of this phase of management. In this period, multi-disciplinary scientific specializations that evolved were a significant improvement over traditional sectoral partitioning of sciences. Multidisciplinary programs and emphasis on multidisciplinary training and education is an outcome of the policies of this management strategy.

During the *Resource Management* era the environment still suffered because controls imposed on the system were materialistic, not naturalistic. This style of environmental policies did not fit well with the environmentalist, and thus came the era of *Selective Environmentalism*. In this style of environmental management, economic considerations were considered to be a subset of the environmental issues. With this phase we entered the era of environmental preservation and planning and the development of environmentally friendly technologies and products followed. Scientific developments concentrated on multidisciplinary specializations within traditional natural and basic sciences.

In the management models described above, only two variables of concern were emphasized, i.e. the economy and the environment. In selecting a specific strategy one aspect was always given priority over the other. At this point,

it became clear to the scientists and also more importantly to the general public that neither of these models were considering harmonious ways of combining these two variables. A review, and combination of the better parts of the earlier management philosophies revealed the concept of *Sustainable Environmental Management* as a resolution of the conflict between these variables. Basic philosophy behind this approach was outlined in the Brundtland World Commission on Environment and Development report [4]. In this approach the environment and economics are considered to be parts of a mutually supporting ecosystem. Long-term issues and long-term solutions became a key consideration for this model.

2 The next step in this evolution

In this evolution, it is not very difficult to anticipate the next step if one asks the right questions. The proper questions to ask may be: "Can there be a Global/Uniform environmental policy and management model?" Or "Based on their characteristics, can different issues, different regions and different applications should have unique environmental strategies?" "Are we really worried about proper environmental management styles for the sake of the environment or economics, or are there other reasons?" It seems that there is a more important reason behind this evolution that led us to the concept of sustainable environmental management. We now realize that one of the main purposes of our search for a proper environmental management model is the protection of populations from adverse health effects. The adverse effects that impact us, which are an outcome of the environmental management strategy, may be of economic or environmental in nature, or they may be related to health effects. When one includes the concept of "health effects" into the overall picture and emphasize and recognize its presence, the policies, principles and methods we were working will change considerably. In the earlier management models discussed above the "health effects" issue was not out of the picture, but it was not emphasized as the primary policy issue. In the earlier management models health effects appeared mostly as a concept, as something to worry about, measure, document, and possibly correct. In the environmental management models summarized above, the emphasis on health effects appears to be more pronounced when the management model emphasizes environmental concerns. When we realize the importance and the depth of the "health effects" concept, we will quickly abandon the philosophy of the *Sustainable Environmental Management*, mainly because it reflects a two dimensional image of a three dimensional problem.

Premise: All human interventions to natural environments, our demand for built environments and natural or forced disasters sooner or later will be associated with health issues.

Based on this premise, it is clear that all environmental intrusion will have health effects implications imbedded in them. This is apparent and repeatedly

acknowledged in all current studies on environmental management. Thus, the next stage of environmental management model we have to work with may be identified as *Environmental Management for Sustainable Populations*. Here the term environment implies build and/or natural environments. In this management model, the goal will be the long term harmonious management of economic resources and environmental preservation, for health, safety and prosperity of sustainable populations. Policy decisions that will be made in this phase will now explicitly include a very complex element, i.e., the dynamic and also the very delicate "population" or the "human" element. When populations are explicitly included in the overall management framework, then social policy, ethics and health issues assume a very important role in the management strategy. It can be anticipated that, to identify and resolve the problems of this management style, scientists from the fields of social sciences, public policy, health sciences, basic sciences, and also the engineering field need to work more closely than they have in the past. To establish this working environment more barriers need to be broken, new rules need to be established, and more importantly, a common language has to be introduced. Technological, scientific and holistic advances made in each field need to be translated into this common language and need to be put to use for the ultimate goal of maintaining sustainable populations. In this approach economic incentives and environmental constraints have to be considered harmoniously, with the main emphasis placed on protection and preservation of human health and sustainability of populations.

3 Integration of engineering and health science programs

Our modern society has developed an ever increasing utilization and undisputed dependence on environmental resources. In any society, the quality of life of citizens and communities is greatly affected by the changes introduced to the environment through natural, deliberate or accidental interferences, burdens of technological or agricultural practices and other human interferences. Environmental resources provide the foundation and lifelines that enable a society to function, grow, and ultimately survive. A historical perspective of conflict resolution practices employed in the human health and environmental management paradigm is outlined above. Based on this evolution, our task is now to incorporate environmental health issues into environmental management model as the primary concern and in doing so we should look at how ready the engineering and health fields are to this integration.

Starting at this point, we first realize that, both from engineering and health science perspective: (i) our present information database is not adequate to fully incorporate environmental health concepts into environmental practices; (ii) the relation between hazardous environmental exposures and their effect on various physiologies are not well understood; (iii) in most cases historical environmental data on hazardous materials and data on hazardous waste management practices are not well known or documented appropriately; and, (iv) health effect consequences of environmental management decisions have not been fully characterized and evaluated. Thus, many pieces of this information do not yet fit,

and others remain elusive. When we find answers to parts of the questions posed above, we start struggling with other questions such as: (i) how do these hazardous chemicals move in the environment among various environmental pathways? (ii) What are the risks of human exposure along this continuum and what are the models to quantify that risk? (iii) What is the correlation between various segments of population, exposure and health effects? (iv) How do we evaluate/measure/document this risk based on uncertainty? (v) What are the biomedical indicators of risk and toxicological profiles of chemicals to enumerate this risk? (vi) What are the management alternatives that need to be implemented to reduce this risk? And more importantly, (vii) How do we integrate engineering sciences and health sciences community and the knowledge base accumulated in both fields in finding answers to these questions? This is a very important task and understanding the interrelationships among these elements is of great importance to the environmental health community. Engineers and health scientists have a significant role to play in formulating answers to these questions.

For a successful integration effort we should start from our educational programs. The research and education activities in engineering and health programs at higher education institutions need to focus on the key questions and relationships identified above. Education programs at these institutions are the starting point to establish this dialog. The curriculum of these programs should be built from bottom-up to address these issues. Through these integrated education programs, next generation of environmental engineers and health scientists should come to the table with basic understanding of each other's issues and more importantly their language. This dialogue can then be extended to include knowledge dissemination to users and stakeholders on research/education processes and products. The integrated programs between key parameters and components of health sciences field, health community and engineering has a lot to offer in addressing the key research/education issues and critical concerns of a diverse community and complex environmental problems.

To address these problems adequately, a variety of professional disciplines must be engaged in these activities. No single discipline can dominate such activities. Thus, we should expect to have engineers, health scientists, epidemiologists, public policy specialists, educators, planners and information technology specialists to be involved in these activities. This interdisciplinary approach is essential if the diverse issues associated with human health management are to be addressed fully and adequately.

4 An example of integration in research

During 1979–1995, New Jersey Department of Health and Senior Services, Division of Environmental and Occupational Health Services, Consumer and Environmental Health Services performed a cancer incidence analysis [3]. This analysis revealed higher than expected childhood leukaemia and brain and central nervous system cancers in the community of Toms River, Dover Township, New Jersey. This has been an area with historically documented

contaminated groundwater that was used as a potable water supply for the Dover Township. To address, understand and analyze public health issues and potential association of childhood cancers with historical environmental contamination, epidemiologists at Agency for Toxic Substances and Disease Registry (ATSDR, CDC) relied on engineering approaches to test and assess study hypotheses. Due to lack of sufficient and reliable data, as we all know health scientists mostly work around hypothesis development. On the other hand, in this case an engineering approach of top-down problem solution approach was necessary to verify or deny the hypothesis developed at the site. These engineering approaches included standard fate and transport analyses of contaminants through water-distribution systems [5] and development of unique algorithms for computational analyses and historical development of events at the site (genetic algorithm optimization [1] and [2]). Results of this health study, which integrates the efforts of epidemiologists, toxicologists, engineers and health scientists, are truly remarkable because out of hundreds, if not thousands, of cancer cluster investigations, this study is one of the only two that have been able to link environmental contamination and health outcome with disease [6].

It is important to acknowledge the leadership of ATSDR/NCEH/CDC scientists who recognized the advantages of implementing a "top-down", problem solving, engineering approach in attempting to link historical environmental contamination events with potential health outcomes and disease for human populations in the United States. In doing so, ATSDR leadership invested agency resources in the development of a programmatic effort referred to as "Exposure-Dose Reconstruction" program. In collaboration with this program, the agency's cooperating partner, the Multimedia Environmental Simulations Laboratory (MESL) at the Georgia Institute of Technology, began a process of developing and applying engineering approaches, analyses, and computational methods to address environmental contamination—health outcome and disease issues (the "environmental health paradigm") for populations surrounding hazardous waste sites in the United States. These activities have lead to the development and application of a methodology now referred to in the literature as "historical exposure-dose reconstruction."

The example above further underscores an important point and the premise of the concepts reviewed in this study. Relying on and applying the engineering systems approach for problem solving may enable health scientists to assess and address the hypotheses they generate in the conduct of epidemiologic studies. The engineering approaches described in the above study, assessed study subject's spatial and temporal experiences in relationship with environmental factors, rather than relying on study subject time-specific diagnoses which happens to be the current mode of operation in health risk assessment studies.

The important step now is the development of health science education programs that not only understands the importance of these approaches and routinely uses these techniques in problem solving but also contributes to the advancement of these scientific developments to further enhance the integrated methodologies. It is important that we educate the next generation environmental health scientists within this framework.

5 Conclusions

The evolutionary models in environmental health management will continue to evolve in its own time frame at its own pace. There will be many contributions to this effort in years to come. As another contribution, the 1st International Conference on Environmental Exposure and Health is organized in an effort to provide this integration at an information exchange, intellectual and scientific collaboration and research dissemination level. The scientific diversity of the participants attending this conference from distant corners of the world should indicate to us that this integration paradigm is not only a desire of a few but also a yearning of a community of new breed of health scientist as well. The interest to come together to discuss common problems, diverse solutions and most importantly acknowledge the presence of a multitude of disciplines in this field has been established during this conference. It is up to this new breed of scientists to carry this torch to other venues such as education, research and service to solidify this integration process and help environmental health science field become a mature scientific endeavour that addresses current issues on environmental health management.

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