

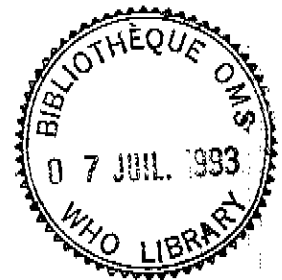
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**WHO CONSULTATION ON THE DEVELOPMENT AND USE OF
ENVIRONMENTAL HEALTH INDICATORS IN THE MANAGEMENT
OF ENVIRONMENTAL RISKS TO HUMAN HEALTH**

Medizinisches Institut für Umwelthygiene
Düsseldorf, Germany, 15-18 December 1992

SUMMARY REPORT



WORLD HEALTH ORGANIZATION GENEVA 1993

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I. INTRODUCTION

The development and use of environmental health indicators in the management of environmental risks to human health formed the focus for a consultation sponsored by the Division of Environmental Health, World Health Organization, in collaboration with the WHO Regional Office for Europe and the Government of Germany. The meeting was hosted by the Medizinisches Institut für Umwelthygiene in Düsseldorf, 15-18 December 1992.

The overall objective of WHO's work in this area is to identify or develop adaptable indicators that can be used for the integration of environment and health issues in the decision-making process at local, national and international levels. The purpose of the present consultation was to review on-going work in this area including the basic background and theory of environmental health indicators, their construction, validity and usefulness for management, and to propose ways and means of coordinating ongoing research in the field in relation to WHO's overall objectives.

The development of environmental health indicators is widely perceived as a part of the sequence of information provision and action, ranging from problem identification through the design and operation of monitoring networks for management, decision-making and for public information dissemination. Environmental health indicators do not, therefore, stand alone but are designed with a clear view of end use.

There are many questions which must be asked when formulating environmental health indicators: how will they be used in practice; how can their effectiveness be evaluated; can they be used by governments to take decisions on patterns of national development; will they gain international acceptance and be used to reflect changes due to human activities which can be redirected, if necessary, by policy decisions?

Specific issues which the consultation was asked to focus on include:

- Can certain sets or subsets of public health data (either collected routinely, or in specific areas at specific times) serve as indicators of environmental conditions or trends?
- Do existing sources of public health data provide the needed comparative basis for assessing differentials in environmental conditions within and between districts, countries or regions?
- Are indicators cost-effective in supporting environmental management decisions in the promotion of human health?
- What kind of data need to be collected as geographic or demographic references for the analysis of environmental health indicators?
- Do current health indicators provide a significant basis for the environmental management of most major environmentally-determined public health problems, and if not, what are the limitations? In what direction(s) should we promote further studies?

Given the broad range of issues in the area of environmental health indicators, a number of different types of indicators may be needed at various levels - local, national, regional and global. Indicators can also be devised to identify priority environment and health problems and the environment and health quality objectives required to solve them at those various levels.

In view of the range of possible indicator requirements, and the different national capabilities, participants were asked to use their experience to assist WHO in developing environmental health indicators as possible components of a health reporting system even if the framework for such a system may be some way off.

As both environment and health are composite concepts a background paper (Section III) was prepared to describe current efforts, enumerate the problems and to act as a focus for discussion. Additional papers were prepared by participants and are listed as Annex B. Copies of these papers are available upon request.

II. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The following conclusions were drafted at the end of the consultation:

1. The consultation understands the term environment to be the sum total of factors, whether natural or anthropogenic, influencing human health and overall well-being.
2. Participants agreed that WHO should continue to explore methods of associating environment and health issues through environmental health indicators with the aim of communicating the interactions of health and environment in the context of sustainable development.
3. Environmental health indicators are designed to clarify environmental influences on human health and well-being. The information is to serve as an aid for decision making in environment and health management. This presupposes that a plausible link between environment and health is established.
4. Specific recommendations for generally applicable indicators can not be provided. The selection of indicators must be adapted to the objective of the eventual use.
5. There are some trade-offs in the quality of information represented by indicators obtained from different scales of measurement, e.g. from regional indicators to individual case assessment. The scale at which the indicator is to be used will be determined by the objectives of the user.
6. The consultation group was unable to examine whether selected indicators could allow a simplified assessment of health status.

RECOMMENDATIONS

On follow-up activities to the consultation, WHO should pursue such activities as:

1. Collaboration with other organizations to explore the use of existing data collections;
2. Determination and description of environmental factors influencing health status;
3. Development of guidelines for the assessment of environmental health indicators;
4. Methodology to link health and environment data should be investigated as a means of supporting decision-making, particularly in data-poor countries.

ENVIRONMENTAL HEALTH INDICATORS - AN OVERVIEW

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1. INTRODUCTION

"Health is a holistic concept, and it is almost impossible to trace separately the inter-relationships of human health with cultural lifestyles, genetic heritage and the conditions of the environment" (UN, 1991). This may be true, except for the most obvious of cases, but despite such difficulties there is an urgent need to evaluate human health in the context of environmental conditions. Human health is considered in the wider sense of the overall well-being of people - not only as an absence of disease. In parallel to this catholic definition, environment is also defined in a broad sense - the immediate human environment together with the more extensive ecosystems within which human societies exist. Both environment and health are composite concepts for which no one variable is adequate as a descriptor. It is therefore doubly difficult to find simple means of communicating the mutual influences and interactions of environment and health.

The WHO Commission on Health and Environment stated that both health and environment are issues which are influenced by many factors - in turn the states of health and environment have many implications and should therefore be considered in a broad development context, taking account of most of the major scientific disciplines (WHO, 1992a). Sectoral issues such as urban air quality, water pollution or food contamination are integrated in our analysis of the broader human and natural environments. Agenda 21 outlined the way forward for such a synthesis of health and environment on the development agenda. This is now being addressed by WHO (WHO, 1992b).

The development of a global strategy for health and environment gives rise to a need for better periodical review and evaluation of environmental health hazard, risk assessment and risk management activities together with the many other activities which focus on human health and the environment - prevention and control of disease or supportive environments for health, for example.

2. DATA

In order to begin to analyse status, trends and interactions between health and the environment, data collection, data manipulation and data comparability from monitoring or other programmes are required. The volume of health, environmental, social, economic, and other data sets is now very large in developed countries. However, data compilation and availability in some other countries are poor; in some data are suppressed whilst in others the lack of consistently applied principles and harmonized approaches are serious constraints to their application in a world wide context.

Data on human health are obtained from national health programmes, data on impacts of natural events from meteorological and geological offices, data on food supplies from agricultural departments and so on. More recently, remote sensing imagery has been used to provide data on large scale events such as floods and forest fires. Such data are sensitive to many sources of error, which may result in misinterpretation. Different philosophies of monitoring, different analytical and statistical methodologies, errors and absence of quality control are all common. Various concepts, definitions and classifications on national and regional scales contribute to difficulties of comparability and data usefulness; such difficulties are more pronounced on a global scale. National

conditions, data needs, statistical capabilities and national priorities all contribute to quite different systems within which data are compiled and used.

It is a relatively common view that much health data, together with economic, demographic and some social data are hard data, whereas those from environmental monitoring may be somewhat "soft", i.e. less accurate. It is difficult to know whether these statements are true generally. They certainly do not apply to the GEMS health related programmes of urban air quality, water quality, food contamination and HEAL where resources have been directed to the collation of accurate and reliable data. Many health and environmental data exist within the UN system-wide Earthwatch monitoring and assessment activities, involving WHO, WMO, FAO, IAEA and UNEP and other agencies. Other programmes collect data to produce UN human settlement statistics, human health statistics and so forth. In addition, data are compiled and reports published through the use of questionnaires via intergovernmental and regional activities of the OECD, UNECE and CEC. Derived data are compiled in UNEP's Environmental Data Report series and WRI's World Resources Reports.

International activities depend upon national sources to a great extent and the reliability, accuracy and comparability of data are fundamental issues if the data are to be used effectively to represent health and environmental conditions through indicators.

3. THE NEED FOR INDICATORS

The large volumes of data, often of variable quality, have to some extent failed to provide decision makers and the public with answers to even basic questions concerned with actual conditions, trends and causes (Alberti and Parker, 1991). The need for indicators for health and environment issues has been increasingly recognized and follows from earlier developments of economic, sociological and traditional health indicators. We are in effect seeking indicators which aid understanding and communication of the issues and processes reflected by health and environmental data. The task is complex - how should we ensure that the indicators are scientifically valid and reflect actual trends while at the same time designing them in a form usable by policy makers for indicating changes resulting from management actions, for example? The target audience and the aims behind producing indicators should be identified - are they for governments, policy makers, international organizations, NGOs, for the public? Can one set of indicators serve more than one purpose? Indicators can help to reveal the causes of reported changes as well as aid understanding of the effectiveness of policy measures. Not surprisingly, consensus on indicators and their usefulness for measuring such issues is difficult to achieve.

4. WHAT ARE INDICATORS ?

Although we don't wish to devote space arguing about definitions of what is an "indicator", compared with an "index" for example, it is worth outlining differences of viewpoints expressed in the literature. Ott (1979) prefers to define an indicator as a mathematical function based on one pollutant variable whereas an index is a mathematical function based on two or more pollutant variables. The US EPA (1990a) defines an environmental indicator as "a characteristic of the environment that, when measured, quantifies the magnitude of stress, habitat characteristics, degree of exposure to the stress, or degree of ecological response to the exposure".

The Norwegians (CBS, 1992) consider that an indicator is a figure used to give a picture of changes in a specifically defined condition. It is not intended to provide detailed and exact information; as the name implies, it is rather a question of *indicating* the broad outlines. Such a qualitative view differs from the more quantitative view advanced by Ott. The OECD indicators of air quality, such as sulphur dioxide/GNP (OECD, 1991), fall within this latter category of giving broad indications of environmental conditions but obviously extend the possibilities of indicators by linking environment and economy and by uniting more than one statistic to produce an indicator (which

could be called an index by Ott's definition). It is obviously necessary to weigh the need for detail against the need for an overview - indicators are not meant to provide complete information on all important aspects of the problem and temporal and spatial scaling are important considerations. Ultimately, it is a matter of choice but indicators may be usefully seen as selective measures of conditions in wider systems.

Indices in some specific areas of environment and health are well developed, especially with regard to biological conditions and with specific communication, management or technical objectives. The Index of Biotic Integrity, for example, relates many variables in aquatic ecosystems and has now been quite successfully adopted in areas where good information on aquatic ecosystems exists (US EPA, 1990b). This is representative of a number of indices in Europe and North America. In most cases, these indices are used where very good knowledge of taxonomy, ecology and ecosystem health exists as a result of study over many years. The indices are used as conveniently simple means of representing the state of the wider system. However, it must be remembered that the apparently simple indices with their reduced demand for monitoring data rely on a huge amount of groundwork for validity and known reliability. Their application in different conditions to those in which they were developed must be approached with great caution and may demand new background work to ensure that the indices can be used.

In the wider context of health in the environment, Dutkiewicz and Dutkiewicz (1991) have proposed novel health indices based predominantly on toxicological information and ecological hazard. Data derived from a series of indices are integrated to provide a comprehensive value which is then used for health risk evaluation.

Indicators and indices have been widely used in the past, often in relatively specific technical situations, but have not always been grouped in general as indicators. They have in common the characteristic that as simple data or more complex statistics they are taken to be representative of a wider and more complex system. The indicator may then be considered as a sort of 'sample' of the system, perhaps summarising a range of different data and representing a particular time period.

In general terms, without the need for precise definition, indicators may be said to reflect the *status* of the system under study as a basic function. Beyond this, indicators may show *time trends*, indicate *sustainability* or give some measure of *management or policy effectiveness*.

5. TYPES OF INDICATORS

In order to develop indicators for health and environment what are the strategic principles we need to consider? What are the criteria, the procedures to enable us to indicate, evaluate and relate environment to human health and health damage.

The purposes for which strategic indicators are to be developed are many and varied and include:

- environmental health reporting;
- priority setting at national and global levels;
- policy making;
- management effectiveness;
- ranking of nations and locations;
- trend analysis;
- predictions;
- early warnings of impacts;
- environmental impact assessment;
- sustainable development;
- risk assessment and risk management;
- public awareness;
- exposure and effects.

Within these categories, there are many points for discussion - two examples might be the use of indicators in regulation and errors in indicators. Should indicators be used as a focus for regulation and legislation? If so, what criteria should we set for revision, accuracy and effectiveness? What margins of error should we tolerate in the measurement of indicators? What are the costs of inaccuracy or of selecting the wrong indicators? What has been learnt in present attempts to develop environmental health indicators - can we identify common criteria, common theoretical bases?

The *users* or target audience of the information in the above categories require considerable clarification for effective design. It is probable that indicators and their use will not give experts any new information as Alfsen et al. (1992) have recognized. Expert audiences usually have an understanding which demands specific techniques of information provision. Indicators can however provide a condensed description of health and environment in a synthesis that is easily understood by non-expert audiences. *Producers* of the information such as UN agencies or regional organizations are easier to identify. A good example of an existing environmental health indicator might be the use of faecal coliforms as indicators of contamination of water by pathogens. In this case we have a well established system which uses a particular variable as an indicator of a wider system with complex environmental and health interactions. There are implications of risk and feedback on management actions but the example of faecal coliforms also draws our attention to the possible limitations of an indicator - it is less suitable for certain environments and must be treated with some caution. Faecal coliforms are also not ideal indicators for more persistent pathogens. Despite these drawbacks, the system has been developed and refined for pragmatic reasons because of its effectiveness - what parallels and experience can be drawn upon to develop health indicators for a wider range of environmental influences?

6. HEALTH INDICATORS

In the past there have been shifting patterns of disease and death. High rates of infectious disease and lower life expectancy in developing countries contrast with more developed nations where there has been a decline in overall mortality from infectious disease and a parallel rise in disability due to chronic illness. This changing pattern has been brought about by better nutrition, housing and public health programmes in the developed nations. The consequence of these changes has been that the population balance has moved towards the elderly in such countries. Traditional health indicators include such statistics as life expectancy and infant mortality rates. However, there is increasing recognition in developed countries that such statistics do not provide a particularly detailed impression of health trends and, taken alone, are therefore not sufficient for informed planning of health services (Culyer, 1983). They can be useful, however, for making crude comparisons over time or between nations. Trends in these statistics over time do not adequately reflect changing disabilities, changes in severity of effect, and are not sensitive as surrogates for "health" or "ill health", particularly in the light of wider definitions of health which describe overall well-being. These health concerns stem in part from changing social phenomena - the elderly, mobility of people, changing family patterns - which require new indicators. Other possible indicators can refer to work days lost, or bed-disability days, and so forth.

The particular health variables to be monitored for use as indicators therefore require careful definition to fulfil the information needs of the audience. An equally important consideration is that of the treatment of the collected data for present needs and for possible future re-analysis. Disaggregated data have enabled specific groups such as occupational workers to be specifically considered but in aggregating data some issues and values are lost, although new information may also be created. Analysis of population subgroups such as the elderly and children will continue to be vital for policy and health management purposes. The current challenge is to present information which is easily communicated in indicator form but which adequately expresses the complex of health issues within the population.

As already stated, the traditional simple concept of health indicators is limited by its consideration of health status as "freedom from disease". If a sociomedical definition of health is

used, such as measures of disability, then information about how health status affects quality of life can be applied to populations. Perhaps both a measure of disability and specific diagnostic conditions giving rise to the disability will be required. This could lead to the use of expert valuation as a means of measuring disability as a parallel to the more traditional direct measurement approach.

There seems little doubt that the assessment of health via health indicators needs to be broadened and combined with indicators of social and economic conditions. The environment, and its many facets, too must be considered within the concept of health and relevance for decision makers. Substantial effort will be required to detail, in a multi-disciplinary framework, the concept of environmental health indicators and to distinguish it from a trendy study.

7. INDICATOR CHOICE AND DESIGN

Environmental health indicators should be components of any health reporting system although international consensus on the framework for such a system may be some way off. The intended use of indicators and purpose behind their use must be considered when they are designed. Critical to this discussion is whether indicators are to be designed to include only hard data from monitoring, for example, or whether expert opinions (such as could be gathered by the Delphi technique - see Inhaber, 1976) or public opinion polls are included (Hope and Parker, 1990). This brings us back to how and where does the indicator fit into the policy framework. There would seem little point in developing indicators outside of the context of information and policy requirements.

Perhaps the following based on some of the proposals of Liverman et al. (1988) can be considered as *criteria* for indicators:

- transparent - aids understanding of the functional relationships between different elements of the system of interest;
- realistic - present an accurate view of the system;
- scientifically valid;
- robust - not influenced by natural variation;
- sensitive - responsive to changes in the system;
- links - linkage to different indicators is important.

Even when an indicator meets these criteria, it is clear that not all experts will agree on whether indicator development will be worthwhile. How much distortion or weighting is acceptable will be one obvious question. Some will argue that no distortion should be countenanced for it may give rise to misleading conclusions. Does the indicator give us a true picture of the system as a whole or is it weighting our perceptions with the consequence that decisions are not made in the most effective way? These controversies can have real impacts if results from inappropriate or incorrect indicators are adopted to determine health outcomes, even if the basic health and environment data used are the best available.

As regards *design* of indicators - what we want the indicator to show us - immediate priorities for discussion include:

- status - how good (or bad) is the situation;
- reference point - is it possible that things can get better;

- trends - what are the differences long term;
- data - do we have the information to put into the indicator.

Choice of indicators is of particular concern. Economic indicators, despite their inadequacies, are well established and understood to some extent by the general public although experts warn against too great a reliance on a few economic indicators. Health indicators in a traditional sense such as morbidity, mortality, birth rate and death rate, are also well understood. The health effects of different socio-economic conditions, for example cultural differences, lifestyle differences or development of immunity to microbial contamination, all raise difficult questions. It is interesting that some sociological indicators could be used as environmental health indicators in a broad sense. For example, elementary school absenteeism has been associated with PM₁₀ air pollution in one study in Utah (Ransom and Pope, 1992). Although school absenteeism can be due to many other health factors, it has proven useful in other areas. Gwynne (personal communication) reports that in pastoral communities in Africa, school absenteeism including absenteeism by age group has been used as an index of drought because more children are needed to shepherd the smaller groups of cattle for foraging during drought.

Expert judgement as well as initiative judgement should be balanced with the needs of real data gathering including data from satellite imagery and GIS studies. Nonetheless, some sociological observations, if properly understood, can act as surrogates for more extensive data sets.

Perhaps one way forward is to develop a framework of indicators with the main classification as follows:

- global problems
- urban problems
- rural problems

This idea is based on the fact that effects indicators would probably be different for these three major partitions and be more applicable to the differences between nations in terms of level of development. In this way perceived global (or regional) problems such as ozone depletion or other global disturbances could be addressed and objectives established to lead to action to solve them. This method has recently been used to establish a consensus in the USA on evaluating health risks (Carlo et al., 1992). It was clear from the study that participants used data from multiple disciplines to assess human health risks. "Environmental health achievement indicators" could therefore follow. This approach may have to be broken down into problem areas such as:

- air quality
- water quality
- food contamination
- soil/waste

but this disaggregates environmental factors which influence health which would not seem to be a useful way forward unless hundreds of technical indicators were envisaged which rather defeats the usefulness and ready acceptance of indicators for public information needs. Another approach at a framework involves:

- state-of-the-nation indicators
- human and natural impact indicators
- sustainability indicators

a. *State-of-the-nation indicators*

Included within this category are those factors concerned with an evaluation of the state-of-health of the whole population - perhaps related to mortality statistics or cancer statistics.

Examples within this category could equate with the *National Environmental Quality Index* published by the National Wildlife Federation in Washington.

It would seem probable that no single set of indicators would be suitable for all countries perhaps we should be looking for a set of indicators which can be modified to suit the health status, environmental conditions, and development status of particular countries. However, caution is necessary in promulgating such a set of indicators in order to ensure that they do not become the prime focus for health data gathering at the expense of information more appropriate and of greater utility at smaller scales such as in category b. Ideally, indicators could fulfil both functions but this may not be possible in practice.

b. *Human and natural impact indicators*

These would be designed to link human activities and environmental quality with human health in a way and on a scale appropriate to the needs of the users of the information. Such indicators could be designed with respect to particular human environmental health influences such as energy, industry, agriculture and so forth or could be oriented to particular management activities - faecal coliforms or toxic chemicals in water, for example.

c. *Sustainability Indicators*

These could relate long-term human pressures on the environment and health impacts. Such indicators would undoubtedly be complex and may relate more to national differences and diversity. We should perhaps ask ourselves a question laden with a variety of implications - **which indicators should we be monitoring now in our environment which will tell us about the health of succeeding generations?**

Perhaps another type of indicator or index should be considered and that relates to assessing national capabilities. Schaefer (1991) refers to several WHO studies designed to assess national capabilities based on 10 "indicators" (legislation, strategy, standards, assessment, enforcement, staffing, research, co-ordination, involvement and delegation). But such a scheme reflects capability rather than performance; the difference is significant.

8. REALITY vs PERCEPTION

One aspect which designers of indicators and their potential users will have to consider is how to relate indicators to legislation and the narrow distinction between acceptable and unacceptable. The distinction which WHO has followed regarding the adoption of guidelines, guideline values and ranges rather than exact standards or criteria, illustrates the way forward. As environmental health issues represent dynamic conditions and implied differences between individuals and populations rather than static conditions, sharply definable conditions seem unworkable. Nonetheless, the use of indicators to distinguish between the good and the bad needs to be recognized (Chapman, 1991).

Equally difficult is the use of indicators in legislation and regulation as the focus for action and monitoring. This was mentioned briefly above. If an indicator is developed for a wider system, can it then become the focus for intervention? How can we choose trigger values for action or decisions in complex systems? Many of the difficulties outlined above should be considered - would we be in danger of treating the symptom rather than the cause?

Decision makers at all levels are facing increasingly complex policy choices for it is they who must respond to public expectation. Increased economic development is sought by many nations so the needs for rapid measures to integrate environmental, health and economic factors into strategic advice becomes paramount. Societal and cultural factors also need to be integrated into this advice, especially when sustainable development is being sought and the needs of future generations considered. "Decision relevant reporting" and "decision relevant indicators" are critically

needed as short-hand methods for examining how well nations are addressing and solving environmental health concerns.

9. CONCLUSIONS

The present paper gives a brief overview of current problems and issues in the development of indicators of health and environment but the issues are complex and require detailed discussion. The complexity of the links between the three composite concepts of health, environment and development are a continuing focus for activity. We require indicators which will reflect these links and influences. Such indicators are difficult to develop, in part because of the variety of uses to which the information is put - the scale of analysis, treatment of data, the framework for analysis are all important factors. Indicators can reflect the status of the system, time trends, sustainability or effectiveness of intervention.

The UN Conference on Environment and Development allowed a number of needs for the interactions of health, environment and development to be identified through Agenda 21. In particular, hazard and risk assessment, costs, combined exposure to multiple hazards and long-term health problems were mentioned - how would the development of appropriate indicators benefit the policy framework and information user addressing these issues, whether on a global or local scale?

A recent WHO (Euro) article asked "How exactly are environmental conditions in Europe causing ill health? The answer is not clear because the necessary information is either not available or not available in a usable form". The search for useful indicators of conditions, status and trends as credible measures of environmental health are long overdue. Indicative research and development of experimental examples should be undertaken as a matter of urgency for it is not at all clear that policy relevant indicators can be developed from present data bases. Should the underlying data not actually exist, or not occur in a usable form, then raw data must be generated to the extent possible.

An examination of pragmatic economic indicators rapidly shows that the traditional approach towards environmental health indicators has been too concerned with scientific details and not enough with broad issues, goals and convenience of use. Weightings and value judgements may well have to be made to balance the need for scientific precision and accuracy with societal applicability and the capacity to be readily understood, "comprehensibility", by those who report them and by those who intend to use them.

Broad indicators of environmental health conditions, rather than routine environmental variables are clearly required. Using a medical analogy, indicators should enable us to "take a pulse" before and after medical treatment to ascertain condition, trends and predictive effects.

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IV. BRIEF SUMMARY OF PRESENTATIONS AND DISCUSSIONS

1. OPENING SESSION

The meeting was opened by Dr Winneke on behalf of the Medizinisches Institut für Umwelthygiene. He described the institute's background in environmental health, particularly in air hygiene and silicosis, and the success of collaboration with WHO.

Dr Scheiner-Bobis spoke on behalf of the Ministry of the Environment of the Federal Government of Germany. She spoke of the frequent interest and support which the German Government gave to the activities of WHO in environmental health and indicated the Government's interest in the results of the present consultation and its willingness to consider the continued funding of such activities.

Dr Slooff spoke on behalf of the Director-General of WHO and on behalf of Dr Kreisel, Director of the Division of Environmental Health of WHO. The meeting was intended to be relatively informal and to discuss important questions on environmental health indicators:

- what are they?
- what are they for?
- how can we improve their validity and usefulness for research and management?

Dr Slooff suggested that the answers to such questions were uncertain at present. There exist many points of view and different sets of indicators for various purposes in a number of countries. The global nature of the consultation was important and it was important that the views from all regions be considered.

Dr Hasse of the Ministerium für Umwelt, Naturschutz und Raumordnung was elected to chair the meeting, supported by Dr Englert of the Bundesgesundheitsamt für Wasser-, Boden- und Lufthygiene as vice-chairman and Mr Jackson of MARC as rapporteur.

2. PRESENTATIONS

2.1 Environmental Health Indicators - an overview. P.J.Peterson, J.A.Jackson and A.D.Willcocks

a. Introduction

We are faced with the difficulty of adequately expressing the interactions of complex systems of health and environment. Broad definitions of health take into account overall well-being and the influences of culture, genetics and environment. Broad definitions of environment consider humans as a part of the wider environment. Both health and environment are composite concepts with complex interactions. The WHO Commission on Health and Environment considered the links between health and the environment in the context of development, a theme given prominence in Agenda 21, the action programme for sustainable development agreed to at the United Nations Conference on Environment and Development, June 1992. The broadening of concepts of health and acknowledgement of links has given new importance to concepts such as supportive environments for health which in turn demand new policies and information needs.

b. Data

There are substantial difficulties with accuracy, validity, comparability, suitability, errors, gaps and harmonization of data. Such difficulties arise on national, regional and global scales. Data are the basis of information provision through indicators.

c. The need for indicators

Indicators can provide an essential information function by condensing and summarising large volumes of data and presenting it in such a way that the user appreciates the functioning of the system under study without expert knowledge. The decision on what information is presented and how it is presented is made with a view to the needs of the target users - whether policy-makers, managers or the public. This has important implications for the design of indicators in information provision.

d. What are indicators?

Is there a distinction between indicators and indices; both are representative of a complex wider system - 'samples' of a wider situation. The purposes of indicators could include - problem identification, status or trends reporting, sustainability measurement, policy and management effectiveness evaluation.

e. Types of indicators

Various types of indicators could be for use in:

policy, management, priorities, effectiveness

status, trends, predictions, early warnings, sustainability

Environmental Impact Assessment (EIA), risk

public awareness

regulation and legislation

Within these categories, what do indicators have in common and how can this experience be used? How were they designed and how are revisions and changes made? What are the costs of selecting the wrong indicators for decision-making or regulation?

f. Health indicators

The use of health indicators is well established but there are limitations of traditional indicators such as mortality in managing the changing health needs of populations. Monitoring and treatment of health data, for example aggregation and disaggregation, are important issues in information provision and in reassessing trends. Changing priorities are making demands on health indicators and data collection in the expression of subtleties and linkages with other sectors such as environment and development.

g. Design and choice

Design of indicators must consider their use and their policy framework context. Criteria for design should include such things as transparency, scientific validity and sensitivity, but the criteria depend on the purpose of the indicators. Indicators can be used to describe status, time trends, sustainability, or effectiveness of interventions within different possible scales or frameworks such as global, urban or rural frameworks. Present environmental signals for the health of succeeding generations could be developed as indicators of sustainable health.

h. Reality and perception

How do indicators aid in discerning good and bad situations in a complex system? Caution is necessary in making indicators the focus for regulation. Decision-makers face complex choices requiring "decision-relevant indicators" as means of presenting information.

i. Conclusion

How do environmental conditions result in ill health? Information provision and presentation are important factors in answering such questions. Indicators provide useful means of information provision and should be designed with regard to broad issues, goals and uses.

Discussion - The discussion began with the suggestion that uses and demands for indicators, links and their comprehensibility to decision-makers were important issues for discussion. While it is possible to put indicators into a framework of global, urban and rural issues, it is difficult to arrive at universal definitions or to propose a set of world-wide core indicators.

The uses and functions of indicators are most important in driving their development. Different countries have very different priorities and problems for environment, health and sustainable development with the result that information needs and indicator use and structure can vary widely. The importance of indicator use on small scales (for example, intra-urban differences) should not be overlooked - it has implications for data collection and treatment and indicator design should be appropriate to the scale of use. Indicators could be used in identifying health-related issues such as equity for environmental health.

Should the indicator be the point of management intervention and the goal of regulation? There are certain limitations to the effectiveness of such an approach - an understanding of the functional position of the indicator variable or variables within the system was essential to answer whether such a strategy would be the most effective.

Environmental health indicators are important in expressing linkages between different sectors. The development of indicators should be appropriate to the scale and use - they should be dynamic and use-defined. It was suggested that WHO resist the development of new statistical questionnaires.

In summary, indicators can fulfil an important information function for a variety of uses in describing interactions of environment and health.

2.2 Research applications

2.2.1 Bioindicators for environmental exposure to hydrocarbons and organochlorine compounds - U.Ewers and T.Eickmann

Work has been done on biological indicators of human exposure to organochlorines such as solvents, pesticides and PCBs. Analysis of residues and metabolites in blood, body fat, milk, urine and exhaled air has given important information on half lives, persistence and food chains.

Frequency distributions of concentrations in exposed populations show elevated levels of PCDF in comparison with baseline frequency distributions. Contaminant indicators such as this may not give much information on effects. The degree of induction of the cytochrome P450-dependent mixed function oxidase system in the liver is a biochemical indicator of effect. However, these biomarkers respond to a variety of inducers and their proper interpretation in assessing exposure requires information on possible exposure routes such as diet or occupation.

Research needs include reference materials and inter-lab tests, reference ranges for background concentrations, factors influencing concentrations, early signs of adverse effects, critical concentration ranges for effects and time trends.

A specific example of monitoring for bioindicators was given - that of benzene. Benzene originates from a variety of sources such as vehicle fuel combustion, industrial activity and smoking tobacco. Benzene has identifiable health effects but its biomonitoring is difficult because of rapid metabolism so analysis of metabolites must be performed. Biomonitoring allows estimation of real exposure and therefore of risk. Once exposure and risk in real situations can be studied, adjustment of environmental standards can take place according to primary routes of exposure.

2.2.2 Immunological Biomarkers as environmental health indicators - H. Idel and E. Malin

Immunological biomarkers can provide early signs of exposure before other effects are seen. The immune system is of obvious importance in health and in this context is providing indicators of the interaction between human health and the environment. Analysis of humoral or cellular elements of the immune system can provide indications of greater or lesser specificity of exposure to chemicals. Immunoprotein profiles use differential suppression and stimulation of immunoproteins in response to chemicals. However, different chemicals may have very different effects on the stimulation or suppression of a particular protein and where the immune system is exposed to a number of contaminants, exposure signals may be confused.

Immunoproteins as indicators have been used in parallel to physiological and contaminant monitoring in the comparison of exposed and control populations as part of a health surveillance programme in Germany. Some success was achieved in early detection of exposure, spatial comparisons and trends but difficulties were encountered in identifying specific and concurrent exposure.

Discussion - Discussion elaborated on the use of non-occupationally exposed groups at control site. If no control site were used, median deviation could be used to identify spatial and temporal patterns.

2.2.3 Reactions of the respiratory system as environmental health indicators - N. Englert

Considerations of ethics, economics, practicability, specificity and sensitivity are important in the selection of indicators. Objective indicators such as disease, functional changes or biochemical changes can be used in parallel to subjective indicators such as pain or coughs. Different indicators have different sensitivity at different levels of exposure. Interviews, functional, biochemical and systemic changes have all been used to generate indicators of health effects. With certain reactions - for example in the respiratory tract - a limited range of reactions makes the development of indicators of specific health influences difficult. Issues of bias and specificity in subjective measures must be considered and the selection of subject groups may be a source of bias. Time factors may be important in understanding indicator information, for example; latency, reversibility, diurnal and seasonal variation, age dependency. A continuing difficulty lies in establishing real health effects resulting from environmental exposure.

Discussion - Hospital admissions can be used as a subjective indicator of health status of a population but there are problems in using this above a local scale because of differences in health care systems in different areas with consequent difficulties for comparison.

2.2.4 Household surveys as tools for assessing environmental problems in low income cities - G. McGranahan

Household surveys may be used as tools for examining environmental health problems and can provide useful information for guiding environmental policy. Just as there are relations between

certain environmental and health indicators and economy on a country level, so there are relations between income group and environmental health indicators on a household level. As the degree of resolution in data analysis improves with diminishing size of sampling unit (region, country, district, city, family, individual) the development of indicators raises issues of scale. Household environments have links to health - for example the link between diarrhoeal disease and water supply and sanitation. Supply and sanitation differ with income group - the use of supply as an indicator has implications of equity and will have different implications and will be influenced by the wider environmental situation with regard to water resources.

Indicators derived from household surveys can be used for health policy and as information for action, governmental and otherwise. Complex interactions of multiple environmental factors with health outcomes make interpretation of indicators difficult. The particular local complex of factors in any one place may mean that the indicator must be considered with a number of other information elements ranging from environment to cultural practice. Direct access to data by a wide audience is important in ensuring maximum use of the information. There are significant problems of context in interpretation in establishing internationally comparable indicators.

2.2.5 German surveys - N. Englert

Surveys of German people were conducted in 1985-86 and 1992 using questionnaires for population activity and subjective health. These surveys were paralleled by general medical assessments and measurements of contaminants in blood, hair, dust, air and water. Trigger values for particular indicators of exposure were developed as a result of the studies. These triggers gave grounds for no action, for observation and for remedial health action based on health risks linked with particular values of the indicators.

2.2.7 Indicators: use for setting priorities for environmental epidemiological research - R. Bertolini

Indicators can be important tools in setting priorities in environmental epidemiological research because they help to describe effects of the environment on the distribution and frequency of disease and associated risks. Simple links between the environment and health are easiest to establish but environmental disease is often multifactorial with consequent difficulties in analysis by traditional methods. To ensure effective use of resources, several strategies are proposed for the use of indicators:

1. traditional methods; for populations with high specific exposure and a well defined geography. Observed vs expected incidence of mortality and morbidity can direct research to particular areas
2. biological monitoring; for estimation of lower exposures in larger population groups. Extension of known effects accompanied by particular biological indicators in high exposure groups to estimate effects in low exposure groups
3. integrated approach; concurrent use of geographical and analytical studies

Environmental health indicators in exposure and effect should aim at effective presentation of integrated environment and health information.

2.3 INDICATORS AS TOOLS FOR ENVIRONMENTAL MANAGEMENT AND POLICY SETTING

2.3.1 Policy development and the use of health and environment indicators - N. Previsich

Canada is a country where public awareness and concern for the environment is high. The link between environment and health is an important issue. Canada's Green plan is a policy framework with emphasis on lower pollution, sustainable agriculture, biodiversity and public awareness. The identification of risk groups, individual and community action and awareness initiatives are all important parts of the strategy. Public consultation identifies gaps in information and has aided in the progressive development of indicators for environment and health. These indicators are designed to be simple and easily understood and include statistics for life expectancy, dietary intakes of pesticides, air quality, skin cancer and tissue concentrations of various contaminants. New indicators will include the proportion of environmental samples exceeding standards for particular contaminants, public concern indicators, body burdens of contaminants and health effects such as birth defects, cancers and hospital admissions. The criteria for indicators should be that they are scientifically sound and defensible, consistent with existing data sets and clearly understandable.

Discussion - care is taken in the Canadian system to use the terms environmental indicators and health indicators, rather than environmental health indicators. The development of indicators has been a careful and rational process, aiming among other things to maximise the use of data. Public perceptions of environmental risks are considered in the process; environment and health indicators give information to meet concern but also to educate as to the true nature of the problem. Public reaction to environment and health issues is important information in policy formation and is packaged with other issues such as economy and health care for the needs of decision makers.

2.3.2 Availability and use of selected environmental health indicators in Europe - M. Krzyzanowski

Indicators are important in interpretation of environment and health and indicators for each can be linked by modifying factors. The Health for All programme in Europe makes use of indicators as health targets - sanitation, housing and health indicators. One problem in such programmes is that data are not necessarily comparable from country to country which can affect the utility of the indicators.

The WHO Euro activity *Concern for Europe's Tomorrow* has made use of questionnaires to collect indicator statistics and information but there has been a relatively poor reporting response from the various countries involved. There is limited availability and comparability of certain health and environment data on a European scale.

Selection of indicators should be made on the basis of use. The poor existing knowledge of causal links between environment and health has resulted in lack of incentive to collect data on links and interactions between the two. Such data are required for the estimation of exposure for risk management. Issues of validity must be considered in generating the data for indicators - validity of measurement, assumptions in designing the study and care in selecting sample groups which are representative of the wider population.

2.3.4 Efforts in the development of environmental indicators - WHO Western Pacific Regional Environmental Health Centre - H. Ogawa

Indicator data for water supply and sanitation, air quality, water quality, solid waste, chemical safety are collected from the countries in the region. The data are weighted according to their significance in the wider context of environment and health and a score is assigned to the processed statistics. A total score and ranking for each country is calculated. This large-scale exercise has the specific aim of identifying country needs, priorities and targets for planning and assessment of regional EHC activities.

2.3.5 Environment and health: the case of Greater Accra Metropolitan Area, Ghana - J. Songsore

Developing countries have important differences in health and environment interactions which are reflected in the design and interpretation of indicators. For example, life expectancy, communicable and environmental diseases have different characteristics and different impacts on the health and makeup of the population. There is a stronger recognition of the links between health, environment and development - issues which were raised in *Our Common Future*. The immediate local environment is often of great importance in determining health and this means that household surveys are a powerful tool in monitoring and analysis of the environment:health complex. Household surveys assess income and housing types, environmental and health risks and health outcomes. Access indicators, service efficiency, hygiene practice, social and financial status and vector prevalence can all be addressed and provide useful indicators for policy purposes. Factor analysis is a possible tool for the identification of priority areas. Indicators may be used for public information - poorer groups may have reasonable risk perception but often lack the resources for self-protection. Indicators derived from these studies can also give valuable information on policy and remediation effectiveness.

Discussion - There are important income influences on using the assessment of vectors as indicators of health - different control strategies are used by different income groups which have consequent health influences. Different classes of indicators when used together can show interactions between environment, health and development and can be used in priority selection but this is still difficult - for example, which action would improve the health of a group most effectively: vector elimination, sanitation or education? Such questions are very difficult to answer but indicators can help to present information for the best identification of priorities. There are of course questions of equity implicit in many of the indicators. Information provision through indicators focussing on various scales can help to identify whether communication, motivation and intervention on environmental health are best conducted at household level or at city level.

2.3.6 Qualitative challenges in the development and use of environmental indicators with respect to health - P. Jacobi

In assessing interactions of health, environment and development it is important to take account of socio-economic and political factors. Social patterns and the context in which environmental and health problems occur are important. Risks, resource degradation, stress, transport and waste problems are associated with unplanned development. Indicators can be used to provide information and suggest options on status, impact, causes and solutions. In addition, indicators can help to identify priorities and arrive at a definition of complexity. In designing indicators, one should take account of equity, scale of analysis and audience. There is a need for an understanding of the interaction between environment, health and development in an urban context from both an institutional and social viewpoint. Such a synthesis of risks, effects, quality of life, social practices and so forth should lead to information provision with a view to action in various ways. Community action arising from adequate information can be aimed at basic environmental problems, socio-cultural practices, perception and risk management and evaluation. Qualitative and quantitative information can play an important part in public perceptions and managerial effectiveness. Effective change is brought about through adequate information and participation at the most appropriate scales in the urban environment.

2.3.7 The limits of health information from water supply and sanitation statistics - proposals for improvement - L. Laugeri

There is at present poor use of epidemiological information in water supply and sanitation. Existing indicators for water supply and sanitation are necessary but not sufficient as indicators of environmental health. Experience has shown that indicators can play a useful role in stimulation of investment in water supply and sanitation. Links between water, sanitation and health are poorly established - morbidity data and causal links with sanitation are particularly lacking. Present indicator systems in the sector do not give very clear insight into the reasons behind environmental health problems. It is essential to address meaning and reliability for a range of information and indicator types: coverage, quality of service, continuity, affordability, sustainability. Improvements in information and indicator provision in the sector could be made through the definition of health zones; monitoring a package of diseases particularly associated with morbidity; indicators for public health impact statements; mixing indicators for environment and health; and establishing a set of indicators and information needs for minimum evaluation.

2.3.8 Investigation of Health Clusters: childhood leukaemia clusters - M. Csicsáky

The identification of clusters of leukaemia cases has raised questions of environmental factors. The identification of a cluster is difficult because although cases may occur simultaneously, the latency may have been different and the leukaemia attributable to different causes. A case study was presented which used a combination of public consultation and expert input to identify risk factors and to provide information to meet public concern arising from the clusters. In other situations, both public consultation and questionnaires have proved valuable in identifying patterns of exposure and risk factors. This can then be reinforced with appropriate action. One aspect emerging from the studies has been that the perception of health risk by the public does not correspond very well to exposure. Information provision plays an important part in focussing media attention and public concern on priority health issues.

Discussion - There are difficulties in separating relative risk factors of different leukaemia types. The identification of clusters can have high sociological impacts.

2.3.9 Geocoded environmental and health indicators for Europe: issues and scale for the region - R. Stern

The monitoring and analysis of environmental and health problems is conducted on various levels of resolution and scales of use. It is important that data is collected and handled in a manner appropriate to the scale of interest. Work is progressing on a set of environmental health indicators for Europe which will be a wide range of variables with an influence on health and well-being. Resolution of data will probably be on a local level and these indicators will be mapped and temporal variation identified where possible. Where the indicators are directly associated with particular health effects it may be possible to map risk factors but this will be more difficult where health issues have multiple causes. Maps have distinct advantages in displaying distribution and different variables can be overlaid with environmental, health, social and economic issues to generate new analyses.

Discussion - There are difficulties of data collection on the most appropriate level - for the maximum utility, data should be gathered at the highest practical resolution to allow the widest range of options in presentation to a range of audiences. Misinterpretation of mapped information is possible and use of maps should not be uncritical - a view should be formed of the function of the map in communication. GIS can be useful in problem and interaction identification, raising issues but not necessarily establishing proof. The Canadian experience has shown that maps are useful for internal policy purposes in focussing effort but they are not used in presenting information to the public because of possible misinterpretation.

2.3.10 Role of Biomarkers for environmental policy making - A. Hasse

Indicators of exposure and health effects are coupled with issues and oriented to the eventual user of the information. There should be more effort directed to the identification of early warning indicators of effects - biomarkers. Such exposure indicators are preferable to symptomatic health indicators in that they allow pre-emptive action to be taken. Once symptoms have been observed, it may be too late for remedial action.

Discussion - There is a need for links between biomarkers and effects - how does the biomarker act as an indicator of ultimate risk? How can biomarkers be linked with other information to demonstrate routes and magnitude of exposure, to couple risk identification with identifying possible options for risk management.

4. GENERAL DISCUSSION

The presentations summarised above were interspersed with and followed by general discussion on indicators.

WHO background - at present it is not possible to give a standard list of indicators. The choice of indicators depends on intended use. Therefore, an overview on concepts and possibilities is more important. Environmental indicators can be considered as tools for management and policy but variations in national needs and capacities mean that global applications or definitions are difficult. Agenda 21 outlined obligations for national governments and WHO and indicators should support initiatives to meet those obligations. Indicators should be viewed in the context of broad definitions of health - health which is determined by many factors and which is part of and influenced by the wider environment. The concept of supportive environments for health is important and should be a background to the consideration of indicators.

Indicator definitions - there were mixed views on whether definitions were necessary or possible for environmental health indicators. Previous attempts had proven difficult and there was some feeling that the indicators were use-defined in the final analysis. Various suggestions were centred on information provision but ranged over scales, impacts, descriptions, communication, decisions, actions and management. It was agreed that for the purposes of the discussion, the following loose definition would suffice:

"An environmental health indicator is information on environment and health which may be used in making decisions and in management for the protection and promotion of human health".

Information use and audiences - It was suggested that indicators were means of information presentation which gave insight into the interaction between environment and health. By making links in this way, the indicators could lead to new and important interpretations of data. The indicator could present information in a way to allow better identification of cause and effect with implications for predictive power.

In essence the indicator is the tip of the iceberg - it is a means of summarising large quantities of information (presumably in such a way as to preserve the relative importance of the elements of the wider system and to express something of the nature of the interaction between health, environment and development). It was agreed that the uses and characteristics of indicators are closely linked - the indicator should be designed specifically with the information requirements of the audience in mind, whether the audience is of policy makers or the general public.

Policy makers require information for appropriate decisions in environmental management to protect health but indicators can also be a means of presenting information for public concern and education or to provide the basis for participation in environmental management at a community level - the possibilities are as wide as the requirement for effectively presented information.

Indicators could be useful in environmental education - decoded information for all levels of society ranging from communication of health issues to environmental planners to advocacy and creating awareness.

Some possible uses of indicators might be to give lead times for corrective measures and early warnings of effects (predictive value), for occupational health, equity or sustainable development - what could be indicators for the health of succeeding generations.

In essence, indicators are a means of communicating information, making the most of what data are available through synthesis and presentation.

Links - The links between health, environment and development are critical in the understanding of wider environmental health issues. In the reports to UNCED from individual countries, few take account of health in relation to the environment. However, environment and health are on a common agenda in a few countries - we need to learn from experience particularly where effective means of information provision have been developed.

It is increasingly apparent that we are looking at health issues in a wider context of environment and development and this acknowledgement of wider issues can raise wider options for health management and the promotion of health and welfare. In some cases a political response is not always forthcoming to environment and health links - in cases where the links are established, there can result wider impacts on government and possible modification of existing indicators to communicate with a wider audience.

Equally it is important that indicators be developed which can better express the links between exposure, effect and risk - how can risk be inferred from environmental quality? What are the implications for control strategies? Is health status better or worse and how does this relate to environmental conditions? How should guidelines and trigger values of indicators be used with respect to effects in regulation?

The scale of analysis is stressed as being important for the use and interpretation of information.

Criteria - Possible criteria for indicators were suggested:

- specificity, sensitivity, availability, feasibility
- predictive value, validity
- data availability
- relevant links

Data - the treatment and presentation of data are critical in information provision and indicator use and are as important as in any other statistical system. Aggregation of data, sample size and location are all issues which should be further discussed. The problem of data gaps is one which can not be solved easily - in many countries there is far from complete monitoring coverage. If we are faced with data gaps, what is the minimum data set with which we can generate functional indicators? In such cases, can expert judgement be a supplement to real data?

Design - there was not a lot of time to consider the difficulties of design of the indicators. It seems likely that the design sequence should start with an analysis of processes of information provision and use for the particular context in which indicators are to be used. The terms of reference for design should begin with the recognition of the need to meet demands for information. The integration of cost and financial implications (e.g. health care) into indicator systems is important and will be of value in making balanced decisions. However, there does not seem to be much information on the costs of developing and operating indicator systems and although some users are aware of the need to evaluate effectiveness in communication, this is not expressed in cost terms.

WHO CONSULTATION ON DEVELOPMENT AND USE OF
ENVIRONMENTAL HEALTH INDICATORS
DUESSELDORF, 15-18 DECEMBER 1992

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CONSULTATION ON THE DEVELOPMENT AND USE OF ENVIRONMENTAL
HEALTH INDICATORS IN THE MANAGEMENT OF ENVIRONMENTAL
RISKS TO HUMAN HEALTH

Agenda
15-18 December 1992

1. Opening session

- Statements by representatives of GOG, WHO
- Nomination of officers
- Adoption of agenda

2. Presentations

2.1. Introduction to subject matter

P. Peterson - Overview: current status of development and use, major issues

General discussion of topic area

2.2. Research applications of various types of indicators

* R. Bertollini - Indicators: use for setting priorities for environmental epidemiological research

* U. Ewers & T. Eickmann - Biomarkers for environmental exposure to hydrocarbons and organochlorine compounds

H. Idel & E. Malin - Immunological biomarkers as environmental health indicators

* N. Englert - Reactions of the respiratory system as environmental health indicators

* G. McGranahan - Household surveys as tools for assessing urban environmental problems

n.n. - Biomarkers for environmental exposure to inorganic compounds

General discussion of topic area

2.3. Indicators as tools for environmental management and policy-setting

* N. Previsich - Policy development and the use of health and environment indicators

* M. Csicsaky - Environmental health indicators for risk management: case studies

+ P. Khanna - Environment - Health Interface Modelling: Case Studies

* A. Hasse - Role of biomarkers for environmental policy-making

* M. Krzyzanowski - Availability and use of selected environmental health indicators in Europe

* H. Ogawa - Efforts in the development of environmental indicators - WHO Western Pacific Regional Environmental Health Centre

* J. Songso - Environment and Health: the case of Greater Accra Metropolitan Area, Ghana

General discussion of topic area

2.4 *How to improve the validity and utility of indicators*

* P. Jacobi - Qualitative challenges in the development and use of environmental indicators with respect to health

* L. Laugeri - The limits of health information from water supply and sanitation statistics - proposals for improvement

* R. Stern - Geocoded environmental and health indicators for Europe: issues and scale for the region

General discussion of topic area

3. **General Discussion**

3.1. *State-of-the-art*

3.2. *Need for Improvements*

4. **Recommendations for future work**

- Short-term

- Long-term

5. **Résumé by Rapporteur**

6. **Closure of the meeting**

* Paper available upon request

+ Unable to present