Unesco-UNEP International Environmental Education Programme

Environmental Educational Series **8**

Environmental Education: Module for In-Service Training of Science Teachers and Supervisors for Secondary Schools

Division of Science, Technical and Vocational Education

P R E F A C E

A series of experimental modules for the pre-service and in-service training of primary-school teachers, secondary-school science and social studies teachers in environmental education has been prepared in the context of the Unesco-UNEP International Environmental Education Programme, and as a follow-up to the Tbilisi Conference Recommendations with respect to the training of teachers in environmental education.

This module focuses on the in-service training of science teachers and supervisors in environmental education for secondary schools. Its main objectives are to (a) foster the acquisition and transfer of knowledge, skills and affective attributes concerning the environment and its problems and (b) develop competence in the teaching and supervision of the environmental dimension of science in secondary schools. In this context, the module addresses itself to (a) historical and philosophical development of environmental education (b) essential knowledge about the environment and its problems (c) teaching methodologies, activities and experiments and evaluation in environmental education; (d) strategies for the implementation of an environmental dimension of secondary school science.

The module for In-service Training of Science Teachers and Supervisors in Environmental Education for Secondary Schools has been prepared under Unesco contract at the University of the Philippines, Science Education Center, Quezon City, Philippines (Leticia P. Cortes, Wulfilda P. Galvante, Violeta L. Rodriguez, Erlinda Y. Basa). In the process of the preparation, the detailed outline and the different drafts of the module were circulated for comments and critics to twenty professionals and institutions around the world. Also, the draft of this module and its local adaptation was studied by teacher educators at the Subregional Workshops on Teacher Training in Environmental Education, 3-16 March 1983 at the National Council of Educational Research and Training, New Delhi, India, and on 18-29 July 1983 at the School of Education, University of West Indies, Mona Jamaica. Unesco is appreciative of the contributions made which have been used towards the preparation of this version edited by Professor Willard J. Jacobson, Teachers College, Columbia University, New York City.

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I. INTRODUCTION

A. SCOPE OF THE MODULE

As an in-service training module, this material covers the many aspects of environmental education essential for secondary level instruction. The topics included are the history and development of environmental education; its philosophy and guiding principles; essential knowledge about the environment and its problems; appropriate instructional strategies; sample experiments and activities; evaluation of teaching and learning; implementation strategies for in-service programmes.

No claim is made to an exhaustive treatment of any of the topics. Perforce the material is selective and concise. Although the writers aim for universal applicability, they can only write with conviction on situations and events within their realm of experience and knowledge. For this reason this module tends to be partial to strategies and solutions potentially workable in developing countries. However, principles and concepts of ecology and environmental conservation and management hold true regardless of geographical location and economic status.

More pages are given to essential knowledge and instructional strategies and activities than to the other topics not only because of their innate breadth and depth but also because of their importance and usefulness to teachers and supervisors. Hopefully this module will provide sufficient material for teachers and supervisors to successfully integrate environmental education concepts into the secondary school science programme.

B. TARGET AUDIENCE

This module is primarily addressed to secondary school science teachers and supervisors who have had little or no orientation toward environmental education. Teachers and supervisors with foundations in resource conservation, ecology and environmental management will find the module a practical guide to the presentation of the environmental dimension of science to secondary level students.

The Tbilisi Conference rightly identified teachers as a key factor in the education of people to an awareness of the environment and its problems. The same conference also took cognizance of the inadequacy of existing teacher training programmes for the teaching of environmental education. This is the reason for this teacher training module.

Teacher behaviours do have an impact on student classroom behaviours (Penick and Shymansky, 1977). It is highly probable that teacher influence extends beyond the classroom. Therefore, it is implicit in activities aiming for changed student behaviours that teachers be the model of the desired behaviours by action or by word.

In-service training can be a means of developing these desired behaviours in teachers that will encourage similar student behaviours. As a study has shown, in-service workshops positively influence teacher attitudes, and hopefully, their behaviours (Butts and Raun, 1969).

C. IMPLEMENTATION REQUIREMENTS OF AN IN-SERVICE TRAINING WORKSHOP BASED ON THIS MODULE

The difference in environments and school systems preclude the prescription of specific implementation requirements. Each training center should devise its own requirements based on local environmental conditions and problems, available resources and the current national, regional and global issues. However, for a product-oriented training programme, the following requirements are suggested:

1. For Fulfillment By The Management (i.e. planners and coordinators) In Preparation For The Training Workshop:

a. Preparation of a course curriculum or a syllabus

The trainees must be informed right at the start what to expect to learn from the training programme. As is customary in course offerings and training programmes a course curriculum or syllabus is prepared to provide such information. A course curriculum sets the tone and the pace of work expected of trainees. The scope and depth of content and the kind and quantity of activities of the programme depend on the duration of the training, the interests of the people involved and the kind of environmental knowledge and problems the community would like their children to know about. A sample course curriculum for an intensive 180-hour (6 weeks) training programme is given in Appendix A.

b. Selection of trainees

What kinds of science supervisors and teachers may qualify for in-service training in environmental education? Anyone interested,... has at least two years of teaching experience,... has not attended school 10 years ago or longer and, therefore needs a refresher,... not older than 45 years or young enough to be open to new ideas? Whatever the criteria selected, they must be made to benefit the educational system both in the short and long run.

c. Preparation of schedule of activities

In the preparation of a day-to-day schedule of activities, consider the acceptability of the dates and duration of the training workshop to the trainees. A short intensive programme held over 5-10 days, or a one-day-a-week programme spread over several weeks? During school days after office hours, or on Saturdays only, or when school is on vacation? The deciding factor in scheduling in-service training is acceptability to trainees as the most opportune time for their learning.

The kind and quantity of available learning resources partly determine the activities for scheduling. The management should make an informal survey of human and physical resources that may be tapped for the training workshop.

An evaluation scheme should be carefully planned from the outset and worked into the schedule of activities. All evaluation materials for use in the workshop should be ready before the workshop begins.

d. Preparation of a budget

The preparation of a budget and the availability of corresponding funds may spell the difference between success and failure of a training workshop. Every activity, facility, personnel and material that will entail some cost should be anticipated and included in the budget.

The preparation of the budget does not end in the planning. Approval by the proper authorities must be sought, and release for use when needed be assured before the budget can truly be ready.

e. Other management activities in preparation for the training workshop:

Seek the support of the political and educational leaders on the implementation site.

Adopt a theme for the in-service training workshop focusing on one or two environmental problems.

Tap local expertise both in the planning and the implementation of the training workshop.

Obtain evaluation of the in-service training workshop from various sources - interested educators, trainers and trainees.

2. For Fulfillment By The Trainees

a. Active participation in small and large group discussions. The gains for the trainee are in the form of sharing of ideas and information, observation of the reaction of people to issues and problems, and the exercise in the articulation and communication of ideas and reactions. The trainee who participates more, gains more.

b. Production of a lesson plan or design of an activity. A lesson plan dealing with one environmental issue, problem or concept may be required of each trainee. The lesson plan should use at least one teaching strategy discussed in this module. Alternatively the design of an activity that will engage students in dealing with a local environmental issue or problem may be required. The write-up of the activity should include objectives, detailed procedures, student tasks, equipment and facilities needed.

c. Production of an evaluation instrument. The trainee may also be required to submit a 1 to 2 page evaluation instrument to assess student learning in terms of knowledge, attitude or interest, or student/teacher reaction or opinion, or instruction and class management of environmental education which the trainee can use when he starts implementing the environmental education programme. The evaluation sheets should be accompanied by a description of how the data obtained from the instrument shall be collated for the purpose of writing an evaluation report.

II. OBJECTIVES OF THE IN-SERVICE TRAINING OF SCIENCE TEACHERS/SUPERVISORS IN ENVIRONMENTAL EDUCATION

A. GENERAL OBJECTIVE:

To develop competence in the supervision/teaching of the environmental dimension of science in the secondary school.

B. SPECIFIC OBJECTIVES:

Through the use of this module, the trainees are expected to:

1. Increase their environmental awareness, sensitivity to and consciousness of the environment and its problems, particularly the local environment and the changes ocurring therein.

2. Develop an awareness and appreciation of the need, importance, goals and objectives, and guiding principles of environmental education.

3. Acquire essential knowledge about the environment and its problems, particularly those relating to the local environment.

4. Develop and nurture an understanding of the fundamental environmental concepts and their science content, and vice versa, of science concepts and their environmental dimension.

5. Realize that the totality of the environment is a fundamental base for interdisciplinarity among school subjects.

6. Develop competence in the use of methodologies most appropriate to the teaching of the environmental dimension of secondary school science, and, in particular, the problem-solving method.

7. Develop skills in designing and using activities and experiments essential to and motivating for the learning and teaching of the environmental dimension of secondary school science.

8. Acquire competence in the development of lesson plans and the preparation of teaching aids on environmentally oriented science in the secondary schools.

9. Competently develop and use evaluation techniques and methodologies to assess the learning of students, the effectiveness of instruction, and the value of the training programme.

10. Learn alternative strategies for planning, development, implementation, management and evaluation of curricula in environmental education.

III. THE HISTORY AND PHILOSOPHY OF ENVIRONMENTAL EDUCATION

A. NATURE STUDY AS AN EARLY EXPRESSION OF INTEREST IN THE NATURAL ENVIRONMENT

Natural environments have been destroyed in the past and subsequently have recovered on their own. For instance, about 50 years after the volcanic island, Krakatoa, blew off its top in a violent eruption, it was forested again. Soil in forest clearings, left unattended after it had been worked and planted and rendered infertile, was found to recover after about 20 years.

A few years back man was very much a creature of nature, dependent on its generosity for his living, and in fear of its power - to create storms, to explode volcanoes, or to let through or withdraw the heat and light of the sun. He had to know more about nature to obtain more of its munificence or to protect himself from its vagaries. His observations and the inferences he made from them made it possible for him to cultivate crops more regularly, domesticate animals, construct a shelter strong enough to withstand the elements. Some men made the study of natural phenomena their main preoccupation. They were the natural philosophers. Every nation had its own philosophers of nature who interpreted the observed phenomena to the people.

B. THE DEVELOPMENT OF DISCIPLINES

In time so much knowledge about nature was accumulated that a single person had difficulty studying all of its different phenomena and to be able to contribute further to knowledge. Philosophers of nature began to specialize in specific subject areas. Science, the systematic study of nature, branched into many fields of specialization - the physical-biological sciences such as, botany, zoology, physics, and chemistry, and the social sciences such as sociology, anthropology, and psychology.

Technology, the application of scientific knowledge, was changing the natural environment into the built environment to make life easier. Only to reveal much later that the change always entailed some cost - in terms of destruction, pollution, and extreme deprivation of some basic elements of the quality of life. The study of nature through separate disciplines has not given us a global view of its effects on nature. Let us now survey the changes technology has wrought.

C. THE EFFECTS OF SCIENCE AND TECHNOLOGY

It is not difficult to see how advances in technology have accelerated the destruction of environments. Mountains were detonated and leveled, and sea bottoms scraped and drilled to yield minerals and fossil fuels. Agricultural lands were tilled faster by tractors and fertilized to yield several times the old harvest. More efficient fishing gear caught boatloads of fish only to deplete the source. Smooth roads were constructed to open up inaccessible areas. This allowed the movement of vehicles and the transfer of goods and people but reduced the amount of land that could be made productive.

In our zeal in using the new-found technology we exploited more than rehabilitated the natural environment. We forgot that our rate of developing and using resources was destroying nature faster than it could recover. We overlooked the rights of future generations to the nonrenewable resources that we used up. We failed to see that the waste materials released by technological processing could build up to toxic levels. And the sad fact was that the world's science and technology had not equally developed and enriched all nations. The 1960's and 1970's was our period of awakening. This awakening found expression on an international scale in the Stockholm Conference on the Human Environment in 1972.

D. THE STOCKHOLM CONFERENCE ON THE HUMAN ENVIRONMENT

1. Global Environmental Concern

In 1968 the Swedish delegation to the United Nations called the attention of the international community to the growing crises in the human environment. This was not the first voice of concern but it served as the first formal call for a global approach to the search for solutions to the worsening problems concerning the environment.

The more highly-industrialized countries were increasingly being confronted with the undesirable environmental impacts of technology and economic activity such as polluted air and water, degraded urban and rural conditions, noise and congestion. They were concerned about environmental deterioration and the consequent threats to their health and well being.

The awakening of the industrialized countries to the environmental problems and the "no growth" policy some of them advocated were eyed with suspicion by the developing countries convinced as they were that rapid industrialization and technological innovations would lead to affluence and the relief of poverty for their growing millions. The developing nations accused the developed nations of using environmental concern as an excuse to prevent the development of the Third World and thus maintain their own economic superiority. The poorer nations were also beginning to realize that the luxurious-living, "throw-away" societies of the developed countries comprising one third of the world's population, yet consuming two thirds of the world's resources, might damage beyond recovery the oceans, the land and the atmosphere, that is, the environment of life. The developed nations, on the other hand, were worried by the great number of people in the developing countries and their high birth rates. These numbers, if unchecked could strain the world's life support systems tremendously to an irreversible point of imbalance.

The position of the developing nations as regards environmental concern being in conflict with commitment to development was understandable. The early perceptions of environmental problems were distorted by the experiences of the industrialized countries.

Thus, concern with depletion of energy for running industries, endangered wildlife, air, water and noise pollution, and solid waste disposal took precedence over concern for famine, soil erosion, diseases and sanitation. Moreover, the usual approach to problems of affluence was reduction rather than prevention. For example, pollution abatement and changes in production technology were generally offered as answers to many environmental problems. Taxes, subsidies and legislation were advocated as ways of cushioning the impacts of industrial pollution and environmental destruction. The developing countries feared that this would raise the prices of equipment and goods they purchase from the developed countries. This would have serious economic repercussions for the developing countries trying to get a foothold in the world trade. It would be an injustice for nations creating most of the earth's degradation to expect poor nations to pay the cost of the earth's recovery.

It slowly became obvious that the environmental problems of the industrialized countries are different from those of the developing countries. While the industrialized countries suffer from pollution due to affluence, the developing countries face pollution due to poverty. How could the developing countries be concerned with the "deterioration of the quality of life" when life itself is endangered by famine, diseases, malnutrition, lack of water, squalid housing conditions and natural disasters? These problems brought about by "under development" may be viewed by the developed nations as "traditional problems"; but as far as developing nations are concerned these are "environmental problems." The widening scope of environmental concern, from being merely pollution abatement and conservation of wildlife to one which includes social justice and land reform led to the breakdown of hostility of the developing countries and the growth of their interest and enthusiasm.

It took four years of groundwork to hold the First United Nation's Conference On The Human Environment at Stockholm in June 1972. The Stockholm Conference captured a concern of world-wide appeal, and from it emerged a great deal of environmental activity.

2. Declaration On The Human Environment

Among the accomplishments of the Stockholm Conference is the adoption of the Declaration on the Human Environment (See Appendix B) which sets out guidelines for environmental behaviour of individuals and states. It is the first joint statement by 113 countries of their concerns and convictions as regards the problems of the human environment. The Stockholm Declaration states that Man, as both environment dependent and moulder of his environment, is responsible for:

a. the improvement of the quality of human life,

b. the protection, management and wise use of the earth's resources so that they may be shared by all mankind - not only of the present generation but of future generations,

c. the prevention, abatement or treatment of pollution and destruction of the environment,

d. the education of people of all ages on environmental conservation and ecological balance,

e. the promotion of scientific research that leads to the solution of environmental problems,

f. the reorganization and redirection of social institutions to secure national and international cooperation toward eliminating or minimizing the adverse environmental effects of human activities, and

g. the maintenance of peace and harmonious relationships between nations through fair dealing, sharing, and disarmament.

3. Action Plan

The Stockholm Conference also approved a wide-ranging Action Plan as the immediate environmental work programme for the international community. The Action Plan focused on: a. human settlement management, b. natural resource management, c. pollution, d. educational, informational, social, and cultural aspects, and e. development and its effects on the environment, and the measures to relieve poverty, malnutrition, disease and illiteracy yet avoiding or minimizing destruction and pollution of the environment.

Over a hundred specific recommendations for action at the international level are embodied in the Action Plan. These may be grouped according to function:

a. Environmental assessment; code-named Earthwatch, was organized to identify and measure international environmental problems and to warn against impending crises. More specifically, the functions of Earthwatch are: evaluation and review - to provide analysis to identify the gaps in knowledge and action, and to determine important short- and long-term environmental trends; research - to provide new information, or new interpretations of old information, leading to a better understanding of environmental problems; monitoring - to gather data on specific environmental variables in a continuous and systematic fashion for evaluation and research; information exchange - to provide data to the scientific and technological communities and so ensure that decision-makers at all levels have the benefit of the best and most recent information available at the appropriate time and in the most usable form.

b. Environmental management refers to the management of the actions taken toward prevention; conservation or restoration of the environment as indicated by Earthwatch. Examples are the improvement of water supply and sewerage systems; the preservation of the world's genetic resources for future generations, and the curtailment of emissions into the atmosphere and hydrosphere of chlorinated hydrocarbons and heavy metals.

c. Supporting measures to facilitate the implementation of the Action Plan can be classified into three categories: education, training and public information to enable people to weigh decisions which shape their future and for them to assume a greater responsibility in environmental conservation and care, organizational arrangements for close working relationships of governmental and non-governmental agencies; financial and other assistance with the establishment of the Environment Fund with contributions from member nations to support the various activities outlined in the Action Plan.

The Stockholm Conference emphasized the urgency of the need for reordering man's priorities - that deep and pervasive changes are necessary in the way man looks at his world, at his role in nature, and at his relations with other men. The Conference also endorsed the premise that environmental concerns need not and should not present obstacles to development. On the contrary, they should be complementary and mutually reinforcing. Stockholm marked the beginning of a new phase in thinking and action on the issue of the environment.

The Stockholm Conference recognized the role of education in bringing environmental matters to the awareness and understanding of the general public. Formal education is one way of reaching a large slice of the human population. No nation can justifiably ignore the need to make deliberate efforts to bring environmental concerns to the school population. For the successful performance of the role of education, the Conference recommended the training of teachers and the development and testing of new instructional materials and methods in environmental education. Many teachers, however, shudder at the thought of teaching topics for which they have had little or no training. And for that matter, so do supervisors in helping teachers. What is urgently needed is in-service training of teachers and supervisors in environmental education.

E. THE INTERGOVERNMENTAL CONFERENCE ON ENVIRONMENTAL EDUCATION

1. The Declaration and Recommendations on Environmental Education

As indicated earlier, the Intergovernmental Conference on Environmental Education was convened by Unesco in cooperation with UNEP in Tbilisi, USSR, 1977 as a culminating activity of Phase I of the Unesco-UNEP International Environmental Education Programme (IEEP). Its most important output is the Declaration (see Appendix C) and 41 Recommendations on Environmental Education.

The Recommendations focus on two main topics: the role, objectives and guiding principles of environmental education; and strategies for the development of environmental education at the national level.

Among the development strategies recommended are those that seek to answer the most pressing needs of environmental teaching especially at the lower school level, namely: the training of personnel, the development of teaching/learning materials, the need for educational research, data monitoring and information dissemination.

2. The Role of Education

Time is of the essence. Every minute some part of the environment is needlessly and heedlessly being degraded. What can education do in the global movement to protect the environment? What is its role in environmental conservation?

The Tbilisi recommendations revolve around a few main roles education may assume:

a. as guide and facilitator of the development in individuals and communities of awareness and responsibility for the environment;

b. as promoter of peace, mutual understanding, solidarity and equity among social classes, different cultures, and nations by espousing a new ethics based on respect for people and their dignity, their needs and their rights;

c. as a proving ground for the development and try-out of processes for solving environmental problems;

d. as a center for information processing and dissemination of environmental matters;

e. as a field of action for initiating preventive and remedial measures toward the improvement of the quality of human life and the environment.

First and foremost, environmental education aims to develop active and well-informed individuals who are aware of their environment and their responsibilities in protecting and conserving that environment. To achieve this aim, education must develop in all individuals an understanding of the interactions and interdependence of the physical, biological, social, economic and cultural aspects of the environment, and of the complex relations between socio-economic development and improvement of the environment. Through education, social groups and individuals should be able to acquire a set of values and feelings of concern for the environment, and the motivation for actively participating in environmental improvement and protection. In addition, individuals and communities must develop skills for identifying and solving environmental problems.

Not isolated efforts but interwoven with the development of awareness and responsibilities is the development of a new ethics of relationship between man and man, and man and his environment, and between nations. Such relationships must be guided by social justice and honest concern for humanity and should result in the eradication of poverty, illiteracy, diseases, malnutrition, and the elimination of the manipulation and exploitation of the naive and the less fortunate. Hopefully the new ethics would strengthen peace, forge international understanding, and lead to disarmament.

Environmental education for professionals and experts is mainly a reorientation toward environmental concerns. It may well result in the development and testing of new ways of solving problems, in the processing and dissemination of information on environmental matters, and in high level participation in preventive and remedial measures toward the environmental enhancement. All professional fields, all occupational categories, all socio-economic classes benefiting from an environmental orientation can bring their particular knowledge, skills and insights to bear on solutions to environmental problems. This is interdisciplinarity in action.

3. Training of Personnel

The Tbilisi conference deplored the inadequate environmental education background of professional groups which has led to their inability to perceive the multifaceted character of environmental problems. Training of personnel came out in a survey (Unesco/Enved 6, 1977) as the greatest need of environmental education on a world-wide scale. It was, therefore, considered vital to include environmental education in the pre-service and in-service training programmes of professional groups whose activities and decisions have an impact on the environment.

Teachers in formal education, organizers of non-formal education, administrative personnel, educational planners and researchers also need training in environmental education to familiarize them with the subject matter and the educational and methodological guidelines in environmental education. Environmental sciences and environmental education courses should be included in the pre-service teacher education curriculum. In-service environmental training is recommended for all teachers, of any field of specialization, who have not had such training before. The in-service training programme should take into account the environmental conditions in the area of work of the teachers.

Professionals, apprentices, and technicians must also be trained in environmental awareness because directly or indirectly their work have a great effect on the environment. Decision makers, development planners, engineers, designers, architects, townplanners, and those in the health, legal, and economic professions should also undergo training in environmental education to develop environmental awareness and skills needed in their work. Lack of such training may result in ecological repercussions because their work involves the transformation of the physical environment particularly through urbanization and industrialization.

4. Developing Instructional Programmes And Materials

The Unesco-UNEP IEEP's survey on needs and priorities of environmental education (Unesco/Enved 6, 1977) placed the preparation of instructional materials and the development of educational programmes as the second and third greatest needs, respectively. The consensus in the Tbilisi Conference was that environmental education is effective if adequate materials, teaching aids and programmes are available. Attention was focused on bridging the gap between demand and availability.

The Conference recommended the following for consideration in the development of programmes, learning materials and teaching aids:

a. Develop low-cost learning materials and teaching aids to make them more available to all students.

b. Draw from existing documents and recent research findings for content and methodologies.

c. Teachers and learners should be involved in the preparation of materials and programmes.

d. Choose content and methodologies that are relevant to students' needs and interests.

e. Programmes and materials should relate to the particular environment of the students (e.g. urban, rural, industrial, commerce and financing, etc.).

f. Give emphasis to ecological concepts and processes in environmental systems such as the atmosphere, lithosphere, forests, oceans, grasslands, etc.

g. Consider the historical and cultural backgrounds of the people who will use the materials.

h. Orientation is preferably on the problem-solving and action approaches.

i. Preparation by an interdisciplinary team.

j. Use real environments, e.g. zoological and botanical garden, park, museum, factory, commercial center, woods, grassland area, as locales for field study.

k. Employ different strategies and techniques of teaching.

l. Employ various kinds of teaching aids and media.

5. Research In Environmental Education

A national environmental education programme should be based not only on experience but also research. Many times in the past, beliefs that we hold dear had been negated by researches. If some of these beliefs are confirmed, all the more reason for furthering research.

The Conference recommends educational researches on:

a. The development and modification of concepts, values and attitudes held by individuals which are involved in environmental behaviour; b. the conditions which foster the development of environmental education such as curricular content, teaching methods, and learning environments; c. educatonal evaluation modalities and tools useful in environmental education; and d. the use of mass media and audio-visual materials in environmental education.

F. THE PHILOSOPHY OF ENVIRONMENTAL EDUCATION

From an amalgamation of observations, concerns, motivations, strategies and societal goals threshed out in conferences and workshops, a set of premises for environmental education has emerged. As expected these premises have both environmental and educational dimensions. These premises are:

1. The rate of social and cultural evolution is faster than the rate of biological evolution. Therefore, biological evolution cannot cope with the environmental imbalances brought about by socio-cultural evolution.

2. Environmental problems are often complex and require the expertise of various disciplines for their solution. To learn about the environment in the natural setting likewise requires an interdisciplinary approach.

3. Environmental problems should be seen, first, in their local context for the individual to see their relevance to him, and second, in their global context to impress on the individual their magnitude and pervasiveness.

4. The human population, more than any other living species, has wrought damage to the environment and, therefore, it should be held responsible for corrective actions that will hasten the recovery of damaged environments and prevent the destruction of others.

5. The welfare and continuing existence of humankind on the earth depends on the values people have concerning: a. regard and consideration for others, particularly the less fortunate; b. care and protection of humanity's resources; c. strong drive to actions that serve humanity as a whole and improve the environment.

6. The behaviour of people to their natural and built environments is the overt expression of their values and attitudes and their understandings and skills.

7. A harmonious ethical relationship of man to his environment, having environmental conservation and enhancement as its theme, can be developed from early childhood onwards through formal and nonformal education.

G. <u>THE FOLLOWING GUIDING PRINCIPLES OF ENVIRONMENTAL EDUCATION ARE DERIVED FROM THE FOREGOING PREMISES</u>:

1. The environment should be viewed in its totality, blurring political, cultural and physical boundaries since each part affects another.

2. An interdisciplinary approach best fits the study of the environment and its interacting and interdependent parts.

3. Environmental education should be a lifelong process, both in-school and out-of-school.

4. Environmental education programmes should develop in each individual an ethics or code of behaviour that leads him to: a. work for the development and utilization of natural resources with the least destruction and pollution; b. seek the improvement of the quality of life for everyone by eradicating poverty, hunger, illiteracy, human exploitation and domination; c. reject the development and economic growth of a nation that may lead to the collapse and debasement of another nation, and the lavish consumption of a few to the deprivation of many; d. utilize technology not only for self gains and a life of luxury in the short term but also for the economic stability and survival of humankind in the long term; e. consider in his consumption of nonrenewable resources the needs of future generations.

5. Since values and attitudes lie at the core of a person's ethical behaviour, environmental education should go beyond cognition

(i.e. awareness and comprehension) and into valuation and attitudinal formation.

6. Environmental education should begin with the local, current and most relevant environmental situations and issues and should move on to issues and situations that are national, regional and global in scope. The focus should be on enduring and never-ending processes, and the concepts, principles and values that are of general applicability.

7. Experiencing, through participation in real and simulated environmental situations, make for greater impact and, therefore, more lasting learning of environmental concepts and values. In the pedagogic sense, local environmental problems are a good starting point for learning environmental attitudes and values.

H. THE GOAL AND OBJECTIVES OF ENVIRONMENTAL EDUCATION

1. Implicit in the Guiding Principles of Environmental Education is its goal which may be stated as follows: to develop in each person an awareness and understanding of the processes and interrelationships in the natural and built environments so that he internalizes values, attitudes, motivations and commitments to environmental protection and conservation leading him to take action toward the solution of environmental problems and the enhancement of the quality of life.

2. Objectives of Environmental Education

More explicitly environmental education aims to develop in each individual: a. a sensitivity to events and changes in the physical, biological, social, economic and political aspects of the environment, and a concern about the problems emerging from them; b. a sincere desire to correct human problems such as poverty, hunger, illiteracy, and social injustice; c. the ability to identify and delineate environmental problems; d. the skill to devise methods and means of solving environmental problems.

From these premises, guiding principles and goals, a philosophy of environmental education may be succinctly stated as follows: For humankind to survive and improve its quality of life, it is absolutely necessary for everyone to become aware of and understand humanity's relation to the environment, develop values and attitudes of conservation and social justice, and act, alone or in groups, in such ways as to correct or prevent environmental problems. Environmental education is a deliberate effort to accomplish this globally for all ages through the formal and nonformal systems by utilizing the knowledges and methodologies of all disciplines.

I. SCIENCE AND ENVIRONMENTAL EDUCATION

It may be recalled that from the outset this environmental education module is intended for science supervisors and teachers in the secondary school. The implication is that science supervisors and teachers shall be trained for teaching environmental education concepts and values through the sciences. One is constrained to ask:

Why a single discipline such as science to teach environmental education concepts and values? Does this mean a breakdown of the interdisciplinarity of environmental education?

To resolve this dilemma, one has to look at the existing structure of the secondary school curriculum. Most secondary school curricula, the world over, are divided into subject areas, one of which is science. To add an interdisciplinary environmental education course will tend to crowd the curriculum and result in duplications. To restructure the curriculum in order to establish an interdisciplinary environmental education as the core will take too long in the planning and will be too unsettling to reasonably expect fast results. Using science and other subject areas to carry environmental education concepts, values and attitudes is one way of bringing environmental education into the secondary school without unduly burdening or upsetting the existing curriculum.

Perhaps there is more than just one interpretation of interdisciplinarity as applied to the secondary school. The term 'interdisciplinary' is commonly used to describe a course in which students learn to deal with a problem, or a concept, skill or value by using the knowledge and methods of many disciplines. It is not also interdisciplinary if the learning is done in several courses within the same year - each course using the knowledges and methods of its own particular discipline and each one linking with the others? It is this second interpretation of interdisciplinarity that is applied when science is used as the matrix for teaching environmental education concepts, skills and values.

To teach the environmental dimension of science is to benefit both science education and environmental education. Broudy (1973), in considering the problem of decreasing enrolment of college students in science in American Universities, speculates on the isolation of science from social events as the possible cause. He suggests the teaching of science as an aspect of social problems to ensure its relevance to pupil concerns. Extrapolating from Broudy's statement, we maintain that science be taught as an aspect of environmental problems. Social problems are a part of environmental problems. And environmental problems are social concerns. To tie up environmental teachings with science appears to be a fitting answer to Broudy's stand on the need for the social relevance of science.

On the other side of the coin, there is no question that environmental education is enriched by science education. A scientific understanding of natural processes and interactions between the natural and the built environments leads to better ways of handling unforeseen effects. The processes of science, particularly logical reasoning, reduce guesswork in finding solutions to environmental problems. To be sure, science is only one of the many subjects in the secondary school which easily lend themselves to developing awareness and understanding of the environment.

J. IN-SERVICE TRAINING: A VENUE OF ENVIRONMENTAL EDUCATION

The benefits derived from in-service training of teachers hopefully do not end at the teacher level but filter all the way to the students. It was shown in an experimental study (Hounshell and Liggett, 1976) that in-service training of teachers in environmental education supplemented by classroom follow-up results in a significant gain both in students' knowledge and their positive attitudes about the environment and in man's role in it. In-service workshops positively influence teachers' attitudes toward the subject (Butts and Raun, 1969). Applying Hounshell and Liggetts' finding, it can be said that the students of these in-service trained teachers in environmental education will tend to develop positive attitudes toward the subject.

IV. ESSENTIAL KNOWLEDGE ABOUT THE ENVIRONMENT

This part of the module is prepared with a view to helping teachers and supervisors acquire essential knowledge about the environment and its problems. An understanding of basic concepts about the environment will aid in developing an appreciation not only of the problems facing conservationists and environmentalists but also the policies, strategies, and regulations by which these problems might be resolved.

A. STRUCTURE AND FUNCTION OF AN ECOSYSTEM

When a person surveys his surroundings, he sees a landscape that is a "mosaic of topographical and vegetational patterns" (Smith, 1966). There are mountains, plains, grasslands, forests, rivers, lakes, and seas. A closer look into these parts of the landscape reveals similarities and differences in their characteristics and the life forms they support.

A mountain, and the plants and the animals it supports including the microorganisms is an ecosystem. A grassland and its plants, animals and microorganisms is an ecosystem. An environment and its non-living parts consisting of the space and the physical-chemical components and its living parts consisting of plants, animals, and microbes comprise an ecological system, or ecosystem.

An ecosystem can be studied through its structure and function (Odum, 1971). By structure is meant: (a) the kinds, numbers, and distribution of plants and animals, and (b) the kinds, quantity, and distribution of abiotic components such as oxygen, carbon dioxide, water, heat, nitrates, sunlight, etc. By function is meant: (a) the volume and rate at which various elements such as carbon, nitrogen, phosphorus, etc. circulate through the ecosystem, (b) the quantitiy and rate of energy flow through the ecosystem, (c) the processes by which living organisms change the abiotic environment, (d) the processes by which the abiotic environment affects living organisms, and (e) the events which regulate population levels of organisms (Owen, 1980).

The biotic (living) components are made up of two groups: the autotrophs or producers and the heterotrophs or consumers. The autotrophs are mainly green plants which fix the energy from the sun into their cells to manufacture food from simple inorganic substances. The heterotrophs can be subdivided into the macroconsumers or phagotrophs, chiefly animals which ingest other organisms or particulate organic matter, and the microconsumer or decomposers or reducers, chiefly bacteria and fungi which breakdown the complex compounds of dead organic matter, utilize part of it, and in so doing release some of the simple substances back into the ecosystem.

Energy flows and materials exchanges constantly occur between the living and the non-living components of an ecosystem. An ecosystem functions through these two major processes. Elements and compounds such as nitrogen, oxygen, carbon dioxide, and water are involved in materials cycles. Organic compounds such as proteins, carbohydrates, humic substances, etc. i.e. the by-products of organism activity, also go into cycles. Physical factors such as soil, solar radiation with its concomitants of light and heat, moisutre, winds, tides, and currents are involved in the cycles. The major source of energy that drives the ecosystem to function is the sun. Although small in proportion to the sun's energy, the heat from the earth's interior also contributes to the energy flow in the earth ecosystem.

1. Types of Ecosystem

There are two major types of ecosystems - terrestrial and aquatic. The terrestrial ecosystems are the grassland, forest, desert and tundra. the aquatic types are freshwater, estuarine and marine ecosystems. The terrestrial ecosystems are classified on the basis of the predominant type of vegetation. The aquatic ecosystems are differentiated on the basis of a chemical property, that is, salt content. Freshwater (very low salt content) ecosystems include lakes, ponds, streams and rivers. The oceans and the seas are marine (high salt content) ecosystems. Coastal bays, river mouths and tidal marshes where freshwater mixes with salt water are estuarine.

The terrestrial ecosystems are often referred to as biomes (Kormondy, 1976). Biomes of the same type are usually found within the same range of latitudes. On tall mountains, as the Andes, Himalayas and the Rockies, the distribution of biome-types is determined more by elevation than latitude.

Latitude plays an important role in determining the type of ecosystem since the amount of solar radiation received, and the temperature developed, depend on it. Latitude also affects wind patterns which strongly influence precipitation patterns. Temperature and precipitation, the main factors of climate, greatly influence the vegetation of a particular place. In addition to climate and vegetation, the type of soil is also a major regulatory factor in the distribution of biomes. Soil and vegetation develop in parallel, influencing each other, and being influenced by climate. Their interactions result in a condition which is characteristic of a specific type of ecosystem. Therefore, depending on its latitudes, a forest ecosystem may be boreal coniferous, temperate deciduous, or tropical rain forest.

Our interests may not always concern the major types of ecocystems. There are lesser ecosystems such as a fallen log harbouring organisms beneath it or an aquarium, or a pool. So long as the basic assemblage of abiotic and biotic components are interacting with each other leading to definite energy flow and materials cycling, regardless of its size, the unit is an ecological system or ecosystem. At the opposite extreme in size is the earth ecosystem consisting of the whole earth and all the organisms in it.

2. Habitat and Ecological Niche

In understanding structure and function of ecosystem, it is important to differentiate between habitat and niche. Generally, habitat refers to the place where an organism lives and all things found in it, both living and non-living. Thus the habitat of a particular organism is the place one would go to find it. For example, you go to a pond to look for frogs and dig into the soil for earthworms. Habitat also refers to the place occupied by an entire community (all the different kinds of living things in the area) e.g. all the plants, animals, microorganisms in a particular pond form a community and the pond is the habitat of this community. The habitat of an organism or group of organisms (population), on the other hand, includes the other organisms in the same area as well as their physico-chemical environment. The ecological niche of an organism refers both to the physical space it occupies and its functional role in the community. It includes what the organism does, e.g. how it transforms energy, behaves, responds to and modifies its physical and biotic environment. Odum's analogy (1971) distinguishes one from the other as follows: habitat is the organism's "address", the niche is its "profession" or "occupation".

3. Concept of Limiting Factors

The idea of limiting factors was first expressed in 1840 by the German organic chemist, Justus von Liebig. He was concerned with the effect of various factors on the growth of plants. He found out the crop yield was often limited by the nutrients, usually the trace elements in the soil, rather than those that are demanded in large quantities such as water and carbon dioxide. He stated that the growth of a plant is limited by the amount of nutrients given to it in short supply. This later came to be known as the law of the minimum. Other investigations led to the conclusion that other environmental factors such as soil, temperature, moisture, and the time element, also limit the growth of both plants and animals. Organisms are impaired by an insufficiency or absence of the nutrients and conditions needed in very small quantities for the sustenance of life.

Later studies on environmental influences on plants and animals showed that not only too little but also too much of a substance or condition affects the presence or success of an organism, and the eventual development of an ecosystem. Organisms are found to live within a range between too much and too little, the limits of tolerance. V.E. Shelford's law of tolerance recognizes that maximum and minimum substances or conditions limit the presence or success of organisms (Smith, 1966). Organisms may have a wide range of tolerance for one factor and a narrow range for another. Hence, organisms that exhibit a wide range of tolerance for many environmental influences would be widely distributed. In some cases, one condition that is not optimum for the organisms limits its tolerance for other conditions. For example, Odum (1971) cites Pennen's study that when soil nitrogen is limiting, the resistance of grass to drought is reduced. In other words, grass in low nitrogen soils require more water than those in soils with high nitrogen content. Some organisms, on the other hand, utilize one item that is abundant as a substitute for a deficient one. Some plants, for instance, respond to sodium when potassium is in low supply (Smith, 1966).

Odum combines the concept of the minimum and the limits of tolerance to arrive at a more general and useful concept of limiting factors. He says organisms are controlled in nature by (a) the quantity and variability of available materials for which there are minimum requirements and critical physical factors and (b) the limits of tolerance of the organisms themselves to these and other components of the environment.

B. ENERGY FLOW IN THE ABIOTIC COMPONENT OF THE EARTH ECOSYSTEM

Radiant energy in the form of sunlight is the ultimate and only significant source of energy for any ecosystem (Komondy, 1976). It is important to consider how much and what kinds of radiant energy reach the earth's surface as they largely determine the conditions that govern life.

1. The Earth's Ultimate Source of Energy

Only a small portion of the sun's tremendous energy output reaches the top of the earth's atmosphere. This is received by the earth at a fairly constant rate. The solar constant is the amount of radiant energy received at the top of the atmosphere and has an estimated value of 2 calories per square centimeter per minute (2 cal/cm^2 /min). This is the average value over the whole globe for the whole year. The amount of solar radiation received will vary slightly depending on the activity of the sun.

The solar radiation reaching the top of the earth's atmosphere consists of a range of wavelengths, from high frequency shortwave gamma rays and X-ray to low frequency long radiowaves. Not all of this radiation reaches the surface of the earth. Atmospheric gases absorb some of it.

Wavelengths may be measured in microns (μ). A micron is one millionth of a meter. The gamma rays of solar radiation, less than 0.12 microns in wavelength, are mostly absorbed by oxygen and nitrogen at an altitude above 100 km. Some gamma rays and X-rays with wavelengths bewteen 0.12 and 0.18 microns are mostly absorbed by oxygen above an altitude of 50 km. Those with wavelengths between 0.18 and 0.30 microns consisting mostly of ultraviolet rays are absorbed by ozone at altitudes above 20-50 km. Wavelengths of 0.30 - 0.34 microns are partly absorbed by ozone. The light waves of 0.34 to 0.71 microns reach the earth almost undiminished.

Some of the incoming radiation not absorbed by atmospheric gases is scattered. Some of the scattered radiation returns to space as diffuse reflected radiation and some reaches the ground as diffuse solar radiation. Still other radiation succeeds in penetrating the top layers of the atmosphere but is still reflected back to space.

Averaged around the year and the globe, the amount of energy that penetrates to the earth's surface is about half of what strikes the top of the atmosphere. Figure 1 shows what happens to the solar radiation that is received at the top of the atmosphere.

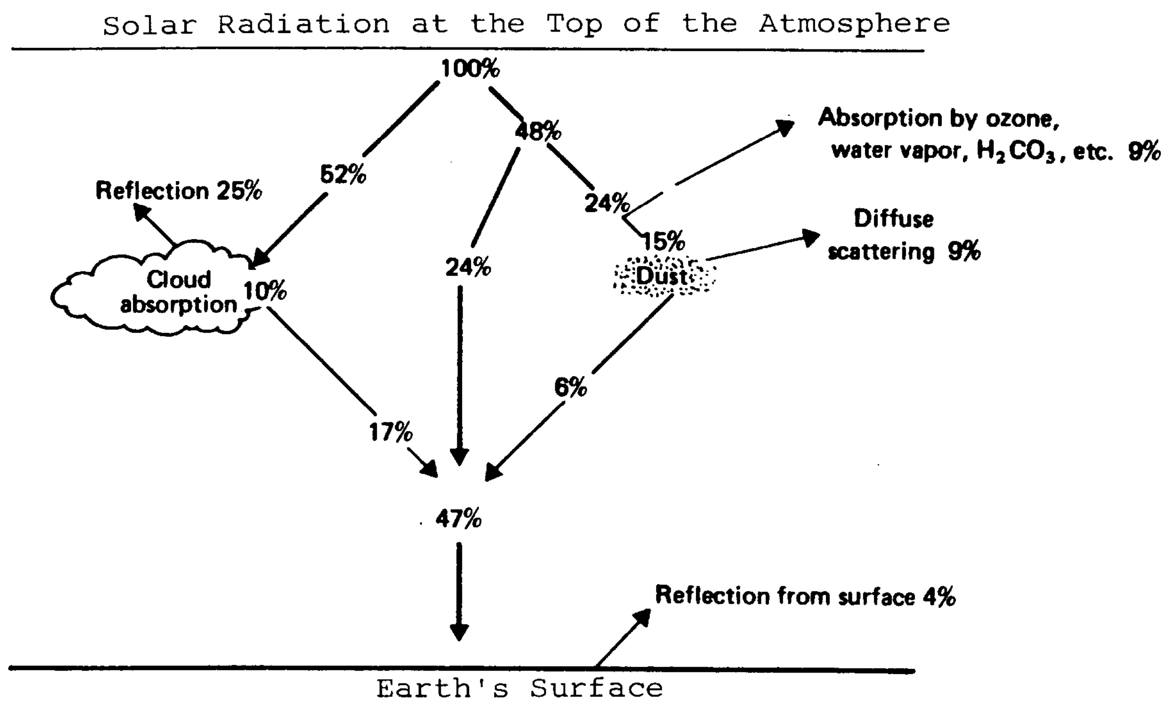

Figure 1. The Fate of Incoming Solar Radiation

2. Factors Affecting Energy Flow in the Earth Ecosystem

So far what has been discussed are global annual averages of energy flow. There are factors, however, that affect the flow of energy and cause it to vary with time and with latitudinal location.

These are the earth's spherical shape, the earth's revolution around the sun in an elliptical orbit, the earth's rotation on an axis tilted 23.5° from the perpendicular to the plane of its orbit.

Due to the earth's spherical shape, not all places on its surface receive vertical rays of the sun. Some places receive slanting rays (Figure 2). The maximum solar radiation is received at a place when the sun is directly overhead and, therefore, its rays are vertical. Decreasing values of solar radiation are received as one moves away from this point on the surface of the sphere (e.g., towards B) and the sun's rays become more slanting.

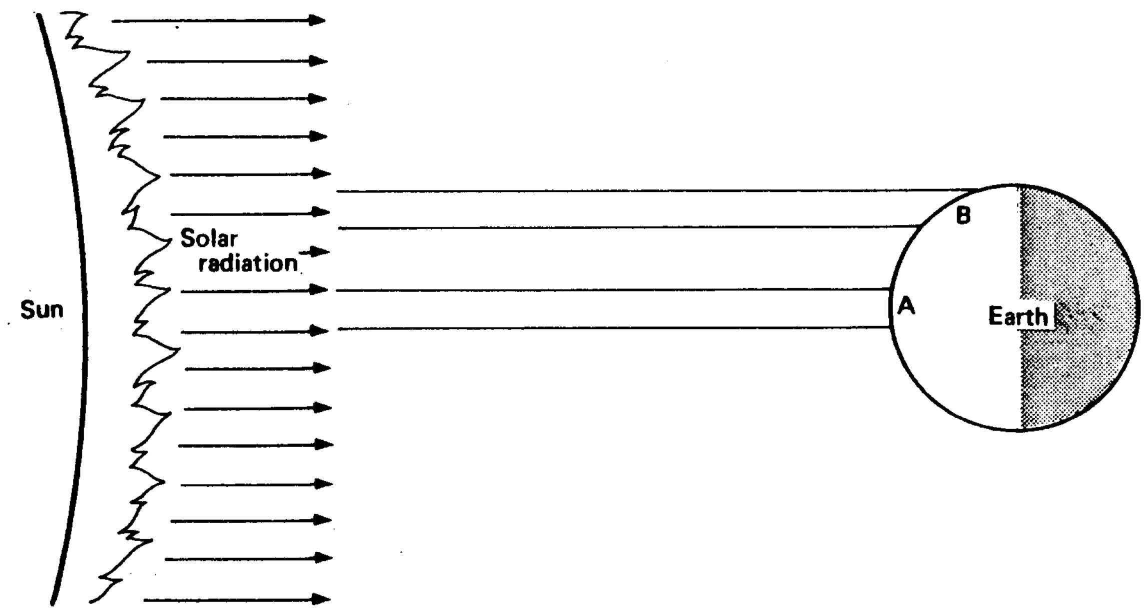

Figure 2. Solar Radiation Value Received Decreases with the Latitidue (not drawn to scale)

The earth's elliptical orbit around the sun causes the distance between the two bodies to vary by about 1.7 percent from the average of 149.6 million kilometers. The earth is closest to the sun in the first few days of January and farthest in the first few days of July (Figure 3). This variation in distance produces a maximum difference of about 3.4 percent in radiation received. (Ehrlich, 1977).

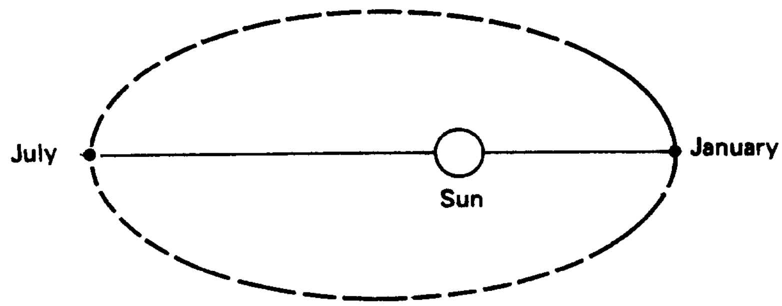

Figure 3. The Earth's Distance from the Sun Varies Due to its Elliptical Orbit (not drawn to scale)

The tilt of the earth's axis of rotation is mainly responsible for the occurence of the seasons. The tilt is fixed even as the earth revolves around the sun. The Northern Hemisphere is tilted towards the sun during the Northern Hemisphere's summer. The vertical rays of the sun and, therefore, maximum solar radiation strike the Tropic of Cancer (23.5° north latitude) on June 21. On the same day, the sun shines in the area North of the Arctic Circle (66.5° N latitude) for twenty-four hours. As the earth continues to revolve while maintaining its tilt, the Southern Hemisphere begins to face the sun. On December 21, the sun's rays strike vertically on the Tropic of Capricorn (23.5° S latitude). On this day the sun shines for twenty-four hours over the area within the Antartic Circle. Twice a year (on March 21 and September 23) the equator receives direct maximum solar radiation. On these two days both the Northern and Southern Hemispheres have 12 hours each of day and night. Also, because of the earth's rotation on its axis which brings about night and day, the solar radiation received at a given location varies. (see figure 4).

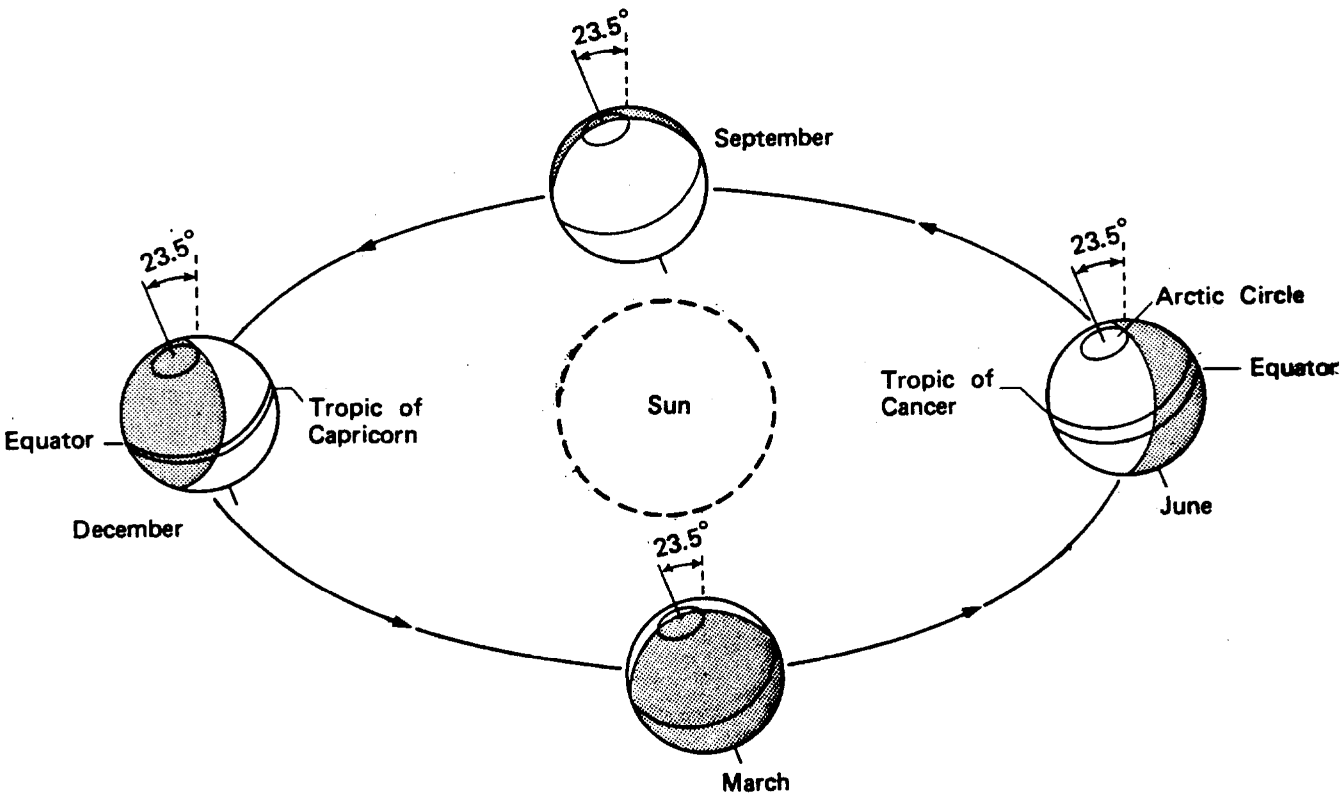

Figure 4. The Tilt of the Earth's Axis of Rotation Produces Variations in Solar Flux. (not drawn to scale)

Earlier it was mentioned that some of the solar radiation that reaches the earth's surface is reflected back to space. The amount of reflected radiation also varies with latitude. More is reflected from the polar latitudes where the radiation strikes the surface at maximum slant. The seasons also affect the amount of reflected radiation from the earth's surface. Less is reflected from the hemisphere tilted away from the sun, and more from the hemisphere facing the sun. Snow and ice reflect more than vegetation and water.

At this point it may be well to recall the two laws of thermodynamics that govern energy changes. The first law states that energy cannot be created or destroyed. It may be transformed from one form to another. The energy coming from the sun is in the form of radiation. As radiation passes through the atmosphere and reaches the ground it strikes some molecules or atoms or ions. Some wavelengths of the radiation are absorbed and transformed into other wavelengths or into heat. Different substances absorb energy differently. Land surfaces absorb more radiation than water within the same period of time, and release more heat. This results in hot and cold areas on the earth's surface which ultimately lead to the formation of wind systems.

Consider a small area on the earth's surface, part land and part water. The land warms the air above causing it to expand and a low pressure system develops. The low pressure air is pushed upward by denser high pressure air that flows over the land from over the water surface (figure 5). The space over the water surface, in turn, is filled by the sinking cold air. The rising warm air eventually cools and flows toward the space created by the sinking cold air. The result is a <u>convection cell</u>. Such conditions often occur near the seashore and result in sea breezes.

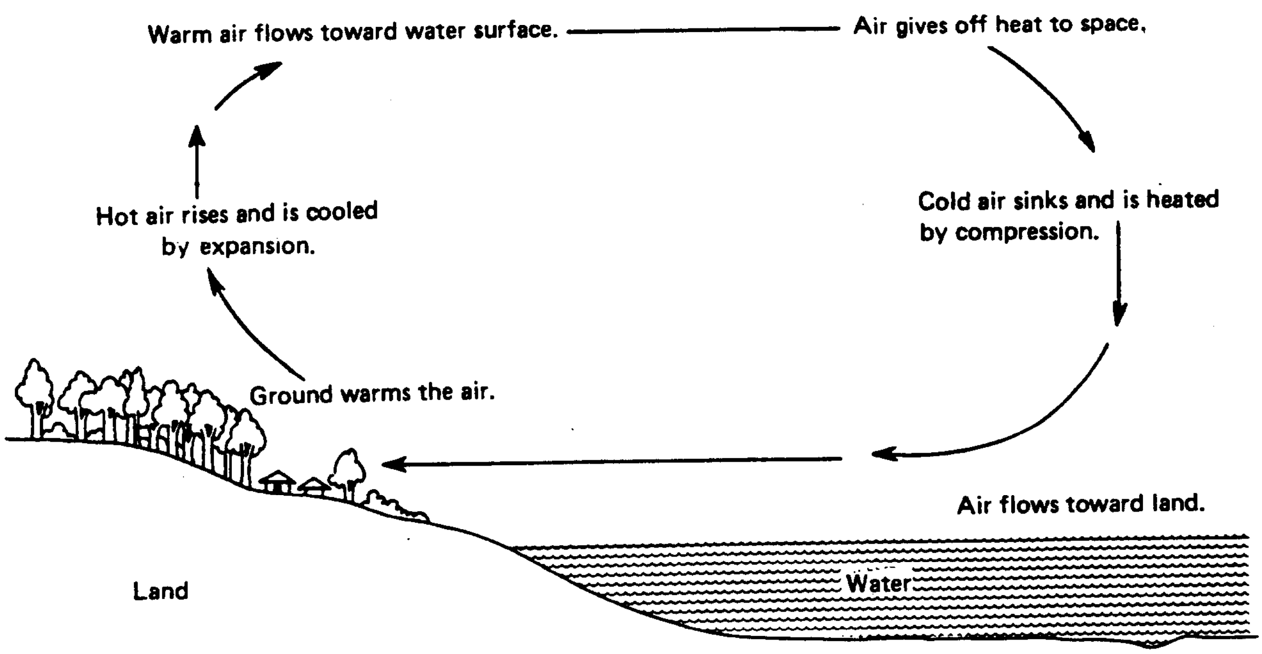

Figure 5. A Convection Cell is Formed by Rising Warm Air and Sinking Cold Air.

The horizontal flow of air in the cell is due to the differences in pressure over the land and water surfaces. Atmospheric pressure is closely associated with temperature. Air flows from an area of high pressure (and low temperature) to one of low pressure (and high temperature).

On a global scale, similar processes of horizontal and vertical air flows occur. Basically, air over the equatorial zone rises and flows poleward where it sinks. Near the earth's surface the cool air from the poles then flows toward the equator (Figure 6).

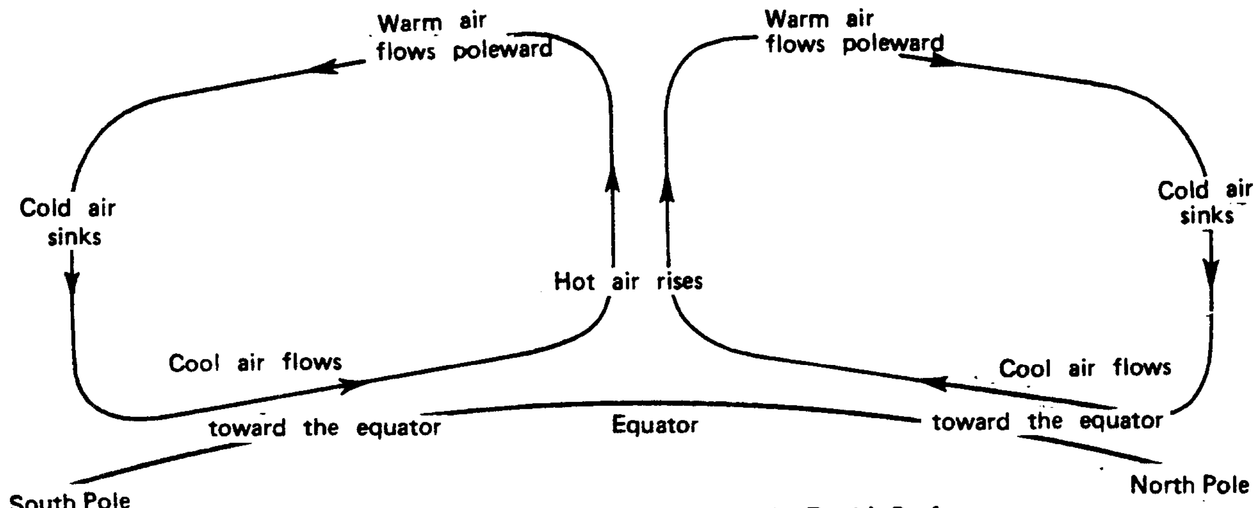

Figure 6. **Huge Convection Cells Over the Earth's Surface**

The flow of air, however, is not as simple as Figure 6 shows. It is made more complex by what is known as Coriolis effect brought by the earth's rotation on its axis. In the Northern Hemisphere, moving air masses turn to the right and in the Southern Hemisphere, moving air masses turn to the left because of the Coriolis effect.

In the Northern Hemisphere, air masses converging toward an area of low pressure from surrounding regions of high pressure turn to the right resulting in counterclockwise moving spirals (Figure 7a). Air masses flowing outward from a high pressure area to surrounding low pressure areas turn to the right but do not spiral because the air masses dissipate (Figure 7b).

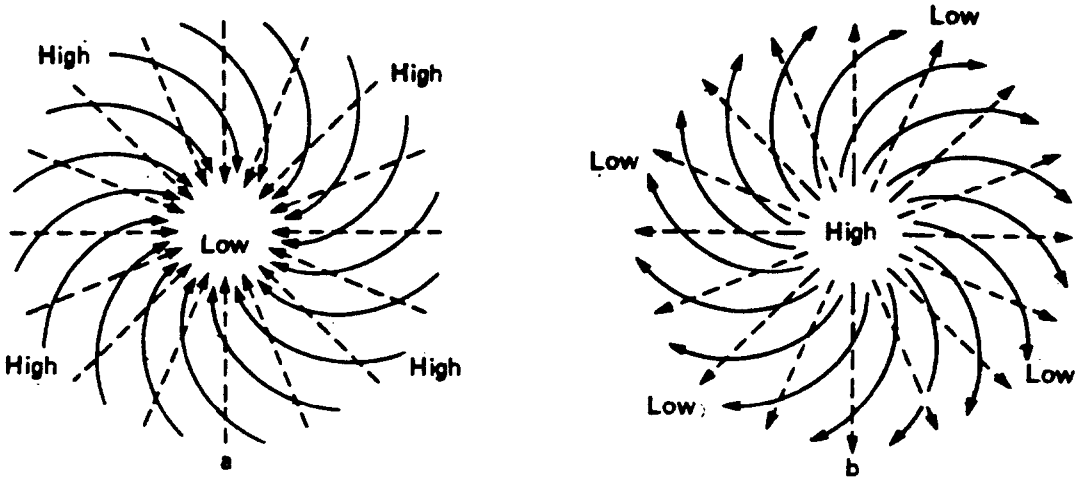

Figure 7. Broken Arrows Show What Would Be the Direction of Wind Due to Differences in Pressure. Heavy Curved Arrows Show the Actual Direction Due to Coriolis Effect.

In the Southern Hemisphere, air flow is in a direction opposite to that in the Northern Hemisphere (Figure 8a and b).

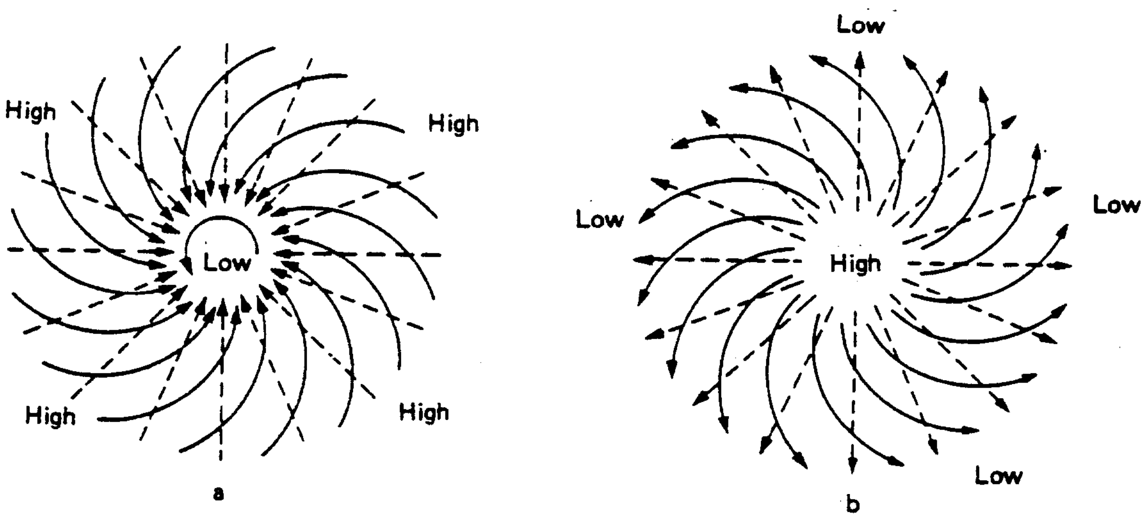

Figure 8. Winds Blow in the Opposite Direction in the Southern Hemisphere Due to the Coriolis Effect.

The air pressure and the movement of air is also affected by the amount of water vapor in the air. Air masses that have a great deal of water vapor in them are lighter and therefore areas below these moist air masses have low air pressure. (Although students might think that moist air masses would be heavy, water vapor which is H_2O has a relative weight of 18 while the mixture of gases that make up air have a relative weight of 29.)

Close to the earth's surface, the wind is slowed down by friction. Together with Coriolis effect and pressure differences, friction causes a change in the overall direction of the wind. Figure 9 shows the presently-accepted overall pattern of atmospheric motion.

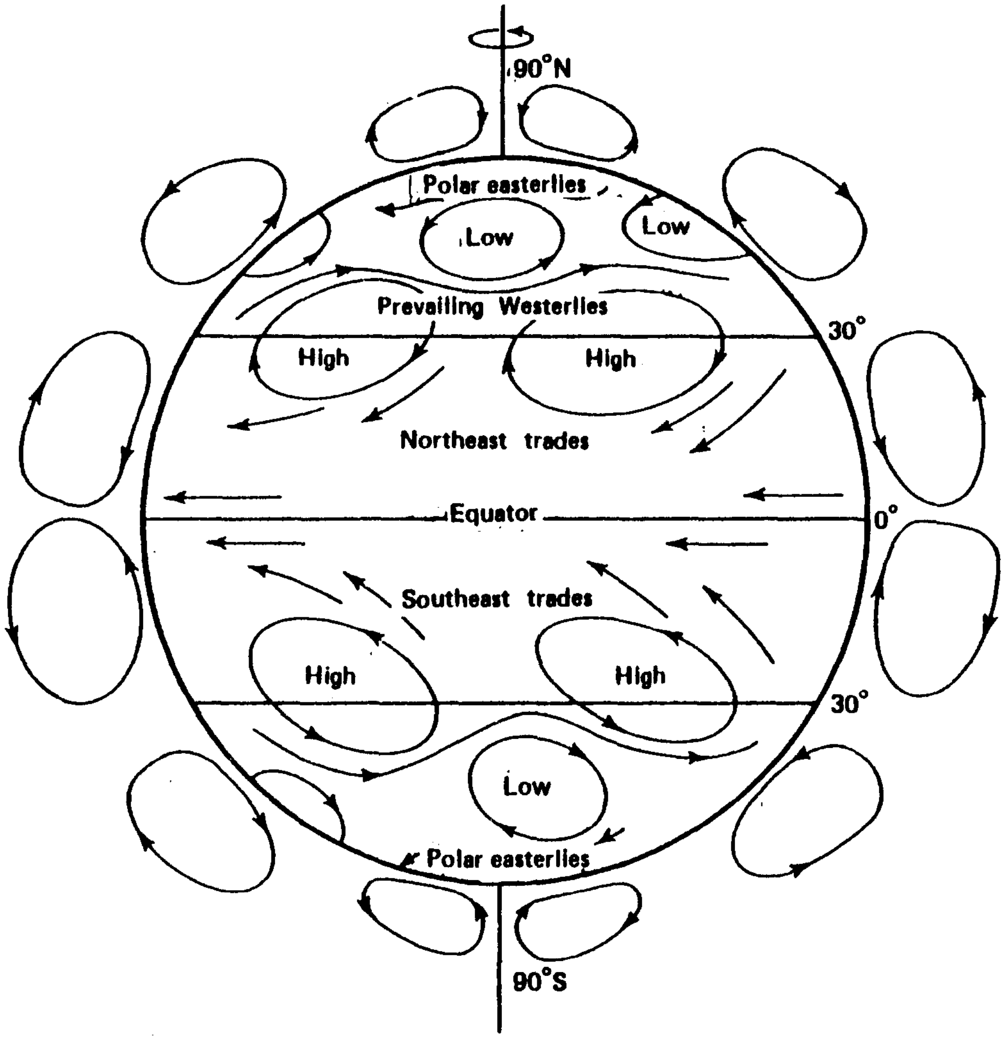

Figure 9. The Presently-Accepted General Global Circulation

3. Water Cycle, Its Role in Energy Flow

Water is an important agent of energy transfer and utilization effected through the water cycle. The water cycle is a set of processes that maintains the flow of water through the atmosphere and the ecosystems on land and water. It involves water in liquid, solid and gaseous states and all possible transformations among the three states. It is these transformations that require and release large amounts of energy.

A gram of ice needs to absorb 80 gcal of heat energy to melt into liquid water. To increase the temperature of one gram of water by one degree Celsius needs 1 gcal of energy. To vaporize one gram of water requires 536 gcal, an enormous amount of energy about fifty times as much as is needed to lift it to an altitude of 5 kilometers (Ehrlich, 1977). The energy used to evaporate the water is stored in the water vapor and is released to the environment as heat when the water vapor condenses back to liquid. Thus, energy received from the sun at one place on the earth's surface may be released high in the atmosphere, and not necessarily over the same location where the energy was delivered. Because of this mechanism of redistributing energy by the transport and condensation of water vapor, wide differences in temperature in different parts of the earth that would otherwise occur due to the variations in incoming solar radiation is avoided. What happens in the water cycle with regards to enery flow clearly illustrates the first law of thermodynamics - the law of conservation of energy.

4. Energy Transformations and Eventual "Loss"

The second law of thermodynamics states that when energy is transformed or transferred a certain amount of energy assumes a form that cannot be passed on any further. Energy in concentrated form is degraded into a dispersed form that becomes unavailable for any more transformations. No energy transformation is 100 percent efficient (Figure 10). Note the loss of heat energy at each conversion point.

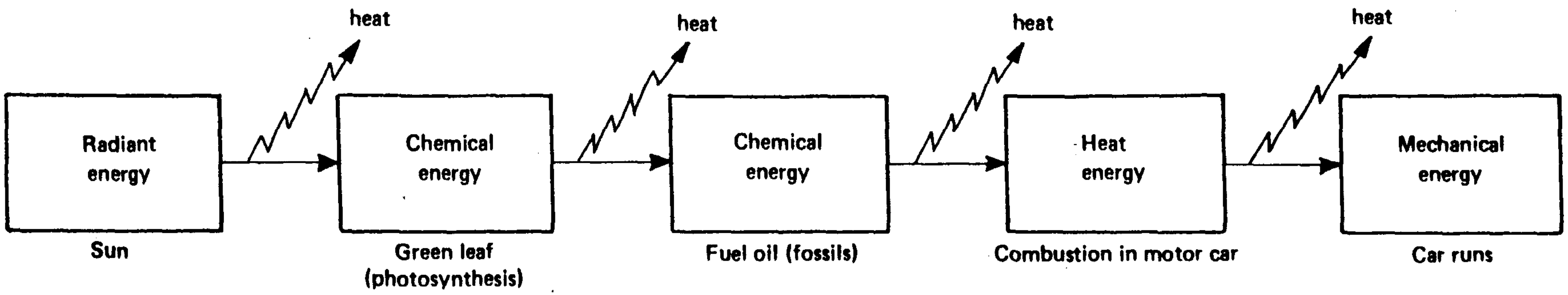

Figure 10. An Energy Conversion Series

What happens then to all the "unavailable" energy? The energy is sent back to space as terrestrial radiation. Referring back to Figure 2, it will be noted that of the total incoming solar radiation, about 66 percent is absorbed by the earth - 19% in the atmosphere (clouds, gas molecules, dust) and 47 percent at the surface. After running the machinery of winds, waves, ocean currents, the water cycle, and photosynthesis what remains as "unavailable" energy usually in the form of heat, is dissipated into space.

5. Energy from the Earth's Interior

The sun is the most significant source of energy needed for the life-giving processes (e.g. water cycle, photosynthesis) on the earth's surface. But it is not the only source of energy on earth. Some geologic processes are known to be powered by energy generated deep in the earth's interior. The energy is in the form of heat and is called geothermal energy. It is believed that most of this heat results from the decay of radioactive elements such as uranium and thorium. It is also thought that Uranium 238 and Thorium 232 and other radioactive substances were already present when the earth was formed.

Heat flows from the interior to the surface of the earth continuously by the processes of convection and conduction. If the earth were completely insulated, the temperature on the surface would continue to increase. But that does not happen. However, measurements of temperature below the earth's surface at hundreds of sites all over the world show a steady rate of increase of temperature (about 20° per kilometer) from the surface toward the interior. This is in accord with the laws of thermodynamics that heat flows from hotter to cooler media. When heat energy reaches the surface, it does not accumulate there but is dissipated into space together with some of the incoming solar energy.

Sometimes the energy from the interior of the earth finds its way to the surface through magma flows, volcanic eruptions and motion of tectonic plates. These phenomena may result in earthquakes which release tremendous amounts of energy in the mechanical form and in the form of heat.

C. ENERGY FLOW IN THE BIOTIC COMPONENT OF THE EARTH ECOSYSTEM

So far what has been discussed is the flow of energy in the abiotic part of the earth ecosystem. But the energy which is of greater significance to the sustenance of human life is mainly through the biotic components of the ecosystem.

1. Photosynthesis

Of the actual amount of energy the earth receives from the sun, only about a tenth of 1 percent is diverted into living systems. (Woodwell, 1970). This fraction of energy is fixed in photosynthesis, a process by which solar energy is used by green plants to produce sugar from carbon dioxide (CO_2) and water. With a few minor exceptions, this process can occur only in the presence of chlorophyll, the pigments responsible for the green coloring of plants, to serve as catalyst for the reaction. Photosynthesis is represented by the equation:

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{675 kcal}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

There are two major phases of the photosynthesis process: (1) photolysis, in which solar energy is utilized to split water molecules in the plant cell into hydrogen and oxygen, and (2) carbon dioxide fixation in which CO_2 combines with hydrogen to form sugar (Owen, 1980). The process transforms solar energy into chemical energy "locked" in the organic compound (sugar) it produces.

2. Respiration

More than half of the energy fixed in photosynthesis, however, is immediately used up to support the living tissues of the plant itself. The plant breaks down the sugar molecules and puts to use the energy that once bound those molecules together. The process by which plants mobilize the energy for their own sustenance is called <u>respiration</u>. To simplify, respiration is the opposite of photosynthesis - sugar is combined with oxygen to produce water and carbon dioxide, and the energy thus released is trapped in chemical bonds of special molecules that transport it to other tissues where it will be used to sustain its own life processes. The equation for respiration is as follows:

$$(CH_2O)_n + O_2 \longrightarrow CO_2 + H_2O + \text{energy}$$

3. Food Chain and Food Web

The energy not used by the plant for respiration is stored as chemical energy in the organic molecules of the plant. Then at any point this stored energy may enter the food chains.

A <u>food chain</u> may be defined as the transfer of enery and nutrients through a succession of organisms via repeated processes of eating and being eaten. An example of a food chain is as follows:

grass ⟶ tiny insects ⟶ lizard ⟶ rat

Each arrow points from one species to another which eats it. But no one organism lives wholly on another. Resources are shared, especially at the beginning of chain. Another food chain that may exist in the same place may be:

grass ⟶ tiny insects ⟶ frog ⟶ snake ⟶ hawk

At the beginning of both chains is grass hence the two are interlinked. In nature no food chain exists as an isolated entity. An inerconnected series of food chains is called a <u>food web</u>. Figure 11 illustrates a food web in a tropical forest.

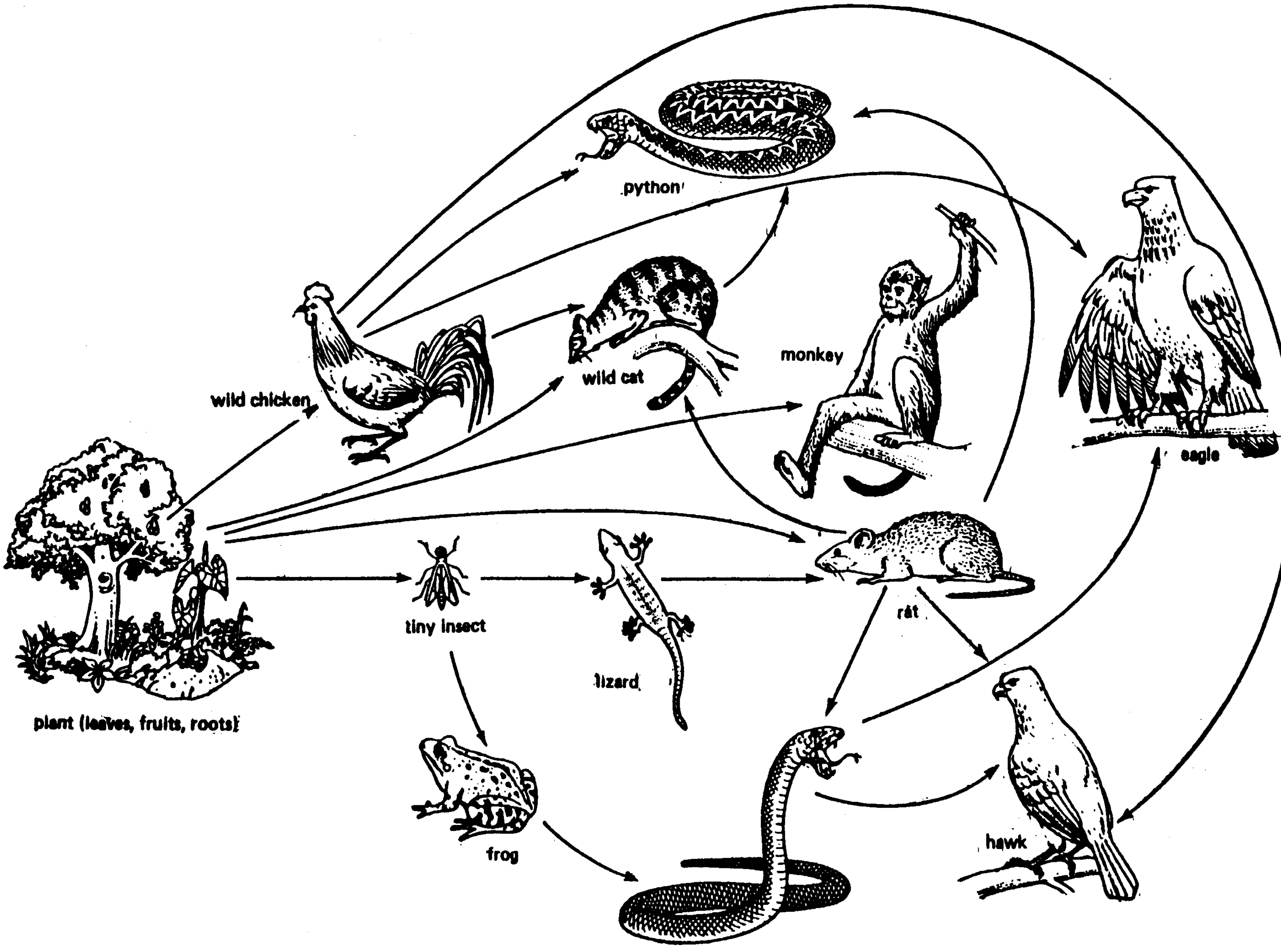

Figure 11. A Food Web in a Tropical Forest

4. Trophic Levels

Now, if the food webs showing all the organisms obtaining their food in the same number of steps are superimposed, the structure can be collapsed into a series of single points, representing the trophic or feeding levels of the community. Thus each step in the food chain represents a trophic level. Animals at the lower level may occupy a single trophic level while those at the top may be found simultaneously in several trophic levels, as do the rat, the hawk, the eagle, and the monkey in Figure 11. Let us try to identify the different trophic levels in this sample food web.

The first trophic level, represented by green plants, is the producers or autotrophs ("self-feeding"). The producers form the base upon which the heterotrophic or "other-feeding" components of the community rest.

Directly on top of the producers are the consumers. Herbivores, such as the tiny insects and the monkey, are the primary consumers. These are the heterotrophs which derive their nutrition directly from plants and are capable of converting energy stored in plant tissues to animal tissues. Herbivores, in turn, are the energy source of secondary consumers. These are carnivores or flesh eaters like the lizard and the frog in the food web example that feed directly on herbivores. Secondary consumers are an energy source for the tertiary consumers. These are carnivores that feed on other carnivores. In the illustrated food web, the hawk, the eagle and the snake belong to this group. Still higher categories of carnivorous animals feeding on higher level carnivores may exist in some communities.

Many consumers do not limit feeding to one trophic level. The human species, for example, feeds on both plants and animals. Many species belong to both herbivorous and carnivorous levels. Consumers that belong to both levels are called omnivores.

Finally, the energy stored at the top consumer level is utilized by the decomposers. They make up the end feeding group. Decomposers are chiefly microorganisms (bacteria, fungi and yeasts) which are capable of breaking down the wastes and remains of organisms into simpler substances. By the action of decomposers, organic matter can become soluble and changed into inorganic forms that plants can use in photosynthesis. (see figure 12).

5. The Ten Percent Law

Earlier it was discussed that only a small percentage of the energy received from the sun is fixed by green plants in photosynthesis. It was also mentioned that some of the fixed energy is used by the plant in its own respiration. Much of the energy input in animals is used to sustain their life functions (digestion, circulation, respiration, excretion, movement, growth, and so on). Hence less than 10 percent of the plant energy is converted into chemical energy in animals that eat the plants. Roughly 10 percent of the energy may, in turn, be passed on to other animals that eat the animals that eat the plants. Consider this food chain:

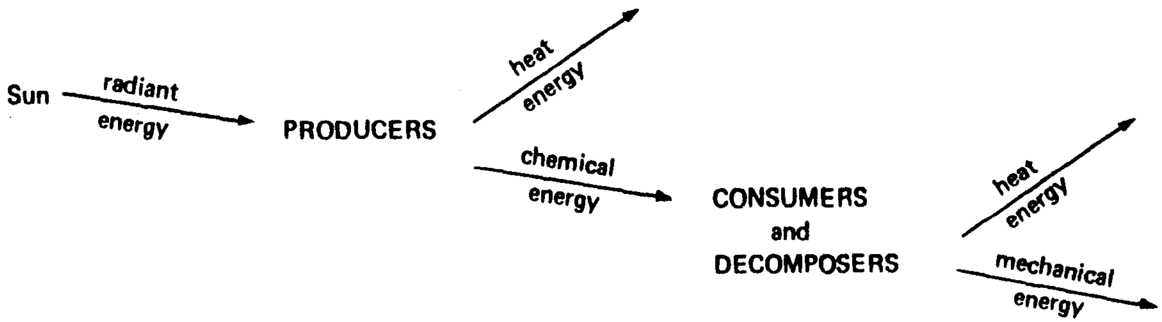

Figure 12. Energetics of Organisms and Ecosystems
(Source: Edward J. Kormondy, CONCEPTS OF ECOLOGY, 2nd Ed., c 1976, p. 10.
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$$\text{grass} \xrightarrow[\text{energy}]{10\%} \text{cow} \xrightarrow[\text{energy}]{10\%} \text{man}$$

The cow is about 10 percent efficient in converting grass into beef. Similarly man is only 10 percent efficient in converting beef into human flesh. Green plants are less than 1 percent efficient in converting solar energy into chemical form in the sugar molecules. Assuming that 1000 calories of solar energy were taken in by the grass, only 0.1 calorie will be available to man at the end of the food chain. This phenomenon is sometimes called the <u>10 percent law</u>. The relationships can be graphically shown by an energy pyramid. (Figure 13).

The ten percent law is a practical expression of the second law of thermodynamics as it applies to food production and energy distribution in biological systems. Biological systems have low efficiency in energy transformations. A large amount of energy always becomes utilizable at each transfer.

Attention is now called to a most important characteristic of energy flow: the movement of energy through the ecosystem is unidirectional and noncyclical. Unlike water and other forms of matter which are in cycles, energy flows in one direction and is not naturally recycled.

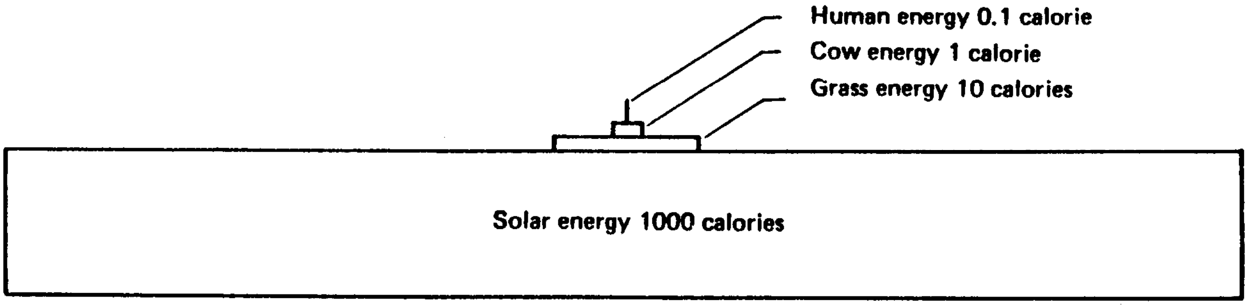


Figure 13. An Energy Pyramid

D. MATERIALS FLOW IN THE BIOGEOCHEMICAL CYCLES

Much as life on earth depends on the flow and distribution of energy, life also depends on the availability of some materials in appropriate forms and quantities. Those materials essential to life are called nutrients. They can be categorized into three groups: (1) the four main chemical building blocks of living (organic) matter (carbon, oxygen, hydrogen and nitrogen); (2) the macronutrients (sulfur, phosphorus, calcium, sodium, magnesium, iron), meaning elements needed in smaller but still significant quantities for life; and (3) the micronutrients, those elements needed in trace amounts yet essential to life processes. These materials flow from the abiotic to the biotic and back to the abiotic component again of the earth ecosystem, in more or less cyclical manner known as biogeochemical cycles. The kind of nutrient involved in the cycle determines the rate at which it is removed and returned to its reservoir.

There are three types of biogeochemical cycles (Kormandy, 1976): (1) the hydrologic or water cycle which involves the movement of water; (2) the gaseous nutrient cycles in which the atmosphere constitutes the major reservoir of the elements (carbon, nitrogen, oxygen) involved; (3) the sedimentary type of cycles (phosphorus, sulfur, magnesium, etc.) in which the lithosphere, the solid part of the earth, is the major reservoir of the elements. All three types involve biological and non-biological agents, and the last two kinds of cycles are both closely related to the hydrologic cycle in one way or another.

Note that, whereas the energy flow in the earth is a one-way or an open system, meaning that the energy comes largely from outside the earth and is dissipated back to space, the materials or nutrients flow in the earth is almost entirely a closed system. Unlike energy, there is practically no source of materials or nutrients outside of the earth itself. Nutrients are cycled and recycled within the earth ecosystem.

1. Earth Processes, Their Role in Nutrients Flow

Before going into the specific steps that nutrients undergo in their cycles, a discussion of how the nutrients are made available and transported to different parts of the earth's surface is in order. In the closed system of the materials cycles, nutrients are distributed in different parts of the earth in varying abundance. Many geophysical processes help in transporting and releasing these nutrients to make them available for use in the biotic world. These processes include mountain-building by uplifting of the earth's crust, the wearing away of exposed rock surfaces by the action of rain, wind, ice, and chemical processes (together these effects are called weathering), the transport of particles of rock and soil by water and wind (erosion), and the formation and transformation of new rocks.

Recent findings about the structure of the earth reveal that the earth's crust is divided into six major tectonic plates that "float" on a semi-plastic mantle (Figure 14). Along the edges of

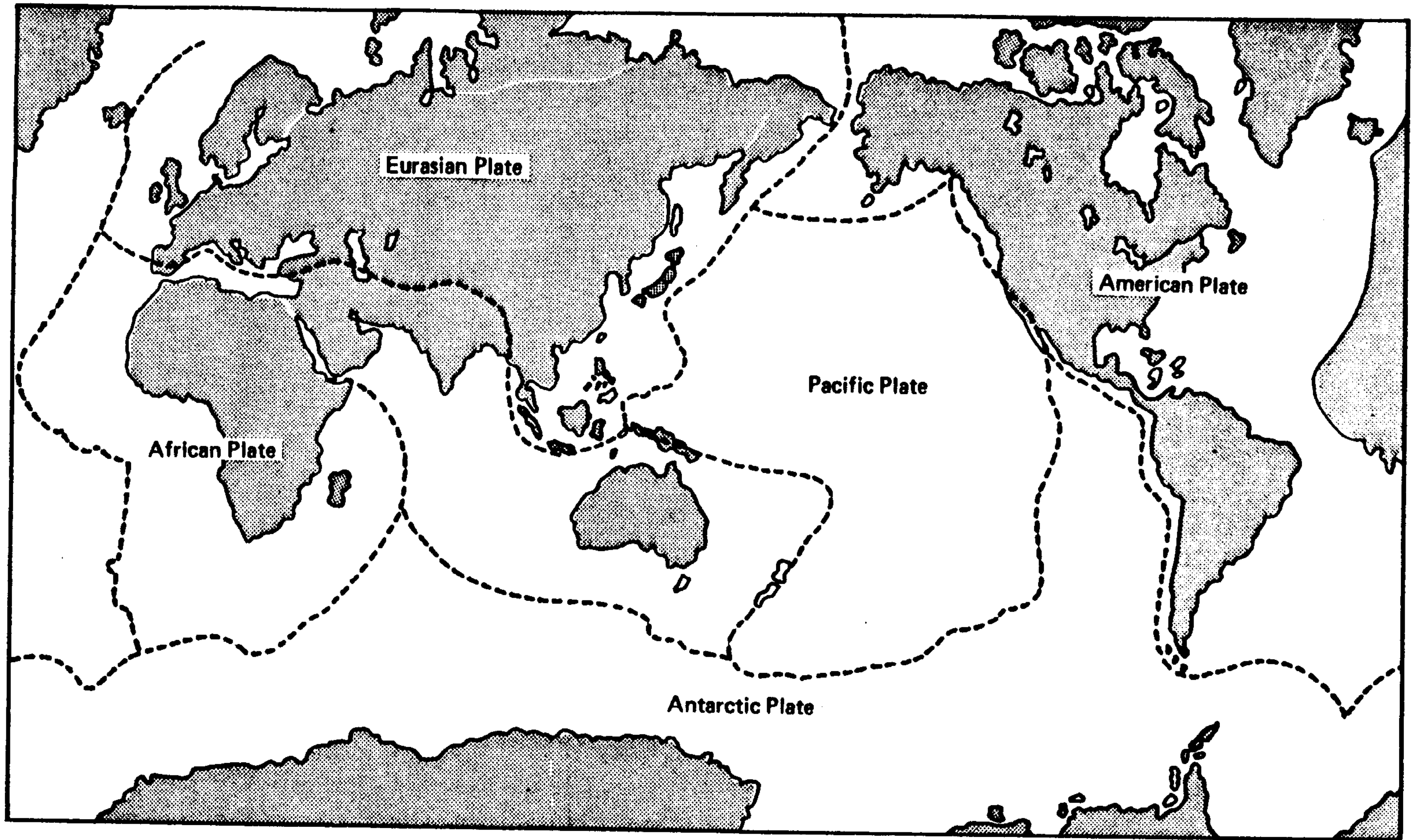


Figure 14. The Six Major Tectonic Plates of the Earth (Modified from Matthews, 1973)

the plates much geologic activity occurs. It is in these areas where most earthquakes originate as a result of the crustal plates sliding past and bumping against each other. From these giant cracks in the earth's crust, new materials from the earth's interior flow to the surface carrying with them elements that would eventually be incorporated into the living world. Motions of the crust also result in uplifting and folding of some areas exposing rocks that would gradually be weathered away by physical and chemical processes. The weathered materials from some of the raw materials for new soil (the formation of which is helped by the action of living organisms). Some of the chemicals liberated from the rock by weathering become available to the biosphere as nutrients. Large amounts of materials transported from high elevations are deposited by ice, wind and water on the lowlands and on the ocean floor. All these processes occur over hundreds of thousands to millions of years.

2. Water Cycle, Its Role in Nutrient Flow

Water plays a significant role as an agent of nutrient distribution over the entire earth. (It should not be forgotten that water constitutes 70% or more of the weight of many living organisms).

Astronauts who have seen the earth from outer space describe it as a blue planet. This is to be expected since 70% of the earth's surface is covered by oceans which contain 97.2% of the world's total water supply. Table 1 gives the approximate percentages of the global water distribution.

Table 1. Water distribution in approximate percentages in different parts of the earth.

oceans and seas	97.2
glaciers and ice caps	2.15
groundwater	0.62
lakes	0.017
atmosphere	0.001
rivers	0.0001
living matter	0.0001

Despite the great amount of water on earth, only about 0.005 percent of the total water supply is moving through the hydrologic cycle (Figure 15) at any instant. The interchanges of water between air, land, and sea and between living organisms and their environment form the links in the cycle. The principal flows in the hydrologic cycle are: (1) evaporation of water from the surface of oceans and other bodies of water and from the soil to the atmosphere; (2) transpiration of water by plants which adds water vapor to the atmosphere; (3) horizontal transport of atmospheric water from one place to another, as vapor or as the liquid water droplets and ice crystals in clouds; (4) precipitation of atmospheric water vapor by

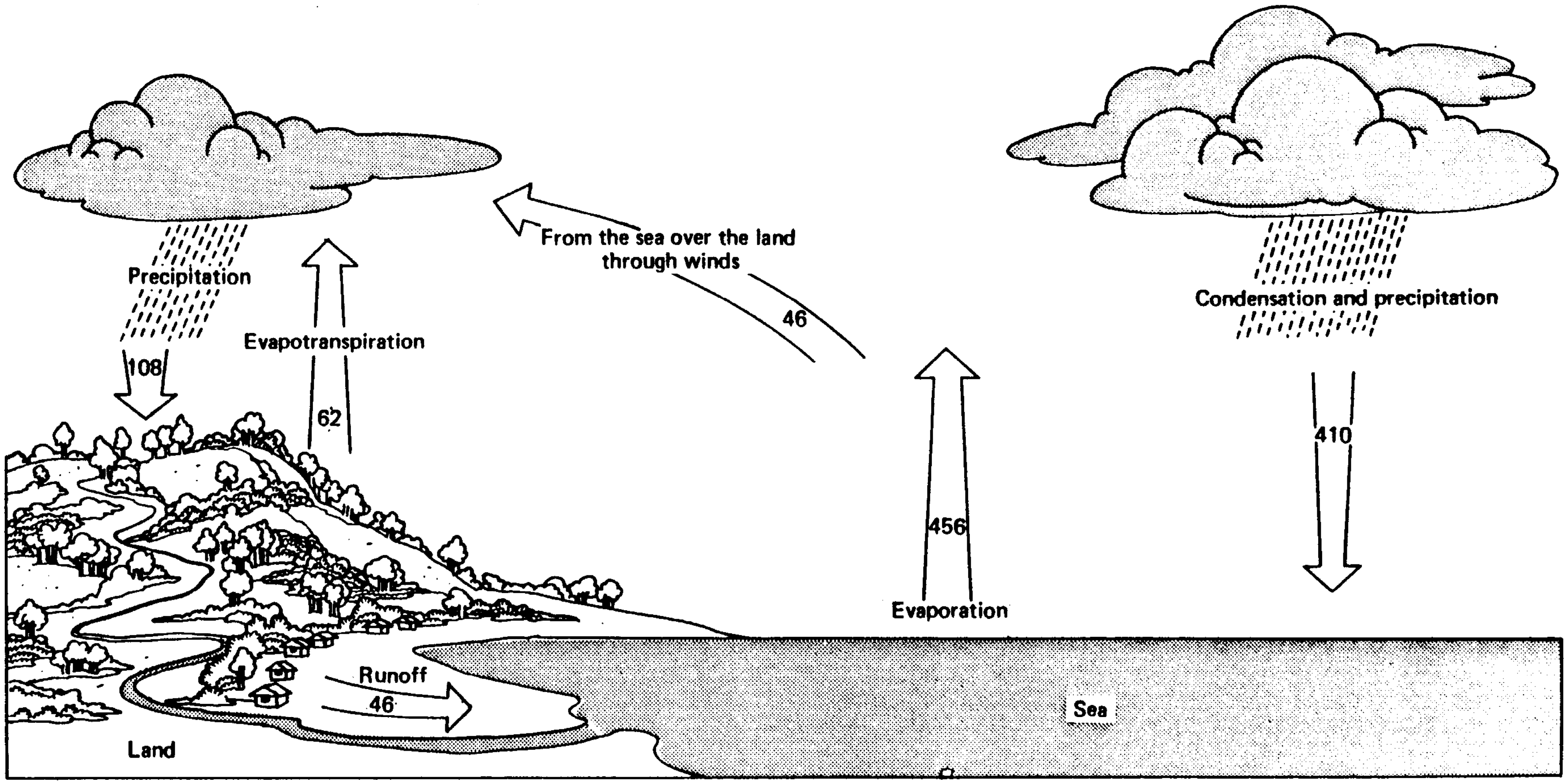


Figure 15. The Hydrologic Cycle (1000 km^3/year)

condensing and falling on the oceans and the continents as rain, hail, snow or sleet; and (5) runoff of water on the earth's surface to lower levels until it reaches the oceans. Over the continents the contributions of evaporation and transpiration are difficult to separate so that they are put together and referred to as evapotranspiration.

Of importance to biologists and environmentalists is the residence time of water in the different parts of the cycle. Residence time is the period a water molecule stays at a particular stage of the water cycle. Such periods vary from nine days to about 10,000 years depending on the location and the physical state of water. (See Table 2). Since water carries with it other elements in the dissolved form, residence times are important in the transport of nutrients. The recent concern for environmental pollution has pointed out an even greater significance of residence time of water as regards the transport of pollutants.

Table 2. Average Residence times of water molecules in the hydrologic cycle

Location	Average Residence Time
Atmosphere	9 days
Rivers	2 weeks
Soil	2 weeks to 1 year
Largest lakes	10 years
Shallow groundwater	10's to 100's of years
Oceans	120 to 300Cyears
Deep groundwater	up to 10,000 years
Ice cap	10,000 years

3. The Gaseous Cycles

a. Carbon Cycle

The main reservoir of carbon is the atmosphere in which atmospheric carbon dioxide (CO_2) is found. Some of the CO_2 is also found dissolved in the waters of the earth. But by the process of diffusion this CO_2 readily finds its way into the atmosphere.

It will be recalled that energy transfers with the consumption and storage of organic compounds by living systems. Follow the carbon cycle in Figure 6 from the time it enters living organisms by way of photosynthesis in the form of CO_2. Carbon in the CO_2, together with hydrogen and oxygen in water and the energy from the sun, becomes a part of simple carbohydrate (sugar). The carbohydrates are then synthesized by the plant into complex carbon compounds in plant tissues. When these plants are eaten by animals (the herbivores), the carbon compounds are resynthesized into other forms. When the carnivores eat the herbivores the carbon compounds are redigested and further resynthesized. Through respiration of plants and animals, some of the carbon is returned to the reservoir in the form of CO_2. The carbon locked up in animal wastes and plant and animal remains is released eventually by the decomposers that act on these materials. Bacteria and fungi break down the complex organic compounds into simpler forms, thereby releasing most of the organic carbon as CO_2 again.

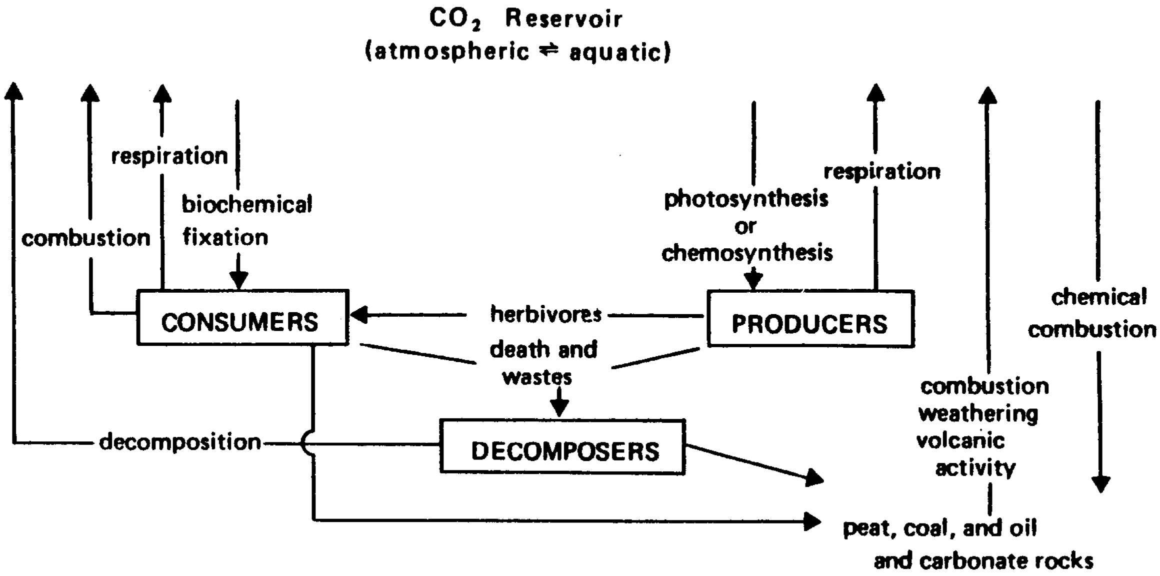


Figure 16. The Carbon Cycle

Part of the organic carbon, however, is kept out of circulation for thousands of years. This is the carbon that becomes incorporated in the earth's crust as coal, gas, petroleum, limestone and coral reefs. Some CO_2 is released from limestones through weathering. Industrialization now liberates much of the fossilized carbon on earth at a rate that is feared to increase the concentration of atmospheric CO_2 to dangerous levels.

b. Nitrogen cycle

Nitrogen (N_2) is the most abundant element in the atmosphere with a concentration of about 79 percent. But this gaseous nitrogen has first to be "fixed" into a compound such as ammonia (NH_3) before it can be used by living organisms. Small amounts are transformed by electrical discharge (lightning) in the atmosphere. Some nitrogen-fixation is also attributed to the energy released by volcanic eruptions. The bulk of nitrogen-fixation, however, is carried out by microorganisms such as bacteria and the blue green algae which abound in soil and water.

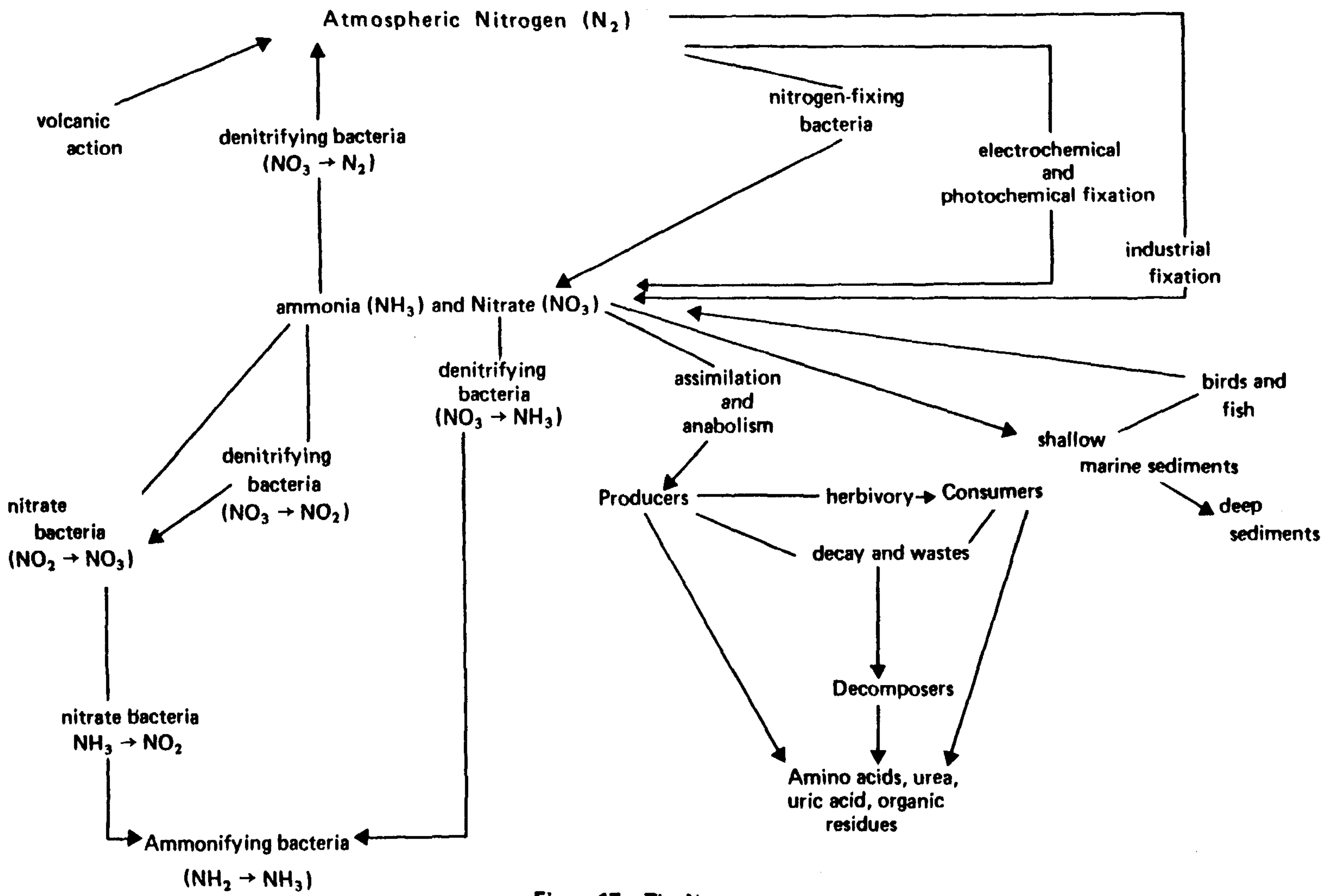


Figure 17. The Nitrogen Cycle

The nitrogen cycle (Figure 17)is a complex web of biological and chemical processes. Nitrogen in the atmosphere diffuses into the air spaces of the soil. Nitrogen gas entering the root swellings (nodules) of legumes is fixed into the plant by nitrogen-fixing bacteria as nitrites and then converted into nitrates. Aided by the bacteria and fungi of decay, nitrates combine with hydrogen forming ammonia which is converted into amino acids, the "building blocks" of proteins. The host plant (the legume) then builds up its own protein from the surplus amino acids no longer needed by the bacteria. When a consumer, for example a cow, feeds on the host plant the nitrogen in the plant protein is incorporated into the consumer's protein (animal protein). The consumer excretes nitrogen-containing wastes (manure and urine). When it dies, its carcass is decomposed by the action of successive groups of bacteria in a process referred to as nitrification. The first microorganisms to act on the carcass are the bacteria of decay which convert the proteins into ammonia. Then the nitrite bacteria convert the ammonia into nitrites (NO_2) such as potassium nitrite. Finally nitrate bacteria convert the nitrites into nitrates (NO_3) such as potassium nitrate. Plants such as rice, corn, trees, or shrubs may now absorb the soluble nitrate through their roots and use them to build up their own protein compounds. Then the cycle starts all over again.

As the cycle proceeds, nitrogen is also transported from one ecosystem to another. The example given here (Figure 18) shows the flow of nitrogen from a terrestrial ecosystem to an aquatic ecosystem and back to a terrestrial one again. This also demonstrates the role of a biotic agent (birds) and an abiotic agent (water) in the nutrient flow.

c. Oxygen cycle

The oxygen cycle relative to the nitrogen cycle, is a simple one, nevertheless vital. The biologically significant oxygen is that found free in the atmosphere or dissolved in oceans. Chlorophyll-bearing plants are the world's oxygen synthesizers through photosynthesis. Both plants and animals utilize oxygen from the atmosphere in respiration and give it back to the atmosphere or the oceans combined with carbon as CO_2. The carbon dioxide in turn, is used by green plants as an essential raw material for carbohydrates synthesis releasing oxygen again in the process.

4. Sedimentary Cycles

Most other elements and compounds differ somewhat from nitrogen carbon, oxygen and water following a basic sedimentary cycle pattern in which the processes of erosion, sedimentation, mountain building and volcanic activity are the primary agents of circulation (Odum, 1971). For these nutrients the earth's crust serves as the reservoir. In contrast to the gaseous nutrient cycles, none of the nutrients in the sedimentary cycles goes through the cyclic flow as readily as carbon and nitrogen. Furthermore, sedimentation in oceans and deep continental lakes results in long-term stagnation stages keeping the nutrient out of circulation (Kormondy, 1976).

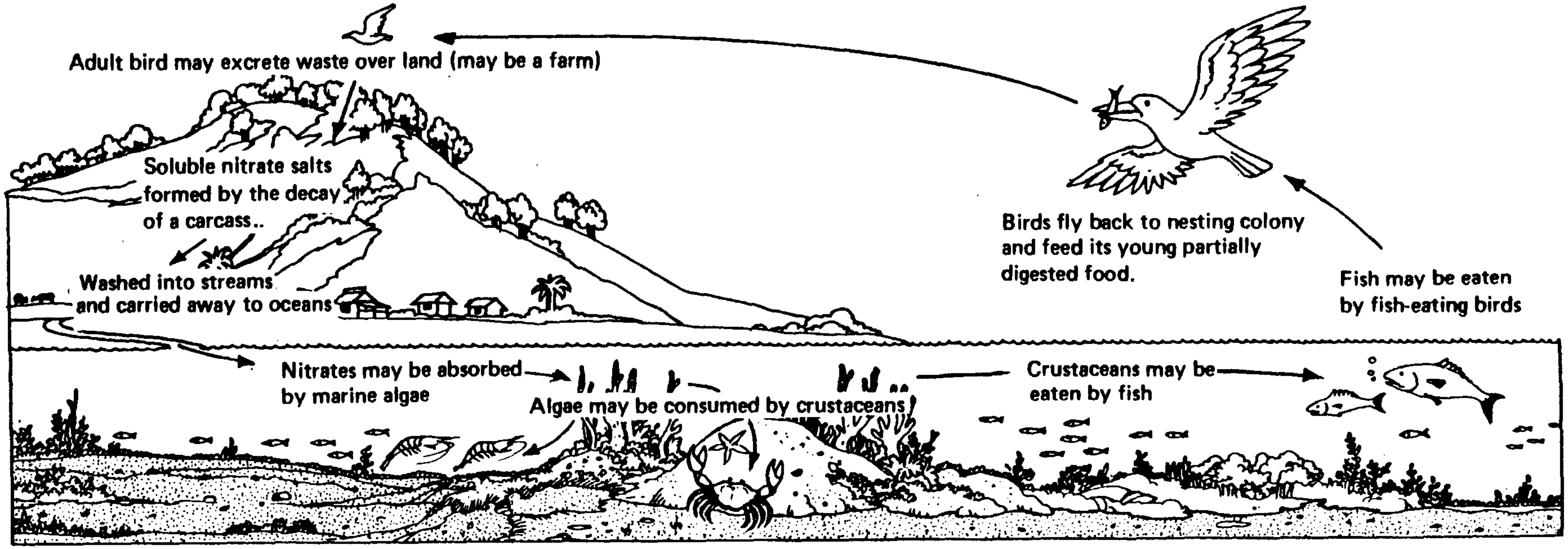


Figure 18. Nitrogen Flow from One Ecosystem to Another

Notable of the elements involved in sedimentary cycles are sulfur and phosphorus.

a. Phosphorus

The phosphorus needed for life sustenance is quite small compared to the demand for oxygen or carbon dioxide. Yet the element is a limiting nutrient in many cases due to its scarcity in accessible form in the biosphere. This natural scarcity of phosphorus is due to its chemical properties. It does not form any important gaseous compounds under natural conditions, depriving the phosphorus cycle of an atmospheric pathway as is common to the other elemental cycles. This ties it to an earth-bound pathway of sedimentation, uplift and weathering which take hundreds or thousands of years or more to complete. Phosphorus forms insoluble compounds in the soil. In insoluble forms its uptake by plants and transport by surface water and groundwater is made difficult (Figure 19).

The phosphorus cycle is similar to the nitrogen cycle in that most of the flows in the cycle are between the living components and the pool of decomposition products. Also, if the nitrogen cycle is aided by denitrifying bacteria, the phosphorus cycle proceeds with the action of phosphatizing bacteria which convert phosphorus compounds in once living tissues into inorganic phosphates.

b. Sulfur

The sulfur cycle (Figure 20), though not yet as well understood quantitatively as the other nutrient cycles is chemically complicated and definitely important in the biosphere. It is very important for several reasons: sulfur plays a significant role in protein structure; its main gaseous compounds are harmful to mammals; its compounds affect the acidity of rainfall, surface water and soil; and it is possible that in the long run sulfur compounds affect the concentration of molecular oxygen in the atmosphere (Ehrlich, 1977).

The fact that sulfur can assume several oxidation states is the main reason for the complexity of its cycle. Aided by bacteria it may undergo many transformations. The compounds formed with sulfur also depend on factors such as presence or absence of oxygen and light and the acidity or basicity of the environment. Sulfur can exist in nature as hydrogen sulfide (H_2S), hydrosulfide ion (HS) and sulfide ion ($S^=$) with a -2 oxidation number; as disulfide ion ($S_2^=$ with a -1 oxidation number; as elemental sulfur (S_2, S_4, S_8) with a 0 oxidation number; as sulfur dioxide (SO_2) and sulfurous acid (H_2SO_3) with a +4 oxidation number; and as sulfur trioxide (SO_3), sulfuric acid (H_2SO_4) and sulfate ion with an oxidation number of +6.

Nutrient flow being cyclic, no new supply is added to the stock at the same time that none is "lost". It may not be the same molecules that go through the biotic system. Some molecules may find their way into places, like the deep seas beyond the range of light, where they become inaccessible, thus out of biological

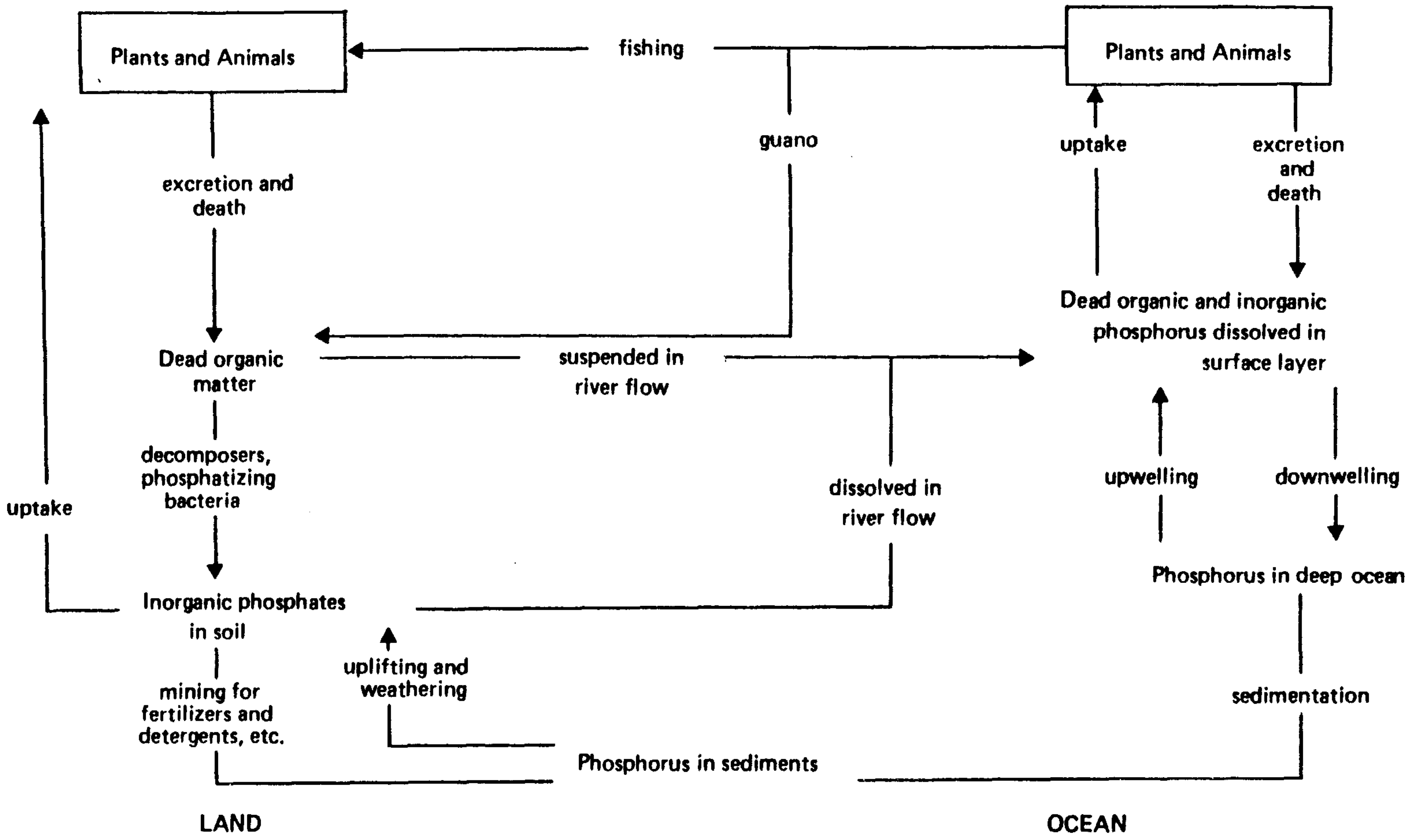


Figure 19. The Phosphorus Cycle

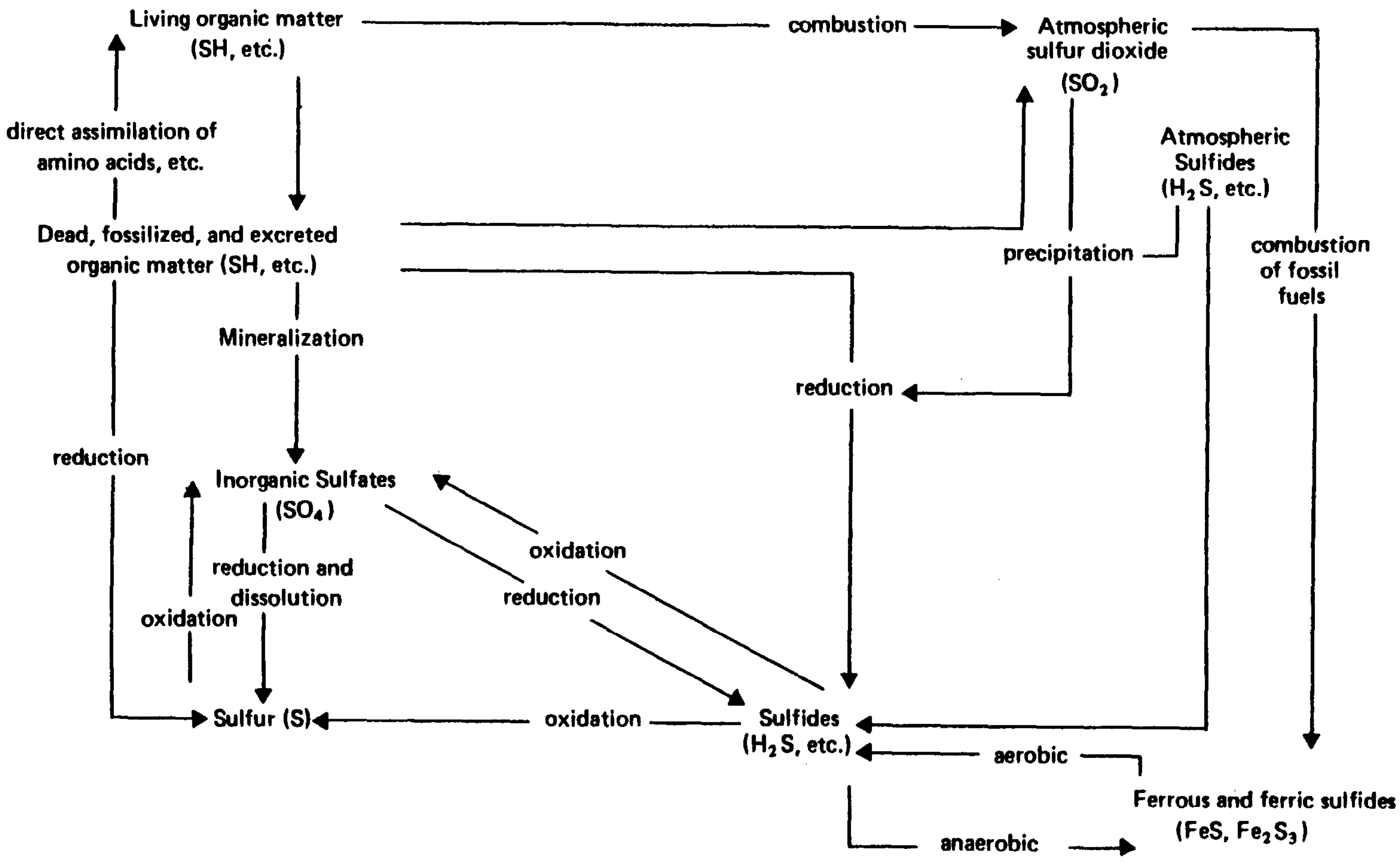


Figure 20. The Sulfur Cycle

circulation. The nutrient molecules may remain in such a stagnation state for decades or even hundreds of years. Human intervention accelerates the flow towards the stagnation pool exceeding the regeneration of new materials from underlying rocks.

5. Biological Magnification

Just as the energy flow is affected by the food chain and its "ten percent law" causing the amount of the transferred energy to diminish so is the nutrient flow also influenced by the food chain but in a reverse manner. Whereas energy is dispersed with each link in the chain, some substances become concentrated. This concentration of substances in living things came to be known as biological magnification (E.P. Odum, 1971). An example of biological magnification is the buildup of DDT residues. Some years back DDT was liberally sprayed on marshes and ponds to destroy disease-carrying mosquitoes. The concentrations used were thought to be not lethal to organisms other than for which it was intended. However, the poisonous residues in the dead decaying organisms became concentrated in the tissues of organic debris feeders, mainly small fishes and scavengers like fiddler crabs. The fishes in turn were eaten up by a variety of birds where DDT residues accumulated in the fatty tissues to levels that interfered with egg shell formation The end result of the widespread use of DDT was the wiping out of whole populations of fiddler crabs and predatory birds like the fish hawk. What began as something dangerous only to one species ended up lethal to several populations.

The effects of human activities on the biogeochemical cycles will be discussed in greater detail in a later section.

E. POPULATION DYNAMICS

The study of populations began in the sixteenth century when Graunt (c. 1662), a British student of human population, first described the human population in quantitative terms (Krebs, 1978). He saw the importance of quantifying birth rate, death rate, sex ratio and age structure of human populations. Leewenhoek made one of the first attempts to calculate theoretical rates of increase for an animal species. Buffon in his Natural History (1756) recognized the fact that human as well as animal and plant populations are subject to the same processes of population regulation. However, it was Malthus who presented the most controversial ideas in his Essay on Population (1798). His calculations showed that, although the numbers of organisms can increase geometrically (1,2, 4 , 8, 16,...), their food supply may never increase faster than arithmetically (1,2,3, 4,...). The great disproportion in their increases led Malthus to infer that reproduction must eventually be checked by food production. Many social scientists questioned Malthus' ideas. Others used them as bases for further work as Darwin did for his theory of natural selection.

The study of populations was greatly helped by work on insect pests of crops. The regulation of population size of insect pests was the main concern of the work. Better understanding of the factors and processes that affect a population came as a welcome dividend of the studies conducted.

As defined earlier, a population is a group of organisms of the same species occupying a particular space at a particular time. A population has a birth rate as well as a death rate, a growth form, density, and age structure and a numerical dispersion in time and space (Smith, 1966). It is a self-regulating system as will be shown in the succeeding paragraphs describing the factors and processes that affect populations.

1. Density

Population density is the size of a population in relation to a definite unit of space. It is generally expressed as the number of individuals per unit area or volume. Thus, for human population density we say 100 persons per square kilometer; for trees, 200 trees per hectare; for diatoms, 5 million diatoms per cubic meter of water. The density of organisms on an area varies. It may change with the seasons, with weather conditions, with food supply, and many other influences. There is, however, an upper limit to the density of a population within a unit area, imposed by size and trophic level (Smith, 1966). Generally, the smaller the organism, the greater is the abundance per unit area. The larger the size of the organisms, the lesser is its numerical density. Also generally, the lower the trophic level of the species, the greater is its density.

2. Natality, Mortality and Dispersal

Natality, mortality and dispersal are determinants of population. Population density depends upon the number of individuals added to the population and the number leaving or dying. The difference between the birth rate and the death rate and the balance between immigration and emigration determine the number of organisms in a given place.

Natality is the production of new individuals in the population. The greatest influence on population increase is usually natality. The term natality is used instead of births because it covers the production of new individuals by birth, hatching, germination, or fission. Natality may be expressed as the number of offsprings produced per female per unit time. For human populations, the term birth rate is used.

Mortality, the antithesis of natality refers to death of individuals in the population causing a decrease of population number. Mortality may be expressed as the number of individuals dying in a given period. The term death rate is used instead of mortality rate for human population. The death rate is the number of deaths occurring in a given time interval divided by the average population.

Like natality, mortality varies with age groups. And since the number of survivors is more important to the population than the number dying, mortality is better expressed in terms of life expectancy. In fact, there are also two ways of describing mortality: physiological or maximum longevity and ecological longevity.

Physiological longevity is defined as the average life span of members of a population living under optimum conditions and dying natural deaths due to old age or senescence. It is a constant for a given population. Ecological longevity, on the other hand, depends on and varies with environmental conditions.

Dispersal of population is the movement of individuals, seeds, spores, larvae, etc. into or out of the population or population area (Odum, 1971). There are three forms of population dispersal. One-way inward movement leading to an increase in the population is immigration. Opposite this is emigration, a one-way outward movement leading to a decrease in population. The third form of dispersal is migration, the periodic departure and return of members of the population. When immigration balances emigration then dispersal has little effect on the total population. Changes in natality and mortality usually have greater effects on population number than dispersal.

3. Age Structure

An important population characteristic that influences and is influenced by natality and mortality is age structure. Reproduction is limited to certain ages and mortality is most prominent in others. A population may be divided into three age groups: prereproductive, reproductive and postreproductive. Changes in the ratios of these age groups will be reflected in the production of offsprings and their survival to maturity which, in time, changes the age structure of the population. A large proportion of the prereproductive individuals characterize a rapidly expanding population. A more even distribution of different age groups leads to a more stationary population. A large proportion of postreproductive individuals indicate a declining population (Figure 21).

4. Population Growth Form

A population grows until it reaches some form of equilibrium with the environment. When a population first colonizes an unoccupied habitat, the environmental conditions may just be right for its needs and the resources may be abundant. Under such conditions the population tends to increase geometrically, doubling its number rather fast. The population continues to grow until the maximum number that the habitat can support is reached. The maximum number is called the carrying capacity of the habitat. In excess of the carrying capacity the detrimental effects of increased density begin to act on the organisms causing a decline in the growth rate. According to Malthus a given environment and its resources has a definite carrying capacity for a given species.

It has been found out that populations have characteristic patterns of increase which are called population growth curves as revealed by graphing population number against time. One is a J-shaped growth curve which shows an exponential increase in density then an abrupt stop followed by a plunge due to a sudden impact of a limiting effect (Figure 22). The other type is the S-shaped or sigmoid growth curve (Figure 23) which shows a slow increase at first, then becomes rapid and slows down again with increase in enviromental resistance.

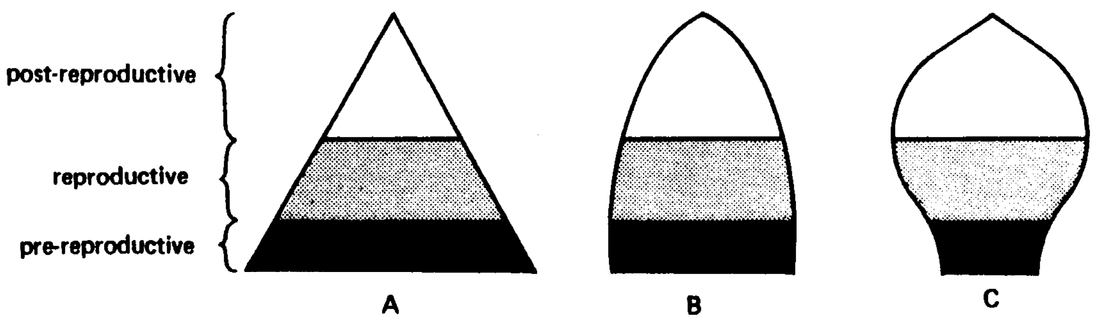


Figure 21. Different Types of Population as a Result of Different Age Group Ratio: A. An Expanding Population, B. A Stable Population, C. A Declining Population
(Source: Edward J. Kormondy, CONCEPTS OF ECOLOGY, 2nd Ed., c 1976, p. 95. Reproduced by Permission of Prentice-Hall, Inc., Englewood Cliffs, N.J.)

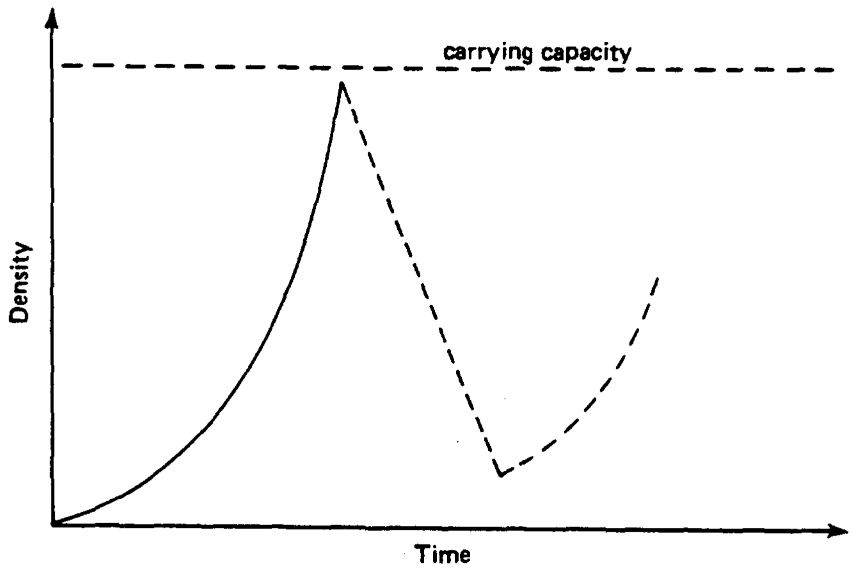


Figure 22. A J-shaped Growth Form

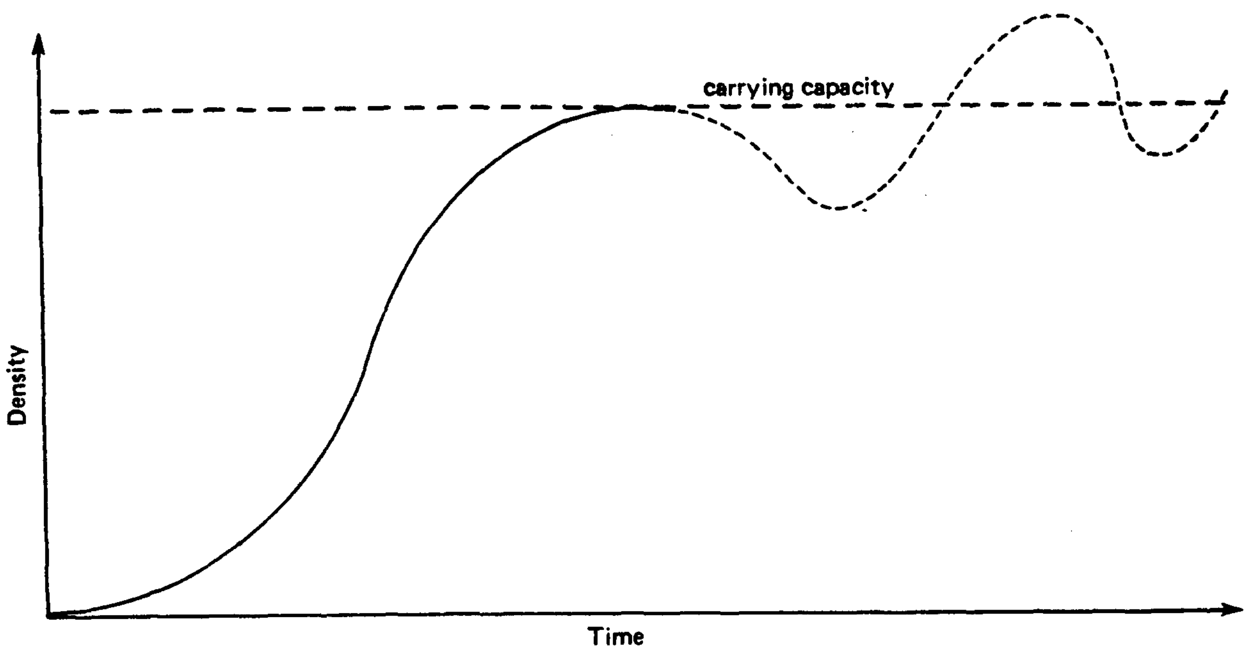


Figure 23. An S-shaped Growth Form

The equilibrium level may be maintained for sometime before a gradual decrease is registered. Studies have shown that the growth of a number of laboratory and natural populations approximates the S-shaped growth curve, especially if introduced in unfilled environments (Smith, 1966). But as populations grow, age structure changes, causing the growth curve to fluctuate around the levels of the carrying capacity. The J-shaped growth curve is often found in insect populations where a sharp drop in the population is observed as the population exceeds the carrying capacity. Growth curves of populations may follow combinations or modifications of the two basic growth curves, depending upon the species and environmental conditions.

5. Regulation of Population Size.

There are two fundamental observations about populations. The first is that abundance varies from place to place. Some habitats are "good" for a certain species hence its organisms are commonly found there. Some are "poor" habitats for the species; its organisms are rarely found there. The second observation is that no population increases indefinitely. The growth of populations - human, plant, or other animals is not limitless (Krebs, 1978). What factors affect the growth of populations?

The factors that bring about natural regulation of population sizes has been the subject of prolonged controversies. The early workers were divided into the <u>biotic school</u> and the <u>climate school</u>. The biotic school proposed that biotic agents, principally predators and parasites, were mainly responsible for the natural regulation of population. The climate school, on the other hand, held that population size was regulated primarily by the effects of weather. Over the years each school was expanded to include newer findings. Smith (1966), for instance, said that the factors that bring about natural regulation of populations may be grouped into the <u>density-dependent factors</u> such as parasitism, disease, competition, predation which are mainly biotic in nature, and the <u>density-independent factors</u> or abiotic factors primary of which is climate (Krebs, 1978). Smith (1966), however, added that climate may sometimes be density-dependent, as in the case of protective refuges. If there are not enough refuges to go around and all the unprotected individuals die, then climate as a factor of natural regulation becomes density-dependent.

The claims of both the biotic and climate schools are valid but for different types of environments. In "good" habitats, i.e. environments that are typically favorable to the species, regulation is wrought by density-dependent processes. In "poor" habitats, environments that are unsuitable to the species, numbers change mainly in response to density-independent processes. It should also be emphasized that a habitat "good" for a certain species may be "poor" for another species. Hence the quality of the habitat as to environment is defined only for a particular species.

What has been mentioned so far are the extrinsic forces, factors of natural regulation that are outside the population itself: food supply, natural enemies, weather, diseases, and shelter. It has been found, however, that these are not the only forces that act on populations affecting their abundance. Some forces are generated with the population. Intrinsic changes caused by self-regulatory mechanisms within the population itself have been observed.

Studies have shown that populations develop buffer mechanisms that prevent or decrease the impact of extrinsic factors. Take, for instance, food supply. Population densities are limited below starvation level by the device of substituting conventional goals of competition for food (Krebs, 1978). Territoriality is exhibited by individual animals that claim a certain area and defend it against others of the same species and sometimes against others of different species. This behaviour is especially conspicuous during the breeding season. Social dominance and hierarchy in populations also help regulate their abundance. Each individual assumes a position in the group depending on its dominance or submissiveness proven by fighting, bluffing and threat at initial encounters. Once social rank is established social harmony ensues in the population with the formalization of intraspecific competitive relations which, thereafter, serve to resolve disputes with a minimum of fighting and waste of energy (Smith, 1966). In addition to social behaviour, studies point to physiologic control mechanisms involving the endocrine system to regulate population size. Evidence suggests that socio-psychological factors affect individuals, specifically their pituitary and adrenal glands (Kormondy, 1976). Stresses brough about by crowding, or social pressures, such as dominance and subordination, result in delayed or even total inhibition of sexual maturation, increased intrauterine mortality, abnormal births, psychological derangement, and kidney and liver diseases, both of which are closely related to adrenal malfunctioning. All of these prevent a run-away increase in population.

Although studies on self-regulation of population were done mainly on birds, and mammals, ideas that came from the researches have been adapted and accepted to apply to most populations.

6. Natural Selection and Evaluation

Another intrinsic form of natural regulation is what is referred to as genetic feedback mechanism. This implies some evolutionary changes within the population involving changes in the genetic properties of the organisms.

Natural selection is a creative process in evolution. It is the differential reproduction of genetic types. It is what shapes populations and species in response to changing environments. Natural selection is responsible for making one kind of genetic information, for example, a certain type of hemoglobin, more and more or less and less common in the gene pool of a human population. This is a response to a change in the environment, probably an increase in the population of malaria-carrying mosquitoes. The presence of that type of hemoglobin in the individual's bloodstream makes him resistant to the disease. Hence individuals who carry this hemoglobin type become more dominant in the population than those that carry the susceptible hemoglobin type. What happens is a gradual change in the population's gene pool and this constitutes the basic process of evolution.

A key point about natural selection is the fact that it can operate only when there is genetic variability in a population. If all individuals are genetically identical with no variation, then no differential reproduction of genetic types can occur. If so, the population is highly vulnerable to environmental changes because it lacks the ability to make evolutionary adjustments. Such a population is probably doomed to extinction.

Other evolutionary forces such as mutation, migration, and genetic drift also cause changes in the gene pools of populations. Mutation changes the chemical structure of a gene. When that gene is introduced in the gene pool it effects a change in the gene pool's constitution. The flow of immigrants and emigrants into and out of a population often results in the introduction or withdrawal of certain genetic characters. Both mutation and migration increase the variability of population, enhancing conditions for natural selection.

When a coin is tossed a hundred times it is unlikely that one gets tails 50 times and heads, the other 50 times. In statistics, this is attributed to sampling error. Likewise, when a certain genetic information is passed on from one generation to the next, the second generation would possess that genetic information in the same frequency as in the gene pool. Thus the gene pool of the second generation would be different from that of the first. This phenomenon is referred to as genetic drift. The magnitude of genetic drift depends on the size of the population. It has a greater impact on small populations than in bigger ones. In a big population the likelihood of passing on the genetic information to more individuals is greater than in a small population but the percentage of the affected individuals to the total of the big population is low. Genetic drift more often than not, results in a decay of variability. Loss of genetic variability greatly reduces the chances for a population to evolve appropriately in response to environmental changes and thus enhance the probability of extinction (Ehrlich, 1977).

F. HUMAN INTERVENTION IN NATURAL PROCESSES

"Pick a pasque flower and you touch a distant star."

The ecologist who said this was of course exaggerating. But the point he wanted to emphasize is the interrelatedness of things in the universe, that a living think affects a non-living object and vice-versa, no matter the distance. When human beings cause some change to occur on one thing in their immediate environment, the effects do not end on that particular object but usually triggers a chain reaction of causes and effects.

Humans have always had some effects on the ecosystem of which they are a part. Their development of science and technology has deepened the human impact on the earth ecosystem. Human activities have altered some characteristics of the earth's surface, increased or decreased the amount of stock energy involved in a part of the natural energy flow, and increased or decreased the amount of materials carried in a part of the natural materials cycles in the earth ecosystem. Humanity has both inadvertently and deliberately caused these modifications. The succeeding discussions deal with human activities that affect natural processes on this planet.

1. Human Activities that Affect Energy Flow in the Earth Ecosystem

Significant modification of the earth ecosystem by humanity began with the development of agriculture. When human beings were merely food gatherers, that is, they subsisted on hunting animals and gathering seeds and wild fruits, their effect on the environment was minimal, being confined to the immediate vicinity of the fires they maintained for warmth and cooking. With the advent of agriculture the effects became extensive due to the clearing of land of its natural vegetation to plant crops. The vast stores of food that became available due to planting encouraged the rapid increase in human population. More people means occupancy of more land, thus further increasing the effect of humanity on the environment.

With the spread of agriculture, trade and commerce flourished and led to the movement of people between settlements. As population increased, humanity's lifestyles became more and more complex resulting in greater demands for energy and materials.

a. Increased combustion and carbon dioxide production

Humanity's demands for more and better material comforts led to increased production and manufacturing processes which required increased combustion. More and more fossil fuels had to be burned to run machines that produced the material things. And the trend continues up to the present. How does increased combustion affect the natural energy flow?

Recall that an end product of combustion is carbon dioxide. This gas is also produced when animals breathe and plants respire. It is also released by decaying organic materials. Increasing combustion by burning more fossil fuels to run industries increases atmospheric CO_2. The concentration of atmospheric CO_2 has increased from the 290 parts per million (ppm) in 1900 to about 330 ppm today (Owen, 1980). If the rate of combustion of fossil fuels is maintained at the 1975 level and if all the CO_2 produced remains in the atmosphere, there will be enough to increase CO_2 concentration by 3 ppm per year. Nature, however, has its own cleansing machinery. Roughly half of the CO_2 produced since heavy reliance on fossil fuels began has been absorbed in the upper layers of the oceans, and converted to terrestrial and oceanic biomass.

The part that remained in the atmosphere is of considerable climatic significance because of the role played by CO_2 in the earth's energy balance through the so called "greenhouse effect"(Fig.24). Recall that the earth's surface radiates back to space some of the energy it receives from the sun. This radiation is in the form of long infrared (IR) rays or heat waves. Carbon dioxide and water vapor trap the IR radiation preventing it from escaping into space. Increased CO_2 in the atmosphere means more IR rays trapped, thereby increasing the average temperature of the atmosphere and the earth's surface. It is estimated that if all other factors remain constant, the

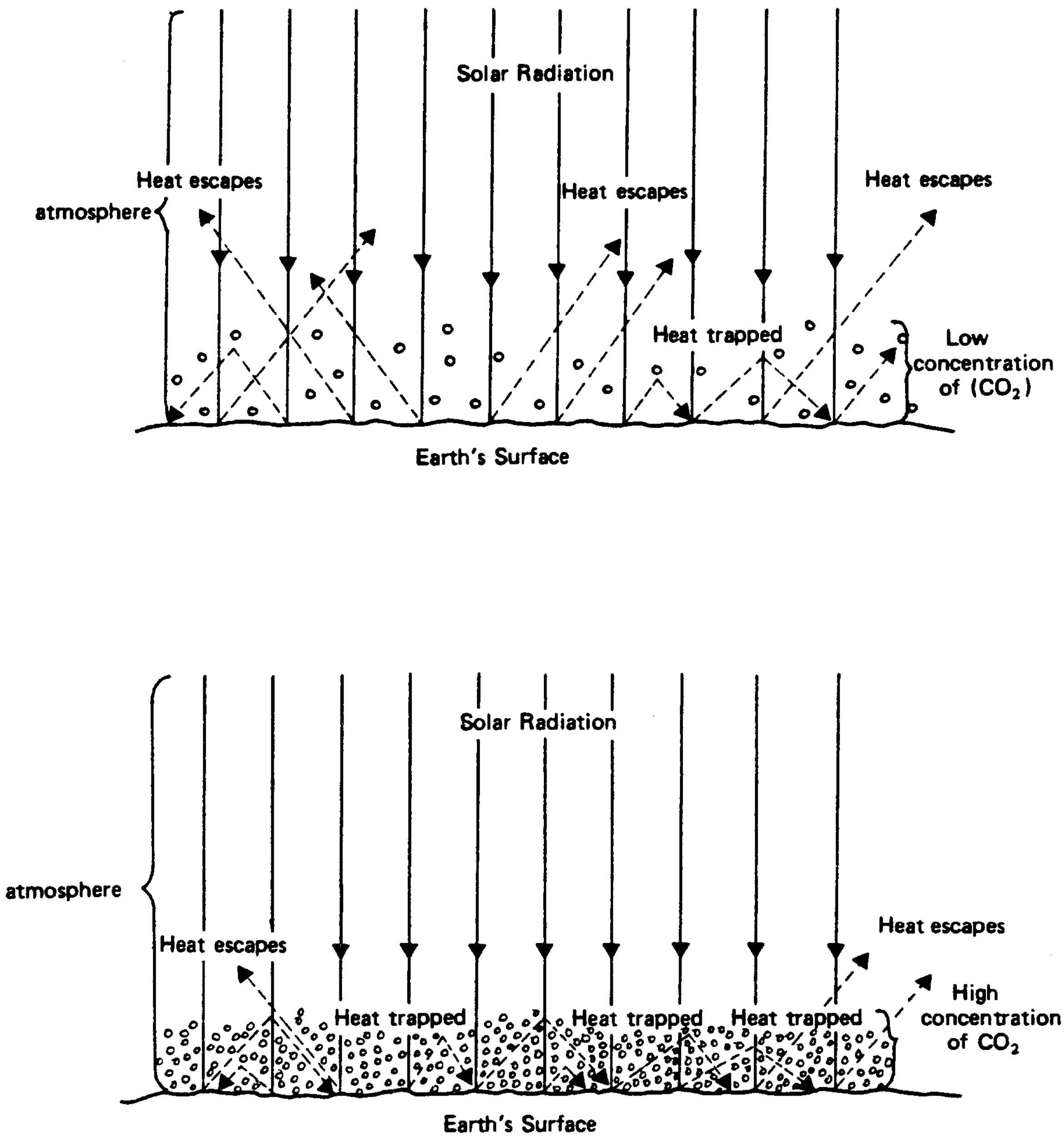


Figure 24. The "Greenhouse Effect" of CO_2 in the Atmosphere

enhanced greenhouse effect associated with the increase in CO_2 concentration could cause a global temperature increase of 0.3°C to 0.6°C between 1975 and the year 2000 (Ehrlich, 1977). Such increase could cause significant changes in atmospheric circulation, desertification of fertile farming lands and extensive melting of polar caps and sea ice with a consequent rise in sea level - a disaster for low-lying coastal areas.

Other effects on the ecosystem due to increased combustion will be discussed later as these involve interference more in the materials cycling than in the energy flow.

b. Smog, soot, and other particulate matter

Varied human activities have also released particulate matter into the atmosphere. These occur in a variety of sizes and chemical compositions including dust, soot, smog (smoke and fog) and heavy metals such as cadmium, mercury, and lead. Particulates with a diameter of 10 microns (1 micron = one thousandth of a millimeter) or less have a very low settling velocity so that they tend to remain suspended in the atmosphere. It is estimated that the total annual load of particulates generated by the earth now amounts to about 800 million tons (Owen, 1980). Sources contributing to this amount include the combustion of fossil fuels; the razing of old buildings; the piles of trash; agricultural activities such as plowing, cultivating and harvesting; slash-and-burn farming in Asia, Africa and South America; forest fires; debris burning by loggers; dust storms and strip-mine operations.

Whereas an increase in the amount of CO_2 in the atmosphere has a warming effect, an increase in the particulates may have a cooling effect. Particulates backscatter (reflect back) the incoming solar radiation to space. An increased particulates load would then reduce the amount of sunlight reaching the earth. Such reduction of solar energy, the power base of all ecosystems, could have profound and adverse effects such as a lowering of temperature and more importantly an impaired growth in crop plants. With the rapidly increasing human population any diminution in food production would be tragic.

Suspended particulates also serve as condensation nuclei inducing precipitation. This has been observed not on a global scale but locally, particularly in urban centers where the warmed urban air combines with the moisture (a by-product of fuel combustion) emitted from industrial smokestacks and motorcars. Recall the important role that the hydrologic cycle plays in energy transfer and utilization. Artificially induced precipitation could cause serious imbalances in the total energy flow.

c. Ozone

Ozone has both a useful and a harmful role to play in this planet. It all depends on where it occurs. At ground level, it can pose a serious health hazard causing irritation to the nose, eyes and throat. But in the stratosphere where it is normally found forming a layer, ozone serves its beneficial role (Figure 25).

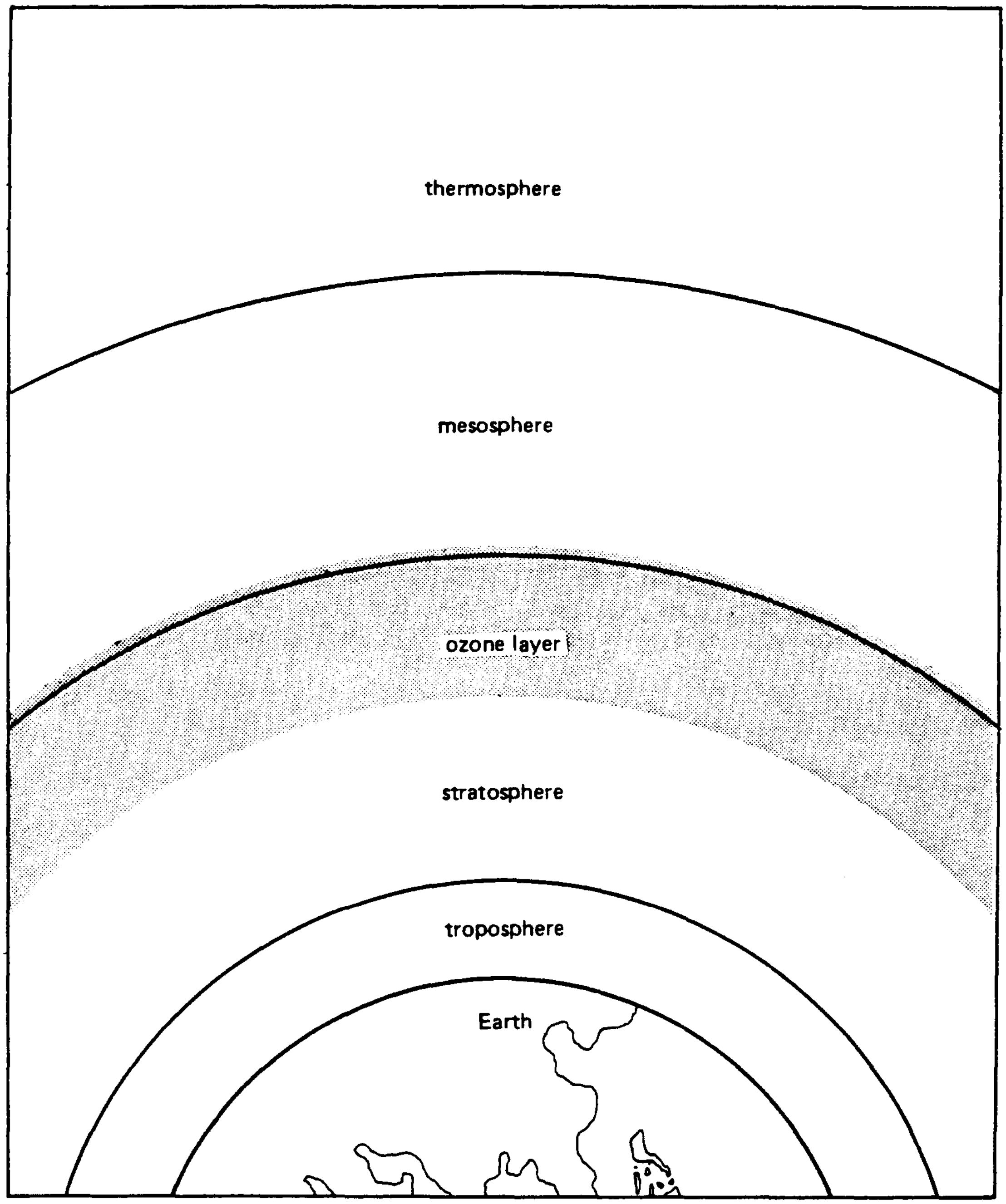


Figure 25. The ozone layer filters incoming ultraviolet radiation. The thickness of the ozone blanket over the earth's surface varies with latitude.

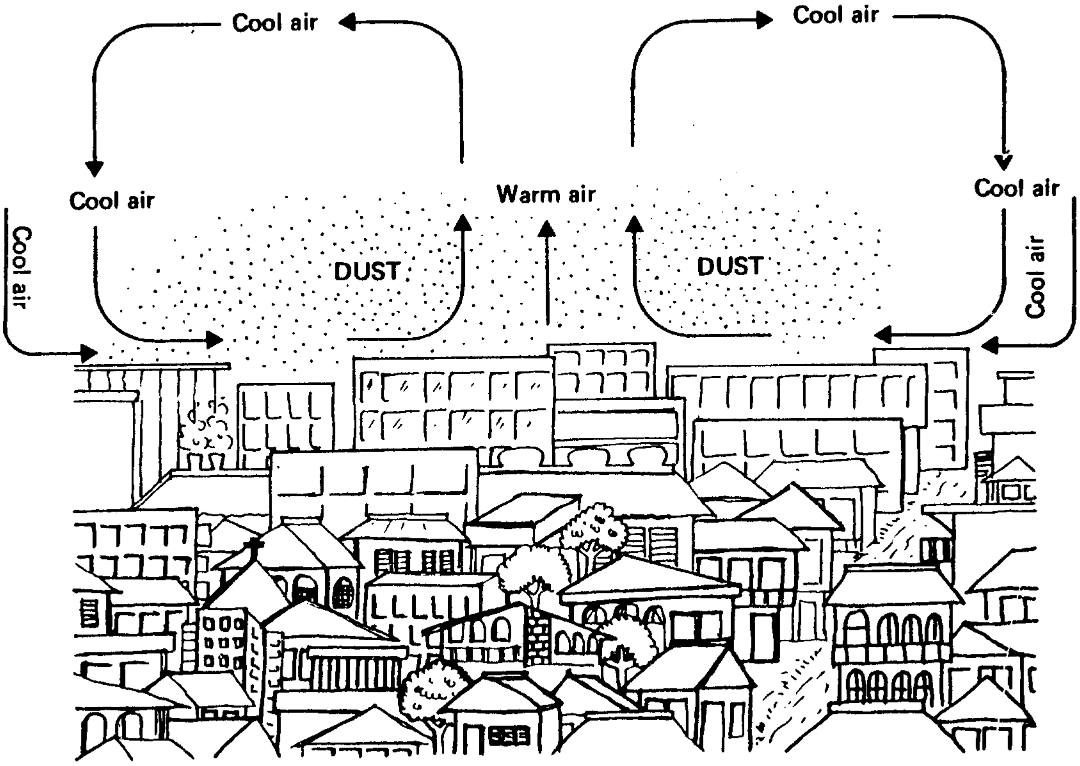
There, ozone screens off the ultraviolet waves which continuously bombard the earth. A thinning out of the ozone layer or its disappearance would result in more UV waves reaching the earth's surface. Increased exposure to UV waves would have detrimental effects on most forms of terrestrial life.

Until a few years ago the amount of ozone in the stratosphere was in a state of dynamic equilibrium. In other words, ozone-forming and ozone-depeleting reactions proceeded at about equal rates so that the net amount of ozone remained fairly constant. Varied human activities, however, have tipped the balance toward accelerated ozone-depleting reactions. Detonation of nuclear bombs, increased combustion of fossil fuels, and wide-use of spray cans propelled by fluorocarbon gases (commonly known as aerosols) have increased the amount of nitric oxide (NO) and atomic chlorine (Cl) which are naturally scarce in the stratosphere. These gases are catalysts for ozone-destroying reactions. Bromine is also known to be even more efficient catalyst for ozone-depeleting reactions than chlorine. Pathways to the stratosphere for bromides have not yet been evaluated but bromides are extensively used in gasoline additives, agricultural chemicals, and flame-retardants (Ehrlich, 1977).

Other threats to the ozone layer being investigated are the effects of using more nitrogen fertilizer thus adding more nitrous oxide (N_2O) in the atmosphere which means more nitric oxide (NO) in the stratosphere, hence less ozone. Chlorination of drinking water and of sewage is suspected to be a source of carbon tetrachloride (CCl_4) which releases atomic chlorine in the stratosphere.

d. Concentration of human population, heat sink and wind flow in cities

Increasing urbanization is also altering natural energy flow in the earth ecosystem. Differences in temperature of about 1° - $2^\circ C$ have been observed between cities and their surrounding rural areas. Several factors contribute to this "heat-island" phenomenon. There are many more heat-generating sources in the city than in the rural environment. They include the mass of humanity concentrated in cities (with an average body temperature of $36^\circ C$), transport facilities, heating/cooling systems, industrial furnaces, and so on. Materials out of which physical structures in cities are made such as concrete, asphalt, bricks, etc. have greater heat capacity than vegetation which abound in rural areas. The dark and irregular surfaces of buildings, with vertical walls that permit multiple reflection of in-coming sunlight reduce the amount of solar energy reradiated back to space, thereby increasing the energy available for heating the air over the cities. Water bodies (streams, lakes swamps) are much less numerous per unit area in cities than in the surrounding countryside so that less heat will be lost because of evaporation of water and more will be available for warming up the urban atmosphere. Also, the large areas of paved surfaces in cities cause water to drain off into sewers rapidly after a rain. The rapid drainoff bypasses the normal cooling, hence the concentration of energy nearer ground levels in cities.



"BIG CITY"

Figure 26. The Heat-Island Phenomenon

The winds in cities are generally lighter than in the countryside. Buildings serve as obstacles to wind flow thereby increasing frictional resistance. Along streets with tall buildings on both sides, there is a channeling effect causing wind velocity to increase. Irregularity of the surface may cause turbulent fluctuations of the wind over cities.

In addition, greater concentration of particulate matter over cities causes greater variability in precipitation. It has been observed, for example, that in Paris average daily rainfall during weekdays is 31 percent higher than on weekends (Owen, 1980). This is attributed to the fact that particulate-generating sources operate on weekdays and are closed on weekends. As discussed, earlier, changes in precipitation patterns have an altering effect on the natural energy flow and on the stock energy involved in the process.

Transport of fossil fuels, specifically oil, to areas of greater demand has often resulted in oil spills on the ocean surface. This also causes a chain of events which could locally alter the energy flow. Oil slicks on the ocean change the reflection of radiation, the roughness (hence the energy transfer from surface to the atmosphere), and the evaporation rate.

Rapid population growth in agricultural and pastoral societies has been pin-pointed to have brought on and aggravated changes in the flow of energy which resulted in regional climatic changes as the droughts in the sub-Saharan Africa. The chain of events can be traced. Increasing population pushes people towards greater food production requiring agricultural practices such as irrigation of arid lands and/or overgrazing. The latter, for example, bares high-reflecting soils, resulting in a drop in the absorption of solar energy at the surface, reducing the heating of near-surface air. The reduction of updrafts resulting from this phenomenon inhibits cloud formation and rainfall, finally producing drought. (Ehrlich, 1977.

Human activities over the past several centuries have actually been directed towards making the environment hospitable. But in the effort to do so, humanity has inevitably caused the deterioration of some aspects of it. Because of the lack of understanding of the balance of nature, humanity has both purposefully and inadvertently modified the environment with both injurious and beneficial consequences.

2. Human Activities that Affect Materials Flow in the Earth Ecosystem

How have humanity's activities affected the natural flow of materials in the earth ecosystem? Ehrlich(1977) categorizes the ways by which human beings contribute towards disruptions in the natural flow: (1) human activities that release large amounts of substances into the natural cycles by overloading part of the cycle (ex., nitrogen), by disrupting a finely tuned balance (ex., CO_2) or by swamping the natural cycle completely; (2) human activities that release materials that are a neglible amount of material as compared to natural flows of the same material in a sensitive spot (ex., oil leaks); (3) human activities that release toxic substances (such as mercury, cadmium, lead, and many radioactive substances) into the cycle of the essential materials; (4) human activities that introduce into the natural cycles synthetic, biologically active substances such as synthetic organic pesticides, PCBs, and herbicides, which are proving to be harmful to organisms.

Industry, transportation, urban construction and other accoutrements of modern living have been pointed to as ecologically disruptive human activities.

It may be well to recall that the essential materials on which life depends and which go through cyclic flows in the earth ecosystem have their reservoir in the atmosphere and in the lithosphere. These reservoirs have lately been gravely affected by varying human activities leading to a degradation of their quality.

a. Air pollution

Air pollution may be defined as the presence in the atmosphere of substances that are toxic, irritating, damaging to property, vegetation, animals and human beings. Thousands of substances contribute to such atmospheric disturbances. These are called pollutants. They exist as solid matter, liquid droplets, or gas. They are produced by car engines, refineries, factories, and as waste of the billions of the human population. The six major air pollutants are carbon monoxide, sulfur oxides, hydrocarbons, lead and particulate matter. Many other polluting substances are found in the air in smaller amounts.

(1) Carbon monoxide

The compound carbon monoxide (CO) is naturally produced by the oxidation of methane or marsh gas (CH_4), which in turn is formed by the decay of marshland organisms. The CO does not build up in nature to harmful concentrations due to its ability to combine readily with oxygen in the air and the action of soil-dwelling organisms which convert the compound into CO_2. The concern for the presence of CO in the air stems from the fact that it is increasing in concentration as a result of incomplete combustion of fossil fuels, and that it is concentrated in a relatively small volume of air over the world's major cities. The CO concentration of urban areas is estimated to be 50 to 100 times greater than the global average (Owen, 1980).

Each year millions of tons of CO is spewed into the air from incomplete combustion in motor vehicles and from industrial smokestacks. What is bothering is the fact that a considerable percentage of the compound is produced knowingly, if not purposefully. In a completely efficient motor vehicle engine, the chemical reaction would be as shown below:

$$2\ C_8H_{18\,(l)} + 25\ O_{2\,(g)} \longrightarrow 16\ CO_{2\,(g)} + 18\ H_2O_{(g)}$$

However, engines run better when there is an excess of gasoline and a deficiency of oxygen in the carburetor. This means incomplete combustion and some of the carbon in the exhaust is in the form of CO rather than the relatively harmless CO_2.

$$2\ C_8H_{18\,(l)} + 17\ O_{2\,(g)} \longrightarrow 16\ CO_{(g)} + 18\ H_2O_{(g)}$$

(2) Hydrocarbons

Another product of the incomplete combustion of fossil fuels is the hydrocarbons (over a hundred different kinds have been identified). Complete combustion of hydrocarbons produces water and carbon dioxide. The highly reactive hydrocarbons, combine with nitrogen dioxide in the air to form photochemical smog which irritates the eye and is suspected to be carcinogenic.

More efficient combustion (i.e., fossil fuel is more completely burned) reduces hydrocarbon and carbon monoxide emission but increases the amount of sulfur, nitrogen, mercury, and cadmium released into the air. These elements are natural contaminants of fossil fuels such as coal and oil.

(3) Oxides of sulfur

As mentioned in the preceding section sulfur is a natural contaminant of coal and oil. Oxides of sulfur are produced in the burning of coal and oil necessary for the operation of electric power generators, space heating of homes and office buildings, running motor vehicles, and producing heat for certain industrial processes such as releasing metals from their ores. Emission from these processes are almost entirely in the form of sulfur dioxide gas (SO_2). Once in the atmosphere, this is readily oxidized to SO_3. The SO_3 reacts with water vapor or dissolves in water droplets to form the strong sulfuric acid (H_2SO_4). The sulfur dioxide can also form the relatively weaker H_2SO_3, and the sulfate ion ($SO_4^{=}$) also appears in a variety of solid and liquid particulates. In the presence of suspended particles the oxidation of SO_2 to SO_4 is increased because the suspended particles provide surfaces that facilitate the reactions.

(4) Oxides of nitrogen

Oxides of nitrogen as air pollutants are in the form of nitric oxide (NO) and nitrogen dioxide (NO_2). Formation of nitric oxide from nitrogen and oxygen takes place at the high temperature and pressure produced by internal combustion engines. The colorless nitric oxide is oxidized in air to orange-brown nitrogen dioxide (NO_2). Nitrogen dioxide reacts readily with water vapor to form nitric acid, HNO_3. This, together with H_2SO_4 and H_2SO_3, cause what is known as acid rain which may fall over areas far from where they are formed.

(5) Oxidants

The presence of NO_2 in the air triggers other pollutant-producing reactions. Absorbing ultraviolet radiation from sunlight, NO_2 breaks down to form NO and O. The O then combines with O_2 in the air to form ozone (O_3). Earlier, it was mentioned that O_3 is essential to life if it stays in the stratosphere to filter out incoming UV radiation. At ground level, however, it is a major component of photochemical smog. O_3 also reacts with hydrocarbons to form aldehydes and ketones. These organic compounds react, in turn, with NO to form another irritating and injurious compound known as PAN or peroxyacetl nitrate.

(f) Other pollutants

Lead, in the form of TEL (tetraethyl lead), is added to gasoline to boost its octane rating. For reasons not fully understood, TEL prevents "knocking" in car engines when under stress. Leaded gasoline contains up to 3 g per gallon. The lead is emitted in the exhaust in the form of very fine particles of the compounds $PbCl_2$, or $PbBrCl_2$.

Atmospheric concentration of lead particles is very high in areas where traffic is heavy. Not only is lead inhaled by humans and animals, but it is also incorporated in plant tissues when it is washed from the atmosphere by rain and dissolved in water taken in by plants. Carried by plants, it enters the food chain that leads to Homo sapiens. In living tissues lead is subject to biological magnification and may reach toxic levels in mammals including man.

Other heavy metals such as cadmium and mercury, also find their way into the food chain. These may be initially emitted by motor vehicles and industrial smokestacks into the atmoshphere, rained out from it into the ground, imbibed by plants or aquatic animals, and finally eaten up by higher forms of animals including man. Biological magnification may increase the concentration of these metals to levels injurious or even lethal to higher living forms.

3. The Human Ecosystem

The human race is the single predominant influence in nature. In obtaining needed materials and energy, humanity has been modifying the natural world and bending it to its will.

Cain (1973) presented a simple schema of the human ecosystem (Figure 27) in comparison to general or natural ecosystems (Figure 28) from which human culture is isolated. The difference underlines the uniqueness of human nature and the culture that evolved from it.

In this schema of the human ecosystem, humanity's contacts with nature occur in the social context. In Figure 27, one sees that the economic utilities that support the individual and the human community are wrested from natural resources by institutionalized application of human labor and capital. Scarcely any productive activity is carried out by an individual alone. The wresting of raw materials from nature and use of nature's products and processes is accomplished by concerted human effort. To accomplish this concerted effort, the human race has created and organized many institutions related to agriculture, forestry, fishing, mining, and so on, as well as to business, financial, industrial, commercial, and social endeavor (Cain, 1973).

The human ecosystem, however, is involved in the production of much more than goods. In this connection, the institutions of the family, and larger social groups and their relation to religion, education, politics, law, security, the creative arts, communication, and their use of leisure time are all readily recognized. There is almost nothing that contemporary human society does that is without

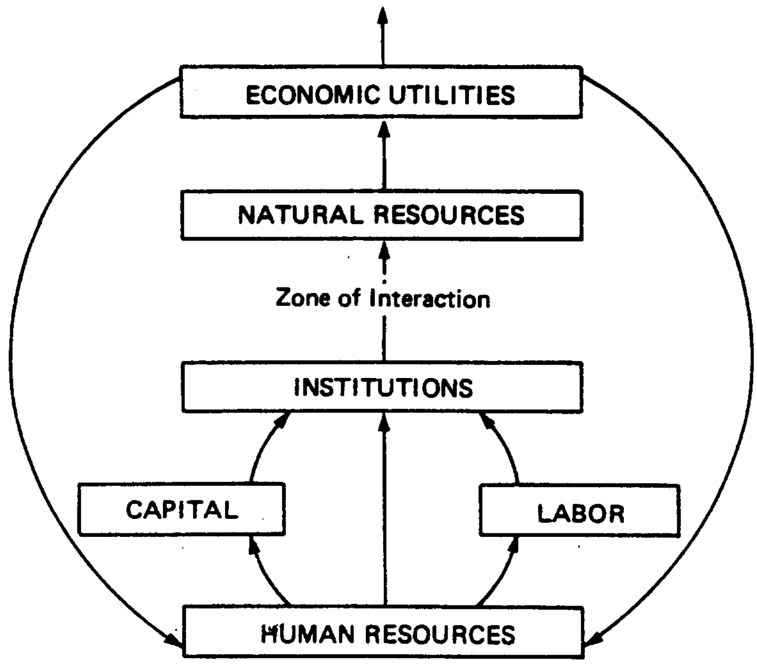


Figure 27 Simple Schema of the Human Ecosystem
(Source: Cain, 1973)

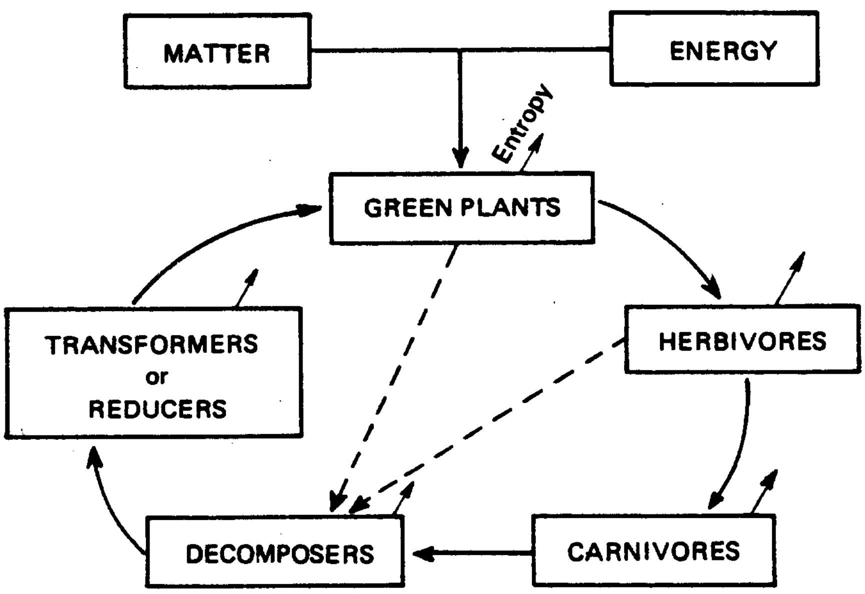


Figure 28. Simple Schema of General or Natural Ecosystems in the Absence of Human Culture
(Source: Cain, 1973)

some institutionalized aspect.

The model of the human ecosystem that Cain proposes uses the economic concepts of labor, capital and economic utilities in a flow scheme that gives institutions a central role. Labor, in this model, includes all of an individual's personal means of production, as well as the portion of the total human population that is productively engaged at any period of time. By capital is meant all of the physical means of production the human race has created. This includes the tools, implements, machineries, and physical facilities that humanity has invented, built and employed in the production process. The flow of labor and capital through institutions in the production process means that all contemporary human productive effort is socialized. Institutions, like the tools of capital, are human inventions intended for the cooperative use of labor in producing goods and providing services. Natural resources include not only the things but also the conditions and processes in nature that humanity can use in life processes, both biological and cultural.

The human ecosystem is biologically identical to a general ecosystem in that it shares the need for energy and materials that characterize all life to sustain the organism and allow it to grow, develop and reproduce. Since human beings are not primary producers, they participate just like any other consumer in a food web through which minerals cycle and energy flows. But unlike other life forms, humans have created a fantastic demand for external, non-physiologic materials and energy - a demand that far exceeds the basic human needs for food, clothing and shelter.

Human ecosystems are capable of attaining a state of homeostasis or equilibrium through self-regulation (Cain, 1973). Its own products can be used to maintain it, such that food produced as an economic utility is used to nourish the labor that produced it, and the materials that are produced are used to develop and replenish the capital that labor used in the production process. Thus the interaction between the human resources - labor, capital, and institutions - and the natural resources in a given human ecosystem can maintain that system as long as the system is viable and the supply of natural resources is not exhausted.

The final and very important point of this simple but fundamental concept of the human ecosystem is that it is capable of growth, development, and evolution (Cain, 1973). When the production of goods of a functioning system is in excess of what is necessary for its maintenance, the excess can be productively invested resulting in the growth and development of the system. This means that the population can grow and that the population can be improved as to its socioeconomic conditions.

Two basic types of human ecosystem which can be found in any part of the globe are recognized - the urban and the rural. As the world's population rises, people tend increasingly to congregate. This actually began with the Agricultural Revolution. Agricultural settlement formed rural ecosystems. When more food could be produced in less area, the farmers were able to feed more than their own families, thus releasing a part of the population from cultivation of the land. This gave rise to a diversity of occupations and the beginnings of specialization of labor and services which characterize urban ecosystems.

The growth of cities in the past was mostly due to migration from the rural areas. Advances in agriculture displaced many farm hands who then moved to the cities in search of work or to develop their special talents and abilities in endeavors other than agricultural. The cities, therefore, grow into centers of non-agricultural pursuits. It is in such a climate that science and technology flourished. But the cities could not cope with the rapid urban concentrations. The very high densities in urban systems were attended by a variety of severe social problems. In 1925, twenty-one percent of the world population lived in urban conditions; in 1950, twenty-eight percent was urban; in 1975, thirty-nine percent was urban. In 1975, 30% of East Asia, 24% of Africa and 60% of Latin America were urban as compared to 77% of the U.S. and Canada. The urban population of the world is projected to reach 50% in the year 2000.

Why do people flock to urban areas? It is because people believe cities are great mobilizers of social classes via jobs, culture, education, entertainment, and modernity. Despite their shortcomings, cities offer a broad diversity of advantages and opportunities not available in rural areas: more medical care facilities, environmental sanitation, welfare, and a variety of recreational and entertainment activities. Urban areas are also characterized by public utilities such as systematized transport by land, air and water, electricity, water and sewerage systems, all of which attract people.

Urban structures are determined by two factors: land use and nature of the transportation system. A city will have its structure partly determined by the forces that govern land use, especially if it has a public land planning programme. The results can be seen in the internal structure of the city and in the growth and development of its peripheral areas. The nature of the transportation network as well as its location limits the extent to which a city could expand. The invention of the automobile revolutionized urban structure. Whereas in the past, urban areas limited by beasts of burden for transportaion tended to be located close to waterways and to be compact, modern cities, with railways and automobiles sprouted and sprawled almost anywhere over the landscape. The automobile also made urban population much more mobile.

Urbanization differs for different countries. In developed countries, for example, the difference between city-dwellers and country-dwellers has become increasingly indistinct. This is due to rapid transportation and the development of mass media. The comforts and amenities of urban living have become available to rural settlements. In less developed countries, urbanization brought a flood of impoverished country people into urban areas. While at this same time, the opportunities in the cities had not increased at the same rate as the migrants. The result was the development of huge slum areas or shanty towns around the cities or even within them.

Cities in developed countries are a source of wealth and power generated through technology and manufacturing. But cities depend on the rural areas for raw materials and food. The goods cities produce are exchanged for these commodities.

In contrast to the urban setting, the rural ecosystem is characterized by human settlements separated by large agricultural areas, and, therefore, low population density. The rural population looks to the urban area as a market for its agricultural products. People in the rural areas depend on the urban areas for manufactured goods such as clothes, shoes, appliances, tools and machines. A part of the raw materials that flow from rural areas to urban areas return to the former in the form of manufactured goods.

Advancements in agricultural technology having eased out excess farm hands, the rural population is low. Therefore the demand of rural areas for materials and energy is also low. Nutritional and fuel energy consumption of rural dwellers, is far below that of city dwellers.

V. ESSENTIAL KNOWLEDGE ABOUT PROBLEMS OF THE ENVIRONMENT

A. FOUR MAJOR DIMENSIONS OF ENVIRONMENTAL PROBLEMS

Human "success stories" are marked by struggles to control and thereby interfere with the environment to wrest a good living from it. Human interference in most cases creates ecological imbalance with deleterious effects. These unwanted effects result in serious environmental problems which, in the long run, may lash back and cause the deterioration of human well-being.

In recent conferences on environmental education, four dimensions of environmental problems in contemporary society have been identified. These are the physical, economic, and social consequences; geographical scale; time scale; and socio-economic systems.

1. The Physical, Economic, and Social Consequences of Environmental Problems

Many human activities, particularly the poorly planned developmental programmes, have detrimental and irreversible consequences. These consequences may consist of resource deterioration, biological pollution, chemical pollution, and physical disruption.

Resource deterioration involves a reduction in the quantity and/or quality of resources. Examples are soil erosion, destruction of vegetation cover and wildlife, insufficient water supply, and the depletion of mineral resources.

Biological pollution occurs when diseases or pests spread. Malaria and schistosomiasis often result from irrigation and other water resources projects. Inappropriate agricultural techniques encourage the spread of pests.

Chemical pollution refers to the release of chemical substances into the environment resulting in the deterioration of the soil, air, water, or food. The chemical pollutants are often traced back to industrial and agricultural processes, transportation, energy production and consumption, use of food additives, etc. A poison that finds its way into the diet through a food chain and the subtle interaction of some chemical with the human body are examples of this type of pollution.

Physical disruption is either an encroachment or depletion effect on the physical environment. Encroachment refers to interference with the levels of productivity or impingement upon the social, mental, or physical well-being of humankind and other living things. Depletion involves the reduction of the future availability of resources. Wasteful use and lifestyles of people may cause the depletion of our precious resources. The exploitation of water, soil, air or forest resources may bring in cash profits but its attendant encroachment and depletion effects may degrade the quality of these resources and finally result in a decline in human well being.

2. The Geographical Scale of Environmental Problems

Environmental problems range from local to global. Global environmental problems call for worldwide action and management based on international conventions. Examples include threats to the ozone layer, the impact of weather modification, exhaustion of petroleum resources, loss of wildlife species, and the destructive effects of nuclear radiation.

Environmental problems at the regional level require the agreement of the affected countries on a plan of action in solving problems of common concern. These problems may include the destruction of tropical rain forests, natural disasters, the pollution of regional lakes or seas, and the spread of diseases.

Environmental problems at a national level may be solved by a nationwide action that considers the country's economic capability and cultural tradition. For example, the human settlement problems are solved in different ways by different types of societies.

Environmental problems that occur at the subnational or local level require the concerted action of groups of people within a state to solve them. Examples of these problems are several polluted streams from different areas polluting a river in another area or the destruction of many woodlands may lead to the adjoining plains being turned into deserts.

3. The Time Scale of Environmental Problems

The impact of human activities upon the environment may be felt immediately or may take time before their effects become apparent. Some impacts have both a short term effect and a long term effect. An example is smog. Smog affects the environment immediately but its effects on human health take a longer time to be felt. It is, therefore, essential that solutions to such problems consider the future risks and the present environmental costs.

4. The Socio-economic Systems Affected by Environmental Problems

Developing countries throughout the world are confronted with problems due to underdevelopment and problems which arise in the course of development. Environmental problems resulting from underdevelopment are poor conditions of human settlements, loss of productivity through disease and malnutrition, vulnerability to natural disasters such as an earthquake and loss of natural resources, for instance, forest destruction and soil erosion. Yet developing countries also suffer in the process of development. Ill-conceived development projects may result in tradeoff with equally undesirable or worse effects. For example, large scale mining may bring in big profits fast but may speed up resource depletion, pollution, and widespread social disruption.

Industrialized or developed countries are faced with more complex environmental problems. These problems may arise from the intensive application of science and technology resulting in industrial pollution, high rates of resource use because of abundance and socio-cultural problems of living in larger cities.

B. MAJOR CAUSES OF ENVIRONMENTAL PROBLEMS

Human activities, since early times, have always resulted in changes in the environment. Yet, it was only in the last few decades that the impact of human activities became accelerated and more pronounced. Pressures from rapid population growth, uncontrolled and lavish consumption, urbanization, industrial expansion, and advances in science and technology have caused these accelerated changes in the environment. They create serious environmental problems which affect not only a certain locality or a certain type of society but also the people throughout the world, developed as well as developing countries.

1. Rapid Population Growth

Population experts' estimates show that world population shortly before 1650 was 250 million, reached 500 million in 1650, and by 1850 or after 200 years, population doubled to one billion. In 1930 or 80 years later, population doubled to two billion. Again after 35 years population zoomed to three and a half billion. With the present doubling trend, the world's population was 4.2 billion in 1980, and may reach 6 billion in the year 2000 (Owen, 1980). Experts fear that the doubling time is still decreasing. If these trends were to continue, the earth's population will be 30 million billion in 800 years! This, of course, is impossible. This phenomenon of very rapid growth and rate of growth is sometimes called "population explosion."

Population growth in different countries has different doubling times. The shorter the doubling time the faster the population grows. Latin America with its doubling time of 25 years is growing faster than the other regions. Africa's doubling time is 27 years. Asia's population doubles every 30 years. Population in the developing countries is growing more than twice as fast as the population in developed countries. Nearly half of the population in developing countries is below 15 years of age. Europe's doubling time is 99 years, North America, 63 years and the USSR, 77 years.

World population is still rising at the rate of 200,000 people per day. An increase in the number of people means increased demand for food, shelter, water, fuel energy, other earth materials and space. The effects of rapid population growth are actually other problems. We shall discuss them in succeeding sections.

a. Food shortage

In terms of number of people without food, Asia has been named the "hungriest continent". Borgstrom identified those countries whose daily average per capita food intake is below the minimum requirement of 2,200 kilocalories as the hungry nations. These are the countries in Asia except Japan, most countries in Latin America except Argentina and Uruguay, and the whole of Africa.

The Hungry World has a young population. More than half of the population is below 18 years. More than half of the infants die before they reach five years of age and about 650 million will never reach adulthood. Even with zero population growth (ZPG) more food would be required simply because infants will have an increasing demand for food as they reach the 10-15 year bracket.

Half of the world's population is concentrated in Asia. Its population exceeds 2 billion and has a growth rate of 2.3 percent annually. Its population is rapidly rising but food is in short supply. Every year about 49 million more have to be fed and about 11 million tons more of rice are needed to provide for these added numbers (Borgstrom, 1973). Thus developing countries' deficits in food production continue to increase. In 1975, a 42-million ton deficit was recorded. If food production and population increase continue at the same rate by 1985, food will be 88 million tons short.

Food production in developing countries is estimated to increase at 2.5 percent but to feed the populations properly, a 4 percent increase is needed. Surpluses in the production of principal crops have been reported in Pakistan, Ceylon, India and the Philippines. These, however, are not available to all. Poorly planned distribution of food supply, spoilage, and rat infestation are causing food shortages in most countries of the world. In fact, the world is able to grow enough food for its present population, but the distribution systems are too often inefficient and ineffective. People starve even though there is or can be enough food for all. According to Quentin M. West of the US Department of Agriculture, food production in the developing countries has increased at about the same rate as in the developed countries (Figure 29). But rapid population growth has absorbed most of the increase in production in the developing countries.

Pressures of a continually rising demand for food are beginning to erode the ecological foundations of the world economy (Brown and Eckholm, 1974). To cite a few examples: the depletion of anchovy stocks off the coast of Peru because of overfishing; food production decrease in Africa because of overgrazing, deforestation and desertification resulting from the expanding demand of the human and livestock population in the Sahelian zone; and the deforestation in the Nepalese Himalayas and surrounding foothills contributing to frequent and severe flooding in Pakistan, India, and Bangladesh. The gross effect of all these is the diminishing capacity of the world to sustain its fast growing population.

b. Decreasing surface area

When there are more people we need more space. Human activities require space. Year after year, the population is exploding on land area which remains constant. The world is running short of space.

High population growth on limited space results in high population density. The average population density of developing countries is more than twice as great as the average in developed countries.

In 1975 the population density in North America was 11 persons per square kilometer; in Europe, 96; and in the USSR, 11. In contrast East Asia's and Southeast Asia's population density in the same year are 86 and 65 persons per square kilometer, respectively. If the present growth rates continue, in 800 years, there will be 50 people to every square meter of the earth's land and sea.

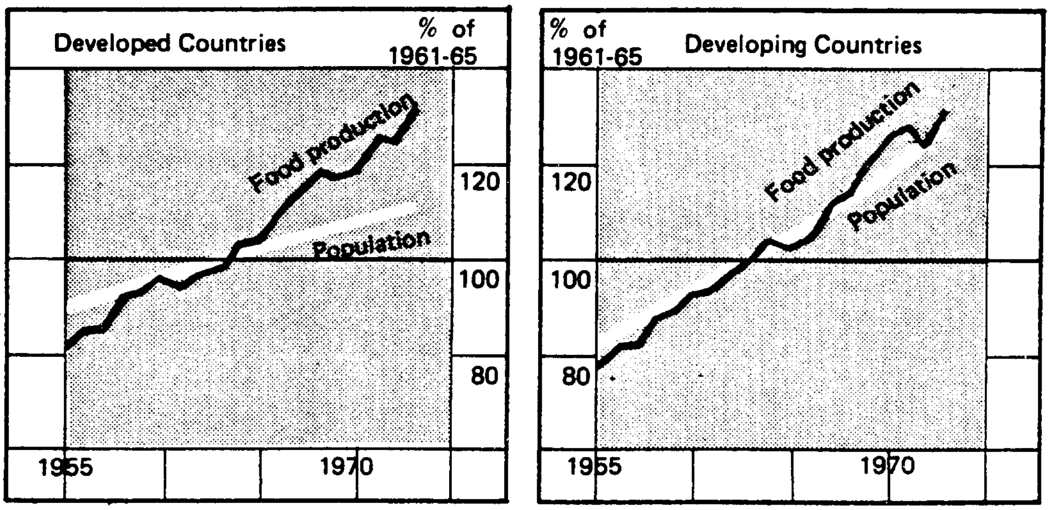


Figure 29. Graphs Comparing Food Production and Population Growth in Developed and Developing Countries
"Reproduced with the permission of Ceres, the FAO review on agriculture and development."

Much of the land is being used for settlement sites and the construction of roads, and other infrastructures. Little is left for forest and agricultural crops to grow. Shortage of timber supplies, death of the single home, and the rise of one-room and two-room types of dwelling for a family are manifestations of the pressure of population on space (Rosenzweig, 1974).

The more critical use of space is for food production. High population growth implies more people to feed. More land must be cultivated to provide food for the increasing population. Some ecologists (Foin, Jr. 1976) point out that the distribution of arable land and not the total land area is the critical factor that limits food production today.

Arable lands are those that have soil and climate conditions which can support crops. About 73% of arable lands are in developed countries. The arable lands in developing countries do not produce enough harvests to feed the rapidly growing population. Hence, food shortages occur. The economic costs of putting marginal land into production is another limiting factor for developing countries.

In Asia, land/population ratios are rapidly falling below one hectare per member of the agricultural force. In most areas, one hectare of irrigated land is enough for family subsistence farming but less than a third of Asia's arable land is irrigated. An estimated number of Asians with no land is already 150 million. The number is still increasing. In all of Latin America the average size of agricultural holdings is under 50 hectares. However, two-thirds of all farm families own or rent less than five hectares.

In the Philippines, a study in 1976 showed that 7.9 million hectares of land are suitable for cultivation. About 7.6 million hectares are already used for agriculture in 1975. In the year 2000, about 9 million hectares of land should be put into production to provide food for a population of 85 million (DAP, 1980).

The world's land surface is one-third grassland or cropland, one-third forest and the rest, barren or unusable. There has been a net loss of 4.5 percent of forests and half of the present forests are being converted to grasslands or croplands. The opening of new lands to agriculture, however, had brought very little net gain in food production. Instead, entire species of plants and animals had been destroyed. Hillsides, valleys, and flatlands have been laid bare. This led to serious soil erosion, flooding of lowlands, siltation of dams and irrigation systems, decreased land productivity because of soil loss, and reduced water-absorbing power of land.

c. Water shortage

Water in all forms on earth is about 400 billion gallons (Miller, 1975). About 97.2 percent is in the salty oceans. The total amount of usable water is 2.8 percent this total but only 0.003 percent of the total supply is available for use. With this amount, there would still be enough water for humanity till the year 2020. Yet, there is imminent threat of water shortage because of unequal distribution, rising demand, and pollution of water resources.

Demand for water is expected to rise with continued population growth. This rising demand for water creates long term problems which will be felt more in the developing countries where most of the world's population is concentrated. In arid regions (the Arab states principally) low rainfall is the main cause of water problems. However, water shortages occur and are bound to be critical in the future even in countries with abundant water resources, for example, the Philippines. Lack of funds to develop water treatment, storage and distribution systems is the reason.

Humans and animals need water for drinking. They need more water for their activities such as washing, cleaning, flushing, etc. This domestic demand for water increases with urbanization. Agriculture both for irrigation and watering livestock, and industry are the heavy users of water. Rapid population growth inevitably intensifies agricultural and industrial activities to demand still larger quantities of water. Expansion of irrigated lands and industries for economic development will exert greater pressure on the water resources of developing countries.

d. Energy crisis

The escalating world energy consumption has brought about the energy crisis that humanity is facing today. The energy problem occurs in two main areas: food and fossil fuel. In both areas consumption outpaces production. In less than 2 or 3 centuries the fossil fuels that have been stored for millions of years will be used up.

In primitive times, humans needed 2000 kilocalories of energy per day mainly from foodstuffs to survive. Today per capita energy use in some countries has reached 230,000 kilocalories per day from food, fossil fuels and other sources. Developing countries where most of the population is engaged in agriculture consume from 12,000 to 26,000 kilocalories per capita per day. But most of these countries actually are still in the primitive level of energy consumption.

Rapid increase in energy consumption in both the developing and developed countries brought about the energy crisis in the early seventies. In developed countries the energy crisis arose from the increased use of energy in technology both to maintain the population and to improve the standard of living. Abundance led to high per capita energy consumption and even wastefulness. In developing countries, the energy crisis arose from the use of energy to sustain population growth and its inevitable degrading effects on the environment. The energy crisis of the poor nations refers more to food shortage. Many are not getting even the minimum energy requirement of 2200 kilocalories.

Environmental degradation results ont only from energy use but also from energy exploration, transportation and processing. Excavation and drilling destroy natural ecosystems at sea bottoms and on land. With the destruction of their habitat species of vegetation and wildlife are annihilated. Oil spills pollute the seas and the land. Fumes from processing pollute the atmosphere. Ground subsidence and seismic activity may result from the withdrawal of deposits. The destruction of the the environment is almost inevitable. Can the oil so obtained improve the quality of human life in the long term?

e. Scarcity of the earth's materials

Every living thing on earth requires not only energy but also materials from the earth. They need food, shelter, and clothing which they get directly or indirectly from the earth's resources. High population growth implies that each day there are more people who require water from the watersheds, timber from forests, food and minerals.

Resources in the environment may be renewable or nonrenewable. Renewable resources are those which can maintain or continuously replenish themselves. Food, crops, animals, wildlife, forest, air, water, and soil are renewable. Nonrenewable resources are those which cannot replenish themselves, and therefore, can be depleted. Coal, oil, and minerals are nonrenewable resources.

The forests of the world are disappearing fast. The famous cedar forests of Lebanon are gone. The tropical rainforests of Southeast Asia are ravaged almost beyond recovery. One cause of deforestation in developing countries is land clearing for agricultural production and gathering of wood for fuel. More trees have to be cut to meet rising demand for agricultural land and cooking fuel. The fuel needs of these countries have exceeded the replacement capacity of local forests. A chain of events follows the disappearance of forests - reduction of wildlife species, soil erosion, flooding and drought, siltation of nearby irrigation systems, rivers and lakes, and disappearance of fish from the silted bodies of water. Soil erosion also increases particulate matter in the atmosphere and probably alters the climate. Thus we see that deforestation can result in the loss not only of timber and forest products but also of leather and meat from wildlife, water, topsoil, certain crops that grow only on good topsoil, and even fish.

Although forests are renewable, the growing time of trees especially the hardwoods, is long - about 50 to 100 years. Progressive frequent cutting may result in denudation because of growing time.

2. New Problems From Science And Technology

"Life is a struggle," our ancestors were wont to say, referring more to the physical aspect than otherwise. It was common tack to picture man in constant battle with nature - gathering firewood, hauling buckets of water, tilling the soil, pasturing animals, fighting off illness with poultices and brews. Many admitted that truly man was at the mercy of nature. The emergence of science and technology has drastically changed this struggle-for-existence picture. Advances made in science and technology now offer hopes for a better and longer life. Through humanity's scientific knowlege and technological ingenuity, crop yields, food supply and housing conditions have improved; many diseases have been prevented or treated, and work is less because of machines. With technology, humanity has learned to generate energy from coal, oil, and the atom, and this energy runs machines that work faster than man, make synthetic products such as plastic, nylon, rayon, and pesticides; and develop machines to convert raw materials into usable products. We were lulled to complacency by the successes of science and technology. By the early '50s science and technology began to show its ugly side. Inappropriate and uncontrolled use of science and technology have caused destruction and pain. The succeeding topics will discuss the unavoidable environmental tradeoffs in the use of science and technology.

a. Medical technology

Before the advent of modern medicine, humanity was extremely vulnerable to lethal attacks of infectious parasites, viruses, bacteria, and protozoa. Diseases such as smallpox, cholera, influenza, TB, pneumonia, and malaria had spread so rapidly that thousands of people were killed all over the world.

Today's medical science and technology are largely responsible for much improved health and longer life span of the human population. In the later part of the 19th century, the causes of many infectious killers were identified and the means of controlling them were developed. Then DDT was considered the most valuable invention of the past 100 years. It had saved more lives and more people had been able to work productively. Malaria was controlled and vast areas of land were opened for productive use.

Public health measures such as improving water and food sanitation were introduced. New antibiotics and sulfa drugs were developed. The main achievements of the medical public health revolution were the eradication of specific infectious diseases, improved personal hygiene, and cleaner food and drinking water.

Death rates have fallen sharply all over the world. In the developed countries, medical science and technology came at about the same time as the Industrial Revolution. When infant mortality declined, parents realized there was no need to have many children to guarantee the survival of 2 or 3. Women started working in factories. Fertility and finally population growth rate were reduced.

In developing countries, the sharp decline in infant mortality had not been accompanied by a significant drop in the birth rate.

With improved medical care, more people are reaching reproductive and working age. The few factories, however, could not provide enough work for all young men, much less, young women. There were not enough schools to develop new skills. Many were too poor to attend higher education. Young people married early. Population soared at a fantastic rate.

b. Agricultural technology

Agricultural science and technology have greatly increased the world's food supply. The science of plant breeding has produced new varieties of plants which are more resistant to diseases, high in yield and adapted to various growing conditions. Scientific and technological advances have been achieved in mechanical cultivation and harvesting, improved methods of fertilization and irrigation, the use of chemical and biological controls against plant pests, and weather forecasting. Modern agriculture has greatly increased the quantity and quality of food that can be produced on a given area of land.

Modern agriculture, however, demands the use of more fertilizers and pesticides, more water, and expensive machineries which displace hand labour. It is capital-intensive and only large landowners benefit from it. Thus, the poor get poorer, and the tenant is driven from the land into the overcrowded cities - a social injustice. Surpluses in food harvest in most cases lower grain prices. Unless efficient distributing and marketing systems are developed, the small farmer's incentive is reduced.

High yielding grains require much water. Costly irrigation installations such as dams, tube wells, and irrigation ditches must be constructed. In a number of cases irrigation has resulted in waterlogging and salt accumulation. Millions of hectares of irrigated lands in Iraq, Pakistan, and India are now waterlogged and saline.

The environmental costs of intensive agriculture cannot be ignored. Runoff water becomes loaded with fertilizers and pesticides to pollute the environment and produce harmful ecological results. Polluted rivers, lakes and seas decrease the production of fish and other aquatic resources. Excessive use of pesticides have resulted in the extinction of certain species, reduction of species diversity, outbreaks of new pests for which the pesticide in use is not effective, and eventual development of resistance in pests. Pesticide residues adversely affect human health and animal life when large amounts accumulated in their bodies. DDT, a pesticide, is known to contaminate mother's milk.

These problems created by modern agricultural technologies are further aggravated in the tropical countries. More pests are generated in tropical areas than other parts of the earth so that they can develop pesticide resistance at a faster rate. In the tropics heavy rains wash away these pesticides and fertilizers. Because of this, more pesticides and fertilizers have to be applied thus amplifying environmental problems.

The traditional grains are being replaced with the new high yielding varieties which have low variability or none at all. The new varieties have been developed so pure that they cannot serve as reservoir for the continuing development of new strains.

The miracle of modern agriculture, left uncontrolled, has turned into a monster of environmental destruction.

c. Energy technology

The two areas of energy technology - food energy and fuel energy - overlap and interrelate.

Mechanization in agriculture requires energy expenditure in the cultivation of the soil, control of weeds, and the manufacture and transport of fertiliers. Energy is also expended in making the farm equipment, and in storing and in marketing food. Thus the energy value of food must also include the energy used by farm machinery and the farm itself (Borgstrom, 1973).

An average citizen of the developed countries who consumes 3,300 kilocalories of food actually consumers about 12,000 Kcal of energy used in producing the food. A citizen of one of the developing countries whose food intake is about 1,900 Kcal is actually consuming 2,800 Kcal. Thus it takes only 1/4 as much energy to keep a citizen of a poor country than a citizen of a rich country.

Fuel energy development has two hidden costs: (1) the economic cost or the actual expenses of energy development; and (2) environmental and social costs. These costs occur during exploration, production and processing, and consumption. Exploration causes considerable land or ocean bottom disturbance. Although oil, gas and geothermal exploration holes are small, environmental disturbance is primarily caused by the size of equipment and the number of personnel involved in the exploration. In addition large areas are often subjected to exploration disturbances before a successful one is made.

Production of fossil fuels by drilling and pumping the ground or ocean floor for oil and gas or by excavating the ground for coal poses serious environmental problems. The ecosystem is destroyed. Oil spills pollute the ground and ocean water. Exposed oil is a fire hazard. The life of workers are in constant danger. Mining for coal and geothermal energy production may cause landslide, land subsidence, and possibly earthquakes.

Refining or conversion of crude oil into useful products emits large amounts of hydrocarbons to the atmosphere. These emissions are toxic and may be carcinogenic. Refineries and their storage facilities are major fire hazards. Transporting processed oil in the aquatic environment may lead to oil spills that pollute the water and cause the death of marine life including fish and sea birds.

The production of nuclear power is considered by some to be the source of the severe environmental degradation. Fission plants have been likened to "time bombs" that could produce radioactive contamination which would take thousands of years for nature to recover from. Accidental explosion in nuclear plants despite safeguards, while highly unlikely, is not an impossibility and could spread radioactivity to affect a large number of population for as long as 250,000 years. Transportation of radioactive materials increases the probability of accidental radioactive contamination along the route. Safe disposal of radioactive wastes into disposal sites is difficult perhaps impossible. The low efficiency of nuclear plants wastes a great deal of the heat energy which necessarily is disposed of in the environment.

Impacts of energy technology on human well-being may be manifested not only in direct economic costs and damages to the environment but also in disruptions in the social systems.

d. Food technology

Science and technology have opened new ways to broaden the base of the world's food supply. Food technology has developed new methods of producing and processing food from substances not considered edible before. Ways of storing surplus food without spoiling have been developed. This is a boon to countries where crops are prone to natural disasters occasioned by periodic storms or typhoons.

On the other hand the advantages brought on by food technology are not without their negative impacts. To facilitate production and to improve appearance, palatability, and shelf life many additives are placed in food. Food preservatives such as sodium benzoate have been used indiscriminately. Adulteration of food has become widespread.

The storage of large quantities of food gave rise to the emergence of storage pests such as rats, cockroaches and weevils. Global spreading of storage pests may be traced to the long distance hauling of food.

Intensive food production and food processing consume large quantities of energy. In the United States, for example, about 6 to 60 kilocalories of fuels is invested in these processes for every kilocalorie of food energy consumed. It has been said often that "Americans eat potatoes made mostly of petroleum" refering to the use of fossil fuels in the food industry - from farming, processing, packaging, transport, marketing, storage, to preparation. It was estimated that the amount of non-solar energy put into production in 1970 is 10 times greater than the energy content of the food consumed. A breakdown of these energy investments into the food systems is as follows: about 25% of the total energy is used on the farm for tractor fuel, electricity for irrigation pumps, and the manufacture of farm equipment and chemicals such as fertilizers, pesticides, tractors, and other machineries; about 40% is used to process, package, and transport food, including energy costs of cans, bottles, and paper wrappings; about 15% is used mainly for refrigeration and cooking in farms and businesses. The large quantities of energy consumed in production, storage and processing releases chemical wastes from the farms, factories, and canneries to pollute the air, land, and water resources.

e. Materials substitution technology

Technological and scientific knowledges have been put to use in developing cheaper methods of producing existing kinds of goods, in inventing and marketing new kinds of goods, and finding substitutes for scarce materials. Synthetic cloths, leatherized materials, and plastics are developed. The synthetic fibers such as nylon and rayon are rapidly replacing the natural fibers of cotton and wool. The production of artificial fibers has two deleterious effects: (a) more energy is needed to produce them and (b) the pollution resulting from the accumulation of those substances that are nonbiodegradable (i.e., substances that do not readily decompose as natural substances do).

Cotton is produced by plants by natural synthesis of cellulose using solar energy. Wool fibers are naturally grown by animals. Little pollution occurs. On the other hand, synthesis of polyamides in nylon production involves processes requiring huge expenditures of energy and releasing large amounts of pollutants. Even the generation of this energy in power plants results in thermal, particulate, and chemical pollution.

Plastic is another synthetic material which has gained widespread use because of its cheapness and durability. But because it is nonbiodegradable, discarded plastic also becomes a pollutant. Steel, glass, paper, and plastic satisfy the increasing demand for material goods but their manufacture adds greatly to energy consumption. Large volumes of manufacturing also produces wastes that pollute the land, water and air.

Technology has made possible the production of useful energy from water, wind and solar radiation. Water to be used for energy generation must be in a position to fall some distance. It acquires the capacity to do this by collecting in reservoirs behind dams. However, standing water in dams in the tropics can breed disease-causing organisms like schistosoma, trypanosoma and malarial parasites. These water-borne organisms easily spread and infect the populace.

Substitution of one material for another like nylon for cotton, aluminum for copper, aluminum and plastic for wood in some ways has eased the pressure on the natural environment. Yet, environmental costs have to be paid in high energy consumption, pollution, physical disruption, and resource deterioration brought about by the extraction and production of minerals and energy sources.

Recycling is another technological method used to control waste and lengthen the life span of our mineral resources. Garbage is made into fertilizer, iron ore dust from steel plants is used to make steel, sulfur dioxide and sulfur from oil refineries is made into sulfuric acid. Paper, glass, plastics, tin cans and many others are being recovered and reused. Yet, recycling is expensive. The cost of recovery sometimes far exceeds the value of the recovered material.

3. Development And Industrialization Bring In New Problems

In the middle 18th century, development and industrialization started moving the now developed countries toward economic progress and affluence. The expansion of industries created more jobs, raised per capita income, and brought about abundance in food and material goods. Mass production resulted in cheaper goods making them available to the greater number of people. Machines lessened the burden of work and shortened working hours, leaving more time for leisure. Development and industry have raised the quality of life in developed countries.

a. Cost of development

Development and economic growth whether for affluent or poor countries do not come without costs. Forests are cleared, the soil is cultivated, and the land is mined. The natural environment of wildlife species is destroyed. Highways, dams, reservoirs, railroads, houses, and buldings are built. Large and irreversible changes in the landscape take place. Encroachment on and deterioration of the environment are inevitable. The built environment is, in another context, a pollutant of the natural environment.

Developed nations have now reached the self-sufficiency stage. They are now beginning to see that additional growth may have its cost in terms of loss of environmental quality. Therefore beyond the state of self-sufficiency, further economic growth can lead to environmental impoverishment.

b. Development in developing countries

The developing countries started the move toward industrialization in the early 20th century. By the middle of the century it was generally accepted that industrialization attempts have not provided the economic impetus that was seen in developed countries. National growth on the average was increased. But the poor in many countries remained poor. The disparity between the rich and the poor became wider. Unemployment and poverty were still widespread. Lately some economists of developing countries have been coming out with their own definitions. Development is the uplifting of the masses to the levels of human decency (Villegas, 1974). More light and medium industries (ex: textile, food processing, shoes) rather than heavy industries (mining, car manufacturing); not only urban development but also rural development; and low or zero unemployment should result from development efforts in developing countries.

Economic analysts identified three main reasons for the failure of developing countries to grow to the developed state. These are: (1) the unanticipated acceleration of population growth (high dependency ratio and increasing labor force); (2) raw materials production (ex: timber, minerals) and heavy industries (ex: car manufacturing) that displaces labour instead of manufactured goods; (3) problem of technology transfer. These are further aggravated by a lack of sicentific and technical traditions and indigenous baseline information on local resources and environmental conditions.

Rapid population growth has eaten up the gains in per capita income in the developing countries. The total national income in developing countries has to be spread out over a greater number of people. High growth rate puts more pressure on agriculture to support more people. Agricultural per capita output that enters the national market consequently decreases. At the same time, the youth growing out of their teens are unable to continue schooling due to poverty. Circumstances compel them to enter the labour force at an early age. Yet the labour market cannot absorb them. In the rural areas where land tenancy rather than ownership is more common so that the sons of tenants have no land to farm and the small farm owner does not find it economical to divide his small land among his sons, the unemployment of the youth is the result. Unemployment leads to mass migration into the cities and places a heavy burden on available social services.

Raw materials production uses heavy machinery requiring less labour, and therefore, does not provide enough employment for the amount of capital expended on it. The masses are not benefited. A suggestion from indigenous economists is to open more factories producing finished products. The trading partners of developing countries (i.e. the developed countries) however, prefer to buy the raw materials. Timber made into plywood and furniture, and unrefined minerals made into metal products, such as copper into electrical wire would have brought processing several steps further and provided more employment.

The technology adopted by developing countries in their industrialization were usually imported from rich countries. Technologies of the rich are capital-intensive and labour-saving, complex, and large scale. The transfer of capital-intensive technologies to poor countries is viewed as producing the wrong kinds of goods in the wrong place to meet the needs of the people. Although these imported technologies may have increased material production (GNP), very few jobs are created in the process. Unemployment and underemployment increased.

The importation of technology from developed countries requires licensing agreements. These agreements often work to the detriment of the importing countries because of some restrictive clauses. These clauses are non-disclosure of information for an indefinite period of time; free grant to and use by licensor of licensee's improvements; exportation upon approval by licensor; non-use of technology and technical information upon termination of agreement; and export prohibition (Afable, 1976). An examination of these restrictive clauses shows that some of the licensing agreements cover subjects and processes that could be supplied by research agencies in the country (Afable, 1976). Some of these are fish preservation and the manufacture of shoes, plastic toys, and inks. Researches on the process should and could be done by the local scientific community not only to reduce the royalty paid to the licensor but also to promote self-reliance.

Transport uses large amounts of energy. In developing countries, the transport industries account for more than 50 percent of the bulk of liquid fuels used. The transport industries have also caused air and noise pollution. Concentration of carbon monoxide, hydrocarbon, oxides of nitrogen, particulates such as lead, and smoke have risen to levels hazardous to health. Noise interferes with work, prevents sleep, has psychological effects and can even damage hearing. This problem becomes more serious in developing countries where motorcycles, old cars and trucks crowd the streets.

c. Increased waste production and pollution

As industrialization increases, the use of polluting materials also grows but at a much faster rate. Paper and plastics are used increasingly as containers to be discarded after use. Plastics, unlike paper, are almost indestructible. Increased use of coal and fuel oils in motor vehicles and electric utilities releases millions of tons of nitric oxide, carbon monoxide, hydrocarbons, sulfur and particulates which pollute the air. Rapid increase in chemical fertilizers results in more chemicals dumped into groundwater, lakes, and rivers.

Developed countries suffer from pollution associated with affluence. This type of pollution is characteristic of high industrial productivity with large amounts of wastes being discharged into the environment of industrial processes that use and emit toxic substances, of agricultural technologies that heavily use fertilizers and pesticides which pollute the land and the water, of transportation systems that pollute the air and create noise, and consumption patterns that form mountain-sized piles of solid waste.

Early efforts of poor countries toward development and industrialization have resulted in wastage and pollution but of a different kind. Since modern technology was imported from developed countries, the developing countries did not immediately possess the technological know-how in the management, operation and maintenance of the machineries used. As a stop-gap measure foreign consultants and managers were imported to run the industries while local engineers and managers were sent abroad for training. The consultants' fees were way above the local salary scale, thus using up much of the capital. The large cash disbursements for salaries of consultants weakened the capital base of the industries thus crippling the operations. This constitutes a form of wastage.

The import of technology shifted incentives from local indigenous inventions and innovations to training and travel abroad. This curtailed the development of local talent and creativity and resulted in imitations of processing techniques and products of developed countries. The time lost which otherwise would have been used in the development of local talent and creativity was another form of waste.

The import of technology necessitated the import of machineries, machine parts and some supplies. When machineries broke down or supplies ran out; the imported replacement did not always arrive on time. Operations stopped, production dropped to zero and labour was idle.

Importations being necessary, it was found convenient to locate industries in cities where the large piers were found in order to eliminate the long distance transport and hauling of imported machineries and supplies. The concentration of factories also concentrated industrial effluents in urban areas to levels injurious to ecosystems. The result is pollution.

d. Cost of pollution

In a paper presented at the International Conference on "The Survival of Humankind: The Philippine Experiment," in 1976, Dr. Felimon A. Uriarte Jr. identified three different ways by which the cost of pollution may be measured. These are the costs in terms of (1) the expenditure in pollution abatement, (2) human health and well-being, and (3) loss or impairment of the quantity and quality of resources.

The treatment, handling, and management of wastes generated from industrial activity is very costly. Land, labour, capital, materials, and energy which may be used in the production of other valuable goods and services are instead diverted to the installation of pollution abatement and control facilities. In the United States, an estimated $87.3 billion represents the cost of water pollution control for the years 1971-80 and by 1982 an additional $3.25 billion. The average capital investments on wastewater treatment facilities in the Philippines amounts to ₱ 340,000 for an average of 120,000 gallons per day and ₱12 million in alcohol distillery plants (Uriarte, 1976).

Table 3. Operating cost-income ratio for selected industries (Phil.)

Industry	OC/IN
Basic Chemical Plant	0.057
Raw Sugar Mill	0.027
Coconut Oil Refinery	0.288
Soy Sauce Factory	0.209
Sugar Refinery	0.046
Textile Mill A	0.716
Textile Mill B	2.437
Metal Finishing Plant	0.053
Meat Processing Plant	1.371
Rubber Tire Factory	0.0003

Source: Uriarte, Jr., Filemon, Cost Consideration in Environmental Pollution Control.

Table 3 shows that the cost of operating a waste water treatment plant takes up a big percentage of the company's income, except the rubber tire company. In some cases, like that of Textile Mill B, and Meat Processing Plant, the operating costs wipe out the profit. Industry would have to recover its investments in terms of higher prices of goods and commodities.

The highly pollutive industries are the alcohol, distillery plants, pulp and paper mills, and mining firms. The costs of wastewater treatment are too high for many industries in developing countries.

The cost of pollution in terms of human life is well documented. Mortality in the London smog in December, 1952 exceeded 4000. Cardiac and respiratory diseases accounted for 84 percent of the increase in mortality. The smog produced by a large steel mill, a sulfuric acid plant, and a large zinc production plant in Donora, Pennsylvania caused 20 deaths and more than 5900 illnesses within a four-day period. Other air pollution episodes associated with severe illnesses and even mortality were reported in Meuse Valley, Belgium, in Osaka Japan, and in New York.

Industrialization has exposed humanity to more and more metallic contaminants in the environment. These contaminants are released into the air, water, and land and enter the body through inhalation and food intake but they cannot be released by the body because of the density of the metal. Industrial effluents containing mercury, lead, and cadmium are known to have resulted in the loss of human lives and immeasurable sufferings.

An example is the famous "Minamata disease" which resulted from eating fish contaminated with methyl mercury released by industries into the Minamata Bay and the Agano River in Japan. A total of 115 persons died, 800 persons suffered extensive and irreversible brain damage, and another 2700 persons claimed to be victims (Uriarte, 1976). Epidemics of mercury poisoning in Pakistan, Guatemala, and Iraq resulted from eating contaminated bread prepared from wheat treated with alkylmercury fungicide (Essam El-Hinnawi, 1980).

The "Itai-Itai" disease which occurred in epidemic scale in Japan in 1940 was traced to increased cadmium intake of rice irrigated with cadmium-contaminated river water. This disease affects mainly the bones, causing them to slowly disintegrate. At least 100 deaths were reported. Cadmium compounds have been detected in automobile emissions, tire residues, coal-fired power plant and phosphate fertilizer plant emissions.

Lead effluents released into the atmosphere from industries endanger the health of the people. Effects of this metal are damage to kidney, liver, brain, and central nervous and reproductive systems. A Philippine study showed that on-the-job exposure to lead is highest among car factory workers. Painters, policemen, and ammunition factory workers have a higher degree of lead exposure than farmers. At 20 cubic meters of air inhaled per day, the bodily intake of lead in cities is 40 to 80 microgrammes per day. About 35 percent of this inhaled lead is absorbed by the lungs (El-Hinnawi, 1980).

Combustion of fuel oils in motor vehicles, power plants and factories contribute to air pollution. The rising incidence of respiratory diseases such as asthma, bronchitis, and emphysema (a disease of the air sacs in the lungs) indicate the increasing concentration of these pollutants in the air. The increased carbon monoxide concentration due to emissions from motor vehicles in a traffic jam may cause headaches, loss of vision, decreased muscular coordination, nausea, and abdominal pain.

The cost of pollution due to loss of resources may be the result of economic and/or technical inefficiencies or a direct result of the degradation of the environment. Large amounts of waste in the form of carbon monoxide and hydrocarbons result from the inefficient combustion of fuel. The 400,000 registered motor vehicles in the Philippines were estimated to emit 67,000 tons of hydrocarbons per year. In terms of fuel, this amount of hydrocarbon emission is equivalent to 90 million liters of gasoline wasted per year worth ₱135 million (Uriarte, 1976). This also means that 0.62 equivalent liters of gasoline are wasted each day per vehicle.

Damage to property due to the corrosive and soiling effects of air pollution is an example of the loss of resources as a direct result of environmental degradation. Natural and synthetic rubber materials are broken down by ozone. Heavy particulate materials, such as carbon and soot , soil laundry, settle on windows, automobiles, and even on people causing the dirtiness of the cities.

Costs of these damages would consist of the cost of soot removal and sandblasting of buildings, extra laundry and dry cleaning, and the accelerated deterioration of rubber tires.

In the Philippines, rice farmers complain of poor crops due to the pollution of the irrigation water. Severe loss was reported in the multimillion milkfish industry due to industrial pollution.

4. Concentration of Human Population (Urbanization)

"People settle where others already are" observed Foin (1976). The worldwide tendency of people to crowd together results in the rising population densities of many cities. At the start of the 19th century, only 2 percent of the world population lived in cities. About 50 cities at that time had population exceeding one million. Now, about 12 percent of the world's population live in and along the fringes of cities. In the year 2000, six people out of ten will be living in cities. In 60 years cities in developing countries grew more than 8 times and only 2 1/2 times in developed countries (Borgstrom, 1973).

The growth of cities is largely due to the migration of people from the rural areas. This migration was stimulated by rapid population growth and agricultural advances in rural areas as the "push" factors and the attraction of modern and comfortable living and the oppurtunities for a better life in cities as the "pull" factors. "Surplus" members of the rural family who are not given any share in the farmlands are pressured to migrate to try their luck in the city environment. Modern agriculture adopted by the large landowners in developed countries require less hands. Subsistence farmers with no means to avail themselves of modern agricultural technology are driven to the cities. A Philippine study showed that low agricultural productivity, low incomes, meager industrial activity, and high tenancy rates have triggered the migration of rural people to the cities.

Urban areas are expected to continue to increase both in developed and developing countries.

a. Unemployment and poverty

The massive and unanticipated migration of rural people to the cities proved to be a disaster. These mirgrants had no skills to offer and the cities were not prepared to cope with them. The cities were not growing economically and were not producing jobs fast enough to accommodate these newcomers. As a result, rapid population growth of cities ran ahead of industrialization and economic growth.

The unplanned growth of most cities both in developed and developing countries has resulted in the deterioration of the quality of life. With no job opportunities to sustain their population, poverty and human misery became widespread. The poor in many Asian countries is characterized by larger household, high dependency ratio, lower unskilled labour force participation of men, low endowment of human capital on education, higher open unemployment and less stable job opportunities (Visaria, 1978).

The influx of rural-to-urban migrants is affecting urban ecosystems adversely, diminishing the quality of life. The urban population has grown much faster than the water, light, housing, and even food facilities could be expanded. Slums and shanty towns proliferate. Many families live in one-room houses and the homeless crowd the sidewalks and sleep on the streets at night. Millions find their food in the garbage dumps. Water facilities are inadequate. Natural waters, if available, are used for laundry, bathing, defecating, and garbage disposal. There is less food and whatever food there is, is costly.

Jobs grow scarce with every passing year. Work to the slum dwellers is in the form of garbage can raiders, rag-pickers, tin can collectors, bottle gatherers and wastepaper bundlers (Borgstrom, 1973). Many activities referred to by Borgstrom as "tertiary activities" are mostly petty hawking, shoe-shining, message-running type of jobs which somehow alleviate the poor families from absolute hunger. But these are not productive activities and, therefore, do not contribute to the growth of the economy. The miserable and subhuman living conditions predispose the migrants to criminality, vices, mental illnesses, injustice and other forms of social maladies.

b. Concentration of wastes

In an undisturbed ecosystem, wastes are broken down by bacteria and reused by plants. A crowded human settlement produces an enormous amount of waste which can exceed the capacity of the environment to decompose wastes. Some wastes cannot be assimilated in the natural processes being non-biodegradable. Thus wastes accumulate to a nuisance level, polluting land, air, and water.

Let us take the case of the Philippines. As in other countries solid waste accumulation is greater in urban areas than in rural areas. In rural areas, the wastes generated are burned and buried. Oftentimes, these organic wastes are recycled into animal feeds and composting. In urban areas, because of limited space and dense population, wastes accumulate at an average of 1/2 kilo per person (NEPC, 1979). Metro Manila's seven million people produce 3.2 million kilos of garbage and 200,000 kilos of litter daily. The squatters have added to the waste problem because of lack of disposal facilities.

Open dumping and burning of wastes often lead to environmental deterioration. The dumping of wastes pollutes bodies of water, produces foul-smelling odor from decaying organic matter, and breeds disease-causing organisms. The growth of pathogenic organisms coming from wastes may deplete dissolved oxygen in surface and ground water.

c. High incidence of diseases

The increasing amount of wastes favors the increase of pests such as rats and cockroaches and disease germs particularly the water-borne. Rainwater may collect in empty cans and depressions and become breeding places for malaria mosquitoes. Big piles of exposed wastes breed flies, the carriers of gastro-intestinal diseases and germs.

Poor environmental sanitation is a major factor leading to the high incidence of communicable diseases in most cities, especially the slum areas. The absence of proper methods of waste disposal of human and solid wastes favors the spread of diseases. The poor water facilities make it difficult to practice hygiene and sanitation.

Industries set up their plants near rivers and creeks to use them for dumping their refuse. This results in widespread pollution and the spread of diseases.

The migrants who come to live in the cities are suddenly confronted with environments very much different from their former environments. They face various adjustment problems. Overcrowded stores, traffic jams, noise and impersonal relationships prevalent among city dwellers produce stress. Ulcers, hypertensions, impotence, glandular upsets, asthma, migraine, lumbago, and cardiac diseases caused by stress are also known as psychosomatic disorders.

Stress may also cause withdrawal from the family or group either physically (called desertion) or emotionally (refusal to socialize) and aggressive behaviour. The rise in crimes, delinquency, vices, mental diseases, and heart diseases are traceable to population stresses.

Many scientists say that when people are forced to live in crowded areas such as the slums of large cities, physiological and psychological disorders may result. All these may lead to a breakdown in the mechanism of social order and eventually to unrest, violence and crime.

d. Malnutrition

When the quantity and quality of food is inadequate, as is often true among the poor, malnutrition and undernutrition are not uncommon. Shortage of calories and nutrients causes malnutrition and undernutrition. A malnourished person lacks specific nutrients in his diet. An undernourished person is one whose daily intake of calories is much less than the minimum requirement of energy. The effects are reducted life expectancy, increased susceptibility to diseases, and reduced productivity.

In communities with a food shortage the working force is "fed first and best." Children are fed with bulky, starchy foods which fill their stomach but lack nutritients to keep them healthy. The body's resistance to disease is reduced. Among the diseases made worse by malnutrition are gastroenteritis, colitis, TB, influenza and pneumonia. Many children die directly of the disease but indirectly of malnutrition.

Studies suggest that in the long run, insufficient protein-calorie in the diet may have irreversible and permanent effects on children's mental and physical development, personality traits, and performance.

The two severest forms of insufficient protein-energy are kwashiorkor and marasmus. Millions of children in Asia, Latin America and Africa afflicted with these diseases suffer from loss of intelligence, stunted growth, and thin and wasted muscles. The children become apathetic, listless, irritable, moody, and less attentive. Thus, malnourished children have greater difficulty learning in school than their better nourished peers (Rosenzweig, 1974).

A number of studies conducted in developed and developing countries show a strong correlation between nutritional levels and physical and mental development in pre-school and school age children of the poor.

e. Conflicting land uses

Conflict in land use results from random, uncontrolled growth of the community. The areas suitable for forestry, for recreation, wildlife, and water management are often the sites for mining, logging, and shifting cultivation. Urban areas spread out and encroach into rural lands. Sometimes prime agricultural land is lost to urban growth. Flatlands, where urbanization often emerges are most suitable for agriculture. Thus good productive soil is lost to building construction, concrete paving and road building.

In developed countries, intensive agriculture frees more land for urban growth. In developing countries, because of the high and rising cost of production by intensive agriculture, extensive agriculture is more prevalent. More land is needed to increase food production to feed the growing population. Thus, the need for more farmland competes with the need for urban growth.

C. BROAD-BASED MEASURES TOWARD THE SOLUTION OF ENVIRONMENTAL PROBLEMS

Environmental problems are spreading globally and causing much concern. Crises in energy, food, minerals, water and other material needs point to pressure on our natural resources. Our biological environment which sustains life and cleans and removes wastes has been severely burdened. There is pressure on society's ability to dispense services like education, medical care, and the administration of justice. There is even pressure on values such as privacy and freedom.

Proposals to solve this wide range of environmental problems are varied. Some of these proposals are to limit the size of population and redistribute wealth. Others thought that technology would be the answer. The proposals to solve environmental problems are discussed below:

1. Control of Population Growth

In developing countries children at an early age are expected to help provide for the economic needs of the family. The more children contributing to the family earnings, the better. However, infant mortality is high, especially in India, Pakistan, Bangladesh, and Africa. To be assured that one or two sons will survive, couples must bear an average of six. In most cases, couples overcompensate by bearing more than one child to replace the lost one.

Culture does not have a very strong influence on the size of family. In poor countries, most women marry and bear children at an early age. They start at age 15 or 16 and continue bearing children to the age of 40. In some countries like India, barren women are considered a disgrace. Tradition, in these countries, reinforced with religious teachings is pronatalist. It is considered immoral to interfere with the reproduction process.

In the past, population control has been through increased mortality rate. The practices of infanticide, celibacy, migration, expulsion, cannibalism, war, ritual sacrifice, abortion, and delayed marriage has been resorted to. Now, the consensus is for limiting the birth rate through education, persuasion, and the use of medical science.

a. Birth control through education

On the premise that people's attitudes are developed in childhood, it is thought that early education can change the reproductive behavior of a population. Expectation of marriage, having a family in the future, and even the ideal size of the family are now culturally transmitted through the schools. Mass education rather than the depth or the average duration of schooling is the most potent force for change. Education depresses fertility in five ways (Caldwell, 1980):

(1) It reduces the child's potential for work inside and outside the home thus changing his role from partner in earning a living to being a dependent.

(2) It increases the cost of bringing up children. School children demand more of their parents than do illiterate children.

(3) The school creates dependency not only with the family but also within the society. Society is called upon to maintain the school through taxation. The family, therefore, has a big investment in every child.

(4) The school speeds up cultural change and creates new cultures. It induces changes in all classes in society.

(5) The school serves as a major instrument for propagating values intended to raise the quality not the quantity of children.

The population policies of several developing countries recognize the importance of education in disseminating population issues. Bangladesh proposes a major educational campaign to draw attention to the seriousness of population growth and to set up group discussions in villages, factories, schools and colleges; the introduction of population education in all curricular levels; the use of radio, television, newspapers, posters, and pamphlets to disseminate information on population problems and methods of family planning, a social work program that stresses population and family planning.

India emphasizes population education by radio and other mass media. Population-related subject matter is introduced in the curriculum of public schools in Malaysia. Thailand introduces programs on population problems in adult education, nursing, midwifery, teacher training and other areas of higher education. The Philippines integrates information on population and family planning with school curricula.

b. Persuasion

Motivation is the single most important factor that can reduce population growth rate. Only determined couples succeed in limiting their families. In Europe, even in Catholic countries, low birth rates have been achieved because couples have managed to avoid having the children they did not want.

In developing countries, couples want larger families and usually end up with more children than they want. Their interest in family planning is not matched by a desire to use modern birth control methods.

Most objections to population policies and control measures can be overcome through persuasion. In Egypt, for example, people learned to seek out population control methods when women were emancipated. Education was opened to both sexes and social security was provided (Ismail - Sabu Abdalla, 1974).

(1) Family Planning - Family planning programs not only provide means for contraception. They also spread the idea of birth control through educational campaigns. Studies on family planning reveal that in developing countries, knowledge of birth control is limited, especially in rural areas. Information dissemination is carried out through independent clinics or in cooperation with maternal and child health agencies or both. In some cases, mobile units are used to distribute pamphlets and circulars. Billboards, radio and newspaper announcements are made. Plays and shows put up by traveling troupes carry the family planning message.

The family planning programme also provides counseling services on marriage, parenthood, child spacing, and assistance to subfertile and sterile couples. Advice on nutrition and child care are often included.

Globally, interest in population control is still low. The high morbidity rates in many African states is hindering the family planning program. Maternal and child health services are now being intensified. In Latin America which has the highest birth rate in the world, the reluctance to accept birth control is partly due to the influence of the church and partly to belief that more people are needed to develop their vast resources. Family planning is accepted mainly for health and welfare reasons and as a means of reducing illegal abortion.

Strong family planning policies reinforced by social and economic measures are responsible for the declining birth rates in some Asian countries. These countries are China, India, Thailand, Indonesia, Sri Lanka, Hongkong, Singapore, Taiwan, and South Korea. But family planning programmes have had very little impact on birth rates in Pakistan, Malaysia, Bangladesh, Nepal, and the Philippines. A large part of the Middle East countries is still pronatalist. Family planning services have been established for health and welfare reasons.

(2) Socio-economic measures - People voluntarily practice birth control under great social and economic stress and insecurity. Limitation of maternal and educational benefits to a few children per family is one such pressure. In the Philippines, income tax deductions are allowed only on the first four children in the family.

Incentives for late marriages and childlessness are measures of population control. For example, bonuses are paid to first-time brides of over 25 years, couples after childlessness of 5 years, or men who submit to vasectomies after their wives have given two births.

Proposals to promulgate laws raising the legal age of marriage in Tunisia, Bangladesh and Iran have been made (Stamper, 1977). Delayed marriage and a reduction in the desired number of children are exptected to lower overall fertility.

Bangladesh offers monetary incentive for vasectomies, tubal ligations, and abortions. Compensation payments for sterilization and IUD insertions are still being used in India.

Motivation schemes for smaller families are also being used. Tunisia provides greater payments to small families and to single persons. Bangladesh restricts ration cards to two children per family and prohibits couples with two or more children from using the fair-price shops. In Malaysia, maternity benefits of government workers are allowed for the first three children only.

Adoption by small families or childless couples can be encouraged through subsidies. Social security pension for aging adults would hopefully change the traditional attitude of parents regarding children as an insurance against old age and illness.

The emancipation of women from their traditional roles of wife and mother, providing equal opportunities in education and employment for both sexes and the provision for child care are persuasive measures to encourage women to seek employment outside the home.

c. Use of medical science - Medical science has made great progress in the development of birth control techniques particularly in oral contraceptives and intrauterine devices. Most of the researches now are concentrated on improving chemical agents for birth control.

Although contraceptive technology has greatly reduced the birth rates in some countries, the population control movement is still unsuccessful in most of the developing world. There is a need to develop a contraceptive that is cheap, easy to use, effective, and free from unpleasant or dangerous side effects.

Some conventional methods and devices for birth control are the condom, diaphragm, cervical caps, various jellies, creams, foams, douche, and rhythm method. Newer birth control techniques like the pill and IUD are the more commonly used.

(1) The Pill - the pill is considered to be the most available and most effective birth control means except abortion and sterilization. It is a contraceptive (i.e. prevents conception) by preventing ovulation. It is composed of the hormone, estrogen, and a synthetic substance, progestin. It is taken daily for 20 to 21 days of the 28-day cycle. Pills can regularize and moderate the menstrual period thus decreasing iron deficiency anemia often observed in women in developing countries. Some undesirable effects are possible blood clotting and stroke observed in some users.

(2) Intrauterine Device - the intrauterine device or IUD is placed inside the uterus to prevent conception. We are still not completely certain as to how an IUD works but it probably works by preventing the implantation of fertilized egg after conception. The IUD is most suitable for women over 30 and who have had one or two children. It is cheap and requires very little attention once placed in the womb.

(3) Abortion - Abortion is the removal of the partially developed fetus from a woman's womb. There are many different ways of performing abortion. But the very crude methods are often harmful and can even be fatal to the woman.

Abortion is legally sanctioned in most industrialized countries. It is often provided free and at very low cost. Legalized abortion in Japan and Eastern Europe have been largely responsible for reduced birth rates.

In most developing countries, resistance to this method is due to religious groups' belief that removal of the fetus destroys the potential human being and, therefore, transgresses a higher spiritual law.

By the early 70s abortion laws of some developing countries have been liberalized. Zambia allows abortion during the first trimester of pregnancy for medical and social reasons. South Korea legalized abortion in 1973 and made it available in government facilities at very low cost and free to women as part of the family planning programme. Uruguay waives its anti-abortion law if done during the first trimester. Only "social" abortion for women with, at least, five living children is authorized in Tunisia. India has increased its facilities for abortion. Bangladesh asserts that legalized abortion is one of its best and most effective strategies for controlling population growth.

Restriction on abortions in some countries has not deterred some members of the population. Abortions are performed secretly and illegally by unqualified doctors or completely untrained persons. As a result, the heatlh of the mother is endangered.

Children of mothers who were denied abortions in Sweden and Czechoslovakia were found to have more health and social adjustment problems. However, until a more effective form of contraception is developed, many people will resort to abortion.

(4) Sterilization - Surgical sterilization is another sure method of birth control for both men and women. The operation for men is called "vasectomy" and "tubal ligation" for women. Both methods are considered almost 100 percent effective in preventing conception, if properly done. This method should be resorted to only by people who are sure of not wanting more children because the process is irreversible.

In India, all fathers of three or more children are urged to have a vasectomy. Sterilization of women is now gaining acceptance in developing countries. Although a more difficult operation than vasectomy, it is often easier to implement than sterilizing men.

2. Using Science and Technology to Solve Environmental Problems

Much of the deterioration in the environment and the impaired quality of life are the direct and indirect results of advances in science and technology. Yet, we are forced by circumstances to fall back on technology to remedy these problems.

Technology is needed to produce emissionless automobiles, power plants, machineries, steel mills and chemical plants. We look to agricultural technology for production methods with the least destructive effects on soil, plants and animals. Technological solutions are also needed in designing sewage and garbage plants to bring back organic waste to the soil. Too much dependence on technological solutions, however, has two basic flaws (Foin, 1976): (1) technological solutions are often limited by social, economic and political climate, and (2) technological solutions result in imperfect remedies because the solutions are also imperfect. An example of the first limitation is the development of the internal combustion engine intended to provide power to run machines and increase production. Used in vehicles it provides greater mobility and prevents isolation of communities. But it also produces harmful by-products which detroy the quality of air. Factory machines create stress-producting noise. The height of factory smokestacks had to be raised to prevent atmospheric inversion caused by low temperature near the ground and high temperature above it from trapping particulates and pollutants at ground level. As a result air over London is cleaner, reducing this health problem. But the pollution problem has been exported to the nearby countries of Scandinavia. The problem with atmospheric inversion is an example of the second limitation.

a. Expanding and Improving Traditional Food Sources

Among the new techniques used to increase production in agriculture are aquaculture, intercropping, multiple-cropping and combined rice paddy-fish culture. Irrigation has made multiple cropping possible. Scientific knowledge of the nature and growth characteristics of crops led to better understanding of intercropping and aquaculture. Many farmers also go into duck raising in fertilized ponds or livestock-raising in tree farms to increase food production. In freshwater fish culture fast-breeding carp and tilapia (mouth-breeding cichlid fishes) are the most popularly used species.

Fish farming and seaweed culture in brackish and saltwater lagoons and estuaries are alternatives to freshwater fish culture.

Plankton and seaweeds can be harvested from the ocean to feed people. Many kinds of seaweeds are traditionally used in many developing countries as food. But recently they are found to be good sources of emulsifiers, gelatins and other additives for use in modern food processing.

Among the promising sources of food are indigenous meat animals such as antelopes, oryx, and the American buffalo. They can be domesticated and raised in farms. Perhaps what we now know as wildlife, when domesticated, can become a major source of protein in the future.

Fortified grain or flour is the result of researches in improving the protein quality of grains. But enriched flour with processed amino acids does not make an impact on the poor and hungry people of developing nations because they are expensive.

Increasing the natural protein content of cereal grains is an alternative to fortified grains. This is achieved through cross breeding to develop grains with greater nitrogen fixing capacity. Raising high protein varieties, however, requires more energy, water and fertilizers thus making it unattractive to farmers.

b. Developing New and Unconventional Food Sources

Synthetic food is fast becoming a reality. Single-cell protein (SCP) can be produced from single-cell organisms grown on petroleum products, sewage sludge or other substrate. If sufficient amounts could be developed and processing would not be costly, SCP could make up the protein deficits in developing countries. SCP has been used as animal feed. It can alternate with or replace corn and soybeans as animal feed so that these crops could be used to feed people.

Algae, a source of protein, when processed into powdered form, may be added to milk and other foods. As a food supplement, algae protein appears to be beneficial in treating protein-deficient children and mothers.

Other proposed protein supplements are brewyer's yeasts, water hyacinth, fish protein concentrate, and leaf protein extracts. Water hyacinths and other water weeds can be converted to cattle feed. Small-sized fish formerly left unharvested because of its low market value is now processed for food. But this would decrease the food for larger fish stocks. Forage crops like alfalfa and sorghum produce large amounts of high quality protein. The fibrous residue could be fed to horses and cattle and the protein extract could be made into protein supplement for human consumption.

Processing of food supplements is complex and costly. Considerable investments in research and development must be put in before they can be made acceptable to consumers. Nevertheless future developments may eventually lead to large scale production.

c. Treatment of Malnutrition

New food combinations made from conventional sources have been developed. Combinations of corn and cottonseed meal enriched with Vitamin A and B known as "Incaparina" was developed by the Institute of Nutrition for Central America and Panama. This food substitute, however, has been unsuccessful in the markets of developing countries largely due to its unacéptability as food.

Special foods made from legumes such as soybeans, peanut, cottonsead, and sesame seed extracts have been widely used. High-protein soy-based food products such as milk, beverage, coffee, and other food products have found their way into the market. Buns fortified with milk solids are distributed to school children in many countries. Consumer acceptance is the biggest problem.

d. Pollution Abatement

Pollution problems have been given technological solutions. Tradeoffs, however, have become inevitable. For example, garbage is collected in order to clean the surroundings but when these wastes are burned the air is polluted or when the garbage is thrown into rivers, river water is polluted. No technology is, as yet, known to completely eliminate pollution. Technology can only help reduce pollution levels below the danger point. Present technology, if properly used, can only provide the time needed to develop more efficient pollution control technology.

Pollution is dealt with in any of four ways: (1) using an effluent treatment or emission control device, (2) modifying the process so that less pollutants are released, (3) using a cleaner fuel, (4) instituting social mechanisms that discourage pollution.

Developed countries confronted with serious pollution problems spend huge sums of money for pollution control. Japan spends about two percent of its gross income on anti-pollution devides (Roxas, 1976). Developing countries with no serious pollution problems could benefit from the pollution abatement technology developed by the affluent countries.

(1) Air Pollution Abatement - Motor vehicle emission and industrial fumes are the two major sources of air pollution. From these sources, the major pollutants are the oxides of carbon (carbon monoxide, carbon dioxide), oxides of sulfur (sulfur dioxide, sulfur trioxide), oxides of nitrogen (nitric oxide, nitrogen dioxide), hydrocarbons (e.g. methane, butane, benzene), photochemical oxidants, and particulates.

An emission control device is installed at the exhaust pipe of a motor vehicle or the smokestack or chimney of an industrial plant. An example is the catalytic converter, a device attached to the car exhaust pipe. As the car exhaust passes through the converter, the carbon monoxide and hydro-carbons combine faster with oxygen of the air. The products are harmless carbon dioxide and water. Using the same principle, particulates are removed from industrial exhaust by means of giant vacuum cleaners known as fabric filter bags, or by electrostatic precipitators or by wet scrubbers. In electrostatic precipitators the particles are given negative charges and then passed through positively charged walls of the precipitator to which they are attracted. The accumulated dust particles are then released to a collecting chamber when the walls of the precipitator are made to vibrate. The wet scrubber removes dust from industrial exhaust by spraying it with water. The cyclone filter removes heavy dust particles with the aid of gravity and a downward spiraling air stream.

Sulfur emission from cars, factories and power plants can be reduced by using low-sulfur coal instead of high sulfur coal. Research is also being done in converting sulfur dioxide into harmless valuable products such as fertilizers.

Distillation of petroleum to kerosene to gasoline yields cleaner fuel with longer processing. Even coal can be processed to yield cleaner coal gas. Alcohol from plants such as sugar cane and cassava is a clean fuel. The processes involved are still too expensive for industrial use. And the processing itself requires the burning of fuels that emit pollutants into the environment.

Electric cars could replace the present motor vehicles. Electric cars are pollution-free, almost noiseless, and more efficient in energy conversion. But these cars use fuel cells which have to be recharged with electricity generated from power plants. Therefore, the pollution removed from the cars is only transferred to fewer but larger sources which are the power plants. Development of newer types of storage batteries with bigger capacity and fuel cells using hydrogen or light hydrocarbon fuels may make the electric car the most possible replacement of the internal combustion engine.

Environmentally aware governments are resorting to taxation on effluents, pollution penalties, and licensing as social mechanisms for air pollution abatement. Such mechanisms can only be successful when used with acceptable standards and with scientific measuring techniques.

(2) Water Pollution Abatement - Treatment plants to control domestic sewage are the result of research and development activities to control water pollution. The aim is to use sewage as fertilizers and to recycle domestic wastewater. But treatment of sophisticated industrial wastes requires a higher level of technology. This requires means of separating and recovering harmful pollutants from large volumes of water.

Domestic sewage goes through three stages of treatment. The primary treatment of sewage includes mechanical filtration, screening, settling, and chlorination. It removes about 50 to 65 percent solids and 25 to 40 percent of the 5-day BOD (Biological Oxygen Demand).

The secondary treatment uses biological processes to remove organic material from the sludge produced after primary treatment. It involves the intensive use of bacterial activity. It removes about 90 percent BOD and 90 percent suspended solids (Ehrlich, et al, 1977). Cost of treatment, and electric cosumption, however, is high.

The tertiary treatment is the most costly. Some sewage treatment plants do not include this last stage. A variety of technologies is used in the treatment of sludge coming from the secondary treatment plant. These processes which may be used in different combinations are distillation, reverse osmosis, electrodialysis, chemical precipitation, ion exchange, and carbon absorption. Phosphate, for example, may be removed from effluent when the effluent is mixed with lime. Nitrogen, as ammonia, may be removed from effluents in a stripping tower where air is blown through the sewage.

Other technological alternatives to sewage treatment are composting toilets, land treatment, and ponding for sewage plant effluent (Ehrlich, et al, 1977).

Other alternative approaches to the tertiary treatment of sewage which are not capital and electricity intensive have been developed. These are rapid infiltration through porous surface layers into deeper aquifers, crop irrigation by overland flow, and crop irrigation by slow infiltration. These involve the treatment of secondary treatment effluents.

Ponding with algae is another way to treat wastewater. Wastewater is placed in large shallow ponds. The bacteria take in the dissolved organic materials and convert them to carbon dioxide and water. The carbon dioxide and nutrients are converted by bacteria to biomass. This biomass is used as animal feed or fuel. The oxygen released by the algae during photosynthesis is used to metabolize waste materials.

e. Recycling

Huge piles of throw-aways like paper, glass, rubber tires, cans, used cars, and plastics represent the lost resources and energy which have been put to use in their production. This kind of waste (the throw-aways) continue to increase its rate of accumulation with the growth of population, industry, and the use of technology and resources. If we are to protect our environment from the adverse effects of wastes, we must control and manage wastes and pollution at the source. This requires more efficient and less wasteful technologies -- technologies that provide for use, reuse, recovery, and recycling of the waste products. Recycling has also made garbage into fertilizers, sulfur from oil refineries into sulfuric acids, and iron dust from steel plants into steel again.

Recycling that involves chemical processing is, in most cases, expensive. Still it will cost less to recover waste at the source than to clean up after they have been dispersed in rivers, in the air, or on the land (Spilhaus, 1970).

The big volume of waste is largely composed of industrial containers and packing materials such as paper, plastics, glass, metal, rubber, and water. Recycling of wastes would definitely reduce the demand for natural resources.

Some efficiency experts contend that in some industries producing from raw materials is still less costly than recycling. However, cutting trees to make pulp is still more costly than removing ink (deinking) from newsprint. About 34 kilograms of deinked pulp is produced from 45 kilograms of wastepaper (R.M. Billings,1972). The remaining 11 kilograms comes out as waste in the form of broken fibers, ink, and foreign materials. This waste cannot be burned because it is 80% water. More energy is needed to dry the waste. Recycled paper is used to produce paperboard, carbon stock, roofing felt, and building board.

The use of paper in animal feeds is another way of recycling paper. An American study showed that cattle put on more weight when fed with a diet containing 10 percent ground newspapers and 90 percent molasses, meal and vitamins than when fed more usual diets.

The wide use of plastics for packaging and making products for housewares, construction toys, appliances, furniture, transportation, footwear, and records has increased the plastic wastes. Most plastic wastes are non-biodegradable. It takes 240 years for one plastic bag to disintegrate (Owen 1980). Plastic that breaks down has already been produced. Polystyrene foam plastic, produced by a Japanese chemist, disintegrates after 6 months' exposure to ultra-violet light from the sun.

No problems on disposal of containers and packing of materials would occur if they could be consumed like the ice cream cone.

Nonbiodegradable plastics may be used as stable landfill materials because they do not decay and pollute underground water systems and they do not change over the years. Plastic bottles are recycled by using them in the construction of concrete bridges. About 30 percent of plastic scraps is mixed with the normal concrete mixture. This means a saving of 817 kilograms per truckload of concrete (Kaufman and La Croix, 1979). In addition the bridge is 9 percent lighter than when all concrete is used and it is also almost equal in strength.

Recycling glass, metals, and rubber involves many kinds of devices. These materials are pulverized, screened, slurried, centrifuged and magnetized to separate metals from glass. Broken glass can be recycled to make new glass bottles or as raw material in the production of materials for road surfacing and floor tiles. Crushed glass is used as substitute for sand to coat much used roads. Technology is needed to make use of waste glass because it takes millions of years for bottles used for catsup and beer to disintegrate into silicon oxide.

Aluminum cans used for beverages can be efficiently recycled. Aluminum disintegrates into aluminum oxide dust in 500 years (Owen, 1980). Nineteen times more energy is needed to make new cans than recycled ones. In recycling aluminum cans, the metal is conserved and pollution is controlled at the plant site.

Millions of rubber tires are discarded every year. Tire casings are reused in the manufacture of synthetic rubber. Tire casings may be ground and hydrogenated for oil and carbon black. One tire company reported a 100 percent recovery rate of used tires and improved the value of the recovered materials. Another tire manufacturer reconditions old tires for reuse. Rubber tires are also being used in building artificial reefs simulating coral reefs in bodies of water where they become encrusted with barnacles and other organisms and serve as spawning and breeding ground for larger species of fish.

3. Planning Human Intervention on the Natural Processes

Maintaining the quality of life amidst population explosion, increased consumption and waste accumulation on limited space and resources call for disciplined human responses and decisions. The disciplined responses referred to are those motivated by a commitment to make a better world, those that lead to satisfaction of basic needs and the abrogation of lavish excessive consumption, those that deny actions harmful to others, and those that promote peace and equity among individuals, groups and nations. Human interventions into natural ecosystems and long-existing built environments should be guided by these disciplined responses and decisions.

Further human interventions into the natural ecosystems are almost inevitable. Knowing that such interventions do not come without costs, it is suggested that -

- the plants (blueprints and specifications) be subjected to a stringent environmental impact study focusing on the immediate local effects, the long term effects, possible chains of events ensuing from it, both the biophysical and the sociocultural component affected, the tradeoffs, the alternative strategies and their consequences;

- eventual choices be guided by an ethics of relationship of man to environment in which the general welfare supersedes self-gains, and conservation is preferred to abuse;

- the direct beneficiaries of the intervention be held responsible for the control of degrading effects, and if reasonable, the eventual restoration of the degraded environment;

- social mechanisms such as licensing fees, taxation, maintenance according to approved standards with penalties on violations be used if warranted;

- the general public be informed of any unavoidable biophysical effects or of any inequities in the socio-cultural environment that may accrue from it, however minimal these effects may be;

- that, if the effects of the intervention are cumulative, the general public be informed and instructed on ways of protecting themselves to minimize these effects.

Knowing also that the effects of human intervention are difficult to contain in locale, and tend to be global, it becomes necessary to invoke international cooperation and commitment of national governments to the improvement of the quality of life and the enhancement of the environment.

Problem areas in which international cooperation would be most needed are: building up food reserves, protecting the ocean and the atmosphere, preventing high casualties in natural disasters, protecting populations against diseases, control of population growth, and improving the structure of the world economy.

The international community through the United Nations is also called upon to lend support in two development areas: grass-roots development and human resource development.

Grass-roots development aims to improve the economic conditions of the poor rural people with the use of their resources and with the least destruction of their cultural and environmental values and the general well being of the people. Integrated in the development efforts are medical and educational services, sanitation facilities, road construction, electrification, and communications. In addition, laws and policies must be instituted to support the development program. The land reform law, for example, is made to provide landownership to most of the people and pave the way for the distribution of rural wealth.

Development schemes at the grass-roots level should lead to increased agricultural productivity among farmers and raise their standard of living. This, in turn, should raise the consumption óf food and other products needed for the health and well-being of the farmer and his family. With improved education, sanitation, and nutrition, fertility should decline and economic dependency rate should be lowered.

The human resource-centered approach attempts to resolve global resource problems through the labor and information intensive activities. It suggests three structural innovations consisting of the community-oriented production structures, integrated area or river basin framework of development, and the "knowledge industries".

The community-oriented structures are those innovations which aim to restructure production towards the community. This involves restructuring social relations and the use of the appropriate technology to serve the needs of the community. The trend is toward ecosystem farming (Talisayon, 1978) or economic ecology as suggested by Dr. M. Swaminathan (Hendry, 1980). These types aim to maximize economic benefits from a given ecological environment and to minimize the risks and hazards to the environment.

The integrated area development, for example, the river basin development framework, is basically an administrative innovation because it requires a strong area manager or area administrator with strong political and administrative power to integrate all sectoral inputs from the central government and bring them effectively to bear on the development of the area. It works on the premise that some environmental problems that affect a certain area or community may, in the long run, affect other areas or communities. The rampant cutting of trees in forests has caused floods in the lowlands which destroy crops, properties and even lives of the people. Thus, the solution of local problems would require the concerted action of groups of people in the area affected by the deforestation problem. This framework would lead to a community need-oriented method of organizing projects rather than one that is dictated by concern only in one sector.

The emphasis on "knowledge industries is predicated on the anticipated need of the manufacturing and power generation industries, in the near future"(Talisayon, 1978). Knowledge and communication industries, especially education and training would become the growth industries in the next decade. This approach assumes that knowledge and understanding of environmental processes lead to the development of a responsible and conserving individual.

It may be deduced from the foregoing that responsibility for environmental management to enhance the surroundings and improve the quality of life rests primarily on the individual. However, human interventions planned to produce minimal negative environmental impacts are best taken up by groups, by the national government with citizen cooperation, and eventually by the international community with cooperation from national governments.

VI. TEACHING METHODOLOGIES IN ENVIRONMENTAL EDUCATION

A. THE QUALITY OF TEACHING

The latest trend in education is the focus on the learning abilities of the child which is determined by his cognitive structure and development, his social learning, and his individual perceptual and cognitive styles. This trend has set off renewed interests in teaching methods. For the quality of learning derives partly from the quality of teaching.

The studies on cognitive development point to student participation as a key to learning. As Bloom (1976) puts it, the amount of active (student) participation in learning (overt or covert) is an excellent index of the quality of teaching. What teaching methods, then, bring about maximum student participation, both overt and covert? Participation reaches its maximum only when the content presentation is interesting and meaningful to students and when students are adequately reinforced.

The Tbilisi Conference is in accord with Bloom's statements. Environmental education is best accomplished through active student partcipation. Teaching methods must be designed to ensure participation by students. Problem-solving, field study and experimentation are a few of the teaching methods that maximize student participation.

The wide variety of methods used in teaching environmental education are practically the same as those used in other subject areas. However, certain methods, particularly those that develop the students' skills in problem-solving and decision-making are more appropriate in learning about an environment that is continually changing. These skills are now given emphasis as the individual assumes increasingly greater responsibility over decisions and actions the environmental consequences of which may be irreversible.

The growing emphasis on environmental education heightens the need for teachers to make their teaching more interesting and appealing to students. Students need varied and appropriate experiences that will enable them to understand the complex environment they are in, assuming that with understanding and interest, action may possibly result. For this reason this module recommends the use of a variety of teaching styles or methodologies.

B. WHY A VARIETY OF METHODS IN TEACHING ENVIRONMENTAL EDUCATION?

Educators hold different views as to the best teaching method and the best sequence of topics. Yet a number of them believe there is no such a thing as best. "Any teaching strategy used effectively and efficiently is a successful method" (Emery, Davey, Milne, 1974). Method here refers to the planned procedure or the instructional moves of a teacher, in teaching a lesson. Method and strategy mean the same and are used interchangeably in this paper. Teaching method refers to the reorganization of content and restructuring of the learning environment, the giving of the right directions to the students at the right time in the right amount, and the provision of opportunities for practice, feedback and correction.

Educators found that every student has a preferred teaching style which facilitates and enhances his learning. Therefore different methods of teaching are necessary to maintain students' interest and increase their desire for further study. The effectiveness of a given teaching method is affected by several variables namely, the learner's aptitude, the content presented, and the delivery system used to present the lesson (Merrill and Wood 1974). Aptitude refers to the natural tendency, readiness or liking of a learner for certain subject areas or teaching strategies. It consists of the skills, experiences or characteristics of the learner that ensure success under a given instructional situation. This is evident when students in a class are made to perform a certain task. They differ in their performance and vary in their responses. Some learn faster with fewer mistakes than others. Some students easily forget what they learn. Others remember the facts and/or procedures longer. This may be due to their varying aptitudes, their previously developed skills and learning sets or experiences. When there is a discrepancy between the students' skills and learning sets and those required to successfully learn a new task, then the students may fail to achieve the set objective in that particular learning situation. One consideration, therefore, in the choice of a teaching method is the learners' aptitude since this partly determines success or failure in learning. Unfortunately, many teachers disregard this and assume that all students have the same aptitudes. This often explains why a certain teaching method bores bright students but at the same time causes frustrations in others. Learning becomes unpleasant when students are placed in a situation in which the demands are unattainable and unreasonable such as when they are asked to perform tasks for which they have no prerequisite skills or when the situation is so familiar that it is boring to go through it at all.

Effectiveness of a strategy is also dependent on the students' capability to integrate new concepts into their cognitive structure or their ability to see the relationships between two or more concepts. As suggested by Jerome Bruner, learners undergo three stages in concept formation: (1) enactive stage when the learner can name or point to the actual object, event or symbols (referred to as referents) which they view; (2) iconic stage when they can imagine verbal descriptions of or recognize pictorial representations of a particular referent such as pictures, models, diagrams and drawings; (3) symbolic stage, when the learners can use various languages and other symbolic structures to represent particular objects or ideas. Teaching strategies or methods used should fit the level of representation or stage of concept formation of the students. Some problem-solving methods of teaching as inquiry and case studies might be difficult for students at a lower cognitive stage. Enactive representations of abstract ideas would greatly improve instruction.

The delivery system refers to the organic or mechanical devices such as audio tapes, projectors, chalkboard, magnetic boards and films used in instruction. These devices greatly facilitate teaching, and although some are expensive, they are fast gaining popularity even in the developing countries. In environmental education, the environment is the classroom. It is a rich source of materials that ingenious and creative teachers effectively use in the absence of audiovisual devices. But when audiovisual equipment and materials are available, they are a means of bringing the difficult-to-visit environment, the rare specimen, and the transitory phenomenon into the classroom for students to experience vicariously.

Audiovisual media are an alternative means of learning concepts and principles and observing laboratory techniques when facilities and equipment in schools are insufficient for the number of students, or when situations render field investigations hazardous or economically unwarranted. The imaginative use of special techniques in filmed presentations such as animation, slow motion, microphotography and macro and global photography can be used to advantage to develop interests and teach difficult concepts.

In the choice of teaching method, consider such basic questions as: What do you want the learner to become? What can the learner do? and, What is the nature of the subject to be taught? What we want the learners to become is described under goals of environmental education. Each lesson moves the learner closer to the goals. What the learners can do depends upon the developmental stage they are in. Bruner's stages of concept formation and Piaget's stages of cognitive development have given us much food for thought on this. Most subjects can be taught in many different ways using different methods. However, some subjects lend themselves better to certain methods than others. For instance, the study of water pollution lends itself better to field study and laboratory analysis. Learners at the secondary level can be expected to do such tasks as conduct researches, do simulation activities or role play. Tasks suited to the learner's developmental stage are easily learned and mastered. What is learned is internalized and becomes part of the learner's cognitive structure. Hence learning becomes meaningful. Knowledge acquired without a sufficient cognitive structure to relate it to may be learned only for the moment. Such learning is not internalized. As a result it is easily forgotten.

Another consideration is the teacher. The teacher is essentially part perhaps the major part, of the delivery system. The teacher is the key factor in mediating the learning process. The method selected by a teacher depends upon what he accepts as the goals of education, his interests and training. A survey of science education in selected secondary schools of Northern Nigera (Spain, 1971) reveals that methods of instructions most frequently used by teachers are demonstration, laboratory and lecture. Hernandez (1980) of the University of the Philippines Science Education Center deplores the large number of teaching methods seldom used by teachers in biology teaching. Most frequently used in the secondary level are the textbook and blackboard methods. In college, the lecture and blackboard methods are more often used. Textbook method here refers to the assignment to students of chapters or sections for reading which are subsequently discussed in class. Chalkboard method refers to the maximum use of the board by the teacher for writing concepts, important facts, and summaries of lessons. Other methods used by secondary school teachers are the discussion, lecture, and discovery methods.

These findings point to a need to enrich the teachers' repertoire of methodologies of teaching. In environmental education it is necessary to adopt the problem-oriented and action-oriented methodologies, which require more learner involvement if we intend to achieve the set goals of environmental education. Emphasis must be on sutdents investigating the events and conditions in their immediate environments and working out solutions to its problems. Teachers must possess the talent and skill to choose from their repertoire of methods the most appropriate for a given situation. They can be given opportunities to try them out on a small group of students or through peer teaching during in-service programs. They must be allowed to try out new ideas and methods. Some of these approaches and methodologies are briefly described in this paper.

C. PROBLEM SOLVING AS AN APPROACH

A problem exists when a novel situation cannot be explained nor can be predicted on the basis of existing principles and theories or whenever an observation does not concur with expectation. There are many physical, biological, social, political issues or problems concerning the environment which have to be resolved. Some examples of these are: The energy crisis, unequal distribution of food between the developed and the developing countries, migration from rural to urban centers, impoverished agricultural lands, rivers and lake pollution through silting and chemical processes, soil erosion, extinction of certain species of animals, the degradation of coastal waters and many others.

Problems are of two types: the divergent problem with more than one acceptable answer and the convergent problem with only one correct answer. Problem solving in environmental education often deals with divergent problems since conditions and needs of different localities vary. Convergent problems when dealt with in class often become a guessing game with students trying to find out the answer that they believe the teacher expects.

In problem solving both discovery or expository methods may be used. When a teacher formulates and demonstrates the solution of a problem and then asks students to apply the principles to solve a similar but not the same problem, expository strategy is used. However, if the teacher merely guides the students in formulating and solving a problem, discovery strategies are used. More often, teachers make use of a combination of the two.

Problems solving skills are basic skills which have to be developed in everyone. These skills are developed mainly through practice. Students who engage in problem solving generally learn to become responsible, capable and creative individuals. One sure way of making them learn is by making them respond actively, collect data, answer questions and organize information. There is a remarkable degree of agreement among educators on the importance of logical thinking and problem solving in learning the sciences both natural and social.

Problem solving can be viewed as: (1) a valued outcome of education (advocated by Dewey in 1916), (Champagne and Klopfer, 1977). Some studies have shown that problem solving method, although believed to be important, is not taught in many schools. In an analysis of many articles on the subject, it was noted that the terms inquiry, discovery, and process or task were used interchangeably, perhaps, due to the educators' changing views of focus on problem solving. In this paper, problem solving is considered an approach to teaching, under which such methods as inquiry, case study, games, role-playing, research and discussion may be employed. In all these methods there is usually a problem to be tackled. They differ only in the steps taken in dealing with it.

In problem solving, it is perhaps important to be reminded of what is now called the force-field approach (Meyer, 1978). This approach considers every problem as having positive or driving forces that tend to push forward a positive change, that is, an improvement of the situation. But there are also negative or restraining forces which resist change and maintain the existence of the problem. Therefore, in problem solving it is necessary to identify and utilize the positive driving forces in order to achieve the desired end. The restraining forces should also be identified to soften their impact or effect if not completely remove them. Is this force-field approach utilized in the various methods in problem solving?

1. Inquiry Method

Inquiry is characterized by a searching for an answer that requires the learner to perform a series of intellectual operations in order to make an experience (a problem) understandable. Inquiry, therefore, emphasizes a student's initiative and his own direction of learning experiences. In the inquiry method, there is usually a topic, a problem or question in which students are interested or which they are curious about. When curiosity is exhibited the teacher should capitalize on it. But normally many students are too shy to make known their questions and knowledge. That is why very often teachers have to resort to other means such as asking provocative questions or demonstrating an event or a process which shows something other than that expected by students.

The topic, question or problem may be tackled as a cooperative undertaking of students working individually or in group, or of students and teachers jointly planning, discussing, hypothesizing, analyzing, and inferring in their attempt to generalize from a set of data. Thus theories are formulated and then tested by means of experiment and/or analysis of data gathered from personal observations and those others to find relationships or give meanings. This method aims to develop students' curiosity and imagination and their ability to express ideas, to inquire, investigate and discover for themselves. They should be motivated to find alternatives or new ways of dealing with complexities when things do not turn out as expected in the search for solutions to the problem.

In this method, concepts can be presented to students in a variety of ways - two of which, are invitations to inquiry and discovery through inquiry.

a. Discovery Through Inquiry

Discovery through inquiry was advocated by Richard Suchman. This technique utilizes various delivery systems, such as films, slides or a narrative story supported by photographs or a demonstration of a phenomenon to pose problems of causality. Here inquiry is conducted without students actually performing experiments or manipulating equipment. The students gather data about the problem by asking questions. Usually only questions that seek data asked in a form that can be answered by yes, or no, are entertained. The rationale behind the students' asking questions instead of the teacher is that when the students observe or explore the teacher cannot tell what cognitive operations are taking place in their minds. But when students verbalize what is in their mind in the form of questions, the teacher gets a clearer picture of how they are thinking. The "yes or no" questions asked by students are intended to eliminate teachers' structured questions that require definite answers and stifle the development of the students' reporting capabilities. The data gathering questions force students to test their hypothesis through what Suchman calls "verbalized experiments". This method aims to make students become critical thinkers and better inquirers, two of the many characteristics needed in problem solving. The emphasis is on raising good questions about the phenomena or situations rather than finding correct answers.

Studies show that students become skillful inquirers through practice. At the start, a teacher can expect few and very general questions. In time, the questions students ask usually increase in number, become more specific and controlled. Inquiry is not new but is one of the means used to develop basic cognitive skills that enable the learner to discover the factors causing the observed changes.

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Sample Lesson 1

Concept: The pollution of many rivers is caused by man's activities and affects the community's water supply.

Objective: Students should be able to recognize man's activities that causes adverse changes in the condition of a river.

Method: Discovery through inquiry.

Materials: Photographs of a river taken at an interval of 20-30 years, maps showing the location of a river.

Procedure:

A. Introducing the Concept:

1. Show the photograph of a river taken recently and another taken 20 years ago and a map location of the river. (The photographs should show the change in the river's condition after a span of

20 years).

2. Allow students to ask data-gathering question answerable by yes or no. From the data gathered, the students should be able to come up with a description of the river, its name, topographical boundaries, head and mouth and the towns through which it passes. The teacher summarizes these data on the board. Allow the students to identify the river.

B. Developing the Concept

After becoming familiar with the river through the photographs and questions and answers, students now inquire to find out the possible causes of its polluted state. Questions asked by students are supposed to be based on their observations and what actually happens along river banks. Some examples of questions that may arise are: Are there houses nearby? Do people bathe in the river? Do they wash their clothes there? Are there agricultural lands nearby? Are there factories? Do fishermen catch many fish?

C. Discussion

1. Data gathered from the yes-or-no questions are analyzed to determine possible causes of pollution.

2. Discuss the probable effects of the pollution of the rivers on the usefulness of the river as source of food.

3. Have students prepare a list of what they can do to save the dying river.

D. Follow-up

Arrange a field trip to a nearby river or any body of water in the community that may have undergone or will probably undergo similar changes. Have students plan and carry out some activities that will help improve the condition of the river.

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b. Invitation to Inquiry

Another technique which aims to make students skillful inquirers is the Invitation to Inquiry. This technique puts emphasis on how data are acquired and converted into knowledge. It shows that learning science is not just knowing from others that which is already known. This is brought about in various ways. One way is by presenting a problem and performing experiments to solve it. Then the data obtained from the experiment are described, analyzed and interpreted by the students. Another way is to have students interpret and/or react to a set of data to form a conclusion. Inquiry teaching is also brought about when a problem situation is brought out and students are invited to develop hypotheses to account for the observed result. The formulated hypotheses may be tested in another Invitation to Inquiry exercise one at a time. Here is a sample Invitation to Inquiry lesson or exercise.

Sample Lesson 2

(In this lesson a problem situation is presented to develop the idea of hypothesis and the skills in formulating hypothesis and controlling variables in an experiment).

To the student:

In many Asian countries such as India, Malaysia, Thailand and the Philippines, floods often occur in certain areas during the rainy season. Dry spells or droughts, on the other hand, are experienced during the dry season. In 1972, for example, certain parts of Central Luzon in the Philippines, were underwater for more than a month. When the water subsided, one to two meters of soil was found deposited in rivers and many low-lying areas. Siltation has been going on year after year with the occurrence of strong typhoons. The problem has gone from bad to worse during the past eight years. Being the major rice producer of the country, Central Luzon has to solve this perennial problem. Similarly in Ghana about 70,000 people abandoned their land due to constant flooding. What do you think are some possible causes of floods?

(Discussion follows in which students present possible causes of floods. Possible reasons may be: increase in the amount of rainfall over the area, excessive cutting of trees or deforestation.)

To the Student:

Studies show that changes in the amount of rainfall are not sufficient to cause flooding. Why do these areas (show pictures, location on a map) yearly suffer floods?

(Students examine pictures, maps, slides or whatever teaching aids are presented by the teacher. They point to and identify possible causes. They try to explain why and how this factor could be a cause of floods. In bare soil, there are no tree trunks to slow down the flow of water, no roots to absorb water and hold soil. During heavy rains, water flows down so fast, very little water seeps into the soil where it could be stored as groundwater).

To the Student:

Hypothesis: Deforestation is one cause of floods. How will you test if this is true? What factors will you consider to make the data as valid as possible? (A sample experiment which students might suggest is: Two slightly inclined ground surfaces of equal areas, one covered with growing plants and trees, the other bare, can be marked off. Water from a hose can be made to flow over both surfaces for a given period of time. Water collected at the end of the incline from the two surfaces can be compared. The water collected from the two surfaces can be compared to the water coming out of the hose as to amount and color). Students should be able to identify the factors to be controlled, e.g. surface area, slope, amount of water allowed to flow per unit time, velocity of water, type of soil, and the factor that is manipulated i.e., the nature of the surface).

To the Student:

How will you explain floods in the rainy season and droughts in the dry season in the same area?

(Fast flow of water prevents much water during the rainy season from seeping in for storage as groundwater. Stored groundwater can be the source of water during the dry season).

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2. Research Methods

Problem solving frequently involves some form of research and many environmental problems are solved through researches, both experimental and survey. These methods should, therefore, be utilized in environmental education to develop the students' problem solving skills.

a. Experimental Method

An experiment, according to Webster, is "an operation carried out under controlled conditions in order to discover an unknown effect or law, to test or establish a hypothesis, or to illustrate a known law." This definition implies the presence of a situation which is better understood only if an operation, an experiment, is carried out. Controlled conditions mean the researcher identifies all relevant variables, maintains them in the normal state except that one which is tested. This variable which is tested is believed to have something to do with or is the possible cause of the problem. Experimenting is actually inquiry through investigation with objects, apparatus and materials under natural or simulated conditions.

Many experiments performed by students in schools are criticized as having nothing experimental about them. The procedure is so structured the students merely follow them step by step until they are finally led to the expected conclusion. This type of experiments may be necessary at the beginning for students to learn basic skills of handling and setting up instruments until they develop enough self-confidence to carry-out unstructured experiments. Bright and capable students, however, should be given opportunities to pursue the problems in their own ways, to develop their self-confidence and stimulate their interest on the meaning of research in science. Let students begin with simple experiments which are of interest and use to them. Many students lose interest in experimenting when they find that the knowledge acquired is irrelevant or when the task is so difficult that they forget what they are supposed to learn. What they remember is the difficulty they experienced. Educators believe that the outcomes of interesting experiments peformed are more likely to be rememberedif they are related to problems students are directly concerned with.

When students perform experiments, teachers must provide an atmosphere conducive to learning. Students must be encouraged, supported and aided in their investigations. Teacher must accept students' ideas, yet tactfully suggest improvement in research plans, if necessary. They must develop a climate of trust among students as well as between the teacher and the students. Students should be trained to prepare well-written reports on the method or procedure followed and the conclusions derived from their experiments.

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Sample Lesson 3

Objective:
1. To differentiate biodegradable from non-biodegradable materials.
2. To identify which type of material is more useful for landfill.

Materials:

Samples of 4 different items thrown as waste (4 pieces each)

Ex. plastic bags, newspaper, tin can, glass
16 pieces of sticks (6 cm long)

16 cards (4 cm x 6 cm)

Procedure:

A. Divide the class into groups. Have each group collect a sample of different items normally thrown as waste. Some examples of these materials are plastic bags, old newspaper, tin can, glass or whatever is available. Try to collect samples of the same sizes. If possible cut them into pieces of 4 cm x 4 cm.

B. Mark off the area where the samples are to be buried. On four cards, write the name of one sample. On each card write the sample number.

Example:	Plastic bag	Plastic bag	Plastic bag	Plastic bag
	No. 1	No. 2	No. 3	No. 4

Do the same with all the other samples. Within the enclosed area push the sticks into the soil where the identified sample is to be buried. Do the same with all the other samples. Bury the 4 pieces of each sample separately under about 6 cm of soil which should be kept moist.

C. After two weeks, pull out a piece from each sample. Describe the condition of the material. See if there is any sign of decay. Record data on a chart. On the fourth week pull out sample No. 2. Do the same with the succeeding sample numbers after every two weeks. After the eighth week all four samples should have been examined and observations recorded. The following questions should be answered:

- Which samples decayed?
- Which samples did not decay?
- Based on your findings which materials should not be used as landfill? Why?

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b. Survey Research

A survey is a way of gathering baseline information. The findings in a survey are and can be used as a basis for and provide direction to certain activities or projects. For example, a survey on the needs of the learners or the community is used as one of the bases in curriculum development. In conducting a survey, the more commonly used data gathering instruments are the checklist, the questionnaire or the opinionnaire and interviews. The respondents' answers to the series of questions and their reactions to statements determine their feelings, attitudes, opinions and reactions toward a certain issue. The reliability of the findings in the survey depend upon the respondents' sincerity in answering the items. Sometimes respondents answer such instruments without giving much thought to the questions. Other respondents confuse their true feelings with what they believe are the feelings expected of them by the researchers.

In a survey, the information provided by the respondents usually should be regarded as confidential. The researchers should always respect the right of the respondents on the information that they give out. Just as in experimental research, students are actively involved. Through these activities their skills for independent learning are developed.

This method is most useful in environmental education since survey can be resorted to in determining awareness, understanding, interest or opinion of community people on an environmental situation. Some possible topics which can be surveyed are: (a) sources of water in the community, (b) people's attitude toward population growth in your town and the possible causes of such growth, (c) location of garbage dumping grounds and determining their effect on the pollution problems in the community.

For a student survey, limit the number of items to five. A long survey instrument is likely to encounter difficulties which could dampen the students' enthusiasm.

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Sample Lesson 4

Concept: There are various sources of water in a community.

Objective: Students should be able to ascertain the adequacy and quality of water supply in their community.

Methodology: survey

Procedure:

A. Preparation of the following

1. interview guide
2. questionnaire

B. Planning

1. Class is divided into groups of 4-5 students.
2. Community is divided into as many zones as the number of groups. Each group is assigned a zone to cover.
3. Briefing of group leaders on how to conduct the interview based on the pointers given in the interview guide, how respondents should go about in answering the questionnaire, and what the other members are to look out for as they move around the assigned zone.
4. Choosing the sample

C. Data Collection

Ocular inspection of the community to gather data on factors and/or conditions in the community which will somehow affect the quality of the water. For example, proximity of toilets or garbage dumping grounds to open wells.

D. Collation, analysis and interpretation of data.

E. Generalization

F. Plan of action based on findings.

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3. Case Method

Another method in problem solving, more often used in the social sciences than in science teaching, is the case study method. The case can be an event, a human behaviour, a news story, a speech, a letter or even an account of an event. Since the case selected from the environment is discussed in class, it shomehow links the school to real life. Once the case is identified, a discussion is conducted to bring out the basic issue or problem. If this happens to be a complex one, the case is further analyzed to break it down into simpler ones until the real basic issue or problem is identified.

The class then breaks up into groups and each group discusses the cause/s of the issue or problem. In each group the sentiments and beliefs explaining the case are presented. The possibilities of how this event could have been and still be prevented are also discussed. Based on the different views presented, every member of the group recommends an action and the reasons behind it. The group decides on the best recommendation. The views, explanations, and recommendations of each group are presented to the class in order to determine the best. Very often the class considers more than one possible explanation and recommendation for action. The discussion analysis is considered the most important part in the case study method. The teacher's role is simply as a guide and supporter who sees to limiting the discussion to the topic and assisting the learner in seeing the applicability of the explanation and recommended action to other related situations.

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Sample Lesson 5

Material: Map showing the location of a dam and a village downstream

Procedure:

A. Presentation of the case

On November, 1980, at the height of a typhoon in the Philippines, the water level behind a dam rose higher than the safe limit. Its gates were opened. As a result, water rushed out and flooded the village causing deaths and destruction to property. Many houses were covered with two to three meters of mud carried by the floodwaters. Furniture and appliances were destroyed. Hundreds of families along the river bank were rendered homeless. Several people carried away by rushing waters were drowned. People believed that the government agency which ordered the opening of the dam should be held accountable for the destruction and loss of lives. What is your opinion on this?

B. Group Work

The class works in groups of 4-5 students. Each group conducts a discussion-analysis on:

1. Did the opening of the gates of the dam cause the flood? Could it not be caused by some other factor?

2. How could this have been prevented? What measures could have been done?

3. Should the agency be held liable for the loss of lives and destruction of property?

4. What needs to be done? What action can be taken to prevent similar disasters?

C. Presentation of alternatives suggested by each group. Analysis of the best alternative.

D. Follow-up Activity

Research on the possible cause of the big volume of water and silt added to the reservoir during heavy rains.

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4. Simulation Activities

In simulation, the participants generally assume roles in various realistic but make-believe situations which may be social, economic, political or biological.

Simulation is a simplified reproduction or model of a phenomenon, a process, or a real-life situation, problem or activity. According to Taylor, 1972, cited by (Hernandez 1980) a simulation activity must have the following major features:

1. It is an informal activity in the classroom in which both students and the teacher partcipate. The players take on roles simulating the real world. They make decisions according to their assessment of the situation in which they find themselves. They experience simulated consequences of their decision and reflect upon the relation of their decision and resulting consequences.

2. It is problem-based; open to multi-disciplinary approaches. For example, social skills directly related to the real world may be involved.

3. It is dynamic; deals with situations that change requiring flexibility in thinking and responding.

Simulation may also refer to activities utilizing a model which may be manipulated so that through the series of trial and error operations the students may be led to arrive at a decision, an explanation or possibly a solution to the problem studied. For example, in studying the effect of stream velocity on soil erosion, stream flow can be simulated in the classroom with the use of a stream table.

Simulations in environmental education generally deal with such topics as resource preservation, land use, population growth, socio-economic issues and many others.

Many shy students find simulation activities difficult at the start. This is because they are required to talk and act in front of their peers. Teachers have to make the shift from a teacher-centered to a student-centered learning gradually. They must prepare their students especially the average and below average group, by having them get used to "doing lessons" rather than "listening lessons". They should vary the degree of student involvement based on their mental and physical maturity, the scope and complexity of the situation.

a. Games

Simulation activities may be in the form of educational games. Hernandez (1980) describes one such game, a card game on Mendelian Inheritance called rumigen which was prepared by UPSEC staff.

Rumigen helps the student understand the meaning of genetic cross, genotype, phenotype and ratio. The game is played in a manner similar to gin rummy. The game starts by giving each player seven cards. A card could be a P_1 (parent) male, P_1 (parent) female, or F_1 (offspring). A card also contains the genotype of the individual in letters. The game proceeds with each player drawing a card from a pile and discarding the card which he thinks has little probability of completing a suit made up of the male P_1, female P_1, and all the possible F_1 as indicated by the P_1 genotypes for a given characteristic. In a series of draws and throws each player attempts to complete as many suits as he can collect. The game ends when a player succeeds in putting down all his cards in completed suits. Each player then gives the phenotype and genotype of each P_1 and F_1 in his completed suit. He also gives the ratios of the genotype and phenotypes of F_1 individuals in his completed suits. (See Figure 30)

b. Role-play

This is another problem solving method where a selected real-life situation is dramatized, the feelings and emotions of those involved are enacted in order to determine its impact on them. It is a method which can be utilized to develop ideas or present both sides of an issue. Role-play is also known as a drama or skit. In this method, the students are given roles to play, and in so-doing they become personally involved in the issues. Role-play activities are generally preceded by long, clear and specific verbal or written instructions on what the situation is all about, the different roles and the stand the player should take. This dramatized situation is very often a conflict situation which is supposed to be resolved when the basic needs are understood and considered. Teachers can prepare their own role-playing activities. They can select any issue which in one way or another affects the students. For example, in areas where geothermal energy is intensively developed, the teachers can ask students to play the roles of a businessman who will be benefited by the power it will generate, a local official (Mayor) who presents the socio-economic benefit the town will derive from the plant, an official of the government agency that administers power plants, a farmer, a citizen, and a meteorologist who will present the good and bad effects the power plant will bring about.

Another example of a simulation activity is the "Population Explosion - Effect on Society" prepared by the American Friends Service Committee. This activity makes the students act out roles which

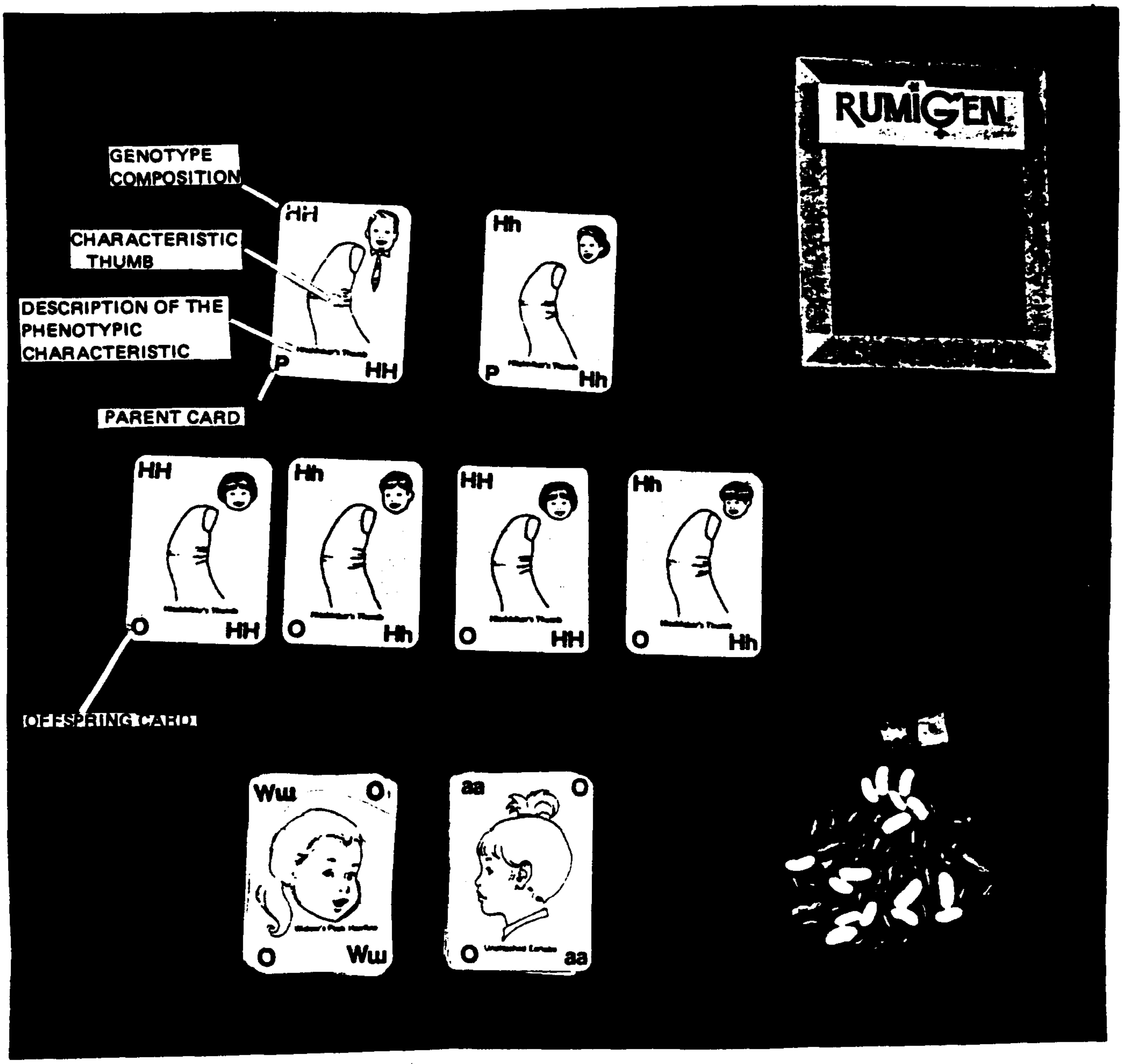

Figure 30. Rumigen Cards

hopefully will make them more sensitive to problems that arise as a result of rapid increase in population.

In this game, the class members are divided into three groups to represent citizens from developed, developing and Soviet bloc countries. Students in each group are given play money and served real meals. However, the size of the group, how much food each group can buy and the amount of space it can occupy are proportional to the real situation in the world.

In choosing the situation, these are two considerations: 1) the situation must be realistic, based on a felt need and closely linked to the lives of the students, and 2) the situation must be simple. Complex problems, consisting of two or more problems may be difficult for the intended target group. They will have to be analyzed to bring out the basic problem. Choosing a simple situation will also make analysis easier.

As soon as a situation or a problem is decided upon, five to six roles may be chosen from the many possible roles. The participants to play the roles are selected. The emphasis is more on the feelings emoted by the participants than on how the roles are played. Therefore it is necessary for the participants to fully understand the situation. When the class is large, those who are not given roles may serve as the decision makers who decide on the basis of the portrayals of the participants. The teacher simply acts as the moderator and sometimes the timekeeper.

The discussion after the role-play is important. It is used as a gauge of the amount of learning gained from the activity. The teacher should explain how this activity can be integrated into the syllabus.

Simulation and role-play differ only on what is emphasized. In simulation games, the process and pattern of social interaction are emphasized, whereas in role-play, character development and awakening of the feelings of the players are stressed. More personal creativity and ability to communicate ideas are demanded of the participants in role-play than in simulation activities. In both simulation and role-play, the students become personally involved in the issues and problems relevant to their lives.

5. Discussion

Problem solving is also possible through a free interchange of ideas called discussion which enables those involved to be informed and, based on the information, to decide and resolve an issue or problem. Discussion aims to stimulate analysis of the issue, encourage the airing of different opinions and attitudes of as many people as possible and in certain instances bring about a change in the attitude of those involved.

Discussion is a classroom activity used by almost all teachers in all grade levels. During a discussion the teacher or students may contribute a bit of information or ask a question which becomes the springboard to discussion. This statement or question may be reacted upon by someone else or may elicit another question or statement. The exchange of ideas are attempts to bring out the important facts and circumstances associated with the problem. Students consider the ideas presented. They may accept or reject them depending on how these relate to his own. When the problem is simple, mere discussion is enough to bring out the solution. Difficult problems and complicated issues may require a number of activities and students, therefore, have to weigh objectively the advantages and disadvantages of these activities. The outcome of any problem solving discussion is a plan of action or the formulation of a generalization based on the ideas presented. Discussion procedures can be divided into three stages, the identification and analysis of the problem, the formulation of hypothesis and generalization or plan of action.

The question is who defines the problem. Many students find difficulty in isolating and stating the problem. So problems for the day's lesson or a series of activities are generally defined by the teacher who writes them on the board. Sometimes problems may also be deduced from the textbook. As the students get used to the method, they should be made to identify and state the problem themselves. As in all other problem solving methods and techniques, the problems tackled should be those closely related to the lives of the students.

Very often many students are able to do the activities assigned to them be it an experiment, role-playing, conducting a survey or participating in a simulation game. But very few may manifest real understanding of the concept or principle the activities are supposed to demonstrate. Discussion is needed to bring about thorough understanding of certain concepts or the development of verbal and intellectual skills.

The success of a discussion is dependent on the interrelationship between teachers and students, the physical conditions of the school and the topic being discussed. Good interrelationships between the teacher and the students may also bring about mutual liking. The teacher whose reactions in class show concern and liking for students are also liked by them. The manner by which a teacher asks questions, the facial expressions and comments also determine whether a response will be elicited or student interest will be enhanced. In a study of the In-school Off-school Program in one of the secondary schools in the Philippines (Hernandez, Gavino 1979) some teachers in all year levels were observed during discussion. Some teacher characteristics that encourage student participation are: expression of pleasure and enjoyment of correct answers; eye contact with student who is responding or to whom a question is directed; addresses student by by name; does not stay rooted to one place throughout the lesson; is careful about the feelings of student; does not act or express feelings disruptive to self-concept of students; is sensitive to the tone of the class and makes adaptive changes easily.

Some student behaviours which teachers should discourage during discussion are attempts to disply irrelevant skills and bits of information to attract attention, presentation of irrelevant opinions or facts, asking silly questions, pretending to be interested. Teachers should readily make students aware of the irrelevance of the information or skill displayed without hurting student feelings.

D. PROJECTED METHOD

Project method involves the carrying out of a task by a group working together or by an individual. It is an activity conducted in or out of the classroom that is not based on a problem but requires active student participation. In this method students are required to plan and carry out a project which requires construction of a mechanical device that shows how the application of a principle can speed up or improve operation. Other projects may be models showing the principle on which it operates. Some examples of such models which students themselves have prepared are solar cookers, windmills, methane gas generators and many others. These are projects which students patterned after those already invented. Student projects may also be an activity, aimed to bring about a positive change in the environment, in school or the community.

The choice of a topic which students will work on is the most crucial part since it determines whether the project will or will not be successfully completed. The considerations in the choice of a topic are student interest and capabilities. When students work on something interesting to them or something they know will be of use they surely will see the task through. Therefore student hobbies may be a potential source of ideas for environmental education projects. As the students work on their projects, teachers must be able to sense the degree of guidance needed (by the students). Students must be made aware, even before they start, of the feasibility, usefulness and cost of the project.

The time needed to work on the project varies depending upon its complexity. More time for planning, research and actual work is needed by complex projects. The availability of materials used and guidance from experts are also factors which students must consider. It would be frustrating for students if they realize that certain parts needed are not available when they are almost halfway through.

An important aspect of any project is the project report. This is one means by which the accomplishment is made known to others. It is also a means to organizing one's thoughts on the characteristics, operating principle, and uses of the project. The report can also be used as a basis for further studies.

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Sample Lesson

Title: A model of a river system in a community and other surrounding features

Materials:

wooden board 1 m x 1 m

old newspaper

mesh wire 1 1/2 m x 1 1/2 m

cardboard

paint - blue, green, brown

paper - 1 m x 2 m

Procedure:

1. Lay down the mesh wire on the board to match the real shape of the land. Show the location of the mountains and valleys. Over the mesh wire, paste several layers of newspaper, a layer at a time, to make it about 2 cm thick. Allow each layer to dry before applying the next.

2. Paint areas covered with water, blue (lakes, rivers, sea) those covered with plants, green and soil covered areas, brown.

3. Cut small pieces of cardboard to represent buildings. Indicate on the card the name of the building it represents. (For example, church, school, market or hospital). Have students determine the proper location of these features on the wooden board so as to produce a model community. Let students paste the cards on the board.

4. On the paper draw an enlarged map of the community. On the map indicate, using the same symbols as on the model, the location of such features such as the river, buildings and other features. The meaning of symbols should be given in a legend on the map.

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E. FIELD TRIP

Field trip refers to any learning activity carried on by a group outside the classroom. It is a teaching method which enables students to gain first hand experiences with materials and phenomena in their true or natural relationships. Field trips take students out of the classroom to wherever they need to observe real conditions and gather actual data on a topic. There, students study and observe the interrelationships in nature and the built environment.

a field trip is a form of outdoor education. Studies show that some learning can be acquired more quickly and effectively in a favorable outdoor environment than in the classroom. Therefore, those lessons that can best be learned outdoors should be taught there. There are lessons, however, that are better taken up in the classroom.

A carefully planned and successfully carried out field trip has the following advantages:

1. Provides opportunities for students to become keen observers.

develops in the students the habit of enjoying the beauty and orderliness of naturally occurring events and circumstances. It is said that only those who appreciate the beauty of his natural environment will be concerned about preserving it.

2. Enables students to verify classroom instruction, library reading or laboratory exercises and make them more concrete in his mind.

3. Students automatically take an active part in the lesson and learn to become responsible members of the group.

4. With proper teacher-student planning, field trips improve the student-teacher relationship, make students become highly motivated and improve or enrich the classroom programme.

Many teachers, however, feel otherwise. They still avoid taking their students on field trips. Field trips to them are hazardous time consuming and only provide students a good time and vigorous exercise. They believe that given the same time in the classroom, the students could have learned more. They believe that a lecture supplied with sufficient audio visual aids such as slides or a movie would give a better overview of whatever lesson is being presented with far less inconvenience. But acquisition of knowledge is not the only goal of environmental education.

The point of most field trips is to show students something in its natural setting. The field is used not only for instruction but for observation and investigation. Field trips should be conducted on the premise that the most valuable student experiences outside school come from actual sense perceptions (i.e. seeing, hearing, smelling, touching) of what they read in books so that they are remembered longer and understood better. The unexpected happenings or problems encountered by students on such trips which they happen to overcome provide unintended, informative experiences.

How to conduct field trips

To make maximum use of outdoor experiences, activities that take the fullest advantage of the resources at hand, should be selected. How can this be done? The teacher and/or the students should survey all possible sites for field trips to be aware of the potentials of a community. The sites should include not only the nearby sites but the surrounding areas as well. The teacher can prepare a file of these potential sites for field trips in cards.Each card can include the place to be visited, its location, what the site has to offer and all other pertinent information. These cards can be collated into booklet form and made available to all teachers in the district or division. Some examples of such places are: aquarium, coastal areas, bird sanctuaries, planetarium, chemical plants, dairies, water treatment plants, geothermal plants, observation ponds, rivers, vacant lots and many others. All these places can be used as extensions of the science classrooms. The concentric approach recommended at Tbilisi can be used as a guide in choosing sites. The learners throughout their schooling should explore a succession of widening environments from the home, community, village, region and finally the world.

All trips must be carefully planned in advance and followed up with meaningful discussions and continued investigations. The teacher should brief the host agencies, mark out the trails to be followed or the places to be visited, in a field trip. Inadequate planning can easily cause dangerous chaos, waste of time and even accidents. It is also wise to divide the group into smaller units to avoid waste of time in checking. Smaller groups will also provide opportunities for students to exchange notes and discuss. The behaviour expected of the students should be clearly established before the trip. Students should be informed of what materials to bring along.

The purpose of the trip whether to introduce a topic, to arouse interest or to find answers to questions, must be clearly understood by the students. The teacher should do some preliminary investigation as to the suitability of the activity to the grade level, the best time for holding this kind of trip, special arrangements needed to be made with school authorities and parents, and for the students' provisions and transportation. It is necessary for the teacher to make a preliminary trip to familiarize herself with the site or sites selected.

Field trips and field exercises are excellent means of enriching environmental education by making students more aware of what is actually going on around them. Field trips, therefore, supplement rather than interfere with class activities. Many teachers still seldom use this method. Perhaps, they object to taking their students on field trips because of the far greater responsibilities involved outside than inside the classroom or because of the legal responsibilities of arranging waivers, permits, etc. or because of economic reasons, the high cost of transportation,meals and pocket money. This problem can be easily overcome if teachers consider field trips to such accessible environments as the schoolyard, school garden plots, ponds, parks and others. John Falk (1980), for example, assigned students to work in teams and had them sample their own front lawns for organisms, an area about 20 m x 20 m, half of which was mowed and the other unmowed. There were 130 species of insects found adaptable since there was no change nor a decline in population before and after mowing. Falk wanted to show that there is a vast teaching resource available as accessible sites for field study.

Many teachers still feel uncomfortable outside the classroom because of the unexpected questions that may arise which they feel they might not be able to answer. These teachers may never overcome these feelings until they try and not until they believe that students do not expect them to know everything but that there are things which they can all learn together. For sure, one great benefit derived from field studies is the strong bond that develops between students and between students and their teachers.

VII ACTIVITIES AND EXPERIMENTS FOR TEACHING-LEARNING THE ENVIRONMENTAL DIMENSION OF SECONDARY SCHOOLS

A. THE NEED FOR ACTIVITIES AND EXPERIMENTS IN ENVIRONMENTAL EDUCATION

Environmental education is meaningful when knowledge gained by the learners can be applied to everyday life. It is meaningful only if the skills developed can be utilized in dealing with problems or difficulties encountered in life. These may be achieved by the inclusion of activities and experiments that will provide students with opportunities to make decisions or choose between alternatives on current issues.

The suggested activities and experiments included in this module are aimed to help teachers teach certain lessons in evnironmental education. The activities may be enriched or toned down to suit the level of their students.

The activities are numbered such that the first digit refers to the number of the objective it supports and the second digit after the dot refers to the activity. Activity 1.4, for example, means the fourth activity under objective one.

B. ON STRUCTURE AND FUNCTION OF THE ECOSYSTEM

Objectives:

1. To define and indentify the components of an ecosystem.
2. To describe the elements of a food chain and a food web.
3. To describe the conditions needed for the ecosystem to maintain itself.

Suggested Activities/Experiments

1.1 Field trip to an area where students can identify the different components of the environment. Decide on the kind of place to study - a grassy field, a forest, or a coastal area. Before the trip, let the students prepare a list of the living things they expect to find within the area. Divide the class into small groups.

Let the groups do the following activities:

Mark off several plots of about one square meter on a large grassy field or a forest, or a coastal area whichever is selected by the class. Assign four to five students to every plot. Ask the students to make an inventory of the different plants and animals in it. Allow them to study closely the characteristic of these organisms. They should compare the pre-trip list with the list they made in the field. Inferences can be made as to why some organisms they expected to find in the area are present and why others are not.

Observe or examine the soil covered by big rocks or rotting logs in the area, if any. Lift the rock or log. Dig into the soil with a shovel to see the living organisms in it.

Discuss the results of the examination. Back in class, ask the students to read on the eating habits, the life span and other interesting information about the less common organisms observed in the field trip. Study the roles, functions, and the relationships that exist among the various organisms and other components in the system. Bring out the meaning of such terms as consumer, producer, decomposer, population and community.

1.2. Ask the students to prepare a mini-ecosystem as a project. Let students arrange the following in layers at the bottom of a large glass jar or aquarium: 5 cm of sand, 2.5 cm of dried straw and 5 cm of garden soil. Small ferns, lichens, fungi and small animals may be placed on the soil. Wet the sand and seal the jar or aquarium. The mini-ecosystem in the large glass jar or aquarium can be observed everyday for two or three weeks in the classroom or in the laboratory.

1.3. Survey the different aquatic ecosystems in the community. Students can be made to identify the streams and lakes, find out their names, location and present condition. One of these ecosystems can be studied in detail: (1) its physical characteristics - color, odor of the water, temperature, etc; (2) the living organisms in it; (3) the uses of the water to the community; and (4) general condition - polluted or not polluted and, if polluted, the possible sources of pollution.

1.4. Let the students identify an important part of their environment that is undeveloped. Ask them to imagine and describe or draw how they think the place looked some 10 years ago or as far back as they can remember. Let them explain the possible causes of the change, if any. Then let them describe how they intend to develop it into an ideal community, given the money. Let the other members of the class consider the possible effects of these changes on the environment and then evaluate them.

2.1 Present pictures or samples of different organisms which students have identified and described as to habitat, food eaten, feeding habits, etc. Examples of common organisms may be presented first, followed by the less familiar ones which students had researched on. Ask students to discuss the relationships among these organisms, and then develop a model based on "who eats who". From the discussion, bring out the idea of food chains and food webs emphasizing the concept of producers, consumers and decomposers.

2.2. Simulation activities: the "Web Roles" Game

This is a role-playing activity devised by Jim Connaly (Science Teacher, Dec. 1977). It is aimed to provide the students with the experience that will lead them to appreciate the interdependence of animals and the natural balances within ecosystems.

The activity begins with students drawing a card from a set to determine which role each is to play. Each card which is color coded contains information about a specific animal such as what food it eats, how it avoids its enemies, and how it takes care of its young. Some animals represented are predators, others are prey. Animals to be used should be those students are familiar with.

After finding out what animal to represent, each player is required to answer questions printed on Card A. The questions deal with problems animals of his kind encounter and how they can survive. Instructions on what the students are supposed to do and other facts about the animals are printed on Card B. Each student should have the animal he represents pinned on his shirt. The students should imagine the 2 1/2 hours spent in the activity as equal to four days. During this time, the students think of themselves seeking shelter and food and avoiding predators. The players are supposed to be back in 2 1/2 hours if they survived, and report immediately if caught by predators or if they starved.

When everybody is ready, the prey are released. As soon as they are out of sight, the predators follow. At the end of the specified time, the students meet and discuss their experiences. From this simulated experiences, conclusions can be drawn about the functions of the ecosystem. The activity should be a real model of a food web.

The activity ends with students answering questions in Task Card C. Some examples of questions in Connally's Task Card C are: What food sources did you find? What food sources were you able to obtain? What does your food supply depend on? How has man affected your food supply?

2.3 Field trip

Divide the class into groups of 4 or 5. Allow them to take a walk around different places such as the schoolyard, the neighborhood, a park or some nearby place to observe. In their walk, ask the students to do the following:

a. describe and draw the plants and animals they see

b. describe what each animal uses for food (If this cannot be observed, they may have to read about these animals to find out).

c. state which feeds on what plants, or animals or both

Discuss and compare group observations. Each group should prepare a chart showing all the organisms. Using arrows, ask the students to link the organisms, to make a food chain. Make them think of a larger ecosystem such as the sea, or a forest.

Another activity which students can do out in the field is to make them look around for evidences of a food chain. Let them draw the food chain and determine if any part of this chain is endangered. Ask how a break in the chain would affect the ecosystem and what can be done to make sure that it is not broken.

3.1 Possible effects of relocating an organism from its usual habitat to a different one can be a topic of discussion after the lesson on habitat. Emphasize the effects of changes in the conditions in the community on the organisms in it. Study also the effects of other limiting factors to population growth such as temperature and salinity.

3.2 Present photographs of a body of water, a river, a lake or a bay. Or bring the students to any of those sites. Back in the classroom, let students state inferences about the condition of the body of water. Assign someone to write these inferences on the board. Based on these, let students think of possible reasons for the conditions. Let them formulate these statements into hypotheses. Divide the class into groups and allow each group to choose the hypothesis it desires to test. Have them submit their plans. It may be necessary for the teacher to help them get the necessary reference books and equipment.

C. ON ENERGY FLOW IN THE EARTH ECOSYSTEM OR ECOSPHERE

The suggested activities and experiments are aimed to show how solar energy reaching the earth is absorbed by air, water, land, plants, animals, and other materials in the ecosystem, and how the energy is changed to some other form.

Objectives:

1. To describe how the various sources of energy on earth can be traced back to solar energy.
2. To identify the different alternative sources of energy affecting the earth and indicate their relative importance.
3. To determine a possible solution to the energy crisis experienced in many parts of the world.

Suggested Activities/Experiments

1.1 Enumerate some materials used as sources of energy. Let students trace each one back to its original energy source. Examples: heat energy from burning gasoline, tap water flowing from river water, from mountain spring.

1.2 Classify certain resources used into renewable or non-renewable resources. Make students report on how fossil fuels are formed.

2.1 Assign students to research and report on other sources of energy aside from fossil fuels. Some of these are solar, geothermal, nuclear, biogas, tides and others. Follow this up with a debate on which of the possible alternative sources should be developed in the country.

2.3 Follow up the discussion of the uses of coal with a film presentation on how coal is mined. If a film on this topic is not available, slides or mounted still pictures showing the processes or steps involved in coal mining can be used. Allow students to analyze these processes and to give their stand on the following:

a. How does coal mining affect the environment?

b. Knowing the economic importance of coal, would you still allow coal to be mined? Why or why not?

c. What can you do to conserve this non-renewable resource?

d. Work out a plan on how you will carry out this idea.

2.4 Let students collect clippings from newspapers and magazines or articles or news items about plans for a large building project, such as a nuclear plant, a smelter plant, a geothermal plant or a dam. Let them find out the importance of each project. This is to be reported in class.

Follow up each report with a discussion on how the project will make life easier for the people and how the project will eventually affect the ecosystem.

2.5 Discuss the advantages and disadvantages of producing electricity from solar, nuclear, geothermal energy and the energy of flowing water. Ask students to choose which they would recommend for future installation in their community if funds were available. Discuss why.

3.1 Panel discussion can be done on the conflicting interests in setting up priorities for distribution of fossil fuel as gasoline. The problem to be resolved is: Which should be given priority if gasoline is to be rationed? Which use should be given a bigger percentage of the gasoline supply? The choices are cars, public transport system, industries, domestic users. The pros and cons of their choices have to be presented. The views presented by some members of the class may be analyzed by the others acting as members of different committees or as private citizens.

D. ON ENERGY IN THE BIOSPHERE

Having learned the different sources of energy of the living components in the ecosystems, focus on how energy stored in food during photosynthesis is utilized in doing various activities and how it is converted to some other forms by organisms in one trophic level to another. The following activities attempt to develop skills in model building using food chains as content, and in determining the decrease of usable energy within the food chain.

Objectives:

1. To describe the conversion of solar energy in the biosphere into other forms of energy.

2. To develop and explain a model of different food chains.

Suggested Activities/Experiments

1.1 Construct a diagram showing how solar energy is utilized by green plants in the process of photosynthesis. Discuss how the products get into the body systems of organisms.

2.1 Simulation Activity - Food Chain Game.

Have students play the card game called "food chain" which was prepared by UPSEC. In this game, the players are given seven cards on which pictures of plants and animals are drawn. Using these cards the players are supposed to lay down the cards one at a time to form a chain representing an eating and being eaten relationship. The card of producer is laid down first. Another card representing an organism that eats it is placed next to it. Several food chains may be formed. The player who lays down all the cards or has the least number of cards in his hands is the winner. (see Figure 31).

2.2. Have students research on food chains. Let them draw arrows and cut out pictures of plants and animals that comprise a food chain. Have small pieces of magnets attached to the arrows and pictures. Let the students present and explain their food chain to class using a magnetic board. Make them realize that food chains seldom go beyond four or five steps or trophic levels since less energy is passed on to the organisms in the next trophic level and that the longer the food chain the less energy is available.

E. ON MATERIALS FLOW IN THE BIOGEOCHEMICAL CYCLES

This section primarily deals with the natural cycles, the gaseous, sedimentary and hydrologic, which ensures the continuous supply of some elements essential for life. The suggested activities are intended to emphasize how humans have disrupted the cycle and affected the availability of these elements. Some activities attempt to instill in the students' minds the need to ensure the continuous cycle of essential elements in the ecosystem.

Objectives:

1. To trace the cycle of essential elements from their reservoir through the food chains and food webs and back.

2. To explain how man's activities have disrupted the different biogeochemical cycles.

3. To identify the various sources of water in the community and explore the possible alternative sources of water to increase the available water of the community.

4. To conduct researches and prepare reports on common problems that beset their communities.

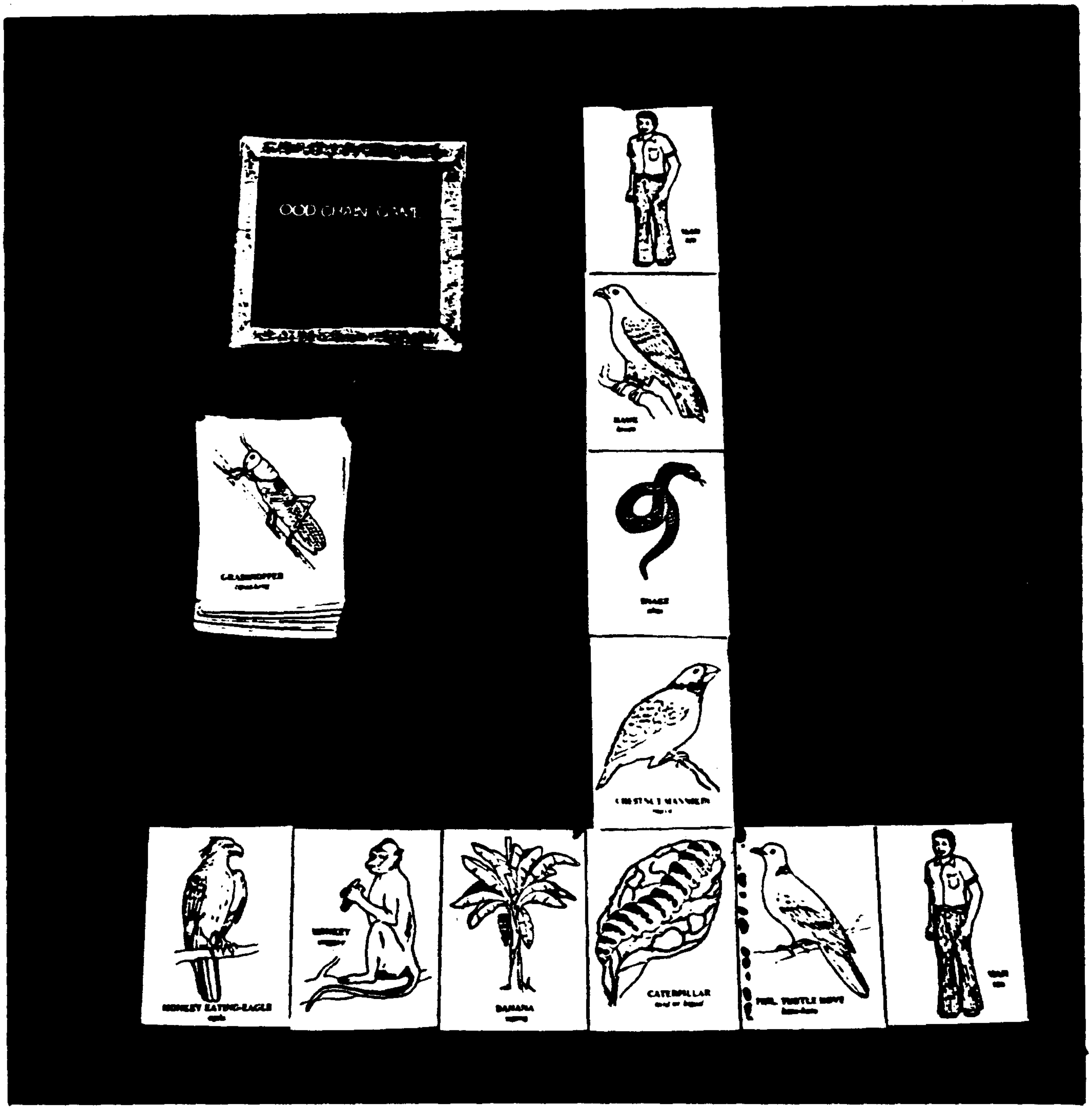

Figure 31. Food Chain Game

Suggested Activities/Experiments:

1.1 Using diagrams or three-dimensional models of the different biogeochemical cycles, let students orally trace the cycles.

1.2 Let students prepare a chart or a three-dimensional model of the hydrologic cycle which shows how underground water reaches the surface and how man is able to utilize ground water.

1.3. Using the chart or model discuss how pesticides used in agriculture get into the bodies of living things including human beings. Let them state their position regarding this issue - If many of the pesticides used are harmful, should farmers still make use of them or not? Make them conduct a research on how pesticides should be used to bring about the least harm to the environment.

1.4 Recycling solid waste. Let students conduct an ocular inspection of the community to see if there is any problem on solid waste disposal. Allow them to find out where this waste comes from, where it goes and how it is disposed of. They should also find out if there are projects aimed to improve solid waste disposal in the community. Discuss whether these suggested projects will or will not cause other pollution problems in the area. Follow-up activities for this are:

a. finding out laws about trash and garbage disposal in the community and how well they are enforced;

b. a field trip to a waste disposal site that serves the community;

c. project for using recycled solid wastes.

2.1 Let students research on how some human activities affect the biogeochemical cycles. For example: the effect of exessive logging of forests on the water cycle, the effect of combustion of fossil fuels on carbon and oxygen cycles, the effect of increased fertilizer production and use on the nitrogen cycle. Let students think of activities they themselves have been doing such as throwing wastes into the river which somehow also disrupt the cycle.

3.1 Let the students do some of the following activities:

a. Survey the different sources of water in the community.

b. Find out new sources of water being tapped. Make a list of all the ways in which you and other members of your family use water.

c. Classify the uses of water in the community into luxury or necessary uses.

d. Name ways by which water can be conserved. (Survey which of these ways people in the community know and practice).

e. Observe and describe the other physical characteristics of the water such as color, odor and turbidity.

f. Observe and collect some samples of organisms present in water reservoirs.

g. Take note of the weather conditions in the area.

h. Test the acidity or alkalinity of water using litmus paper or bromthymol blue or any acid indicator.

i. Take water samples and place them in jars. Bring these jars to the laboratory for study.

1. Allow the water in each jar to settle for 24 hours.

Compare the amount of solids at the bottom in terms of the number of centimeters of sediments or let the water settle in a graduated cylinder or any calibrated glass jars.

2. Examine a drop of the water samples under a microscope. Draw and identify the organisms you see. Try to count the number of organisms in the drop.

j. Study the quality of water in two sites. Prepare a report based on the data gathered, comparing the quality of water at the two sites. Find out which has more microorganisms. Describe how the quality of water affects the living things in the water.

In this activity it will be wise to make the students develop the skills needed in gathering data and preparing reports by making them observe and study water in an aquarium or a small creek prior to field trips for data gathering.

3.2. Take the class out to study a river. Identify two stations for the students to study, a station upstream and another downstream. Choose places where the students will detect differences in the quality of water. At these stations, let the students do the following tasks:

a. Collect samples of water from each station in separate jars. Label and cover the jars and place them aside.

b. Measure the water temperature at the surface and at 50 cm below the surface of the stream.

3.3 Assign students in groups of five to research on selected topics. Each group is to represent a committee which is assigned a topic or a problem of relevance to the community to study and research on or to find possible solutions.

Some of these committees could be -

Committee to report on floods that occur, their frequency, destruction and possible causes. The report should not only include observation but also what local/national officials have done or are doing to control floods and how effective these projects are.

Committee on land use to study the way lands in the community are used. It should report the changes on the use of certain parts, for example, farmlands converted to subdivisions. This committee should study possible effects, both positive or negative, of the change.

Committee on food production to find out and suggest ways by which the community will be able to increase food production and preservation to reach self-sufficiency in certain items such as vegetables and meat products.

F. ON POPULATION DYNAMICS

The following activities attempt to make students realize that the unlimited population growth on earth cannot be supported by the finite resources of the environment. Emphasis is on the liimits to the number of people the earth can support and the rapid population growth as one of the causes of the numerous environmental problems the world is facing today.

Objectives:

1. To compare population growth in a developing and a developed country.

2. To become aware of the different environmental consequences of rapid population growth.

3. To describe the different ways of controlling population growth.

Suggested Activities/Experiments

1.1 Make students graph the population growth of a city in a developed and a developing country. Using the graph let them determine whether the growth is linear or exponential.

1.2 Let students construct age pyramids to illustrate age structure based on data derived from the census and statistics office. Data can be analyzed to determine the ratio of the young dependent group compared to the productive segment of the population, that is, the labour force. The analysis should include the effects of the two population groups on economic and social conditions.

1.3 Let students perform an experiment to test the rate of population growth. They can start with a certain number of living things (micro-organisms) placed under a favourable environment and then counting the population at given intervals of time.

1.4 Ask students to gather information about their town or their municipality from the census and statistics office on the following:

Average number of children per family

Total population

Age structure - (Number of persons under these age groups:

under 18, 18-64, over 64)

Let students compute the dependency ratio (dependents are those under 18 or over 65) and have them describe the age structure.

1.5 Conduct debates on such topics as

a. The key factor in the numerous environmental problems we are facing today is due to rapid population growth.

b. Abortion should be/not be legally allowed.

2.1 Discuss the environmental problems brought about by rapid growth of cities. Point out the positive and the negative effects on the various components of the environment. Bring out the following:

a. Could the people's lifestyle cause harm to their environment?

b. Can your own style of living harm the environment?

c. How can your style of living be changed to help maintain a healthful environment?

2.2 Case Study

Present this problem to the class.

The rapid growth in population has brought about increasing demands on the environment. Demands for food, water and energy are far greater now than several years ago. Energy is needed to increase production to provide employment and this demand has caused industry to look for alternative sources of energy. The more popular alternative source used in many developed countries and recently in a few developing countries is the nuclear power plant. Would you like one to be constructed in your country?

Group discussion analysing the case should focus on the following:

What are the advantages of putting up a nuclear power plant?

What are its dangers?

What problems will the construction and operation of a nuclear plant create?

Is a nuclear power plant necessary as an alternative source of power? Give your reasons.

Are there other possible alternative sources of energy? Which of these alternatives can be utilized in your country?

Would you rather that these alternative sources be developed and used than the nuclear plant? Why or Why not?

2.3 Traffic along the intersection of West Avenue and North Avenue has always been heavy. One sees the long line of cars and buses at peak hours. Findings show that gasoline consumed for transportation is about 35.7% of total consumption of the community. With the increase in the price of oil, measures have to be taken to improve traffic conditions. A smooth flow of traffic is one way of conserving energy.

a. Prepare a design or a model of a traffic system that will ensure smooth flow of traffic especially during the peak hours in this intersection.

b. Explain, using the design, how clogging of traffic can be smoothed out.

2.4 On the problem of garbage disposal resulting from rapid population growth, let students play the role of a garbage collector, a municipal engineer, a building contractor, and a businessman. Each one has a proposal and brings out its advantages to convince the members of the municpal council to accept the idea and approve its funding. Ask the rest of the class to act as the members of the municipal council.

Present this problem to the class.

Assume that the community in which you live is located on the seacoast. As the population increases, your town is faced with the problem of garbage and waste disposal. The district engineer and the people in the community disagree on how to dispose of the garbage so people are requested to present their proposals to the members of the municipal council. The proposals are as follows:

1. Garbage collector - hauling the garbage out to the sea and dumping it.

2. Municipal engineer - using trash and garbage to fill part of the bay to provide additional building sites.

3. Building contractor - using trash and garbage to fill lowlands around the town and make them suitable for building sites.

4. Businessman - compressing the trash and garbage into blocks then covering them with concrete and using them as building materials.

To the members of the municpal council:

What position would you take on each of these views and why? What alternative/s would you suggest?

3.1 Discuss the different ways of controlling population growth, namely: conception control, birth or fertility control and population control. Bring out the various considerations in the choice of growth control method. Other considerations are: scientific readiness, political feasibility of the method, ethical feasibility, the short and long range consequences, and the effectiveness of the method.

3.2 Present this case to the class

Suggestions are now being made to control the population of large towns by building new and smaller towns in less populated regions of the country. Certain large industries would be invited to build factories in each new area to provide jobs for the new residents. Supporting businesses, such as groceries, utility companies, clothing goods and many others, would supply the needs of each new town. These new towns would expand to a limited size according to a plan based on predicted population increase. Pollution control could be begun as soon as the first citizens arrive.

Suppose you are one of the planners for such a town. You are to help decide where it is to be located and what large industries to include. Where to set up the systems for water supply, sewage control, power supply, and transportation are all under the control of your planning group. Location of industries, businesses, schools must also be decided by you and the other planners.

Consult with your classmates in setting up your planned community. Assume that your town will start with 500 families and permit an increase in total size of 100 new families during the next 20 years. Here are just a few of the problems you will face.

a. From where will the town receive its food and water? Will the amounts to be made available sufficient for the community and its projected increase?

b. What responsibility will your town have to the nearest neighboring towns?

c. What recreational facilities will be provided?

d. What will be the source of power for the town?

This task will take much time and effort. You will see that being a town planner is a tough job and will require answering a hundred other questions. Your task won't be complete until you and your group have prepared a written plan. Be sure to include sketches of the proposed layout for the new town.

G. ON HUMAN INTERVENTIONS IN ECOLOGICAL PROCESSES

The functions and activities of human beings have greatly affected the quality of the environment. There is a need, therefore, to make everyone aware of the behaviour patters and attitudes that bring about negative effects to the ecosystem. These negative effects should be avoided. Those activities which result in the improvement of the environment should be understood and reinforced.

Objectives:

1. To increase student awareness of the possible causes of degradation of the environment.

2. To show how an increase in the amount of detergents in water affects the living things in it.

3. To conduct a solid waste disposal survey in the community.

4. To analyze given problems and be able to suggest alternatives or possible solutions.

Suggested Activities/Experiments

1.1 Have students collect newspaper clippings or magazine articles about projects being undertaken or decisions being made for political reasons which may have an adverse effect on the environment.

1.2 Cite examples of situations where owners of large factories have manifested the higher value they have placed on economic goals than environmental quality. Discuss what actions could be taken by the people who are affected or by the government against these violators.

1.3 Present news reports or clippings taken from newspapers or magazines or even photographs of current situations indicating signs of impending crises. Ask students to examine each photograph, draw inferences from the details and answer questions such as:

a. Can you identify the signs of a coming or a current environmental crisis shown in the photograph?

b. Is there anything which seems to show or indicate that something is growing too fast? Which factor/s seem to be growing exponentially?

c. Can you tell how this change will affect the quality of the environment? the quality of living things in the environment?

1.4 Present photographs of parts of the students' communities such as barren field, plaza filled with people, congested area with factories emitting smoke, a highway with an unbroken line of cars, and malnourished children. Then ask the question - which of these environmental stresses are parts of your environment? Based on your students' answers determine their level of awareness of the environment.

1.5 Discuss why the following activities may help increase world food supplies but may not solve the problem of food shortage or may create other environmental problems.

a. cultivation of more lands

b. sea farming

c. making synthetic food and animal protein substitutes

d. irrigation of dry lands.

1.6 This problem on food shortage can be presented to the class for them to analyze and discuss. Based on the discussion, the students should be able to come up with possible recommendations and solutions to the case under study.

The food supply in many developing countries is still scarce in spite of the reported yearly increase in food production. Two reasons for this food shortage are: (1) insufficiency of food being produced and (2) spoilage of food during storage and distribution. How can these problems be solved? Let students report on the various methods used to increase food production and decrease loss by spoilage.

1.7 Let students collect as many photographs or newspaper pictures as they can showing changes in the environment due to human activities. Using the photographs let the students identify the human behaviour that caused this and classify them by putting a plus (+) sign to the activities that help maintain a healthful environment and a negative sign (-) to those that are damaging to the environment, after each activity. Let students collate and analyze the data, and prepare a report on their findings. A survey with the same objective as the photograph collection can be administered on a larger scale by using statements that describe the activity instead of photographs and making the respondent put a check (✓) in the appropriate column.

	Effect		
	(+)	(-)	(Not sure)
Ex. throwing waste into the river		✓	

Perhaps the survey can include the same statement but this time the respondents are asked to check (✓) those they practice.

	Yes	No	Don't know
Ex. throwing waste into the river	✓		
burning trash in the backyard		✓	

2.1 Let students perform the following experiment to find out the effect of detergents on living things in a pond.

Half-fill six jars with pond water. Add daphnia or any small fish as guppies, elodea or hydrilla plant and some algae in each jar. Number the jars 1 to 6. (If the small fish begin to show ill effects from the experimentation, they should be removed and placed in an aquarium or other tank of water).

Dissolve a teaspoon of detergent in about 150 ml of water. Add 5 drops of the solution in Jar 1, 15 drops in Jar 2, 25 drops in Jar 3, 40 drops in Jar 4, 90 drops in Jar 5. Jar 6 which contains pond water only serves as the control.

Place the six jars in sunlight. Observe and record your observations everyday for two weeks.

The discussion that follows the experiment should bring out (1) the effect of increasing amount of detergent on living things in the pond, (2) the probable effect of the growth of algae (algal bloom) on the system in terms of biological oxygen demand and how this leads to the polluted state of the water. Prior to discussion on water pollution bring out the meaning of pollutants and their detrimental effects on the color, turbidity, hardness and temperature of the water and the effects of these changes on the conditions in it. Some examples of these effects are the differences in the amount of sunlight that water can transmit at various depths and the ability to absorb gases from the air. A field trip to an actual site where this taking place may be undertaken. Possible sources of phosphates, nitrates and other pollutants may be identified.

3.1 Ocular inspection of the community to see if there is a problem of solid waste disposal. Let students find out what happens to the solid waste from homes - where it goes, how it is disposed of, whether there are projects aimed to improve solid waste disposal. Let students speculate on whether their community will have a problem of waste disposal in the future or not and let them explain why.

4.1 Present those situations and let students express their views based on the role they play.

4.1.1 A province with a small population is almost completely without industry and depends only on agriculture for its income. The amount of tax money available to the province is not enough to provide quality education for its children. To increase the provincial tax income, the governor has invited industry to build plants there.

A mining company discovered huge deposits of coal in a provincial recreation area near a lake in the province. A well-known electrical company, therefore, feels that the provincial recreation area is also an ideal place for a new power plant. The coal removed by stripmining can be used as fuel. Water from the lake can be heated and the steam produced can be used to turn turbines. Used water can be returned to the lake. The electricity will be sold to the province at a lower price. The tax money of the province would increase by 25%.The power plant will provide electric power to surrounding provinces.

Make the students pretend that they are members of the provincial board. Ask them - How would you vote on the question of allowing these industries to operate in the province or not? Explain your answer.

Discussions should point out the following:

a. What are the probable effects of these industries on the air, water and land in the nearby areas?

c. What requirements should be placed on such industries?

4.1.2 A strange fungus has suddenly attacked large areas in a certain farming region. The farmers want to use large-scale spraying of insecticides in order to kill the fungus, save their crops, and prevent further spread of the disease. Other people are protesting the use of the insecticides. They think the infected crops should be burned in order to kill the fungus. Of course, the farmer's crop would then be a total loss.

What are the advantages and disadvantages of either choice? What would you suggest as a solution?

After reading and, hopefully, trying out some of these activities and experiments, the teacher/supervisor trainee is enjoined to write an original activity/experiment setting it in his own locale. He may present the activity/experiment to his fellow trainees for their critique and suggestions for improvement.

VIII. EVALUATION IN ENVIRONMENTAL EDUCATION

A. RATIONALE FOR EVALUATION

Evaluation is a necessary concomitant of any educational activity intended to assess its worth or its success. Needless to say, evaluation entails some costs - in man-hours, supplies consumed, salaries of personnel, etc. If the majority of the personnel and participants involved in an educational activity are satisfied with it, is there need for formal evaluation? Despite the inevitable costs of evaluation, the answer generally is yes.

The rationale for evaluation lies in its uses: (1) to give an account of the inputs and outputs of the activity, (2) to improve the activity by identifying areas of strengths and weaknesses, (3) to motivate the personnel and participants involved in the activity by providing feedback on the progress of the activity, (4) to direct the activity toward the desired goals (5) to provide directions for decision-making.

1. Accounting of Inputs and Outputs

The report on expenditures of a project is not a sufficient accounting of the inputs and outputs of an educational activity. Without diminishing the importance of cost accounting, educational activities are more fully accounted for by including intangibles such as values and attitudes, knowledge acquired, cognitive skills developed. These intangible inputs and outputs of education are of great importance in policty formulations and should influence decisions regarding expansion/termination of a project, the funding of similar projects, the move to the next phase of the project, etc. These intangible inputs and outputs may include family values enhanced or denigrated by the activity, additional student- or teacher-hours spent in school which could otherwise have been spent doing chores for the family or some community service, the build-up of new knowledge or the breakdown of old ones, and the change in old practices. An evaluation that takes into consideration these intangibles which are difficult to put a price on would certainly serve the cause of environmental education.

In the final accounting, the essential criterion of the worth or success of environmental education activities is student learning. Evaluation must provide evidence that learning has taken place and that this learning is attributable to the educational activity. The evidence may consist of behaviours or products of some activity (e.g. a written plan to campaign for only healthful foods to be sold to the schoolchildren within the school grounds) as manifestation of learning.

2. Improving the Environmental Education Activity

An ongoing educational activity may be evaluated at several points in its course to provide insights on the direction it is going and to identify areas of weaknesses and strengths. Evaluation of this kind known as <u>formative evaluation</u> enables the project leaders and staff to institute corrections where and when needed in order to improve the project or activity. An evaluation conducted when the activity is ending or has ended is known as summative evaluation involves comparison of this activity with alternative activities and may help improve similar projects in other sites or conducted at some future time.

3. Motivating Personnel and Participants

From experience we know that any form of evaluation generally motivates participants to perform well along the lines of expectation set by the evaluation instrument. It is in the nature of the human being to desire not to be found wanting. The knowledge that evaluation is an essential part of an educational activity motivates both staff and participants, teachers and students, to work hard to attain the objectives. It is this function of evaluation that justifies national or regional examinations. Seen in this light, it can be said that the type of evaluation partly influences the quality of learning. If the evaluation instrument calls for memorization of facts, then students learn facts by memorizing them. If the evaluation instrument requires critical thinking and logical reasoning through a manipulation of facts, dates and events, then students strive to acquire them. If the evaluation instrument tests the sensitivity and reaction towards environmental events and problems, the students learn to be sensitive to the environment and to articulate their reactions. Therefore, the quality of evaluation affects the quality of learning.

How will the participants of project know what will be evaluated? If several data gathering sessions are scheduled within the course of a project as in formative evaluation, the first session will give participants clues on the focus of the evaluation. In the case of pre- and post-activity evaluations, the pre-activity data gathering session provides the clues. It is also possible that informal talks between coordinators and participants unwittingly leak out the general points of emphasis. In projects repeated in different sites, word on areas covered in the evaluation inevitably gets around. In some projects, the participants are directly informed of the emphasis of the project and its evaluation. It is, therefore, not at all unexpected that the quality of evaluation influences the quality of outcomes.

4. Directing the Activity Toward Desired Goals

Not all projects attain the desired objectives by way of the originally planned paths. Some unexpected event may intervene and disrupt the activities, or some unforeseen element may make its presence felt. For instance, a two-week flood disrupts class schedules so as to disorient coordinators and participants alike. The originally planned strategy loses its impact with the disruption. The evaluation should be able to identify the source of loss of interest of students. To go on with the plan is to lose relevance with the current event. Whereas to change content and strategy by using the event to teach the same environmental education concepts may mean stronger impact and more meaningful learning. The evaluation scheme should reveal when a change in plan is needed. On the other hand, an evaluation scheme should also be able to tell when the change instituted is getting out of hand and not leading to the desired objectives. In another example, an unforeseen element, such as the build-up of competitiveness in opposing groups during discussion of alternative strategies, is developing other undesirable attitudes and beliefs. This should be detected by a perceptive evaluator from his study of collected data. Thus evaluation should be able to help redirect an educational activity toward stated objectives.

5. Providing for Decision Making

In the past, well-informed and highly intuitive educators with years of experience in the profession had ably rendered off-the-cuff decisions without formal evaluation bases. Our fast-changing world, however, has increased the variables of education and the complexity of their relationships. Intuitive decision-making without research and evaluation has become more risky because of these complexities.

A growing number of education policy-and decision-makers now prefer to base their fomulations and pronouncements on the findings of well-planned evaluations. Immediacy may not be one of the advantages of evaluation-based decisions, but a higher probability of making the right decision is.

Environmental education is one broad educational activity that encompasses all levels of education (i.e., elementary, secondary and tertiary), all domains of education (i.e., policy-making, curriculum development, teaching-learning, research) and all subject areas (e.g., science, humanities, communication arts). Any activity at any level, domain and subject area can and should be evaluated. The concern of this module is limited to the evaluation of teaching-learning of environmental education at the secondary level.

B. THE OBJECT OF EVALUATION

A large part of the success of evaluation lies in the identification and specification of what to evaluate, that is, what the object of evaluation is. What, in the teaching-learning domain of environmental education, can be evaluated?

Evaluation of teaching-learning generally focuses on: (1) teacher performance, (2) learning environment, (3) student learning. The assumption is that teacher performance and learning environment are at their best when they maximize student learning.

1. Considering the Evaluation of Teacher Performance

What aspects of teacher performance may be specified for evaluation? - organization of subject matter in the day-to-day lessons; knowledge of subject matter; use of strategies appropriate to subject matter and level of students; choice of teaching materials and aids appropriate to topic and nature of students; points of emphasis and how they are related to students' everyday life; Interpersonal relationship with students, fellow teachers and administrators; ability to shift levels and pace to accommodate interests and talents of students. The evaluation can be planned to assess any one or more of these teacher skills and performances. To accomplish this the evaluator must be familiar with teacher tasks. Then criteria of effective teacher performance must be set up before an evaluation instrument can be constructed.

2. Considering the Evaluation of the Learning Environment

What characteristics of the learning environment in the classroom are indicative of effective instruction in environmental education? - focus on local environmental conditions and problems; open exchange of ideas and opinions on various ways of studying the environment and solving problems about it; student-initiated tasks and activities; respect for each other in discussions, in group projects and other school activities; more student talk than teacher talk; more flexibility in class protocol. An evaluator may also want to find out how the class management scheme adopted by the teacher leads to a positive/negative learning environment. These indicators of effective learning environment are in consonance with the guiding principles of environmental education.

3. Considering the Evaluation of Student Learning

If student learning is to be evaluated, what can be its indicators? - awareness of the environment; sensitivity to changes particularly those caused by human intervention; knowledge and comprehension of environmental processes; values and attitudes of social justice and human consideration in all activities; consideration of alternative strategies in dealing with environmental problems; participation in community action on environmental issues; manifestation of conservation behaviours. It may be desirable to evaluate retention and transfer of student learning after some period of time such as a year or two years have passed.

The above lists of indicators of teacher performance, learning environment and student learning are far from complete. The decision on what should be evaluated may be preceded by observation and informal talks with teachers and students to give the evaluator an idea of the object or objects of evaluation that would accomplish the objectives of the evaluation. The objectives of the environmental education project are a good take-off point toward the identification and specification of what should be evaluated.

C. <u>THE PROCESS OF EVALUATION</u>

Like any deliberate human activity, the process of evaluation consists of decision-propelled steps. The evaluation process actually begins with the decision to conduct an evaluation. Then a decision on what to evaluate is made. Next comes the decision on strategy of information gathering. The evaluator decides on whom to get information from (the source of information), what instrument to use in getting the desired information, and when to schedule information gathering.

1. Source of Information

From whom shall the information about the object of evaluation be obtained? The teacher answering test questions to provide a measure of the extent of his knowledge is a direct source of information. The student who checks off topics that interest him in an interest inventory is also a direct source of information. The parent who writes down questions likely to be asked by his seven year old son is an indirect source of information. The teacher who indicates on a questionnaire whether his students will find certain topics very easy, easy, difficult or very difficult is an indirect source of information. Where the object of evaluation is a situation or event, the persons who actually experience it are the direct sources of information. Observers or raters who describe or rate the reactions of people who experience it are indirect sources of information.

A direct source of information is one from whom the information originates. An indirect source of information is one who transmits or interprets information. In many cases, a direct source is preferred over an indirect source for the reason that no one is better able to demonstrate knowledge, beliefs, values, attitudes, interests and reactions than the person himself. However, in cases where the direct source is likely to fake his choices, as in interest and awareness inventories in order to present a more socially-acceptable image, or when a direct source will be put to a disadvantage by responding to the instrument, the directly obtained information may distort evaluation. This is not to say that information so obtained is useless but that the information should be cross-checked. Sometimes, of course, the direct source of information may not be available. An alternative is to use an indirect source of information.

2. Instrument Construction

Some kind of instrument is needed to collect data about the object of evaluation. The instrument may be a written test, rating scale , checklist, interview schedule, anecdotal record or self-report. Today various types of instruments for educational evaluation can be constructed or even be purchased at some cost from publishing houses. Environmental education being a relatively new field, only a few standardized instruments (those tested and have known norms for a given population) can readily fit into its evaluation design. Evaluators are finding out that they need to construct and develop their own instruments to fit the needs of the particular environmental education activity to be evaluated.

Instruments for evaluation may be differentiated according to types of response required as follows: (1) written response, (2) oral response, (3) performance. The written reponse type is the most commonly used because of the ease and convenience of obtaining and analyzing information. The oral response type is used when, for some reason or another, the respondents are unable to write their responses as in the case of the manually handicapped or the pre-school children, or when it is essential that all questions are answered by the respondents, or when facial expressions and mannerisms during the time of response need to be recorded. Performance is the best type of response for evaluating physical skills.

a. Written-response instruments

Tests, questionnaires, checklists and rating scales are evaluation instruments that require written responses. Of these, the test is the most widely used by teachers. Most tests seek to measure knowledge of certain disciplines (e.g. science process test) or aptitude for learning (e.g. intelligence test, reading readiness test, mathematical ability test). Questionnaires, checklists, and rating scales are instruments for obtaining information about existing conditions or events, reactions to conditions or events, or estimates by individuals of their own capabilities and skills.

The two main types of written tests are the free expression type and the forced-choice type.

(1) The free expression type of test enables the respondent to freely express reactions and opinions or state conditions without being compelled to choose from a set of options. Examples are the essay test, paragraph completion test, and the open-ended questions. Sample test items are shown below:

Essay test item

Discuss in about 300 words your assessment of the Scientific Farming Techniques Project and its effects on the participants and the locality in general.

Paragraph completion item

Make a paragraph by completing the beginning sentence and following up with 4 or 5 sentences more.

Seeding a freshwater lake with fingerlings of a non-indigenous species may result in ______________________

____

____

____

____

Open-ended question

Answer the following question briefly in 2 or 3 sentences. What could be the reasons for the change in crops grown by most farmers in town E from tobacco to cotton?

As may be seen from the sample questions, the essay type of questions allows the respondent more freedom in his responses. The respondent can focus on the points that interest him most although he has given evidence of knowledge of other points.

He can express varying intensities of reactions to a situation, object, or event. The inherent weakness of the essay type is the subjectivity of rating responses. Rarely will any two or more raters grade the same response equally. It requires a rater who is conversant with the nuances of the given problem. In short, the grade or rating is not reliable.

(2) The forced-choice type of test, in contrast, is highly objective. With a correct answer key, any rater, even an untrained one, can check and grade the test. Examples of the forced-choice objective tests are the multiple choice, the matching type, the true-false test and the completion type. Of these, the multiple choice type is the most versatile. The choices could be given in single words, phrases, sentences or in pictures. It can test knowledge of subject matter, methodologies of a discipline, or the cognitive style adopted during learning. The probability of the respondent guessing the correct answer is low, as opposed to the true-false test. It calls for less recall and more analysis of the question to answer it correctly. Below are sample questions of the multiple choice type to show its versatility.

Test of knowledge of subject matter

Question: the main objection to eutrophication is the

a. population increase of one species overcoming other species.

b. phosphorous consumption by blooming plants depriving water animals of this element.

c. oxygen depletion in the water due to excessive decomposition of plants.

d. release of large amounts of slimy materials from plants suffocating bottom-living organisms.

Test of understanding of research procedures

A farmer wants to find out which of pesticides X and Y works better with vegetables. Two seedling boxes are sprinkled with cabbage seeds and two with lettuce seeds. All boxes are of the same size. All are given the same amount of water every day. As the seedlings grow, cabbage box A and lettuce box A are sprayed with pesticide X, and cabbage box B and lettuce box B are sprayed with pesticide Y. A visiting scientist told the farmer that his conclusions are not reliable. Why?

Answer by choosing from numbers 1 to 4 the correct combination of reasons given in a to d.

The reasons:

a. The amounts of seeds sprinkled in the boxes are not the same.

b. There should be a third cabbage box and a third lettuce box not treated with pesticides.

c. The amounts of pesticide used are not the same.

d. Observations of the effect of the pesticides on the human body have been neglected.

The combinations to choose from:

1. a, b, c
2. a, c
3. b, d
4. b, c, d

Test of cognitive style

Having read about water pollution, select from number 1 to 4 the combination of 3 steps you would take to learn more about it. The steps (not sequenced) are given in a to g.

The steps:

a. Observe a river described by some people as polluted and look for signs of pollution.

b. Read on chemical investigations conducted to set standards of pollution.

c. Consult a water pollution specialist to give you the most important information about it.

d. Track down possible cause of pollution by interviewing people and observing activities in and around the river.

e. Design a laboratory investigation to examine water samples from the river.

f. Bring back water samples and conduct a laboratory study. The combinations to choose from:

1. a, d, f
2. b, c, e
3. b, a, c
4. a, e, f

Questionnaire. A questionnaire is a list of questions arranged systematically to be answered accordingly. The sequencing may imply a relationship between some questions which otherwise may not be brought out. The questions may seek factual information, reactions and/or opinions of the explanations for certain actions taken or the occurrence of events.

> Sample questions for a questionnaire:
>
> 1. Who are the most frequent users of the references in the library on the environment?
> 2. Which of the reasons given by oil industries in requesting for permit to increase oil prices are justifiable? Which are not?
> 3. What possible dangers could the construction of a nuclear reactor for generating electricity bring to the inhabitants of the area?

Inventory or checklist. An inventory or a checklist is a list of topics, behaviours, situations, descriptions of feelings, activities,etc. The respondent is asked to check off the items that he likes or dislikes, or recommends or rejects, or possesses or not.

> Sample items for a checklist.
>
> Check the activities that you would like to engage in
>
> | | |
> |---|---|
> | _____1. dancing | _____4. tennis |
> | _____2. hobby craft | _____5. soccer |
> | _____3. watching TV | _____6. sightseeing in the country |

Rating scale. A rating scale consists of statements to which the respondent is asked to agree/disagree, express like/dislike, or indicate interest/no interest on a scale, usually a 5-point scale. The scale enables the individuals to express degrees of feeling between opposite poles. See the sample items on the next page.

Sample rating scale items:

Indicate how you feel about the statement of phrase by putting a circle around the number that expresses it.

New industries that will pollute the environment should not be allowed to open.

1	2	3	4	5
strongly agree	agree	neutral	disagree	strongly disagree

Field study as a school activity

1	2	3	4	5
like very much	like sometimes	undecided	dislike sometimes	dislike very much

The scientific explanations of how modern man's activities can destroy the ozone layer as a topic for inclusion in your science class.

1	2	3	4	5
very interesting	interesting	undecided	not interesting	not very interesting

The checklist and the rating scale are easier to construct than either the questionnaire or the multiple choice test. They have the added advantage of ease of cheking. The information obtained from these instruments, however, is not too reliable. It is easy to fake responses to conform to evaluator's expectations.

Anecdotal record. An anecdotal record consists of brief factual notes on the behaviour of an individual, or incidences involving the individual. The observation of the behaviour of incidence is done unobtrusively, that is, the individual observed is not aware that he being evaluated. The behaviour or incidence occurs in a natural setting. The anecdotal record is used to reveal aspects of the individual's personality, values, capability, and skills which otherwise would not be taken into account in evaluation. It is usually intended to supplement the main data collected, and not considered the main data itself.

Self-report. A self-report is a record made by the individual of his own activities, or thinking or new ideas as they occur or come to him. The self-report is limited to the area of interest to the evaluator. It does not include all activities or all ideas of the individual. For instance, an evaluator instructs a student to record the times, the occasion, and other pertinent data of participation in group action on an environmental issue. The self-report is similar to the anecdotal record but the entries are made by the individual himself.

b. Oral response test

Oral responses are made to oral quizzes, graded recitations and interviews. All these methods of evaluation are commonly used in teaching, although the teacher is more likely to use the informal interview. In an informal interview the teacher may sound as if he is making small talk with a student, for example, asking about his activities in summer, seeking his opinion on the new school regulation, or asking if he has read about the closure of a multinational company and what his opinions are about it. Actually the teacher is conducting an informal interview in a manner that does not frighten or offend the student, or causes him to put up his guard. All three methods of obtaining information - oral quiz, graded recitation, and interview - require advance preparation of questions. Oral responses are preferred when the evaluation puts weight on spontaneity and takes into account facial and behavioural reactions to the questions.

The interview itself is a procedure; the prepared questions for use in the interview is the instrument. The interview instrument is called interview schedule. In its construction, a decision must be made as whether the interview should strictly follow the interview schedule or probe into some questions. The points at which probing is likely to be needed may be identified before the interview, although sometimes it may not. The final decision of whether to probe or not is actually made by the interviewer.

c. Performance evaluation

Mastery of motor skills and knowledge of procedure are best evaluated by rating actual performances. Although verbal expression of subject matter knowledge may be considered performance, as used here it denotes some motor activity. Performance evaluation of affect (i.e: values, attitudes, feelings) is not impossible, however, it is difficult to stage or schedule. One simply waits for it to happen. Formal evaluations whether written, oral, or performance have timetables to adhere to. For this reason performance evaluations are more frequently used on motor activities rather than on affect.

Like the interview, performance is not an instrument. Performance is the object of evaluation. The criteria for performance and the rating scale used with it make up the instrument. If the performance is long or complicated it is usually divided into steps or stages or phases each of which has its own criterion or criteria and rating scales. Without the instrument, performance evaluation becomes highly subjective. If so, then evaluation is unreliable.

d. Validity and reliability of instruments

All instruments for evaluation must yield information that is both valid and reliable. The quality of information that an instrument collects depends on the kind of items of questions in it. No instrument can contain all the pertinent questions that can be asked about the object of evaluation. The extent to which the questions in the instrument samples these pertinent questions expresses the degree of validity of the instrument. It is possible that some questions in the instrument are not even pertinent. A panel of specialists on the particular object of evaluation can examine each item in the instrument and decide which items are pertinent and which are not, and if the number of pertinent items are sufficient to measure that which is being evaluated. This examination of items by specialists is known as content validation. When the instrument is found to have sufficient number of pertinent questions then it is valid and its expected results are consequently also valid.

The instrument collects information that is reliable when at least two successive administrations of it to the same group of individuals consistently yields about the same results. However, due to other errors not inherent in the instrument but instead found in the respondents or the environment, no instrument can be perfectly consistent. Some variations in responses may be attributed to fatigue, ill health, distractions in the environment, uncomfortable surroundings, etc. In general, the more consistent the responses, the higher the reliability.

If information is valid, then it is reliable. Information with high reliability is not necessarily valid. Repeated use of the instrument on the same individuals may yield consistent results. The instrument has high reliability. However reliable the instrument, if the questions do not test or assess the intended object of evaluation, then it is not valid.

e. Data gathering

The instrument constructors should review and criticize the items for content and language errors. Then a try-out or pilot study of the instrument should be conducted before its final administration. The try-out is intended to: (1) identify defective items, that is, items that are too difficult, too easy, ambiguous, or complicated in phrasing, and (2) determine appropriate time limits for the administration of the instrument.

The schedule for data gathering depends on some deicisions which should be made long before instrument construction. If the evaluation to be conducted is formative, data gathering should be scheduled at several points during the course of the activity. If the evaluation is summative, the instrument should be administered only once near the end or after the project.

The data can be collected from groups or from individuals on a one-to-one basis. The decision whether to collect data by group or individual should be made before instrument construction. For purposes of accounting, policy formulation, and diagnosis of project defects, collection by groups leading to group analysis and interpretation is not only justifiable but wise. However, for motivation and for diagnosis of individual difficulties, individually collected data allow for greater insight.

The raw information obtained from the use of evaluation instruments has little meaning. Analysis and interpretation with or without mathematical treatment can reveal trends, directions, associations, and other relationships. Comparing, categorizing, inferring, determining frequencies and percentages are useful in analysis. For a more sophisticated evaluation there are various statistical techniques such as the t-test, chi-square, analysis of variance, to name a few. For more information on analytical techniques you may refer to books on measurement and evaluation and on statistics.

IX. STRATEGIES FOR THE IMPLEMENTATION OF THE ENVIRONMENTAL DIMENSION OF SECONDARY SCHOOL SCIENCE

A. CONCEPTUAL FRAMEWORK FOR AN ENVIRONMENTAL EDUCATION PROGRAMME

The teaching of the environmental dimension of secondary school science is built around the following main ideas:

- The science programme serves as the medium for teaching about the environment.
- Learning science content and processes should be motivated by a desire to know more about environmental components and processes and by a concern about environmental problems and issues.
- Learning science content and processes should go beyond explanations and understandings and aim for affective development (e.g. greater awareness and appreciation of one's environment, sensitivity to changes in the evnrionment, concern for the damaged environment and the organisms it harbors, deeper sense of responsibility for the conservation and protection of the environment, and willingness to participate in actions to solve problems in the local environment).
- Science lessons should build on and draw from local and current environmental conditions and issues for transfer of learning and reinforcement.
- Science lessons should venture into the moral and social implications of scientific activities, technological development and industrial thrusts; and develop students' social conscience.
- Open-ended questions and considerations of alternative strategies, which are techniques used in scientific investigations, should also be applied to the formulation of school project designs and other suggested planned changes in the environment. Consideration of trade-offs, a technique from economics, is also useful in such planned changes. Students should have experiences in using these techniques.

B. PRE-IMPLEMENTATION STRATEGIES

A great deal of groundwork needs to be done before the actual implementation of an environmental education project. The main pre-implementation strategies are as follows:

1. Needs Assessment

It is presumed than an innovation such as the teaching of the environmental dimension of science is intended to answer needs. Perhaps the need is felt but not properly identified and specified. A needs assessment can be conducted to determine what the needs are, how intense they are, how the needs may be met and what needs should be given priority.

The types of evaluation instruments discussed in Chapter VIII are also useful in needs assessment. The items should draw out information that will reveal community needs, student needs, teacher needs, local environmental problems, the state of awareness and concern of the community people regarding these environmental problems, the willingness and competence of teachers to teach environmental education, and the interest of students to learn about their environment.

The findings of the needs assessment serve as the baseline information in planning and designing an environmental education programme.

A study conducted by the UNESCO-UNEP in 1975 to determine world-wide priorities and needs for environmental education shows very high needs on the global scale. The most intense need is for training of personnel (81% of the countries), followed by the development of instructional materials (73%) and the development of educational programmes (68%).

Statements of global needs are rather broad. At the national or community level, the statements of needs should be narrowed down to the kinds of skills teachers need to acquire competence, the content and strategies in developing instructional materials, and the content and strategies they can use in classroom instruction.

2. Objectives

The objectives of the intended implementation of an environmental education programme must be well thought out and articulated by the coordinators, supervisors and teachers before implementation begins. The following objectives for teaching the environmental dimension of secondary school science are suggested:

a. To learn the basic concepts of matter and energy and the changes that matter and energy undergo in natural and man-devised processes.

b. To understand the basic functionings of the living body and how it adapts to its environment.

c. To learn to appreciate the diversity of life and the complexity of the environment through an understanding of the interactions and interdependence of living things and the environment.

d. To understand the physical, biological, intellectual and social capacities of the human individual, how they affect human population dynamics and how the human population changes the environment.

e. To acquire competence in using the processes of scientific inquiry (i.e. systematic observation, problem specification, identification of variables, setting up controls in experiments, inferring, finding relationships, critical thinking and reasoning) in discovering how nature works and in solving environmental problems.

f. To explain scientifically how human activities enhance or damage the environment.

g. To develop, through studies of the effects of human intervention in the natural processes, an ethics of relationship between man and his environment, among men, and among nations that is guided by a social conscience and responsibility for the conservation and enhancement of the environment.

3. Curriculum Development

No amount of oral exhortation to integrate environmental education with science is likely to be heeded by teachers without support materials. A supplementary curriculum guide specifying the points the science program at which environmental concepts and values may be introduced, developed and reinforced in instruction should be prepared in advance. The curriculum guide would be most helpful if it includes suggestions on teaching strategies, appropriate teaching aids to use, and possible student tasks. The availability of such a curriculum guide gives the environmental education programme a better chance of being implemented at the instructional level.

Workbooks and supplementary readers for students, handbooks and manuals for teachers, and teaching aids like charts, maps, and demonstration devices, when made ready in advance of teaching can make life less hectic for the teacher. The teacher is, thereby, allowed more time to plan out the day-to-day lesson.

From the philosophies and principles of both science and environmental education, some guidelines on the development of materials for teaching the environmental dimension of science can be drawn.

a. Build on the science content to develop the essential environmental concepts.

b. Use the science processes to investigate the natural and the built environments, their interactions and their relationships.

c. Stimulate the learning of science content and processes by starting with some information on local conditions and problems, and conversely, clarify and reinforce the learning of science content by using them in the investigations of local conditions and problems.

d. Involve students in tasks that call for actual doing in real environments as the schoolground, a farm, a park, a grassy area, a seashore, a river bank, etc.

e. Employ different strategies of presentation throughout the course to make it interesting.

f. Make room for student-initiated activities that conserve or enhance the environment, or improve the quality of life.

g. Encourage the student to look at an environmental issue from many sides, and to learn alternative ways of dealing with a problem.

h. Bring in the social implications of scientific discoveries and events to let the student see that science does not operate in isolation but links inextricably with other disciplines.

i. In order to change the role of students in learning from that of passive receptors to initiators and active seekers of knowledge, student tasks should include asking questions about their environment, and designing and putting into action projects that enhance the environment.

j. The curriculum material should treat science not as an activity in isolation of society but as an enterprise in which society has invested its best minds in order to yield long term benefits to humankind.

4. Teacher Training

Some projects fail in implementation because the implementors are not fully committed to the project, or do not fully understand the rationale of the project, or do not possess the necessary skills or information. The key implementors of an environmental education programme are the teachers. For a successful implementation of such a programme, the teachers must

- understand the rationale, and be convinced of the worth of the environmental education progamme

- possess the essential knowledge and skills

- have a commitment to the project.

An in-service training programme is the usual strategy to prepare teachers for the implementation of a new programme. A short intensive training held some weeks before the start of implementation, usually in summer, is preferred by many teachers because at this time they are free of other academic cares. However, short intensive one-shot training programmes are found to be less effective than those held periodically, for instance, every Saturday or every other Saturday, throughout the school year. A sustained training conducted in the same year of implementation has a greater transfer of learning to classroom teaching.

In the end, the schedule for in-service training depends on the availability of funds, the readiness of the training coordinators and instructors, the availability of supplies and facilities, and the willingness of teachers to attend it.

In formulating an in-service training programme for teachers, consider its appeal to teachers. A study identified the attributes of an in-service training programme in environmental education that appears to be needed (Ritz, 1977). According to science teachers, an in-service training programme in environmental education should -

a. be appropriate for teachers with a great variety of backgrounds;

b. provide training in environmental education methods as well as content;

c. have a strong motivation impact on teachers;

d. bring teachers to direct involvement to particular environments;

e. engage teachers in exploring their personal assumptions, values, feelings about society and self, and the relationship of society and to the natural world.

Silberstein (1979) warns that oftentimes in the zeal of in-service trainers to provide much help to teachers, considerable attention is paid to the understanding of specifics such as content, activities, phrasing of questions, and matching of tasks to concepts so that little attention is given to the general characteristics or the 'spirit' of the curriculum. The attention to detail precludes the long-range effect of the intended innovation.

To focus on the general characteristics or the spirit of the innovation, Silberstein recommends that teacher training should -

a. focus on the difference between the old programme and the innovative programme and how the teacher can effect transition from the former to the latter;

b. develop the willingness in teachers to make the transition;

c. develop competencies that will enable the teacher to make the transition.

5. Preparing for Evaluation

All environmental education programmes must be evaluated to benefit future programmes. An evaluation plan must be designed and instruments constructed and developed in preparation for implementation. If the evaluation is to be formative, then the first instruments to be used must be ready, that is, constructed, developed and printed in the number needed, before implementation begins. If the evaluation is to be summative then the instruments must be ready for use at about the end of the project. For details on evaluation of environmental education projects refer back to Chapter VIII.

6. Schedule of Activities

A Schedule of major activities for implementation must be drawn up before the project begins. During the period of implementation tasks completed can be checked against the schedule of activities to determine if the project is progressing as expected, or falling behind, or pushing ahead of schedule. The schedule also serves as a reminder of tasks that need attention on specific dates.

7. Other Considerations Preparatory to Implementation

a. Securing permit and authorization

The implementation of an educational innovation, such as the environmental education programme, needs to be cleared with education authorities. A permit or authorization to use certain schools and certain classes (if implemented on small scale), or to modify the science programme of all secondary schools (if implemented on a national scale) can prevent delays and facilitate transactions with school officials, teachers, students and community people. This permit must be obtained even before the plans for implementation are completed. It is essential to get the services of education officials, school administrators and teachers to help in the planning and implementation. It prevents delays and facilitates encounters with people who may initially resist the innovation.

b. Site selection

If the implementation involves only some selected sites, then selection of the sites must be done in the early part of planning. Final selection depends on the acceptance of the project by the community, the willingness of the teachers to share in the work, the ease of communication and transportation between site and coordination center, and a few other factors deemed important to the success of implementation.

A survey of the selected sites is recommended to anticipate some possible difficulties. Plans can be revised for certain sites to offset minor difficulties.

c. Funding

No new programme can move ahead without funds to support it, at least, at the initial stages. The programme coordinators must take steps to obtain assurance of a funds source and the release of the funds during the course of implementation.

C. IMPLEMENTATION STRATEGIES AT THE MANAGEMENT LEVEL

The implementation of an environmental education programme or any educational programme, for that matter, is generally carried out in three modes: the administrative mode, the geographical mode, the curricular mode.

1. Administrative Mode

The administrative mode refers to the method or plan for the administration or management of the programme. In practice, administration of an educational programme is exercised through any one of the following:

a. A centralized system where the central coordinating unit is vested with the authority to make pronouncements that designated the mode of implementation schools have to follow. An example of this system is the Ministry of Education and its network of schools on the national scale, or the school division or prefecture on smaller scale. The advantage of this mode of administration is the speed and ease of instituting an innovation that requires organizational or curricular changes. The disadvantage is the possibility of implementation at the classroom level with little or no comprehension on the part of teachers of the "spirit" or the main characteristics of the innovation. Teacher compliance is exacted by virtue of authority from above with or without conviction and commitment of the teacher.

b. A highly credible and respected educational unit or agency with no authority over schools but whose actions and pronouncements are generally adopted by schools. A university research and development unit is an example. Such a unit may produce an environmental education programme for try-out in some schools. The university personnel administers and manages the try-out implementation with approval from the central government agency in charge of education. Having no authority over schools, this external unit seeks to formulate a programme that works and produces results but may not be implemented without support from the proper authorities.

c. A tie-up between a highly credible and respected external unit which formulates the programme and manages its implementation at the classroom level and a high authority system which takes charge of the implementation at the management level. This arrangement seems to be the most commonly accepted mode of implementation of an educational innovation.

d. An external unit not directly associated with schools. An emerging administrative mode of implementation is that of a commercial publishing house engaging in curriculum development, try-out, and implementation. In such an enterprise curriculum materials for use in schools are produced by the publishing company according to specifications set by the Ministry/Department of Education. The vast resources of the company make speedy production possible. Known educators, usually the authors of the printed materials, are employed by the company to handle one-day or two-day seminar orientations.

Students buy the books, sometimes at prices they can ill afford. Give-aways are an attraction to teachers. The danger in this set-up is that the teachers may push the sale although the printed material is not suitable to the students and their milieu.

2. Geographical Mode

The geographical mode refers to the distribution and location of the implementation sites. It, therefore, specifies the scale of implementation.

When all schools in the country, of the type specified in the design, are involved then it is a full nation-wide scale. An area implementation may involve all schools of the specified type within a designated area such as a province or a city or a town. The implementation may start on a provincial scale rapidly progressing to national scale.

For try-out implementation, a national or a real sampling may be done. This means that the nation is divided for the purpose of the tryout into areas; then the schools in each area are randomly or selectively sampled.

3. Curricular Mode

The curricular mode identifies the grade level or levels and the subject areas involved in the implementation. For instance, environmental education is implemented only in grades 7, 8 and 9, and integrated only with science. Or implementation of the programme involves only the upper secondary school and integrated with science, social studies and communication arts. Thus the curricular mode specifies the degree of implementation as regards the curriculum.

D. IMPLEMENTATION STRATEGIES AT THE INSTRUCTIONAL LEVEL

Implementation strategies do not end at the management level. Perhaps more crucial are those at the instructional level where the environmental education programme actually reaches its intended audience - the students. Three main events take place at this level: teacher preparation, class interactions, student learning.

1. Teacher Preparation

Mastery of subject matter alone does not make a good teacher. He must also plan his strategy of teaching. To ensure that this is done some schools require daily lesson plans of teachers. Other schools leave it to the teacher to decide the size of a comfortable teaching unit to prepare for. Some teachers prefer to work on small learning units which can be finished in 2 or 3 days. The course of study or syllabus for the academic year or the semester serves as the overall plan.

Teachers need to plan the presentation of subject, the design of the learning task and the teaching aids to use. The preparation is likely to be sound when the teacher keeps in mind his two main functions: (1) to motivate students to learn, and (2) to facilitate their learning. A student learns best under a state of sustained motivation beginning as arousal of interest, developing into expectancy (waiting to see how the event will turn out or expecting some satisfaction), later turning into incentive (a move to action) toward the attainment of a goal, until it becomes a discipline (a self-imposed rigorous activity which itself brings satisfaction) (De Cecco, 1968). Student learning is facilitated by bood organization or structure of subject matter (Bruner, 1963), meaningfulness of subject matter and activities and tasks that match the students' readiness (Travers, 1977). All these the teachers bear in mind as they make the many decisions on how to structure and sequence the subject matter, what to emphasize, how to pace content development, what examples to use, what tasks to give, what skills to develop, what equipment to specify for student activities, what real life situations for students to experience, where to go for field studies, when to have discussions, what questions to ask, etc.

How does a teacher prepare to motivate and facilitate the learning of the environmental dimension of science? The generalizations (given in the preceding paragraph) found workable in many subject areas are likely to work just as well in environmental education. The many possible applications of them preclude specific prescription. But a few specific suggestions can be made.

To motivate learning:

- Start the lesson with a brief survey of students' thinking on an environmental issue or problem relating to the science topic on hand.

- Display articles on a recently approved law and the public opinion on it relating to the science lesson. Get students to react on them.

- Show pictures of a well-conserved environment. Discuss what people can do to maintain it and the scientific explanations behind the actions.

To make the subject meaningful and facilitate learning:

- Explore students' experiences relevant to the topic.

-Call on students to use their special talents in art and poster-making to educate the public about environmental conservation.

-Engage them in speculation of what would happen if.. (a certain condition in the environment is allowed to develop or changed).

- Let students design a class activity that would improve the physical environment, social relationships in the community, people's awareness of a particular conditon in the environment, etc.

- Get students to use the science processes in learning more about a particular aspect of their own environment.

2. Class Interactions

Teacher plans, when executed, do not always turn out as expected not only because of the multiplicity of variables but also because of the ineractions among them. The three main interacting elements in a class are the teacher, the student and the course including the equipment and teaching aids used in it. The interactions create a climate or atmosphere in the class which affect both teacher and student performance. What unfolds as behaviour or performance in class transactions feeds back into succeeding behaviour or performance of the teacher and the students.

The course or programme by itself is static. But it can be changed in parts by the teacher. The creative teacher can restructure it, trim it, simplify it, or embellish and enrich it to accommodate the needs, interest, abilities and special talents of students. The average teacher most likely will try to put it across faithfully as the curriculum developers have produced it. The less talented teacher may even mangle it. The students can only react to the lessons presented to them by the teacher.

The teacher being the recognized 'leader' of the class tends to set the climate. In studies of best-liked and least-liked teachers, students have listed more personality traits than competencies and skills in describing them. The best-liked teachers are described as helpful, cheerful, human, companionable, etc. The least-liked teachers are too cross, never smile, sarcastic, haughty, etc. The warm friendly teachers influence their students positively toward the subject, and the cold teachers influence their students negatively (Reed, 1962). It was found that changes in student interest in science seem to be more strongly influenced by the teachers' personality and value systems rather than their training, teaching experience, and science background (Rothman, 1969). Student behaviours are strongly influenced by teachers behaviours. The teachers whose behaviours are examples of what they seek to develop in students tend to facilitate the learning of such behaviours (Penick & Shymansky, 1977). In environmental education where behaviours and actions are seen as the ultimate evidence of learning, the teacher becomes a focal point of student learning.

Student performance and behaviour in class are cued by teacher behaviour. It has been shown that students taught by direct teachers, that is, teachers who give more direction and rarely ask for opinions and ideas of students, learn less than students taught by indirect flexible teachers who ask more questions and give less directions (Amidon and Flanders, 1961).

E. SUPPORT ACTION TO IMPLEMENTATION

Implementation is not done in a vacuum. It is carried out where a population, institutions, and a social and econmic order exist. Its probability of success is greater when it obtains support, both moral and financial, from the existing establishment. To obtain support, the following actions are recommended:

- Include people from the community, government agencies and organizations in the planning and implementation committees to orient them to the programme and to avail of resources they can offer.

- Consider the topics and methodologies suggested by the people for inclusion in the programme since they are more conversant with the conditions and problems of the environment.

- Encourage the community to make it their own project - to formulate, implement, maintain and nurture.

- At the initial step of implementation at the instructional level, cluster trained teachers in the selected schools to give the programme at least an even chance for survival.

- Supervisors should take on a consultative rather than inspectorial role.

- Use media (TV, local radio station, local newspapers) to inform the community of the new programme.

- If necessary, seek legislative action endorsing and providing financial support to the programme.

X. TO THE TEACHER/SUPERVISOR

At this point, perhaps what is appropriate is not a conclusion for you have just made a quick overview of environmental education and are now at the threshold of a new venture - that of implementing environmental education, nor a summary for right now your understandings and your values have not, as yet, firmed up and your view of your way into implementation is still rather hazy. This is more by way of encouragement.

After going through the in-service training on the teaching of the environmental dimension of science -

1. Do you feel that environmental education in the secondary school is of value to the students and to society?

2. Do you consider science in the secondary school an appropriate matrix for the integration of environmental teachings?

3. Do you believe you should teach the environmental dimension of science to your classes hereon?

If your answer is "Yes" to all three questions, then you have made a commitment. If there is one word that sums up a person's predisposition to attain success in an undertaking it is commitment. Because of this commitment it will not be surprising if now or in the near future, you will want to -

1. expand and deepen your understanding of and valuation in environmental matters by further readings;

2. seek out the professional environmentalists in your own country or locality to request information on environmental impact studies on local projects;

3. Share your experiences and exchange ideas with other teacher implementors of environmental education;

4. devise ways of making your teaching more interesting and meaningful to your students even if it means departing from the known and prescribed paths (methodologies and teaching aids) and coming up with new methods and devices;

5. put into practice in your very own classroom or among the people you work with the environmental ethics or code of behaviour that emphasizes equity and social justice, and rejects the advance of one to the debasement of another.

If you do, then you are well on your way to becoming a most effective teacher/supervisor of environmental education.

- E N D -

Appendix A

Environmental Education Syllabus

First week

Pretest - an examination may be given the trainees on the first day of the programme to determine their existing knowledge, attitudes and values.

Content: Toward an environmental education ethics

Discussion: The need for environmental education in schools

The recognition of local, regional and global environmental problems as reflected in mass media, laws passed, and the problems being discussed in national and international forums.

Activities:

Make a list of issues or problems that you have read or heard about which you consider environmental in nature

Show slides, display pictures and newspaper articles on environmental degradation

Discussion: The history of environmental education

Traditional attitudes of people about the environment

- as an inexhaustible resource
- an an inhospitable habitat to constantly wrestle with

Changing attitudes of people about the environment as an effect of developments in science and technology

- man as a master of his environment and can therefore use it to his advantage
- destruction, pollution and wastage as the consequences of this attitude

The Stockholm Conference - a global concern for the environment

- its Declaration of Principles
- its recommendations for action

The Belgrade Workshops - a recognition of education as a venue for developing positive conservation attitudes about the environment

- its guiding principles
- its recommendations for the development of new ethics

The Tbilisi Conference - toward strategies for the development of environmental education

Activities

Read Appendices A and B and comment on the contents.

Discuss views concerning the contents of Appendices A and B.

Invite a resource person who had been involved in a project that wrought changes in the environment to talk about the nature of the changes made, their consequences and the attitudes of the people about the project.

Second week

Discussion: Essential knowledge about the environment

Structure and function of an ecosystem - components of an ecosystem, habitat and niche, limiting factors, types of ecosystem.

Energy flow in the earth ecosystem (or ecosphere)

The flow of solar radiation into and out of the earth ecosystem

The water cycle as a pathway of energy transfers

Energy flow in the biotic component - photosynthesis and respiration , food chain and web, trophic levels, the ten percent law

Materials flow in the earth ecosystem

The biogeochemical cycles - the water cycle, the carbon cycle, nitrogen cycle, oxygen cycle, phosphorus cycle, sulfur cycle

Biological magnification

Activities

Display charts of energy flow and materials cycles as discussion proceeds

Third week

Activities

Visit a densely populated human settlement or

Show a map of the city or province where training is located

- identify densely populated areas, industrial areas, commercial areas, parks and recreation areas

Discussion: Population Dynamics

Density, natality, dispersal, mortality, population growth and its control, age structure

Activities: Obtain local population data and write up a report on the dynamics that must have been in operation to produce its present structure

Discussion: Human intervention in natural processes and its consequences

Concerning energy flow - increased combustion and the pollutants emitted and their consequences

Concerning population - concentration of human population in urban areas, accumulation of waste, pollution

Concerning materials flow - the consumption of renewable and nonrenewable materials, and its consequences

Activities

Visit a busy area of the community and then a quiet, least trod area. Compare the two areas in terms of biotic and abiotic components, natural and built components. State possible reasons for this development of the two areas.

Fourth week

Discussion: Problems of the environment

The dimensions of environmental problems - physical, economic and social consequences of environmental problems; geographical scale; time scale; major causes.

Rapid population growth - its consequences: food shortage, decreased space, water shortage, energy crisis, scarcity of the earth's material; its geographical scale: Asia, Africa, South America; its time scale: from the development of science and technology to the present; its major causes: medical advancement coupled with little job and educational opportunities for the youth, agricultural technology and the resulting oversupply of food.

Pollution, destruction of the environment, and accumulation of waste - result of concentration of human population, poverty, industrialization and infrastructures as approaches to development

Activities

Obtain national population data and construct the age structure of the population. Make projections on what the age structure will be after 15 years and after another 15 years. Explain the factors and dynamics that would bring about these age structures in your projections.

Write a report on your predictions of the kinds of environmental problems that the population 15 years from now would probably encounter.

<u>Fifth week</u>

Read Chapters VI and VII

Choose a topic from Chapters III or IV and write a lesson plan on it, using ideas picked up from Chapters VI and VII.

Teach the lesson you have prepared using your fellow-trainees as your make-believe students. Check with your trainers on your choices of topics, methodologies and activities.

Evaluate the lesson presented - All trainees except the presentor of the lesson shall evaluate the lesson according to set criteria agreed upon by the group before lesson presentations began.

<u>Sixth week</u>

Continue lesson presentations for 4 more days.

Evaluate the workshop by filling up prepared evaluation sheets.

APPENDIX B

Stockholm Conference
5-16 June 1972
The United Nations Conference on the Human Environment

I. Declaration on the Human Environment

Proclaims that

1. Man is both creature and moulder of his environment, which gives him physical sustenance and affords him the opportunity for intellectual, moral, social and spiritual growth. In the long and tortuous evolution of the human race on this planet a stage has been reached when, through the rapid acceleration of science and technology, man has acquired the power to transform his environment in countless ways and on an unprecedented scale. Both aspects of man's environment, the natural and the man-made, are essential to his well-being and to the enjoyment of basic human rights - even the right to life itself.

2. The protection and improvement of the human environment is a major issue which affects the well-being of peoples and economic development throughout the world; it is the urgent desire of the peoples of the whole world and the duty of all Governments.

3. Man has constantly to sum up experience and go on discovering, inventing, creating and advancing. In our time, man's capability to transform his surroundings, if used wisely, can bring to all peoples the benefits of development and the opportunity to enhance the quality of life. Wrongly or heedlessly applied, the same power can do incalculable harm to human beings and the human environment. We see around us growing evidence of man-made harm in many regions of the earth: dangerous levels of pollution in water, air, earth and living beings; major and undesirable disturbances to the ecological balance of the biosphere; destruction and depletion of irreplaceable resources; and gross deficiences harmful to the physical, mental and social health of man, in the man-made environment, particularly in the living and working environment.

4. In the developing countries most of the environmental problems are caused by underdevelopment. Millions continue to live far below the minimum levels required for a decent human existence, deprived of adequate food and clothing, shelter and education, health and sanitation. Therefore, the developing countries must direct their efforts to development, bearing in mind their priorities and the need to safeguard and improve the environment. For the same purpose, the industrialized countries should make efforts to reduce the gap between themselves and the developing countries. In the industrialized countries, environmental problems are generally related to industrialization and technological development.

5. The natural growth of population continuously presents problems for the preservation of the environment, and adequate policies and measures should be adopted, as appropriate, to face these

problems. Of all things in the world, people are the most precious. It is the people that propel social progress, create social wealth, develop science and technology and, through their hard work, continously transform the human environment. Along with social progress and the advance of production, science and technology, the capability of man to improve the environment increases with each passing day.

6. A point has been reached in history when we must shape our actions throughout the world with a more prudent care for their environmental consequences. Through ignorance or indifference we can do massive and irreversible harm to the earthly environment on which our life and well-being depend. Conversely, through fuller knowledge and wiser action, we can achieve for ourselves and our posterity a better life in an environment more in keeping with human needs and hopes. There are broad vistas for the enhancement of environmental quality and the creation of a good life. What is needed is an enthusiastic but calm state of mind and intense but orderly work. For the purpose of attaining freedom in the world of nature, man must use knowledge to build, in collaboration with nature, a better environment. To defend and improve the human environment for present and future generations has become an imperative goal for mankind--a goal to be pursued together with, and in harmony with, the established and fundamental goals of peace and of world-wide economic and social development.

7. To achieve this environmental goal will demand the acceptance of responsibility by citizens and communities and by enterprises and institutions at every level, all sharing equitably in common efforts. Individuals in all walks of life as well as organizations in many fields, by their values and the sum of their actions, will shape the world environment of the future. Local and national governments will bear the greatest burden for large-scale environmental policy and action within their jurisdictions. International co-operation is also needed in order to raise resources to support the developing countries in carrying out their responsibilities in this field. A growing class of environmental problems, because they are regional or global in extent or because they affect the common international realm, will require extensive cooperation among nations and action by international organizations in the common interest. The Conference calls upon Governments and peoples to exert common efforts for the preservation and improvement of the human environment, for the benefit of all the people and for their posterity.

III. Declaration of Principles

States the common conviction that

Principle 1. Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations. In this respect, policies promoting or perpetuating apartheid, racial segregation, discrimination, colonial and other forms of oppression and foreign domination stand condemned and must be eliminated.

Principle 2. The natural resources of the earth including the air, water, land, flora and fauna and especially representative samples of natural ecosystems must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.

Principle 3. The capacity of the earth to produce vital renewable resources must be maintained and, wherever practicable, restored or improved.

Principle 4. Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat which are now gravely imperilled by a combination of adverse factors. Nature conservation including wildlife must therefore receive importance in planning for economic development.

Principle 5. The non-renewable resources of the earth must be employed in such a way as to guard against the danger of their future exhaustion and to ensure that benefits from such employment are shared by all mankind.

Principle 6. The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems. The just struggle of the peoples of all countries against pollution should be supported.

Principle 7. States shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.

Principle 8. Economic and social development is essential for ensuring a fabourable living and working environment for man and for creating conditions on earth that are necessary for the improvement of the quality of life.

Principle 9. Environmental deficiencies generated by the conditions of underdevelopment and natural disasters pose grave problems and can best be remedied by accelerated development through the transfer of substantial quantities of financial and technological assistance as a supplement to the domestic effort of the developing countries and such timely assistance as may be required.

Principle 10. For the developing countries, stability of prices and adequate earnings for primary commodities and raw material are essential to environmental management since economic factors as well as ecological processes must be taken into account.

Principle 11. The environmental policies of all States should enhance and not adversely affect the present or future development potential of developing countries, nor should they hamper the attainment of better living conditions for all, and appropriate steps should be taken by States and international organizations with a view to reaching agreement on meeting the possible national and international economic consequences resulting from the application of environmental measures.

Principle 12. Resources should be made available to preserve and improve the environment, taking into account the circumstances and particular requirements of developing countries and any costs which may emanate from their incorporating environmental safeguards into their development planning and the need for making available to them, upon their request, additional international technical and financial assistance for this purpose.

Principle 13. In order to achieve a more rational management of resources and thus to improve the environment, States should adopt an integrated and coordinated approach to their development planning so as to ensure that development is compatible with the need to protect and improve the human environment for the benefit of their population.

Principle 14. Rational planning constitutes an essential tool for reconciling any conflict between the needs of development and the need to protect and improve the environment.

Principle 15. Planning must be applied to human settlements and urbanization with a view to avoiding adverse effects on the environment and obtaining maximum social, economic and environmental benefits for all. In this respect projects which are designed for colonialist and racist domination must be abandoned.

Principle 16. Demographic policies, which are without prejudice to basic human rights and which are deemed appropriate by Governments concerned, should be applied in those regions where the rate of population growth or excessive population concentrations are likely to have adverse effects on the environment or development, or where low population density may prevent improvement of the human environment and impede development.

Principle 17. Appropriate national institutions must be entrusted with the task of planning, managing or controlling the environmental resources of States with the view to enhancing environmental quality.

Principle 18. Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind.

Principle 19. Education in environmental matters, for the younger generation as well as adults, giving due consideration to the underprivileged, is essential in order to broaden the basis for an enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human dimension. It is also essential that mass media of communications avoid contributing to the deterioration of the environment but on the contrary disseminate information of an educational nature on the need to protect and improve the environment in order to enable man to develop in every respect.

Principle 20. Scientific research and development in the context of environmental problems, both national and multi-national, must be promoted in all countries, especially the developing countries. In this connection, the free flow of up-to-date scientific information and transfer of experience must be supported and assisted, to facilitate the solution of environmental problems, environmental technologies should be made available to developing countries on terms which would encourage their wide dissemination without constituting an economic burden on the developing countries.

Principle 21. States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 22. States shall co-operate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such States to areas beyond their jurisdiction.

Principle 23. Without prejudice to such criteria as may be agreed upon by the international community, or to standards which will have to be determined nationally, it will be essential in all cases to consider the systems of values prevailing in each country, and the extent of the applicability of standards which are valid for the most advanced countries but which may be inappropriate and of unwarranted social cost for the developing countries.

Principle 24. International matters concerning the protection and improvement of the environment should be handled in a co-operative spirit by all countries, big or small, on an equal footing. Cooperation through multilateral or bilateral arrangements or other appropriate means is essential to effectively control, prevent, reduce and eliminate adverse environmental effects resulting from activities conducted in all spheres, in such a way that due account is taken of the sovereignty and interests of all States.

Principle 25. States shall ensure that international organizations play a co-ordinated, efficient and dynamic role for the protection and improvement of the environment.

Principle 26. Man and his environment must be spared the effects of nuclear weapons and all other means of mass destruction. States must strive to reach prompt agreement, in the relevant international organs, on the elimination and complete destruction of such weapons.

Appendix C

DECLARATION OF THE TBILISI INTERGOVERNMENTAL CONFERENCE ON ENVIRONMENTAL EDUCATION

The Intergovernmental Conference on Environmental Education, organized by Unesco in co-operation with UNEP, convened in the City of Tbilisi reflecting the harmony and consensus achieved there, solemnly adopts the following Declaration.

In the last few decades, man has, through his power to transform his environment, wrought accelerated changes in the balance of nature. The result is frequent exposure of living species to dangers which may prove irreversible.

The Declaration of the United Nations Conference on Human Environment organized in Stockholm in 1972 proclaimed: "to defend and improve the environment for present and future generations has become an imperative goal for mankind". This undertaking urgently calls for new strategies, incorporated into development, which particularly in the developing countries is a prerequisite for any such improvement. Solidarity and equity in the relations between nations should constitute the basis of a new international order, and bring together, as soon as possible, all available resources. Education utilizing the findings of science and technology should play a leading role in creating an awareness and a better understanding of environmental problems. It must foster positive patterns of conduct towards the environment and the nations' use of their resources.

Environmental education should be provided for all ages, at all levels and in both formal and non-formal education. The mass media have a great responsibility to make their immense resources available for this educational mission. Environmental specialists as well as those whose actions and decisions can have a marked effect on the environment, should be provided in the course of their training with the necessary knowledge and skills and be given a full sense of their responsibilities in this respect.

Environmental education, properly understood, should constitute a comprehensive lifelong education, one responsive to changes in a rapidly changing world. It should prepare the individual for life through an understanding of the major problems of the contemporary world, and the provision of skills and attributes needed to play a productive role towards improving life and protecting the environment with due regard given to ethical values. By adopting a holistic approach, rooted in a broad interdisciplinary base, it recreates an overall perspective which acknowledges the fact that natural environment and man-made environment are profoundly interdependent. It helps reveal the enduring continuity which links the acts of today to the consequences for tomorrow. It demonstrates the interdependencies among national communities and the need for solidarity among all mankind.

Environmental education must look outward to the community. It should involve the individual in an active problem-solving process within the context of specific realities, and it should encourage initiative, a sense of responsibility and commitment to build a better tomorrow. By its very nature, environmental education can make a powerful contribution to the renovation of the educational process.

In order to achieve these goals, environmental education requires a number of specific actions to fill the gaps that, despite outstanding endeavours, continue to exist in our present education systems.

Accordingly, the Tbilisi Conference:

Appeals to Member States to include in their educational policies measures designed to introduce environmental concerns, activities and contents into their education systems, on the basis of the above objectives and characteristics;

Invites educational authorities to promote and intensify thinking, research and innovation in regard to environmental education;

Urges Member States to collaborate in this field, in particular by exchanging experiences, research findings, documentation and materials and by making their training facilities widely available to teachers and specialists from other countries; and

Appeals, lastly, to the international community to give generously of its aid in order to strengthen this collaboration in a field which symbolizes the need for solidarity of all peoples and may be regarded as particularly conducive to the promotion of international understanding and to the cause of peace.

Appendix D

UNESCO - UNEP INTERNATIONAL ENVIRONMENTAL EDUCATION PROGRAMME (IEEP)

Recommendation 96 of the Stockholm Conference stated that "The Secretary-General, the organizations of the United Nations system, especially the United Nations Educational, Scientific and Cultural Organization, and the other international agencies concerned, should, after consultation and agreement, take the necessary steps to establish an international programme in environmental education, interdisciplinary in approach, in school and out of school, encompassing all levels of education and directed towards the general public, in particular the ordinary citizen living in rural and urban areas, youth and adult alike, with a view to educating him as to the simple steps he might take, within his means, to manage and control his environment".

In response to the above recommendation, Unesco and UNEP launched the International Environmental Education Programme in 1975 to promote reflection and action as well as international cooperation in this field.

The objectives and priorites of IEEP are the following:

- to develop, refine the theory, principles and applications of environmental eucation as a dimension of knowledge and experience;

- to integrate environmental education into existing formal and nonformal educational systems, taking into account the needs of urban and rural populations;

- to develop and support programmes in education to generate environmental awareness at policy and decision-making levels in the public and private sectors and in consideration of all aspects of development;

- to assist governments in incorporating environmental dimension in educational policies, programmes and projects;

- to promote and support the pre- and in-service training of personnel in environmental education;

- to encourage the development of educational resources, instructional materials and audiovisual aids for the purposes of environmental education;

- to establish a system of information exchange and dissemination;

- to promote and support research, experimentation and appropriate evaluation procedures in environmental education.

In this context, the Unesco-UNEP International Environmental Education Programme has undertaken numerous activities which have enhanced the exchange of information and experience, research and experimentation, the development of content, methods and materials, training of personnel, and regional and international co-operation in the field of environmental education. The following is a summary of these activities:

As regards the establishment of strategies for the development of EE, the IEEP organized the International Workshop on Environmental Education in 1975 in Belgrade whose recommendations and guidelines constituted a preliminary framework for the development of environmental education on an international basis. The organization of five regional meetings of experts on environmental education, held in 1976-77 in Africa, the Arab States, Asia and the Pacific, Europe and North America and in Latin America and the Caribbean helped to identify regional activities, reviewed the Belgrade recommendations and guidelines, formulated strategies for the development of environmental education in the light of regional and subregional priorities. An international survey of environmental education needs and priorities of Member States was completed. A document entitled Trends in Environmental Education was published in 1977, and financial and technical assistance were provided to 20 environmental education pilot projects representing all regions of the world and encompassing various levels and forms of education which promoted the development of experimental programmes on curricula, methods and materials for environmental education.

The Intergovernmental Conference on Environmental Education organized in October 1977 in Tbilisi, USSR, constituted the culmination point of Phase I of IEEP. Its results laid the basis for the development of environmental education at the international level; defined the goals, objectives and guiding principles of environmental education as a common ground for environmental education (EE) activities in all processes of education and confirmed and stressed the objectives and priorites of the International Environmental Education Programme (IEEP).

As regards general awareness of the necessity of EE, the IEEP has played a very important part. Today the concern for problems of the environment and, more particularly, for an education pertaining to these problems -- which before was a matter of interest for particular groups within a limited number of industrialized countries and which, besides, was mainly oriented toward 'conservation' -- finds an echo in all regions of the world, as testified by the efforts and experiences made in this field by numerous countries with the co-operation of the IEEP.

For facilitating contacts among policy-makers and professionals in environmental education, the IEEP has been steadily building up a computerized information system. The IEE Programme's international newsletter Connect, which appears in five languages and is distributed to about 13,000 individuals and institutions, has contributed to international awareness and the promotion and development of environmental education and training.

The IEEP has developed strategies for programme formulation, curriculum development and teacher training in environmental education and has trained curriculum developers, teacher educators, school administrators and education planners at the regional and subregional levels for their adaptation to national and local situations.

As for educational contents, methods and materials relating to the environment, the International EE Programme has developed a coherent set of didactic materials, including methodological guides and source-books for teachers, a sourcebook in non-formal environmental education, a thesaurus, an annotated bibliography, an international directory of institutions and programmes, as well as a series of modules for the conduct of EE at the primary and secondary levels. Complementary to these core elements, surveys and guides have been developed which are devoted to the problems of methodology particularly relevant to environmental education, such as use of the modular approach, use of simulation, and the approaches and methods for the evaluation of environmental education practices. A multilingual glossary has been prepared, as well, to standardize internationally current EE terminology. A series of research activities on methods and materials in environmental education has also been undertaken.

Similarly, the IEEP has developed a series of six teacher training modules, one of which is this one, to serve as textbooks or teaching units for the pre-service and in-service training of primary- and secondary-school teachers and supervisors in environmental education whose local adaptation by certain teacher education institutions in some Member States has already been started.

Through the regional subregional and national training workshops, seminars and pilot projects which were organized in all regions of the world, the working documents and final reports issuing from them and widely distributed, key personnel have been made acquainted with EE as a perspective to be incorporated into all subject-matter of the educational process.

With respect to teacher training in EE, the Programme has developed more intensively since 1978, nine regional and subregional training workshops in Africa, Arab States, Asia, Europe, Latin America and the Caribbean for such educational personnel as curriculum developers, teacher trainers, and administrators, as well as thirty-five national training workshops in all the regions. Similarly, an international training course was organized for participants from 14 developing countries in September 1982 in Czechoslovakia. Two subregional workshops on teacher training in environmental education were organized from 3 to 16 March 1983 in Delhi, India and from 18 to 29 July 1983 in Jamaica.

Perhaps the most direct example of the IEEP's multiplying effect has been the EE training of key education personnel numbering well over 2,400 individuals, among them teachers who in turn have trained many more teachers in the principles and practices of environmental education.

The IEEP has stressed the interdisciplinary approach in environmental education and in this connection supported an international seminar on interdisciplinarity at the primary and secondary levels, Hungary, 1980. Similarly, studies have been undertaken on the incorporation of environmental education into technical and vocational education and non-formal education.

The IEEP has significantly aided efforts of Member States concerning the incorporation of an environmental dimension into their educational practice, both inside and outside the formal school system. So far a number of states have officially introduced EE into their educational plans, policies or reforms through new legislation or appropriate institutional arrangements. In many instances, they have established ministerial or interdisciplinary committees as a follow-up to the regional meetings, national training workshops, research activities supported by IEEP which have led to the incorporation of environmental education into their formal and non-formal educational system. With similar aims thirty-five pilot projects have been developed in all regions.

With respect to the use and dissemination of the results of pilot projects, the IEEP organized in 1983 in Bulgaria, an international symposium to review ways and means of incorporating an environmental dimension into curricula and teacher education. Similarly, concerning the incorporation of environmental education into general university education, the IEEP supported a regional seminar organized from 17 to 21 October 1983 in Hungary.

For fostering regional and international co-operation in environmental education, the IEEP has provided consultative services and advisory missions to Member States and has supported five international and regional meetings and conferences organized by governmental and non-governmental organizations.

THE INTERGOVERNMENTAL CONFERENCE ON ENVIRONMENTAL EDUCATION

1. The Declaration and Recommendations on Environmental Education

As indicated earlier, the Intergovernmental Conference on Environmental Education was convened by Unesco in cooperation with UNEP in Tbilisi, USSR in 1977 as a culminating activity of Phase I of Unesco-UNEP International Environmental Education Programme. Its most important output is the Declaration (see Appendix C) and 41 Recommendations on Environmental Education.

The Recommendations focus on two main topics: the role, objectives and guiding principles of environmental education; and strategies for the development of environmental education at the national level.

Among the development strategies recommended are those that seek to answer the most pressing needs of environmental teaching especially at the lower school level, namely: the training of personnel, the development of teaching-learning materials, the need for educational research, data monitoring and information dissemination.

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