GUIDELINES of LAKE MANAGEMENT

A FOCUS on LAKES/RIVERS in ENVIRONMENTAL EDUCATION

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FOREWORD

Masayuki GOTO

Recent drastic increase of human activities since the beginning of this century is now causing serious degradation of the environment not only within particular nations or regions but on a global scale.

In order to prevent the world-wide critical situation which we can anticipate in the near future if things are left as they are, we need to do everything we can in all aspects such as technology, law, economy and politics. Equally, we all need to change our attitude and lifestyles to coincide with the principles of sustainable development. In this respect, environmental education must play an important role in positively changing the human behavior towards environmental issues. While such environmental education should be made available to all generations, the education targeted at the young generation is undoubtedly the most important and the most effective.

The Environment Agency, the Government of Japan, recognizing the significance and importance of environmental education, started a five year project to support environmental education in developing countries in 1991 and committed the project to the International Lake Environment Committee (ILEC), taking their achievement hitherto into account. We sincerely appreciate the efforts of ILEC as the project concluded in great success in 1996.

We cordially approve the publication of this Guideline Book with the intention of disseminating and diffusing the results of the project and we hope this Guideline Book will contribute to the advancement of environmental education of Lakes and Rivers in the world. Finally we are heartily grateful to all the editors, writers and other contributors who aided in the publication of this Guideline Book.

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PART I

GENERAL GUIDELINES

CHAPTER 1

INTRODUCTION

Sven Erik Jørgensen

1.1 Urgent need and present status of environmental education

Environmental issues have become increasingly important in our society over the last three decades or so – since the first green wave resulting from Rachel Carson's book "The Silent Spring". At that time, it was the general opinion that environmental problems could be easily solved by the application of the proper environmental technology. Today, it has been acknowledged that environmental considerations have relations to many aspects of our everyday life and that we cannot solve the environmental problems without the use of a wide spectrum of initiatives. Environmental technology has been supplemented by environmental legislation, green taxes, cleaner technology and ecotechnology. Furthermore, it is an absolute necessity that everybody participate actively, if the abatement of the environmental problems is going to be successful. The attitude of everybody to the protection and conservation of nature, to the application of possible recirculation and to the selection of "green" products in the supermarket are crucial for solutions to the environmental crisis. Therefore, all citizens in all states should understand the environmental policy which is imposed on them and be in opposition to the legislation if it is insufficient. They should take the right environmental decisions in their everyday involvement in environmental issues:

- when they are discussing local planning on all levels,
- when they are shopping,
- when they are considering their own transportation and work,
- when they consider different local solutions to all waste problems or
- when they are taking care of their own waste.

This will obviously require a very profound understanding of the environmental problems and call for an environmental education on all levels from kindergarten to university and postgraduate education.

We have today introduced environmental education in many contexts and on many levels. The question is, have we introduced the right form for environmental education? This issue will be discussed further below.

Science has changed during the last few decades. Due to the many serious problems and crises of today – the deterioration of the environment, the shortage of energy and

resources and the overpopulation problems – science has been forced to descend from its ivory tower and be more occupied with "down to earth" problems. This has uncovered the shortcomings of our present science: it is an excellent tool to analyse a relatively simple relationship in nature or even better in a laboratory, but it is not a very good instrument in the understanding of complex systems or in seeking solutions to complex problems. Science has up to now built too much on simplification which may be valid in a laboratory but not in nature, where many components and processes are interacting steadily. This has influenced the recent development of various scientific disciplines and particularly environmental science and ecology, where the need for a more holistic approach has been most evident. It is, however, difficult and time consuming to change the course of a large a body as the scientific community. It is therefore not surprising that the use of a more holistic view in science is still in its very initial phase, but it emphasises the need for introduction of more holistic viewpoints and approaches in education to ensure that the coming generations are prepared to meet the challenge of the urgent global problems that we are facing.

The introduction of environmental education started in the early seventies in several industrialised countries. At that time, the effort was concentrated on university studies, particularly those related to environmental and ecological problems, such as sanitary engineering, chemical engineering and biology. In some countries the sanitary engineers changed their name to environmental engineers with more emphasis on ecology, environmental science in general and a deeper understanding of the relation between various forms of pollution and their influence on nature. Some biological students also became specialised in environmental biology or ecology with emphasis on conservation of nature or other related ecological disciplines. The role of a multi- and interdisciplinary approach and the simultaneous applications of several scientific disciplines, biology, physics, chemistry, geology and so on, were emphasised. It was, however, easy to make educational planning with profound understandings of the urgent needs, but much more difficult to force different disciplines with their individual traditions to work together with the aim to create a multi- and interdisciplinary education. Environmental education at the university level in the seventies was therefore in most cases very traditional and to a certain extent only an introduction of yet another subject or at best new (environmental) illustrations of already accepted scientific ideas.

The need for an early environmental introduction course with a multidisciplinary basis in (almost) all studies was stressed by an OECD working group focusing on environmental education. This resulted, however, in only a few initiatives in this direction during the seventies.

Slightly later the same tendencies were adopted in many gymnasium, secondary and elementary schools. Environmental education was in most cases simply included into

a subject, most often biology, as illustrations of the basic concepts.

During the eighties, many more studies included environmental issues into their syllabus, for instance, law, economy, agricultural engineering and medicine to mention the most important. It did, however, only in a few cases, imply that the old traditional borderlines between two or more scientific disciplines were broken down and a more wide application of several disciplines at the same time introduced. The public schools in the eighties were to a certain extent more open for project-oriented multidisciplinary educational initiatives than universities, mainly because the public school probably more generally deals simultaneously with many disciplines. In some countries (see for instance the description of the Danish experience in Part II) the legal framework for the activities in the school law made it possible to support project-oriented multidisciplinary educational initiatives, which obviously facilitated the introduction of environmental problems and issues in the education.

Still today, when we are approaching the year 2000, only a few multi- and interdisciplinary initiatives on all educational levels have been taken, because old traditional disciplines still exist and the gaps between them are not easily bridged. The need for holistic and system analytical education is more urgent than ever. The global problems are far from being solved and will only grow in the time to come. It is therefore of utmost importance to take this into account in the planning of future educational developments.

The status of the environmental education today may be elucidated and summarised in the following points:

- Many good initiatives have been taken and are implemented on all educational levels.
- The need for professional skill in environmental issues in many particular higher educations has inevitably provoked the emergence of many very useful courses in environmental topics from environmental legislation and economy to environmental technology and ecology.
- The needs for more holistic and system analytical approaches in science due to the complexity of our global problems including pollution problems has turned science towards a more multi- and interdisciplinary direction, but the development in this direction is going very slowly compared with the urgent need for changes. This is probably caused by the presence of obsolete, traditional borderlines between the various scientific disciplines.
- Therefore only a few real multidisciplinary and holistic educational initiatives have been taken. Although it may be possible to find them more represented in public schools than in universities, they are still relatively rare on all educational levels.
- Project and problem-oriented education may be found to a certain extent on all

educational levels, also with relation to environmental education, as this educational approach is more generally accepted today than one or two decades ago.

This status, particularly the shortcomings of the present environmental education, may be used to find the key factors in improving environmental education in the future.

The objectives and scopes of environmental education in the future may be listed as the following points:

1. **Change of Attitude.** Environmental education should change the attitude towards the environment and nature, from indifferent to very concerned.
2. **Insight into How Nature Works.** Environmental education should give a certain insight into how nature is functioning, why nature can absorb some pollutions but not all. Why nature at the same time is very robust but also very vulnerable.
3. **Present Basic Natural Principles.** Environmental education should and could present the basic natural principles which we must adapt, if we want a sustainable development:
    a. the role and importance of recycling, because of conservation principles
    b. the role of the chemical composition for all living components,
    c. that all components are tied up in a network, which explain their interdependence,
    d. that all natural systems must be open (or rather non-isolated) because they are dependent on an energy source and a heat sink, and so on.
4. **Stress the Nature of Complex Systems.** Environmental education should underline the nature of complex systems and how predictions on the reactions of complex systems require a very profound knowledge on many aspects at the same time. This underlines the urgent need for a holistic multi- and interdisciplinary environmental education, which is covered in the following two points (5 and 6).
5. **Contain Holistic Elements.** Environmental education should have at least some holistic elements. It is important to use what could be called a macroscope – see the whole and not the details – several times in the course of environmental education.
6. **Draw on several Disciplines Simultaneously.** Environmental education should at least have some multi- and interdisciplinary elements to illustrate the importance of drawing on several disciplines simultaneously to solve real life problems.
7. **Be Problem-Oriented.** Environmental education should be problem-oriented, as the practical application of the education would focus on problems. The problems should be well defined, quantified and the possible solutions to the

problems discussed with view points from several angles.

8. **Use Practical Projects.** Environmental education should to a high extent be in the form of projects, preferably very concrete projects, in order to bring the education "down to earth". This would facilitate the introduction of points 5, 6 and 7 in the environmental education.
9. **Present our Dependence of Nature.** Environmental education should reveal our complete dependence on nature, and the vulnerability of our modern society to any changes in the basic properties of our environment. In this relation our dependence of access to recreational areas and a wide spectrum of natural resources should also be mentioned. The relation between our health and the environment is also significant in this context, for instance the importance of high quality drinking water We are indeed dependent on nature, while nature particularly on a long term basis is independent of mankind. We can influence nature, but we cannot change the fundamental laws of nature.
10. **Include the Role of Environment as a Social-Economic Factor.** Environmental education should also consider the role of our environment in the society as a social-economic factor. It should reveal how many social-economic problems can be explained as environmental problems and how insufficient shortsighted environmental decisions can create social-economic problems.

The ten mentioned objectives should be considered in all levels of environmental education, not necessarily with the same weight on all levels, but it is considered of utmost importance to include *all* the mentioned elements to be able to turn environmental education in the right direction, i.e. the direction which would consider the above mentioned characteristics of environmental problems. It will be illustrated in this guideline book that it is possible on the public school level to include all the 10 elements by a suitable choice of project and by the integration of the project into several school subjects. The national experiences gained by this school project launched by ILEC, demonstrate that this is possible even by relatively simple means, at least if the focus of the environmental educational project is on inland water environments. This is discussed further in the next section.

1.2 Environmental education focusing on inland water environments and resources

Pollution problems and shortage of resources are often coherent, because the shortage is frequently caused by a deterioration of resources from pollution. Examples where the two problems are linked are an excellent illustration of the ten objectives of environmental education listed above, because they give the opportunity instantly to illustrate the use of a macroscope, how complex real problems are and how problems and ecosystem components are linked together and cannot be separated. Inland waters are excellent examples of this relationship between pollution of natural systems and the need for maintenance of the quality and quantity of the natural

resources that are so essential for our society – in this case sufficient water of an acceptable quality which has great influence on the public and social economic factors.

Inland waters have the advantage as objects for environmental education that they may be found almost everywhere and that the local society often consider the adjacent inland water, either a lake, a wetland or a reservoir, as the most important local recreational area. It usually attracts a lot of recreational activities such as swimming, boating and fishing. This facilitates the possibilities to raise a natural interest for the inland waters by the pupils of the adjacent schools. This is illustrated in Part II particularly for the Danish and Japanese school project, where the schools are adjacent to lakes which are particularly important recreational areas of the region, but in principle it can be seen from the results by all the natural experiences.

How the use of inland water environments as the focus for a school project is able to meet all the above mentioned ten objectives is discussed below. The numbers refer to the numbers used above.

1. The local interest for the inland water(s) adjacent to a school should make it easy to awake the concern for nature. It is in this context important that the pupils visit the focal inland water several times and thereby get a sense for its beauty and its role as a recreational area in the region.
2. This discussion will inevitably lead to an assessment of the conditions for the inland water, including a discussion of the water quality and its importance for the use of the inland water for recreational purposes. This gives occasion to discuss the loading of organic matter and nutrients and the possibilities of the ecosystem to absorb at least partially these pollutants. It should be applied to

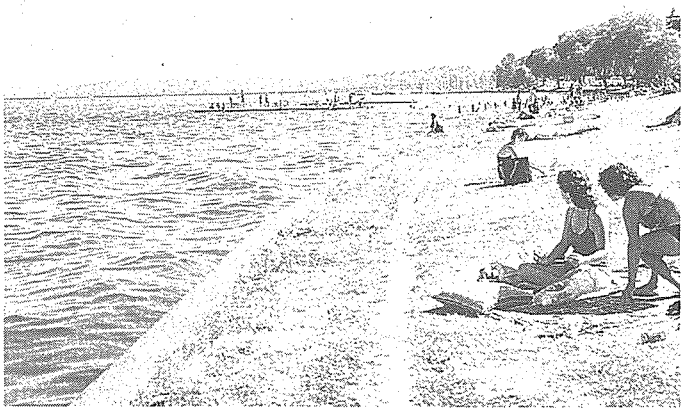


Fig. 1 Uses of lakes – 1) Recreation. Lake Washington (USA).

Fig. 2 Uses of lakes – 2) For daily life. Washing on the shore of Lake Toba (Indonesia).

illustrate that ecosystems possess ecological buffer capacities which can reduce the impact of any pollutant but only to a certain extent. Above a certain limit the ecosystem will deteriorate which – and here inland waters are excellent examples, too – may lead to an irreversible reduction of the ecosystem quality. It implies that it will often cost more effort to bring the system back to normal than expected: prevention is therefore better than abatement coupled with restoration.

3. By continuous analyses of inland waters it is possible for the pupils to exemplify the basic properties of ecosystems. The annual cycle illustrate simultaneously the cycling of nutrients, because the concentrations of available soluble nutrients are different from winter to spring to summer to fall because of the nutrients cycle. The water cycle is also another illustrative subject to be discussed in relation to inland waters. The relation between drinking water, waste water, waste treatment and the water quality in a lake or reservoir can easily be understood by 8 – 12 years old school pupils.
   The analyses of the water quality also give occasion to discuss the concept of the limiting factors, which is embodied in the basic composition of plants. Furthermore, the annual cycle of zooplankton illustrate the dependence of the food source, phytoplankton, and give occasion to discuss food web and thereby the ecological network of ecosystems.

Finally the relation between phytoplankton growth and solar radiation which is nicely illustrated by the annual cycle clearly demonstrates that inland waters are open (non-isolated) ecosystems. The inflows and outflows are further illustrations of the openness of ecosystems. The ecosystem is dependent on all the activities in the entire watershed and the entire watershed is dependent on the processes in the interrelated ecosystems, whatever we are focusing on lakes, reservoirs, rivers or wetlands, are excellent examples of the ecosystem properties. It can therefore be concluded that inland water, whatever they are lakes, reservoirs or wetlands, are excellent examples of the ecosystem properties.

4. The application of almost the entire spectrum of natural sciences, physics, chemistry, geography and biology, by the observations and analyses of inland waters is evident. It is however also easy to utilise other subjects which may be considered an unique opportunity to demonstrate that the problems of real life cannot be solved by the use of one subject only but require always an integrated and simultaneous use of several subjects. An environmental project focusing on an inland water could be utilised in art (drawing), mathematics (graphs, calculations of areas, volume, loadings etc.) and languages (reading of manuals).
5. Because of the close relation between water quality and the ecology of inland waters, they are also excellent examples of the need for a holistic view. It is clear that one water quality parameter does not reveal much, but has to be integrated with the other parameters, with the analyses of phytoplankton, zooplankton, insects, birds and fish species and with the general impression of the ecosystem and its surroundings to be able to assess the ecosystem health and the possibilities to improve it and the water quality. The analyses and

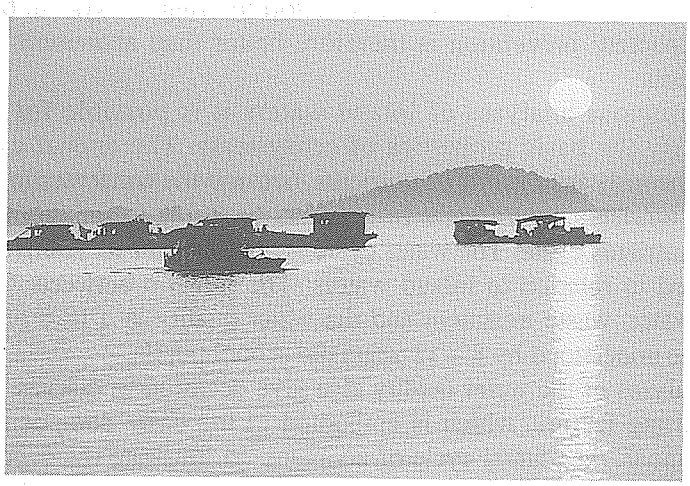


Fig. 3 Uses of lakes – 3) Waterborne transportation. Boats are still the most important means of cargo transit on many lakes and rivers of central China like this Tai Lake.

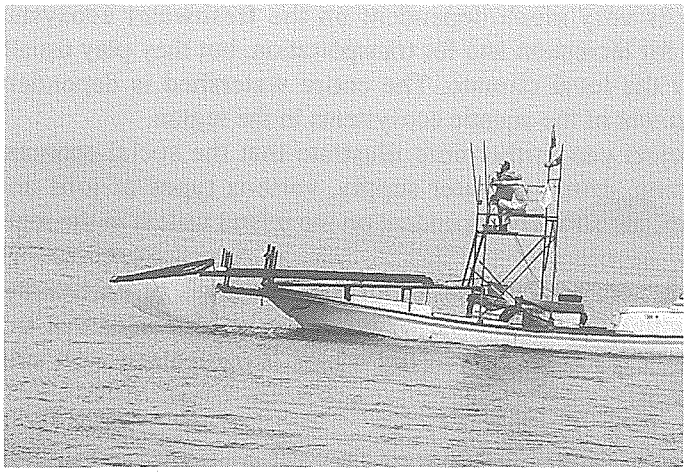


Fig. 4 Uses of lakes – 4) Fishery. Mechanised scoop-net fishing on Lake Biwa (Japan).

observations are carried out for the entire system which emphasises the importance of the system level.

6. The application of inland waters in environmental education makes it possible to stress the need not only for multidisciplinary approaches but also for interdisciplinarity. The assessment of the ecosystem health for an inland water requires that biological, physical and chemical parameters are evaluated in parallel which is only possible by integration of the knowledge based on the various disciplines.
7. The problem orientation is important in environmental education because our concern for the environment is associated with real and often very urgent problems. In addition, our knowledge, skill and know how in real life are again and again confronted with problems and the comparisons of possible solutions. In the school on the other side, very few real problems are in focus. It is therefore an unique opportunity for the school to use real life problems in education to use inland waters as an environmental project, because it is in most cases simple to give emphasis to real problems: the shortage in water supply, the odour when floating blue-green algae are forming foam in the late summer, the transparency of a lake used for sailing or swimming, the reduced species diversity of fish and so on.
8. Environmental education in general is very well suited to formulate an educational project. Current examinations of a lake or reservoir and the implications of the present water quality for the use of the water and the ecosystem is a straightforward project which is realistic, illustrative, problem-oriented and multidisciplinary at the same time.
9. Such a project gives also occasion to discuss the relationship between the lake, river or reservoir and the adjacent local society. Again, selection of inland waters as focus for environmental education meets this objective, as the local

society is very much dependent on the freshwater ecosystems, for water supply, for recreation and for transportation, but they play usually also a major role for the local climate. The entire watershed is dependent on a proper management of the aquatic ecosystems in the region.

10. The project can furthermore illustrate that the social-economic life, health conditions, drinking water supply, various types of jobs and recreational activities, are strongly dependent on the inland waters in the region.

On the basis of this brief discussion of the objectives of environmental education given above with relation to inland waters, it can be concluded that an environmental educational project focusing on inland waters is particularly well suited to meet all the ten objectives.

Details on how to implement such educational environmental projects focusing on lakes or reservoirs are given in Chapters 2 to 4, while the experiences gained by pilot school projects in 6 different countries with very different cultural and climatic background are summarised in Part II. The final selection of a suitable environmental educational programme should obviously consider on the one hand the objectives and available tools to meet these objectives and on the other the social-economic-cultural basis for the education. It is therefore considered of significance to find a feasible solution to the implementation of inland waters for environmental education in both developing and developed countries of different geographical regions to be able to give recommendations which can be used widely. Obviously, the industrialised countries will be able to offer better equipment for the implementation of an environmental educational project than it is possible for developing countries, but it does not imply that the industrialised countries can offer better school projects. The success of the environmental educational school projects is probably more dependent on the enthusiasm of the school teacher than on the quality of the equipment. It is an important challenge to make useful equipment for lake and reservoir observations with what is at hand and at no or almost no costs. The educational result of this challenge may be more important than a series of accurate measurement by use of sophisticated equipment.

Guidelines on how to make low cost equipment are given in Chapter 3 but can also be found in UNESCO-UNEP-ICCE's publication "Suggestions for making and using low cost equipment from 1992".

A few ideas to implement in context with environmental educational projects with reference to the ten objectives are given below. It is important to use the proposed activities for a wide discussion on the environmental aspects and turn them around several times and from different angles for a better understanding according to the objectives. The ideas given below are mentioned in more detail in connection with the national experiences in Part II.

A. *Measurement and observations of the annual cycles of temperature (profile), water transparency and concentrations of nutrients* can be used for objectives 2, 3 and 8.
B. *Observations of fish, insects and bird species* can be used for a discussion of objectives 3, 4, 5 and 8.
C. *Drawings and photos of the inland water environments* can be used for objectives 1, 8 and 9.
D. *Following the water cycle: drinking water supply → waste water → waste water treatment (if any) → discharge of treated waste water → self-purification in the lake or reservoir → evaporation → rain (better quality? air pollution?)* can be used for the objectives 2, 3, 6, 7, 8, 9 and 10.
E. *Comparing different inland waters in the adjacency of the school* can be used for the objectives 2, 3, 4, 5, 8, 9 and 10.
F. *Examination of the quality of the rainwater* can be used for the objectives 3, 4, 5, 6, 7 and 8.
G. *Examination of the food chain in the inland waters* can be used for the objectives 4, 5, 6 and 8.
H. *Examination of the use (fishery, drinking water supply, swimming, boating) of the inland waters in the region* can be used to cover the objectives 6, 8, 9 and 10.
I. *Examination of the water regulation* can be used to cover 1, 5, 6, 8 and 9.

1.3 ILEC and Environmental Education

ILEC has an interest in all projects which can increase concern for and the information about inland waters environments. It is therefore natural for ILEC to support an environmental educational project focusing on inland water environments. For a period of seven years, ILEC has supported and followed the environmental educational project referred and summarised in this guideline book. The main idea has been to assess the educational methods that give the best and most certain results in different countries, with different backgrounds. From the very start it was considered of importance to run pilot plant projects in different geographical regions to gain experience based on different cultural and climatic backgrounds. It has been possible to obtain experience from Argentina, Brazil, Denmark, Ghana, Japan and Thailand. As seen, it has been possible to get a wide geographical coverage with two industrialised countries from Asia and Europe and four developing countries from three continents. There is no doubt that it has influenced the results in the different countries, that water and water quality plays a different role in the six countries. This issue will be further discussed in Part II, where the national experiences are presented.

ILEC's general interest in environmental management has emphasised the need for a

multidisciplinary approach and for the role of the watershed. In lake and reservoir management it is stressed again and again that we cannot solve the problem of a lake or reservoir, if we don't look into the entire watershed, because what is going on in the watershed influences the lake, the river or reservoir and these aquatic ecosystems influence the entire watershed and its social-economic life. An inland water is an open system which is highly dependent on the forcing functions determining the inputs. Only through a proper control of the anthropogenic forcing functions it is possible to solve the environmental problems. This is consistent with objective number three, mentioned above.

The emphasis on the impact by the entire watershed should be reflected in environmental education and is furthermore consistent with objective number nine and ten. It is recommended to include in the environmental education the role of the entire watershed, for instance by the application of the following list of questions:

I. Find the drainage area of the considered inland waters.
II. How many inhabitants are there in the entire drainage area?
III. Where is the waste water in the drainage area discharge? After which treatment?
IV. How is the water supply for the inhabitants of the drainage area covered? Ground water or surface water? What is the quality of these two types of water? Which treatments are used?
V. Which industrial productions characterised the drainage area? Which compositions and amounts of waste water, smoke and solid waste are coming from these productions? Where are these amounts of waste water, smoke and solid waste discharged and after which treatment?
VI. Which more or less toxic compounds will as a consequence of V be discharged to the lake or reservoir? What effects will they have?
VII. What agricultural activities are going on in the watershed?
VIII. Approximately how much fertilisers and pesticides are used? Which types of fertilisers and pesticides? What do we know about the fate of these compounds? With relation to the inland water quality?
IX. What has been done to reduce the pollutants originated from agriculture (reference to question VIII)? What should and could be done? How?
X. Survey the touristic activities in the watershed. Which inverse effects on the water quality have these activities?
XI. What has been done to solve the problems related to tourism, see question X?
XII. Which other activities are of importance for the water quality in the watershed? Which considerations have been carried out to solve the related problems?
XIII. What are the social-economic implications of the inland waters? What role do they play in the social-economic life of the region?
XIV. What is the general environmental policy of the region? Does it consider sufficiently the local and regional environmental problems? How is it

coordinated with the regional policy in other areas? Is the environmental questions considered sufficiently in, for instance, the economic planning of the region?

XV. How many jobs in the region are directly dependent on the water quality?

It is not necessary to include all these questions in every planning of environmental education, but it is important to include some of the questions to demonstrate the relationship between watershed and the inland waters, because that will give a clear impression of the human impact on inland waters and also indicate that something can be done, provided that we control (reduce) at least the part of our activities that have the most pronounced effect on the environment. It is crucial in environmental education that there is a very narrow relationship between the anthropogenic forcing functions and the conditions for the ecosystems. A control of the forcing function based on a good understanding of the fundamental functions and properties of ecosystem is therefore crucial in environmental management. This is one of the most pertinent messages to give in environmental education, as it opens for a positive attitude towards the measures to be taken, even if they imply a reduced consumption or welfare. These aspects of environmental education are significant in democratic societies where the attitudes and everyday behaviour of every citizen count and will imply a certain effect – in this case on the quality of inland waters in the region.

Some of the questions I-XV would require too much insight in local or regional conditions to be answered by the lower grades in the public school. It is, however, essential to apply the watershed view in all grades, but it may be advantageous to reserve the most comprehensive and widest use of the watershed view, perhaps including the more social-economic aspects (mainly questions XIII, XIV and XV), to the gymnasium or at least to the grades 8-10. If the pupils are considered to have sufficient insight into regional and local problems, then watershed planning in general is an excellent topic to include in discussion of social sciences, as it is easy for the teacher to find local, easily understood, illustrations.

This part of the guideline book has given some indications of how inland water environments can be used as illustrative examples in environmental education. The core objectives of environmental education have been presented as a tentative basis for the implementation in practical school work. It has been demonstrated that inland waters give some particular possibilities to meet these objectives, which is made concrete by a series of components that could be included in an environmental educational project.

In this section the importance of the watershed view has been emphasised. The application of this view in environmental education was illustrated by 15 questions which could be incorporated in environmental educational projects.

This part of the guideline book gives some basic ideas and considerations, but does not give a sufficient basis for practical implementation of inland water environments as the core theme in environmental education from grades 1-12.

The practical educational recommendations are presented in Chapters 2 and 3, details about the incorporation of environmental education in current school education programme, preparation of curricula, preparation of teaching materials, suggestions to laboratory experiments and field studies are given.

Chapter 4 of this volume discusses environmental education classes, involvement of local communities and the training of teachers, of particular interest for developing countries.

Part II presents the national experiences gained by ILEC's educational pilot plant project. The results are compared and discussed with reference to the basic aspects presented in this part and the practical aspects presented in Chapters 2 to 4.

CHAPTER 2

DEVELOPMENT OF CURRICULA

Sirmsree Chaisorn

Practices in the development of school curricula in different countries depend on their educational systems and educational theories they adhere to. In many countries where education is more centralised and national syllabi are prepared for all schools, it is difficult to find schools where teachers take the initiative to adjust or add new aspects to the curricula. However, that initiative is most desirable if students are to gain meaningful learning experiences. Curriculum framework should allow for diversities and flexibility so that school learning can be made more relevant to students' practical-life needs as well as to the present and future needs of each society. School personnel, administrators and teachers alike, should be empowered to enhance or design learning experiences appropriate to local, regional, and global communities. Students need to learn how to tackle problems facing their own life and communities effectively. In such a school-based programme, awareness of world-related issues must also be developed since we are all living in increasingly interdependent world environments.

Environmental education school curricula developed in the six countries participating in the ILEC-EE project focusing on inland water resources during 1989-1995, are examples of various school-based curriculum development efforts which could be applied in both centralised and decentralised educational systems. The projects in some countries such as Japan, Ghana and Argentina have had profound effects on environmental education curriculum development and production of new teaching materials at the provincial or district level of their educational systems.

The present educational system in most countries participating in the ILEC project, have no compulsory independent courses for environmental education. Some courses such as "Environmental Studies" and "Surrounding Environments" which are in the lower-secondary school curriculum of Thailand, for example, are offered as electives and need to be made more localised, more experiment-and inquiry-based, and more stimulating. Teachers of "Life Studies" course in the first and second grades in Japan used more effective teaching approaches supported by ILEC. Environmental education is normally integrated into various subjects in the curriculum such as science, social studies, language, art, and agriculture.

To practically develop successful environmental education in schools, either through these courses or some other approaches, many aspects can be learned from the ILEC school projects.

2.1 Developing school policies that foster environmental education

School administrators should themselves be truly concerned with the state of the environment and problems of all levels if they want school teachers to be active and forward looking in organising environmental education for students. School policies must be continuously established, to set forth action needed during the specified amount of time. Policies that foster environmental education must include the following attempts:

- Familiarising school teachers of all subject areas with updated information about local and world environmental situations.
- Inviting innovative ideas or projects from teachers to increase both teachers' or students' understanding of environmental matter.
- Allowing the implementation of challenging projects by providing supports of all kinds.
- Encouraging cooperation with other organisations outside schools to help with environmental education projects. These organisations may be universities where there are many experts in various fields, local and other national authorities, or non-governmental agencies, etc.
- Encouraging cooperation among teachers of different subjects to work together in organising learning experiences for students both in course work or special projects.
- Making school environments a resource centre for students' study to be friendly with the natural environment and reinforcing attitudes such as their love-of-nature.
- Promoting enjoyable scientific learning activities both in classes and outdoors to cultivate students' scientific mind.
- Setting for environmental education activities for the entire school at least a few days once a year so that teachers and students can plan and work together to get everybody, including the local community, involved in learning about environmental issues and thinking about solving some of the environmental problems.

These policies should be announced to all school teachers early in the beginning of each school year to allow discussion and plans for action.

2.2 Alternative programmes and organisations for environmental education in schools

1. Infusion approach

This approach calls for the revision of and addition to existing courses. Teachers of each school subject should re-examine their course content in order to add new topics, examples and cases, some details, including learning activities that are related to understanding of natural and socio-cultural environments. In Danish schools,

where teachers have much freedom to select their own topics since there are no examinations or grading required in the first seven grades, it is easy to introduce a topic such as "Lakes" into many subjects. Each subject treats the topic in its own specialised ways. Teachers can even team themselves to carry on many learning activities together if they work on changing their teaching schedules so that they can teach related topics about the same time. In reading and written, students can read passages and write about important local or world water bodies and environmental problems we are facing. They can make a written or oral report of their study on danger of pollution, or describe the importance of their local water resources to their lives. Some subjects lend themselves to treat environmental topics deeper than others. These subjects include science, social studies, language, and agriculture. In Japanese pilot schools, at least 10 hours in each class of different subjects are spent for environmental education during the academic year. The infusion of environmental topics into various existing subjects creates multidisciplinary curriculum development in the selected themes. This approach depends much on individual subject teachers' views and their recognition of the values of contents to be added. However, if the school policies are made prominent in this regard, it should be the responsibility of all teachers to act. Schools must have some way of monitoring in order to reinforce teachers' efforts or help solve some problems they may encounter. The trouble of the infusion approach of curriculum development is that when all teachers know that it is the responsibility of everyone, then someone may not take action. It might end up with only a few subject teachers making an effort.

In Denmark, pupils learn ecology in biology, measure pollution in chemistry, analyse costs of pollution in mathematics, illustrate the concepts of food chain in art classes. In Ghana, environmental education is integrated in social studies, cultural studies, life skills, general science, agricultural science. Students took environmental education four periods per week in schools but not every week.

2. Addition of new courses or new integrated units

New independent courses may be added to the syllabus with one teacher or a group of teachers in charge of course management. In many countries, this is a recent approach since the curriculum development committee, either at the Ministry of Education level or at the provincial or school level, realise the necessity to extensively educate young people about our community and global environment. These new courses are added to certain subject areas, normally to science and social education programmes.

Some of these new courses are electives. Some are required. The latter are added into the syllabus as parts of the core courses which all students in schools must study. These new whole courses may be organised using interdisciplinary or integrated concepts which mean the course content are selected according to the themes. Each theme becomes a unit. The content and learning activities selected for one theme or

one unit may come from various disciplines. It might be necessary to create an interdisciplinary team comprising different subject teachers to carry on these integrated teaching and learning units. Although the experiences from the school projects in Argentina indicated that the interdisciplinary approach is more effective in primary schools, where contents are quite basic and one teacher can manage to organise learning activities for their pupils easier than in the secondary schools, it is still a sound curriculum development approach for the problem-based content. Open-minded and cooperative teachers holding holistic views of environmental issues are the key elements to bridge the gap between theory and practice.

In the syllabus of some countries where new courses in environmental education are not yet introduced because room is still being arranged to add new courses, one big unit can be organised by a group of teachers from related disciplines in order to plan for exciting learning experiences for students. Of course, close cooperation and planning time among teachers are needed. And this is the most difficult part. In the case of Thailand's Chiang Mai project, science teachers and social studies teachers planned and taught students on "Water and Life" unit for 10-12 hours in lower-secondary pilot schools using "Environmental Studies", which is an elective course in social studies area, as a base. The same unit with simpler content was taught at the elementary school level where the individual teachers of "life-experiences" can manage the whole instructional plan and activities by themselves.

3. Co-curricular activities

Through various students club activities, environmental education can also be promoted. Students learn to manage all kinds of plans and activities by themselves under the supervision of teachers. Usually students who have similar interests will belong to the same clubs. Nature-loving clubs or Nature Conservation clubs are among the most popular groups. Furthermore, clubs such as the Photography, Journalism, and Tourism might also play a vital role in providing environmental knowledge. Not only can they pursue their interests without worrying about grades like in the programmes of study, students could also disseminate their findings to other students in schools and to the public at large as well.

In Argentina, Secondary School No.71, which is a pilot school in Concordia city, started an extra-class workshop for 30 students. With some training in collection and interpretation of information, they could develop skills in social communication for the community with understandings of environment problems and conservation. The relocation of residents caused negative attitudes toward the Salto Grande Reservoir. Students were successful in changing people's attitudes so that the reservoir can be used and enjoyed. This project was awarded a citation by the municipality of Concordia. In the second year, the project students used the kitchen of a house nearby the reservoir as their laboratory for meetings and study of blue-green algae, pollution of the reservoir. In Brazil, a "Water quality kit" was designed by a staff member of

the University of São Paulo and provided to more than 20 schools. Students used the equipments in the kit for extra-curricular activities, collected data weekly for a period of 6 months. Data from various watersheds were compared.

4. Special projects

Special projects may be related to many courses or they may be special events planned for the whole school and communities. Two main pilot schools in Denmark were very successful in working on multidisciplinary projects centred around science. The Seven Stars School had three major lake projects integrated in science classes of three different levels. In Project 1, "Excursions to Lake Fure", third grade students sampled phytoplankton, zooplankton, measured water quality and collected data relating to seasonal variations. In maths classes, students plotted graphs on different topics. Project 2, "Water cycle", fourth grade students visited a drinking water plant, and sewage treatment plant, discussed about water consumption and reduction of consumption. Water consumption was calculated in mathematics. Students studied birds, fish in the lake and on lake shores. They produced posters of their observations. Project 3, "Lake model software", fifth grade students learned from computers. The lake project in this school continued to grade six in which groups of students studied and compared different lakes to learn about lake ecosystems. For seventh grade, they got to analyse nutrients in lake water in chemistry class, studied deeper the biology of freshwater fish and birds. Another special project is the yearly one-week project for all classes in the school to study one local theme such as "Urban ecology" and "The rain forest".

At the Vestervang School, another of the Danish pilot schools, the entire school was involved in "The Energy project". Students studied energy consumption, ways to reduce the consumption, greenhouse effect and acid rain. Another interesting project involving the whole school was called "Nature", where students had opportunities to go on a one-week nature camp. Upon their return, some wrote about their experience in the school journal. Other projects that were carried on in some classes included "Rivers and streams" and "Our school".

In Ghana, pilot school projects attempted to get joint participation of community members in some outdoor activities such as "Cleaning up our environments". Residents along the Densu River bank worked with school children in various project activities. Student-made posters of health problems, sources of pollution, sand boxes, and a model of the Densu River basin were used to educate the local community. The schools were successful in trying to involve community residents in the identification of solutions to environmental problems such as health problems, unsanitary waste disposal, and pollution caused by household waste. People changed some of their habits. They boiled river water before drinking it. Ghanian school projects did have positive impacts on the local community. It was, however, suggested that tactful approaches were needed at the initial stage to get community agreement.

The Shiga Prefectural Board of Education in Japan offered various environmental education programmes for fifth grade students in the floating school, Uminoko. This big boat can take up to 240 students at a time. Students studied the water quality of Lake Biwa and the physical environment in and along the shores of the lake.

2.3 Curriculum designs appropriate for real-world education

All the ILEC environmental education school projects had put theory into practice in terms of designing curriculum and instruction appropriate for local and world needs. Every project began with choosing water bodies that are close to school areas and significant to people's lives as the study sites.

- Brazilian project schools used Lobo-Broa watershed and Lobo reservoir.
- Shiga schools studied Lake Biwa, the main source of water supply for millions of people in Japan.
- For Danish people lakes are important recreation areas.
- Chascomus Lagoon was the study-site for project schools in Chascomus, Argentina. Also in the city of Concordia, students studied Uruguay River and Salto Grande Reservoir.
- Densu River and Weija reservoir were the centre of Ghanian school projects.
- Pattani River Basin and mangrove forest in the southern part of Thailand were the main study areas of the students in Thailand's Pattani project.
- For Chiang Mai project in the northern part of Thailand, Ping River and its watershed were used.

Experiential learning was emphasised in all projects. Both elementary school and secondary school students were provided opportunities to observe, experiment, analyse, construct, work on many sub-projects, discuss and learn about their surrounding environments. They learned the causes of environmental problems and tried to find various ways to solve such real-life problems. Problem-based learning helped students gain many essential life skills together with scientific and social processes. Curriculum designs focusing on experiential learning or problem-solving relating to environmental studies need consideration from various viewpoints and cooperative actions. Using thematic units which can be multidisciplinary or interdisciplinary seemed to stimulate students' concerns and curiosity.

2.4 Arrays of learning objectives for environmental education

From Chapter 1, ten important objectives of environmental education were stated. The project reports of the six countries revealed arrays of learning objectives which can be viewed as the modification of those ten objectives. The following are the objectives analysed from the reports of each country in terms of students' learning outcomes. Students should be expected to acquire knowledge, attitudes, and skills as follows.

Objective 1: To change learners' attitudes toward the environment and nature from "indifferent" to "very concerned"

- To gain knowledge of and be more concerned with environmental problems.
- To be more sensitive to environmental problems and life quality.
- To take active roles in protecting the environment and water resources.
- To help community people understand the concepts of environmental conservation.
- To have the attitudes of human living in harmony with nature.

Objective 2: To promote understanding of the function of the nature

- To be aware of the limitation of natural resources.
- To gain deeper knowledge of natural resources especially wildlife, forests, and water resources.
- To realise the magnitude of the impacts of human activities on the environment.
- To be aware of the limited capacity of nature in absorbing some pollution.
- To learn about origins of pollution, and the kinds and effects of diseases caused by pollution.

Objective 3: To increase knowledge of basic natural principles

- To be able to apply conservation principles in daily lives especially the principles of recycle, reuse, and reduce unnecessary consumption.
- To understand sustainable development strategies.
- To realise the interdependence of natural components in ecosystems especially aquatic ecology, and rural and urban ecology.

Objective 4, 5, 6: To enhance holistic, multidisciplinary and interdisciplinary approaches in learning about environmental conditions and problems

- To be able to analyse their immediate environment and global environment using an holistic approach.
- To be able to describe the relation between immediate environment and global environment.
- To understand the needs of multidisciplinary and integrated approach for understanding and solving complex environmental problems.

Objective 7: To encourage problem-oriented methods of teaching and learning

- To realise the discrepancy between measured values and sensory estimates.
- To have direct contact and experiences in local reality.
- To be able to use scientific language and equipments for experiments.
- To value scientific experiments.
- To learn scientific processes, thinking skills, inquiry skills, investigation skills, problem-solving skills.
- To learn to listen and be tolerant to others' opinions in group work.

- To know how to measure water quality.
- To have skills in related subject fields that are used in collecting and analysing environmental data: Calculation skills, statistical analysis and presentation, interviewing, recording, drawing, communicating, performing, composing, etc.

Objective 8: To encourage concrete projects in environmental education

- To be able to transfer knowledge to action.
- To participate in cooperative activities between school and community.
- To learn how to obtain cooperation from the public or outside-school authorities.
- To be actively involved in community development programmes.
- To be able to create projects that help improve community environment and raise people's life quality.
- To propose ways to disseminate information about environment problems and their effects to the public.

Objective 9: To reveal man's complete dependence on nature

- To understand the relationship between human lives and natural resources.
- To realise the danger of shortage, deterioration, and contamination of natural environment to mankind.
- To identify global problems relating to environment and the quality of life.

Objective 10: To consider the role of our environment in society

- To find a social-economic factor.
- To reveal how many social-economic problems are explained as environmental problems.
- To reveal how insufficient short-sighted environmental decisions create social-economic problems.

2.5 Scope of environmental content for school students

Lessons of inland water resources conducted in the ILEC school projects in all countries have provided a variety of topics to be covered. Samples of these topics are illustrated below:

1. Watershed ecosystem and subsystems:

- Water bodies: lakes, reservoirs, rivers, canals
- Bio-diversity: forests, wild-life, natural resources, vegetation, geology, flora and fauna in lakes or rivers, fish and fisheries, bird life in the lakes, reed community, aquatic insects, macrophytes, phytoplankton, zooplankton
- Use of water, water cycle
- Food chain
- Renewable/non-renewable natural resources

- Self-purification of nature
- variability and adaptability of nature

2. Affective links between waterbodies and people:
- Human settlement
- water supply and treatment for drinking water
- Agricultural use/irrigation
- Recreation areas
- Effects of nice and clean water and environment on people

3. Local and global environmental problems:
- Loss of bio-diversity
- Pollution from industrial, agricultural, and domestic sources.
- Water pollution and other types of pollution
- Solid waste accumulation and unsanitary dumping and disposal
- Problems of phytoplankton, algae, and red-tide phenomena
- Sediment or suspended matter
- Acid rain/acidification
- Deterioration of recreation areas
- Deforestation/desertification
- Overuse of chemical fertilisers in agriculture/ground water quality
- Soil erosion/alteration
- Analysis of human overconsumption of all types of resources, consequences, solid waste, waste water, seasonal changes, change in visual scenics, toxic chemicals, health problems, water-associated diseases
- Ozone depletion
- Marine pollution
- Global warming/greenhouse effect

4. Solving environmental problems:
- Management of solid waste and waste water
- Sustainable development
- Concepts of "reduce, reuse, and recycle"
- Eco-tourism
- How to improve water quality
- Laws and ordinances

5. Experimentations:
- Acidic solution, neutral solution, alkaline solution
- Measurement of water quality of water samples, water temperature, transparency/turbidity, pH, conductivity, dissolved oxygen, phosphate ion (eutrophication), pH of rain water, pH in soil, light penetration in water, (water samples – domestic wastewater, river water, lake water, juice, tea, industrial

wastewater, liquor, vinegar)
- Climate – radiation, air temperature, humidity, wind direction, precipitation, soil temperature, light penetration in forests
- The wonders of the microscopic world in the laboratory
- Solution which dissolve gas, Metal in diluted HCl,
- Lime in paddy fields.
etc.

In most cases, many environmental concepts taught in elementary schools were basically the same as those taught in junior high schools. However, content and experiments studied and engaged by upper-grade students were more complex and more detailed. Some schools gradually increased the scope of content from common interests or students' immediate environment to the more complex ones. Daiho Elementary School which was one of the pilot schools in Japan, for example, introduced first graders with "wildlife animals", expanded it to "living things" for second graders, discovering and exploring things in Nakanoi River in the third and fourth grades, exploring Lake Biwa in the fifth grade and learning about global environment in the sixth grade.

2.6 Recommended teaching methodologies and techniques

All the students who participated in the ILEC environmental education project reported their appreciation and excitement of the learning activities they had gone through. The following approaches in teaching and learning concluded from the projects, therefore, have been proved effective to the large extent.

1. Activity-based learning/teaching: This method stimulates students to actively study about environmental conditions and principles. Teachers must develop the programmes that centre around students' action both in and out of classes. Students should also be allowed to choose and plan their own activity. The teacher should encourage the curiosity of the students and provoke them to ask "why?". This would initiate the student engagement in activity-based learning. Some activities can be short and can be done within 1-2 class periods. Others can be long-term projects involving many kinds of investigations and thinking processes. Survey activities in real environmental settings, for example, help students identify the origin of pollution of the rivers receiving industrial, agricultural and domestic effluents. In many pilot schools, after the examination of phosphate ions in water samples, students were helped to proceed to the thinking and discussion of how to prevent the eutrophication problem of the rivers and lakes under study. These kinds of activities finally can lead to action plans and implementation to help solve some community problems.

A campaign and drawing contest on Pattani River conservation including organisation of an " Environmental Day" were examples of activities done after the

survey study and experiments on water quality of the Pattani River in the Pattani project in the South of Thailand. Students also wrote essays and set up exhibitions of mangrove forests they studied.

2. Field-trips or excursions: Students could learn to observe, investigate, and appreciate important environmental concepts such as ecological systems, environmental deterioration and pollution sources, and conservation strategies through excursions or field-trips. Besides nearby rivers, lakes, reservoirs, students in our pilot schools also visited watershed areas, supply water plants, waste dumping sites, museums, etc. Teachers gave orientation before the trips so that students knew what to do during the trips and later in class discussion, experiments, or summary. Students might need to collect water samples, take photos, record climate and water condition. These outdoor activities allow students to have direct contact with the environment. Nature trails in camping sites or in the watershed areas may be arranged for students. Given appropriate time, place, and necessary equipments, students could make their own discovery through such direct contact. During the nature-walk activities, for example, students could be encouraged to see, hear, smell, and feel the wonder of our natural world using all their senses. Some tasting activities can be done with caution. Children or students could learn to appreciate the sounds of nature such as rustling leaves, birds, squirrels, waterfalls, etc. Students of Chiang Mai project have seen the clearness of water at the waterspring upstream of a branch of Ping River and the sedimented Ping in most parts of the downstream.

Field-trips to certain places may be far away from schools. Excursions, however, could be in nearby surroundings close to schools or even in the school ground where students can learn about some environmental aspects in depth. All pilot schools in our project used excursions as one of their major learning activities. Different kinds of artistic expressions such as drawing, painting, making collage from dried natural materials, making up stories relating to natural world, writing poems, writing for school journal, could also be fostered during and after excursions and field-trips.

3. Scientific experiments: The value of scientific experiments must be stressed if students are expected to experience the excitement of learning and to learn about environment in depth. It was made clear in the Shiga project in Japan that environmental education is not just involvement in the activities such as cleaning public spaces, growing flowers and trees, but that science education has its major role.

Students must learn to realise the advantages of different scientific ways and levels of analyses to understand our environment deeply. For instance, to really understand about acid rain, it is, as the Shiga project suggested, insufficient to use only litmus papers. Students must collect water samples and measure pH of rainwater in the areas. Scientific experiments can be carried out both in school laboratories and at

outdoor study sites depending on the subjects under study. Besides the process of discovery, students will gradually get acquainted with scientific language and be able to use scientific equipments more skilfully. This knowledge and skills will tempt them to further search for more understandings about local and global environments.

More details in organising environmental classes such as for laboratory experiments will be illustrated in Chapters 3 and 4.

4. Group investigation or group work: In most observational and laboratory studies, for instance, soil analysis or research of insect diversity, students can work in groups. They can learn to help each other in planning, observing, recording, making hypotheses, collecting more needed information, preparing equipments, carrying on the experiments and making conclusions. Through group research projects and other types of group work such as discussion and problem-solving, students will learn to listen, share ideas and experiences and learn to be tolerant to others' opinions.

In Ghana project, students in a school worked in groups to make posters of health problems and sources of pollution, to construct sand boxes, wind vanes, sun dials, rain gauges. Reforestation is another kind of activity students can do in groups.

5. Problem-solving approach: Problem-solving is a natural-life process of humankind. Problem-solving steps might be slightly different when different people talk about or use the approach. In general, it encourages learners to:

- recognise the problem,
- seek information,
- analyse it,
- propose possible solutions,
- test consequences of those solutions,
- select a solution and evaluate the selected solution,
- make a summary.

Teachers in Argentinean pilot schools used the following steps:

- study real situations,
- identify problems and search for relevant information,
- collect information from various sources using various methods,
- sketch possible solutions and select the most appropriate one,
- make suggestions or proposals for implementation.

Classroom atmosphere can be serious but good and stimulating with students actually spending time on learning tasks. Learning can be serious, fun, and experiential. The pilot schools in Ghana successfully involved local community residents to work

cooperatively with students in identifying environmental problems and solutions. This joint school and community activities gave students realistic experiences. They used this particular approach in place of their inadequate laboratory settings. That means so many things can be done to give students meaningful environmental experiences.

It becomes clear that the more real and authentic the problems chosen for study are, the more motivated and skilful students would be.

6. Discussion: This teaching method is very important for enhancing thinking abilities. It can be used together with all other teaching methods and all other kinds of activities. Teachers may lead the whole class to discuss about particular topics or conditions in any stage of the lesson being taught at the beginning, during main instructional activities, and the lesson closure. Students may be assigned to exchange ideas or opinions among themselves, in pairs or in small groups. Environmental education deals with real-life surroundings or situations which need a lot of discussion. Many times an actual case method is used to give students some information or knowledge to discuss about. Role-play and other simulation activities would lack their meanings without discussion of the situations and the solutions to solve the inherent problems. In order for students to discuss, it is advisable that teachers prepare sets of key questions to use in classes or in all other learning activities. In Sawayama Elementary School in Japan and in the Seven Stars School of the Danish project, as in other pilot schools, questions were raised to guide students' discussion and research.

a. Examples of questions in Sawayama School were:
   - Can acid rain dissolve concrete and metals?
   - What are other solutions that can dissolve metal?
   - What can we do to prevent damage from acid rain?

b. Examples of questions raised for class discussion at Seven Stars School were:
   - Why is the lake so green?
   - Do you like to swim in green water?
   - Why is the water warmest at the surface during summer?
   - What does zooplankton eat and who is eating zooplankton?
   - Can we reduce water consumption?
   - Why should we reduce water consumption?

7. Using resources for inquiry learning: Teachers can provide some information for students with the purpose of building up their curiosity to learn new things. They can use any kind of media or resource together with stimulating questions as a springboard of students' inquiry. The term "Resources of learning" covers places, audio-visual materials or multi-media, and persons. Teachers act as facilitators of

learning by asking questions and providing resources while children are observing water plants, for example. Teachers sometimes give incomplete or partial answers, just enough for students to do their own further thinking and find out essential information needed by themselves.

Many pilot schools produced small textbooks on various kinds of topics for students. The design of these textbooks should lead to inquiry activities within which students enthusiastically probe into the topics and search for information or answers that sometimes are not included in the texts.

Inquiry learning may be short or long scientific learning projects. It can be close-ended inquiry where teachers let students think of the expected answer from analysing different types of instructional media. It can also be open-ended inquiry where both students and teachers together put the efforts in finding out about certain environmental aspects. Teachers should be models of inquirers through both their sincere actions and words in order to lead students to be truly interested in the natural and social environments and phenomena. If teachers always look, hear, smell, and listen to things in nature, using necessary equipments, their students would use their own senses the same way.

Preparing teaching materials to foster students' inquiry is a very important task that teachers or those who are working for teachers must be truly concerned with. There are many kinds of resources that we can use for inquiry learning as follows:

- Audio-visuals: pictures, video-tape, charts, slides, real cases, constructed cases, work sheets, learning packages, etc.
- Equipments: laboratory equipments, measuring tools, etc.
- Interactive media: games, simulations, role-play cases etc.
- Places: parks/watershed, water supply plant, factories, sewage treatment plant, governmental offices, rural communities, urban communities, school ground, dump sites, lakes/rivers, etc.

8. Evaluation of environmental education programmes: Similar to all other programmes, environmental education programmes need to be evaluated so that their successful aspects can be reused or reproduced and some can be refined, modified, improved, revised or eliminated before the next attempts. Moreover, the elements found effective can usually be good examples for the others who want to run new environmental education programmes. The simple way to go about evaluating the programmes is to ask these questions:

I. **What are the things we want to evaluate?**
This decision is the most important step. The list below illustrates some aspects to evaluate. Programme objectives are usually the main source of the list.

a. Students' progress and achievements
   - Students' increased awareness of natural and social environmental concepts and problems
   - Students' deeper knowledge of nature and environment especially in relation to humankind
   - Students' attitudes toward reasonable approaches for conservation and participatory learning
   - Students' abilities and skills in scientific processes and learning in general
   - Students' unexpected learnings

b. Teachers' roles and teaching competencies
   - Teachers' knowledge and awareness of environmental issues and problems
   - Teachers' ability to plan for and implement the instructional plans
   - Teachers' enthusiasm in the programme and expansion of their own knowledge and skills
   - Teachers' ability in using scientific tools
   - Teachers' ability in guiding students' inquiry learning in classrooms, laboratories and outdoors
   - Adequacy of teachers' preparation or training of environmental classes
   - Appropriate guidebooks for teachers' use

c. School and community recognition and acceptance of the importance of the programme
   - Their agreement with the objectives and the activities of the programme
   - Their cooperation with teachers and students in students' learning activities and actions
   - Their awareness of the programme impacts

Evaluation criteria should be established to examine the relevance, effectiveness, and the impacts of the programmes and programme management.

II. Who should be the evaluators?

The evaluators may be project committee who guide or arrange the programmes, teachers and students who are in the teaching and learning contexts, school administrators who provide support for the programmes, local authorities and communities who participate in programme activities and receive the impact from the programmes. All may be needed to give evaluative judgement.

III. How should we evaluate?

What evaluation methods and instruments should be used? If we want to find out the facts, it is suggested that we should use a variety of evaluation approaches and instruments. Here are some examples.

- Tests on different topics (paper and pencil/performance tests)
- Questionnaires/lists of open-ended questions
- Self-reporting
- Observation
- Discussion/seminars
- Interviews

Samples of open-ended questions the Argentina project used with their teachers were:

- Consider to what extent the programme stimulated learning.
- What aspects of the programme will have to be kept, modified, or eliminated to improve or strengthen it?

Samples of test questions they used with primary-level children were:

- Describe what happens in a lake in different seasons of the year.
- Do you consider that the lake or small stream is in good condition? Justify your answer.

It is through sound evaluation that we will learn whether our programmes are based on real problems of local communities and the real world or not. Necessary change needs to be done if the results of the evaluation reveal the ineffectiveness and inappropriateness of even the small parts of the programmes so that learners could be better taught to acquire essential skills and are encouraged to learn and act in accordance with the environmental principles.

CHAPTER 3

DEVELOPMENT OF TEACHING MATERIALS

Munetsugu Kawashima

3.1 Necessity and importance of teaching material development

Since the United Nations Conference on the Human Environment in Stockholm in 1972, many conferences have been held to solve environmental problems. The importance of environmental education has also been emphasised since the International Environmental Education Workshop held in Belgrade in 1975. The Belgrade Charter states:

1. **Goal of Environmental Action:** To improve all ecological relationships, including the relationship of humanity with nature and people with each other;

2. **Goal of Environmental Education:** To develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skill, attitudes, motivations and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones.

On the other hand, such environmental problems as global warming, acid rain, ozone depletion, ocean pollution and more localised regional environmental problems are still advancing. It is extremely difficult to find effective measures to essentially solve these problems. Even if every possible measure is taken in the fields of technology, law, politics and economy, global environmental problems cannot be solved, nor can the sustainable society be established, unless the life style of the people in the world undergoes significant changes. Thus, the importance of environmental education has increased, and the progress of environmental education will play a significant role in human efforts to prevent environmental disruption.

The concept and the importance of environmental education have been discussed and developed worldwide. However, it cannot be said that its methodology has been fully examined and therefore, environmental education has not been sufficiently implemented. Under the circumstances, it is not quite easy at this moment to indicate how to systematise the curriculum and develop the teaching materials for environmental education in school education as well as in-service education.

3.2 Viewpoint of teaching material development

When we take up environmental problems in school education, some can be dealt

with in the framework of existing subjects, but some may include content that can be adopted neither in science nor in social studies, and the different perspective for teaching materials may be requested. The following points should be considered in this context:

1. Environmental problems have not fully found their causes and effects and any environmental problem is an ongoing problem. It is important to realise the situation where education becomes necessary to address these problems without the causes or effects fully identified.
2. It is important to be willing to convey the correct information to students, but we should realise that this is not always possible. In addition, the perspective of prediction (future perspective) is needed, but it is also important to keep in mind that scientific predictions are uncertain.
3. Environmental problems are not coming from an immediate reaction for a short period of time, but are taking place slowly. We need to take time into consideration. It is inadequate just to make haste in showing and describing the cause and effect (the situation of damage), and it is necessary to try to handle the ongoing changes with students' participating in experiments, researches, and observations.
4. Environmental problems are not just problems taking place far away and therefore, it is important to conceive them as a problem adjacent to the social structure or system, where we live. It is advisable to adopt as many studies that utilise the local materials as possible.
5. In elementary and junior high schools, in terms of the characteristic of growth stage, it is important to locate the teaching materials for environmental education in the neighbourhood or in daily life. Adopting daily life materials or local materials makes it possible to develop studies through observations and experiments.
6. Environmental problems are often handled through a natural scientific approach. That means that the viewpoint of the destruction of nature or ecosystem tends to be emphasised. Since environmental disruption was brought about by human activities, it has also a social scientific background, which gives opportunities for an important approach.
7. Environmental problems are complex. It is important, therefore, to make the teaching materials, considering the age, growth stage of the students, as well as the previous studies. At the end of the class, more than what they have learned tends to be represented in a summary, which often confuses the students. It is recommended to summarise only on what they have learned, and give them enough time for discussion. It is also important to try to develop the teaching material that answers their questions.

Based upon the above, the points to be attended to in proceeding environmental education can be summarised as follows:

1. We should set a certain location for the studies based on the students' own experience, and give them as many opportunities as possible to come in contact with natural objects and phenomenon and to observe what human society really is today.
2. We should adopt as many direct experiences as possible by use of experiments, observations and research, and nurture an inquiring attitude. A scientific view and way of thinking should be emphasised.
3. We should aim at the studies that are continuously enjoyed.

Consequently, it is essential that teachers understand the environmental problems near the schools and make environmental education programmes so as to satisfy their students' desires to learn more about the environment in depth. Therefore, a positive and voluntary attitude to create teaching materials by themselves is indispensable. In elementary and junior high schools, in terms of the characteristic of growth stage, it is important to find the materials for environmental education in the local area or at the place of living. Therefore, it is desirable to develop studies by experience with the daily life material and the local materials introduced. Environmental education in the future should not be regarded as a concept of being a mere out-door or natural education, but should be developed into a creative one that will resurrect the earth and the regions where natural disruption and environmental aggravation have progressed. That will create a more desirable environment.

Considering the perspectives given above, the ILEC Environmental Education Project has developed an environmental education focused especially on the lake environmental problem and acid rain. We would like to introduce the materials that we have developed, which, we hope, will be of some reference.

3.3 Teaching materials on lake environmental problems — focusing on eutrophication

The lake environmental problem was originally regional. Though it is not included in so-called global environmental problems, the lakes found throughout the world are, more or less, plagued with the common problem of pollution, that could or can be addressed all over the world, whether in industrialised or in developing countries. According to the fact-finding survey on the condition of lakes worldwide conducted jointly by UNEP and ILEC (1994), environmental problems peculiar to lakes that are closed water areas are categorised into the lowering of water level, rapid siltation, acidification, contamination with toxic chemicals, eutrophication, and resultant disintegration of aquatic ecosystems and loss of bio-diversity (Fig. 3.1).

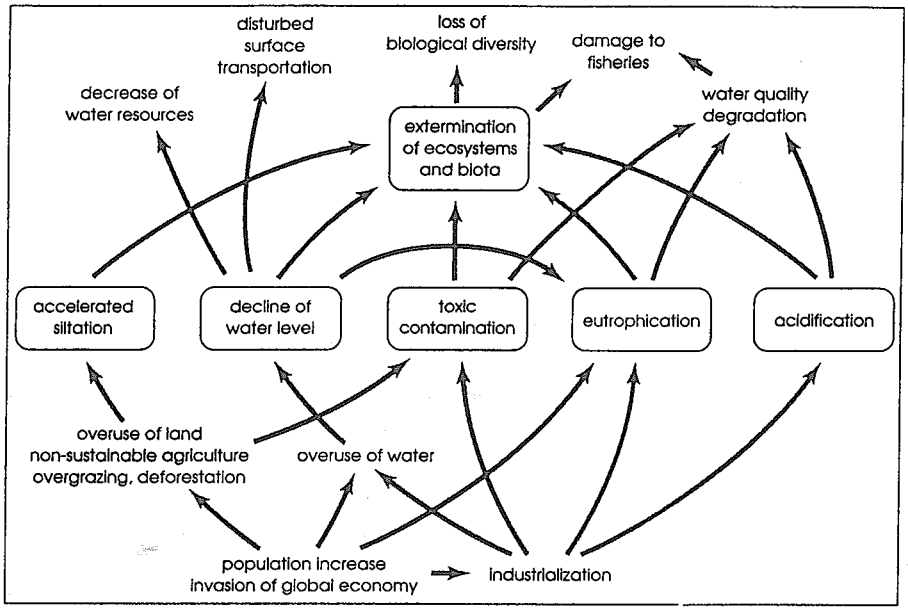


Fig. 3.1 The six major environmental problems in world lakes/reservoirs and the ways they are related to one another (UNEP/ILEC).

All of the problems are serious and should be addressed toward solution as soon as possible. Above all, many lakes all over the world suffer from eutrophication. Eutrophication is defined as "a series of change in aquatic ecosystem caused by the increase of supply of nutrients such as phosphorus and nitrogen". Furthermore, the first ordinance addressing the eutrophication problem in Japan "the Ordinance Related to the Prevention of Eutrophication in Lake Biwa, Shiga Prefecture" defines eutrophication in more detail as "the phenomenon where the substances containing nitrogen and/or phosphorus flow into the closed water area, in which with phytoplankton growing and other aquatic plants luxuriating, the water quality accumulatively deteriorates".

The drainage from factories, the runoff from fertilised fields, the sewage from homes in the land area, as well as the increase of the loads of nutrients due to precipitation, and the drop of natural self-purification owing to the renovation around the lake cause the concentration of nutrients in the lake to rise. In consequence, phytoplankton and water weeds increase in the lake. In some lakes, red tide and water bloom are observed, and as a result, degrades the value as water resources such as the source for drinking water, fishery, and recreations. In some regions, it may cause the prevalence of Bilharzia and increase carcinogenic substances such as trihalomethane in tap water. In the stratified lake, the problem of oxygen depletion occurs in the bottom water.

As mentioned above, there are various causes that make eutrophication proceed. Though its influence is also complicated, it is truly a problem brought by human activities, and is deeply linked to our life. Since the lakes as well as the rivers exist close to us, they provide us with excellent materials for environmental education. In other words, they can give us the teaching materials that are easy to follow and effective in the studies of understanding the environmental situation, the environmental deterioration by human activities, and the interaction among ecology in the lakes and their watersheds. Through these studies, it is expected to foster a positive way of thinking and attitude for the students to solve environmental problems.

Below we would like to introduce the teaching materials and the related tools that have been developed.

1. Turbidity of water

Water is originally colourless and transparent, but the environmental water that we see is turbid in many cases. Turbidity is divided broadly into the following: turbidity from soil particles; turbidity by organic pollutants drained from homes and factories; and turbidity caused by the growth of phytoplankton occurring in the stagnant water such as lakes and wetlands. Many cases of the turbidity from soil particles are attributed to soil erosion, and are closely related to the destruction of forests. In lakes, turbidity is often caused by the growth of phytoplankton, with the inflow of drainage and the progress of eutrophication. The level of turbidity can easily be measured by children with the transparency/turbidity meter or the Secchi disk, either of which is simply made by themselves.

I. Transparency/turbidity meter

We made a transparency meter with the students in order to measure the level of turbidity in the river. The transparency meter has a one-meter transparent pipe with a rubber plug attached to the bottom, carrying a white plate on which a double line is drawn horizontally. Pour tested water until it covers the double line, then read the height of tested water by centimetre. Though a transparency meter of 30 to 50 cm long is sold, it is a little too expensive to use at school, and is too short to measure in clear water. The principle of the transparency meter is so simple that the students can understand what the data shows and can use this tool without difficulty.

At one elementary school in Japan, the students were instructed to measure by turns the transparency level of the river near the school every day except on Sunday, to indicate the data on a bar graph, and to inform all the students of the result. At first children were not interested in the river that they just passed by and saw every day, but after doing the survey and examining the graph of the transparency level that showed drastic changes, they started to take an interest in water contamination, waste, plants and aquatic life. They also showed further interest in the source of

contamination in the upper reaches of the river and the destination of the river, and started searching the upper and lower reaches. The result of the research was taken up in class, which became the starting point of the studies of eutrophication, and further led the children to voluntarily clean up the river.

II. Secchi disk

Because the level of turbidity in lakes is usually smaller than that of rivers, the Secchi disk is suitable to measure turbidity. Make a white disk with a diameter of 30 cm out of wooden disk or metal, suspend it with the graduated rope, and attach a plummet.

III. Application of simple filtration apparatus

The filtration apparatus used to filter lake water and river water ranges from large ones, small ones to portable ones. A syringe with a plastic holder (e.g. Advantec PP-25) attached is easy to handle, and suitable to observe the quality of suspended solids. When water is filtered, suspended solid colours filter paper, and the leap of filtrate gradually decreases. The students can infer the causes of turbidity in the river and the lake by comparing the colour of suspended solid on the filter. They also learn the level of transparency by comparing the water pressure (how far filtrate splashes) when filtering.

When eutrophication is selected as the theme of studies at elementary school in Shiga prefecture, the students usually measure the transparency of the lake, and examine phytoplankton and zooplankton with the microscope. As long as these experiments are not connected with each other, however, they are not appropriate as teaching materials for eutrophication. Therefore, we attempted a new material so that the students could find it easy to learn that the decrease of transparency level in the lake is mainly caused by the growth of phytoplankton. That is, after passing lake water through the simple filtration apparatus, they examined the colour of suspended solid on the filter paper, then further observed filtrate and suspended solids under the microscope. Through this experiment, the students learned that lake turbidity is primarily attributed to phytoplankton.

So far we have introduced the experiment with the use of a simple filtration apparatus that is purchased. If a filter or a filtration material is devised, however, another interesting and simple experiment can be developed. For instance, an appropriate container and a cloth make a filter for water. Cut off the bottom of the PET bottle, place it upside down, and pack it with sand, then it also makes another filter. Many alternatives could be devised.

2. Teaching materials on the causes, effects and measures for eutrophication

When we conduct the studies of eutrophication, it is indispensable to teach photosynthesis and respiration. The following Redfield's equation should be fully recognised by students.

$$106\ CO_2 + 16\ NO_3^- + HPO_4^{2-} + 122\ H_2O + 18\ H^+ + (\text{Trace-elements} + \text{Energy})$$
$$\text{(photosynthesis)} \downarrow\uparrow \text{(respiration)}$$
$$(CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 138\ O_2$$
algal protoplasm

or more simply,

Carbon dioxide + Nutrients (N & P) + Water + Proton + (Trace-elements + Energy)
(photosynthesis) ↓↑ (respiration)
Phytoplankton

It is important to have all the factors prepared in order for photosynthesis to proliferate phytoplankton. Although the above equation does not mention it, water temperature is also a significant factor. Any element lacking in the equation prevents phytoplankton to grow. For instance, if light is shut off, phytoplankton does not only grow, but contrarily consumes oxygen to be resolved into original inorganic elements (respiration), which is the same phenomenon observed in the hypolimnion. Of course, it is not possible to cut off light over the lake. Controlling carbon dioxide is not possible either, since it dissolves into lake water from the air. All these factors exist even when the lake keeps an oligotrophic state. Even oligotrophic lakes carry nutrients, though in low density, and keep a good balance between photosynthesis and respiration. In the oligotrophic lake, the loads of nutrients caused by human activities has increased, which leads to various evil effects. Phosphorus normally acts as a limiting factor for phytoplankton in many cases. Besides, the fall of natural self-purification due to the inappropriate renovation around the lake is another factor that brings about the increase of nutrients in the lake water.

Nutrients including nitrogen and phosphorus are essential nutrient elements, and many foodstuffs contain a large amount of nitrogen and phosphorus. Therefore, domestic wastewater makes a major source of nitrogen and phosphorus. Drainage from the food and textile industry, where natural organic matters are used as raw materials, is no exception. Since nitrogen compounds such as nitrate and ammonium ion, as well as phosphate, are widely utilised in industrial production activities, many of the industrial wastewater contains nitrogen and phosphorus. Nitrogen and phosphorus are also essential for agricultural activities that produce grain and vegetables. Fishing and livestock industries are other large sources of the two nutrients. As an example, see the figure of the rate of nitrogen and phosphorus loads into Lake Biwa in Shiga Prefecture, Japan. (Fig. 3.2)

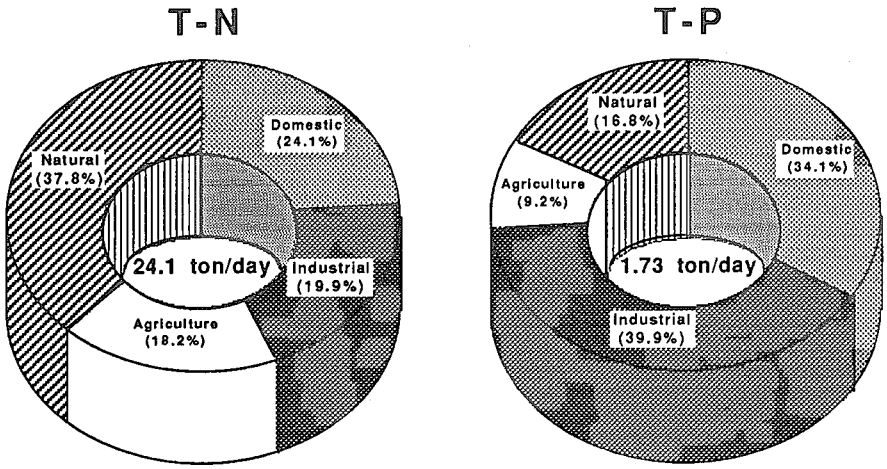


Fig. 3.2 Nitrogen and phosphorus loads into Lake Biwa and their sources (Shiga Prefecture).

The concentration of nitrogen and phosphorus in precipitation is normally higher than that of Lake Biwa, and occupies the majority of natural sources indicated in the figure. Therefore, it is more like an artificial source based on air pollution than a natural one. Thus, the sources of nutrients have a wide variety, but they are indeed the product of human activities in the watershed.

In order to arrange environmental studies based upon above, various kinds of teaching materials have been developed and devised.

I. Cultivation experiment of phytoplankton with domestic waste water

By culturing phytoplankton with the use of food waste or vegetable waste from homes, the students learn that the above waste is the cause of the growth of phytoplankton. More specifically, they study it through a simple experiment as follows. Prepare an Erlenmeyer's flask (or an alternative container), and pour 50 ml of lake water. Add a drop of liquid food such as soy sauce, milk, beer, or juice consumed every day, or juice squeezed from vegetables, as well as liquid fertiliser. Then leave it by the window for about 10 days. The water that was almost colourless and transparent at first will turn green. It is necessary to make the experiment in a room appropriate for phytoplankton growth with careful attention to water temperature and light.

II. Detection of phosphate ion

The growth of phytoplankton by the addition of foodstuff and vegetable waste can be confirmed by the above experiment. We would like to adopt a more advanced experiment showing that this liquid contains the nutrients (phosphorus and nitrogen) which are indispensable for phytoplankton growth. The measurement of nitrogen (ammonium ion and nitrate ion) is difficult for elementary and junior high students,

but as for that of phosphate ion, qualitative analysis is relatively easy to conduct by the molybdenum blue method (see Annexe). The liquid food, juice, or wastewater brought by children is either used as it is, or diluted if it has colour. Vegetable waste is extracted to make solution as tested water. When the detection indicator for phosphate ion is added, most tested water detects phosphate ion. For the controlled experiment, the use of fertiliser containing a large amount of phosphorus, which is also familiar to children, would help them understand the result of the experiment.

It is necessary to use a spectrophotometer or a colorimeter in order to measure phosphate ion. Since these meters are expensive, however, most elementary or junior high schools are not equipped with them. Therefore, we developed a simple colorimeter which utilises emission diode as the light source and CdS as the detector (see Annexe). The concentration of phosphate ion that can be detected ranges from 0 to 1 mg/l, and detectable minimum is 0.02 mg/l We found it very effective to apply this equipment to the environmental studies of eutrophication in junior high school. In 1995, we provided one to other member countries participating in the ILEC Project.

III. Removal experiment of phosphate ion with soil

After learning that wastewater containing phosphate ion advances eutrophication, the studies of how to reduce the phosphate loads on lakes and rivers are important. The children learned that by passing phosphorus-contained wastewater through the soil, the concentration of phosphate ion decreases. In other words, by comparing the intensity of colour development of phosphate ion by the molybdenum blue method before and after passing tea through the column packed with soil, the effect to pass it through the soil is evident. Through this experiment, they studied that it is better to discard wastewater on the soil than to directly drain it to the river for the prevention of eutrophication.

IV. Function of attached algae

It is important to study how to reduce the inflow loads of nutrients such as phosphorus for the prevention of eutrophication progress, but we would like to further teach that the function of contamination prevention is working through self-purification within the lake. To study the importance of purification by the reed community and others, a method was devised to test the function of removing phosphate ion by the algae attached to reed or stone. Pour some solution with phosphate ion in an appropriate container like a beaker, put a segment of reed or a stone collected around the lake, and leave it under the sunlight with air bubbled into the container. When we compare the colour development of phosphate ion by the molybdenum blue method before and after the experiment, the decrease of phosphate ion by photosynthesis is clearly observed. For a controlled experiment, make the experiment without reed or stone simultaneously. The use of a waterweed such as water hyacinth will result in the same decrease of phosphate ion.

3. Oxygen depletion of bottom water

Regarding respiration, the contrary process of photosynthesis, it is necessary to comprehend in terms of eutrophication effects. In the hypolimnion where light fails to reach, the carcass of phytoplankton which has sunken consumes oxygen to be decomposed. In the stratification period when no oxygen is supplied, dissolved oxygen decreases in the hypolimnion, and the oxygen depletion, eventually anoxic condition proceeds. Moreover, when the bottom water has no dissolved oxygen (reducing state), nutrients and heavy metals again release from the bottom sediment which has a considerable effect on lake water. To study the above, a new teaching material was tested at a junior high school. Put the collected bottom sediment in the airtight glass jar, quietly pour the lake water, and shut the lid tightly. For a controlled experiment, prepare the jar without a lid. Assuming the bottom layer of the lake, leave the jar in a dark place for several days to one months, then observe the change in colour of the bottom sediment. In the controlled experiment (in which oxygen is fully supplied), the surface of the sediment is covered with an oxidised layer, and the colour remains light brown.

On the other hand, in the airtight container, with the consumption of the remaining oxygen, the oxidised layer disappears, and the sediment turns to dark grey. The measurement of the dissolved oxygen and phosphate ion shows the connection between the decrease of dissolved oxygen and the dissolution of phosphate ion.

4. Pollution of lake and water circulation mechanism

Sea water and land water evaporate into aqueous vapour, which is cooled up in the air to again fall over the sea and the land as precipitation (rainfall or snowfall). The precipitation reaching the land forms lakes and rivers, and moistens the soil. Though some is accumulated as subterranean water, in the meantime, utilised by plants, human beings and other animals, it again runs into the sea by way of lakes and rivers. Repeating this process, water circulation has formed itself on the earth. In elementary schools, the students learn about the large-scaled water circulation from an early age. We would suggest that the responsibility of human activities be added to the studies of water circulation. That is to say, in the process of water circulation, human activities pollute water and degrade water quality.

In the process of water circulation, precipitation is polluted in various ways. When aqueous vapour becomes rain or snow in the air, it takes in some substance as a nucleus (rainout), or adopts various substances in the air until it falls down to the ground in the form of rain or snow (washout). As a result, in precipitation there exist in the form of either dissolved ion or in the form of suspended solid, gaseous substances and dusts in the air, as well as sea salts (ion in the sea) which are carried to the air when sea water scatters and evaporates. Human activities especially, which emit sulphur oxides and nitrogen oxides deriving from the smoke of cars and factories, give various influence over human life and ecosystem in the form of acid

precipitation or in the form of supplying nutrients to lakes. (For more details, see 2.2.4) Moreover, when precipitation reaches the ground, most eventually arrives at lakes and seas as river water, though some is stored as subterranean water. Meanwhile, water is utilised for various purposes by human beings. Consequently, it returns to rivers and lakes, finally to sea as contaminated water.

A new teaching material was developed to understand that the fact that human activities are largely connected with water circulation. It can be used in the class of fourth graders of elementary school. After studying water circulation in detail and discussing its importance as a resource, an experiment was introduced to observe the results of human activities. Put some distilled water (water evaporating from the sea or lake) and various kinds of wastewater from homes on the evaporating dish, heat it to make it quietly evaporate, and compare the colour and the quality of what remains on the dish. Through this simple experiment, the students learn that a number of substances are present in wastewater, even if it looks transparent. It is meaningful to study water circulation in relation to human life, not just as a mere theme in science.

5. Mapping of waste water streams

Where does wastewater from homes and factories go? This is a question often asked by students when they make an experiment of water turbidity. To answer this question, research on the drainage route or the stream in the neighbourhood is effective. Each student starts from school or home to trace the drainage route or the stream, and draws a map of the watercourse. The students bring their own map to complete a drainage route map of the whole area. Putting this research together with the measurement of turbidity and phosphate ion mentioned earlier helps to understand the change in water quality. Also through this survey, the children are led not only to examine water quality, but also to see waste, aquatic life and plants around the river bank, which helps them to understand how human activities contaminate rivers as well as lakes.

In relation to these studies, it is advisable to introduce a tour in an area where a sewage treatment system is fully equipped. Taking this opportunity, students realise how difficult it is to dispose of contaminated water, discuss the relations between water consumption and contamination, and are encouraged to think about how to reduce water consumption as well.

6. Trihalomethane problem

The problem of trihalomethane may be difficult to directly deal with in elementary or junior high school, but teachers should definitely understand this problem in relation to eutrophication. Therefore, we would like to provide some significant points relating to this matter.

When nutrients are excessively loaded in lakes, phytoplankton grow due to

eutrophication, which causes musty water, increases the concentration of carcinogenic substances such as trihalomethane in tap water, thus threatens human health. Chloroform, dichlorobromomethane, dibromochloromethane, and bromoform are known generically as trihalomethane, but none of them are detected in raw water for water supply such as in the lake. Trihalomethane is produced at the pre-chlorination process in the water supply plant, where chlorine added to oxidise and decompose ammonia and organic matters in raw water and precursors such as humic acid react to each other. In addition, chlorinated organic compounds such as trichloroacetic acid, another carcinogenic substance are also generated. The more polluted raw water becomes by eutrophication and organic contamination, the higher the concentration of chlorinated organic compounds becomes in tap water. Since trihalomethane is carcinogenic, it is prohibited by law in Japan to make for drinking usage tap water containing more than 100 µg/l of trihalomethane on average a year. It is estimated that four out of 100,000 persons will have cancer if one continues drinking water with this much trihalomethane. The WHO recommends that the concentration of 25 µg/l should be set as the criterion, with which one out of 100,000 is likely to have cancer when a person weighing 70 kg drinks two liters of water every day, taking into consideration that the probability of getting cancer increases proportional to the amount of poisonous substances taken up by the body. No matter how small it may be, the concentration of safety standards never exists, and zero should be the goal for the concentration of such toxic substances.

Boiling is often discussed as a measure against trihalomethane. It is true that chloroform is removed from water by boiling, because its boiling point is lower than that of water. (Since when boiling, the concentration of trihalomethane temporarily becomes higher than that of tap water, it is necessary to continue letting it boil.) However, because the boiling point of many other chlorinated organic compounds is higher than 100 °C, boiling does not only drive the substances out, but also concentrates them as water evaporates. Besides, since one person needs approximately 1.2 litres of water per day, removing trihalomethane through boiling will lead to large consumption of energy and the increase of carbon dioxide. At the water supply plant, as an alternative of chlorination, the use of ozone has been introduced, and another technology to reduce organic matters before chlorination by treating raw water with micro-organisms has recently been developed. Such technological progress can reduce trihalomethane in tap water, but the new technology is expensive, and it takes a long time to supply safe and good water for all the citizens. It would be desirable to spend as much on the utmost effort to prevent eutrophication and contamination of raw water as on the new technology at the water supply plant in the form of symptomatic treatment.

3.4 Teaching materials on acid rain

Even non-polluted air contains carbon dioxide, and the distilled water in contact with

this air is acidified. Because the distilled water which is in equilibrium with carbon dioxide in the air (the representative value in the 1980s is 340ppm) has pH = 5.6 (at 25 °C), the rain with acidity of less than pH 5.6 is defined as acid rain. However, since sulphur oxides and nitrogen oxides, the principal causes of acid rain, are emitted not only by burning fossil fuel, but also in natural phenomenon such as volcanic eruption, some argue that the rain with acidity of less than pH 4.8 to 5.0 should be defined as acid rain, considering this influence. In any case, the rain with high acidity of the level of pH 4 falls everywhere in the world. A recent survey found acid rain of pH 4.5 also in Japan. Besides, as the effects of acid rain, the withering of forests, acidification of lake, the damage to marble or concrete buildings have been conspicuous as a serious problem all over the world, including Europe and North America.

Above is a brief outline of acid rain. Since the sources of sulphur oxides and nitrogen oxides, dry and wet deposition of reaction products of these gaseous compounds, as well as environmental influence is largely linked to chemical and biological reaction, the reaction mechanism of acid rain is extremely complicated. At the same time, the viewpoints in case of taking this problem as environmental education may also have a wide variety.

Because it rains unexceptionally in every region, the students can directly touch rain, collect it, and measure it in various ways. Therefore, the problem of acid rain is comparatively easy to handle as studies through experience. However, many classes only use audio-visual materials such as video, and tend to deal with this theme through an explanatory approach. Pictures and video are effective in showing objects hard to obtain or distant situations difficult to actually see, but they often represent only the results of environmental destruction, and are hardly connected to the understanding of the ongoing process and mechanism of environmental disruption. Comprehending the mechanism of environmental disruption is indispensable to foster a scientific view and way of thinking and thus, the introduction of environmental studies through experiments are recommended. Hereunder are some practical examples focused on a natural scientific approach.

1. pH measurement of rainwater

First of all, when the students collect rainwater, what kind of container should they use? What does it mean to the students to collect rainwater? When elementary school students were asked to collect rainwater, they used different types of containers such as a bucket, a kettle, a film case, or a ceramic cup, and in various ways; some received rain coming from the sky directly into the container, some collected runoff from the roof, others scooped water from rain puddles in the playground or the asphalt road. Needless to say, the pH varied, for example ranging from pH 4 to pH 8. After comparing different values, the question arose "why is acidity different, though it is the same rain?", which further developed the studies.

There are two methods of pH measurement: one by meter, and the other by indicator or test paper. The pH indicator (acid-base indicator) is less expensive than the pH meter, and is easy to handle because the correction by pH standard solution is not necessary. Also this experiment appeals to the eye through the colour difference and change. For these reasons, the use of an indicator is recommended. As an indicator measuring acid rain, one that simply distinguishes between acidity and alkalinity, for example, litmus paper is not appropriate, therefore, BCG (colour change ranges pH 4 to 5.8) and BTB (colour change ranges pH 5.8 to 7.4) should be prepared. Indicators are widely used in elementary science class, and students will find it easy to use it after a few minutes of practice.

2. Continuing observation

The students should be encouraged to continue measuring the rain falling in the school district. The pH of rainwater fluctuates every day, and sometimes it is not acid. The results obtained for five consecutive years in Otsu City, Shiga Prefecture show that according to the amount of rainfall, climate, the concentration of dissolved ions, it ranges widely from pH 3.5 to pH 6.5. In the limestone area of Shiga Prefecture, alkaline rain is observed from time to time. At an elementary school which continues survey on rain as an extracurricular activity, the students realise that rain with high acidity is falling in their town through experience, which provokes their desire to learn more about the cause and the effect of acid rain. This kind of continuous research is not only effective in enhancing the interest in environment, but is also important as the premise to introduce acid rain to the environmental class.

3. Acid rain damage

The influence of acid rain such as the withering of forests, acidification of lake, the damage to building surfaces, and concrete icicles (acid rain icicles) manifest themselves after a long period of time. Therefore, the progress is hard to reproduce by experiments during a one-hour class. We recommend the use of a colour change indicator, in order to show that acid rain erodes the surface of metal and concrete. When a piece of concrete or steel wool is put in the solution (acid rain) with acidity of about pH 4, actual reaction cannot be directly observed. However, by adding the indicator, colour of solution changes with the progress of neutralisation, and it is possible to visually observe the reaction. Drop BCG, place a piece of concrete in rainwater of pH 4 showing yellow, and leave it undisturbed, then it is observed that the surface gradually turns from yellowish green to blue. This reflects the pH change in accordance with neutralisation of the concrete surface. The change can be observed in a few minutes. Stirring the solution makes the reaction quicker, but it is more effective to examine without stirring, and to realise the reaction taking place on the surface as it is. BTB can also be used as an indicator, but in terms of the measurement of the present acid rain (of the level of pH 4.5), BCG would be more suitable. According to the report made by the students after the class, though some could acknowledge the phenomenon of eroding concrete, most students

acknowledged it as something that happened with the reaction of the concrete surface and rain. However, when they saw the video on concrete icicles later, it helped them to comprehend the content of the previous experiment. Regarding the problems including the withering of forests and acidification of lake, it is difficult to learn of the phenomenon through experiments or experience. In this case, audio-visual materials such as video and pictures would be effective.

4. Causes of acid rain

When the textbook of science or social studies describes acid rain, all it mentions often is that sulphur oxides and nitrogen oxides emitted from cars and factories are the principal cause. In order to prove the fact by experiment, we developed a method by which the pH level and the conductivity of the solution can be measured in the class, when exhaust gas (from gasoline/diesel cars) and the gas and smoke emitted in burning heavy oil, paper, waste or sulphur are dissolved into water. In accordance with the plan submitted to the students, gas was collected and dissolved into distilled water, and the pH level was measured. For instance, when gas is collected in a large waste bag, and water is added to shake, acid solution can be obtained without difficulty. This method can also be utilised for the experiment of concrete dissolution. Handling the burning of the objects close to our daily life as the experiment of the source provides the students with the opportunity to have further discussion of environmental problems and their relations to human activities.

So far we have introduced several simple experiments that can be adopted in the class in natural science. Please remember that students are full of ingenuity, and they often provide teachers with various ideas on the method of experiments and the like. If necessary, social scientific approach in relation to international treaties (the reduction of sulphur oxides and nitrogen oxides), as well as the problems of border, waste, natural resources and energy could be adopted in the class.

3.5 Use of regional information and audio-visual materials

In making environmental teaching materials for environmental education, it is necessary to select materials which interest the students, and leads them to think about the problems. The willingness to respond to their requests is also indispensable to avoid "one-way knowledge". There is plenty of information on environmental problems around us, and therefore, only if we keep ourselves attentive, can we obtain as much information as possible from newspapers, TV, magazines, books, Environmental White Papers, statistics, the reports from local governments, regional bulletins, and other sources. It is not hard to collect the materials to fulfil the students' necessity. Spending time in making scraps and copying will give teachers the benefit of grasping the whole picture of real-time environmental changes. At the same time, the positive participation to the regional community will also reveal new teaching materials. As recent education has advanced in content, the community has become

detached from school. Just as there used to be a term "the blending of school and community", it is necessary to retrieve school education so that it is closely tied up with the regional community. The best thing that teachers can do is to participate in local events to resume communication with the people living there. Teachers should play an important role as one of the opinion leaders in the community. This is also significant in terms of making teaching materials from local sources in environmental education.

Although learning through experience is given top priority, it is impossible to learn everything through experience and therefore, audio-visual materials such as pictures and video are effective from time to time. Even if we wish to adopt the studies by experience, they are limited by time and space in some cases. Especially when we study the environmental problems in a foreign country, in a remote place or in a place where we are unable to go (e.g. the bottom of the lake), audio-visual studies can be conducted.

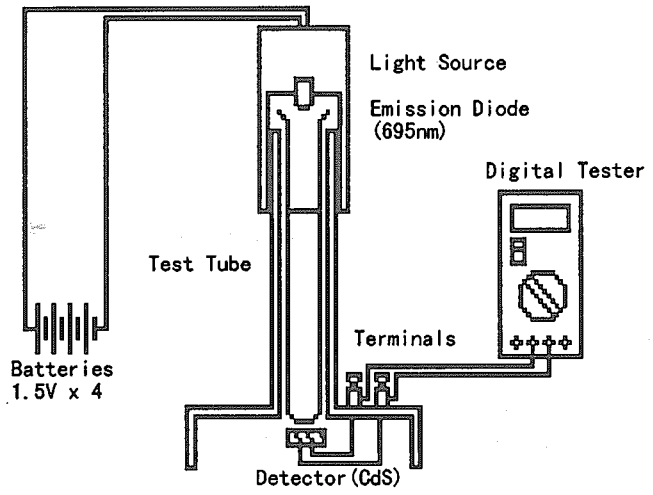
So far, introducing specific teaching materials on environmental studies, we have touched upon how to make teaching materials especially for the studies of eutrophication and acid rain. However, many more materials would be needed. Such studies can be realised by teachers who make constant contact with students. Each teacher has different natural or social environment around him or her, has different type of students, or has different views to make teaching materials for the class. Especially when environment is treated, it is necessary to select the material that interests the students, and to make them consider the problems as their own.

ANNEXE

INSTRUCTION MANUAL OF A SIMPLE COLORIMETER SP-11 AND MEASUREMENT OF PHOSPHATE ION BY THE MOLYBDENUM BLUE METHOD

Simple Colorimeter SP-11

1. Structure



2. Procedure

1) Put four batteries (1.5V) in a cell case.
2) Connect the lines from the light source to the terminals of the cell case.
3) Confirm the lighting of the emission diode inside the light source.
4) Put the batteries in a digital tester.
5) Connect the tester to the terminals of SP-11.
6) Mark with marking ink at a position of 10 cm above the bottom of the test tube.
7) Pour the sample solution into the test tube up to the mark.
8) Insert the test tube slowly into SP-11.
9) Put the light source on SP-11.
10) Read the electric resistance value.
11) Convert the value into a logarithm.

3. Measurement of SRP by the molybdenum blue method

SRP (Soluble Reactive Phosphorus) is nearly equal to phosphate ion in natural waters

such as lakes, rivers and rain water.

1) Reagents

(1) 2.5M H_2SO_4
(2) Ammonium molybdate solution: Dissolve 20 g of $(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$ into 500 ml of distilled water.
(3) Ascorbic acid solution: Dissolve 1.32 g into 75 ml of distilled water.
(4) Potassium antimonyl tartrate solution: Dissolve 0.2743g of $KOOC(CHOH)_2COOSbO{\cdot}1/2H_2O$ into 100 ml of distilled water.
(5) Mixed reagent: mix the above four reagent solutions at the volume ratio of 10:3:6:1
(6) Standard solution of SRP (stock solution): Dissolve 0.4394g of KH_2PO_4 into 1000 ml of distilled water in order to make the standard solution of 100 µg-P/ml.

<Remarks>

(1) If tap water has no SRP, you can use tap water instead of distilled water.
(2) It is convenient to stock the mixed solution of 2.5M H_2SO_4, the ammonium molybdate solution and the potassium antimonyl tartrate solution. Before use, mix with ascorbic acid solution.

2) Procedure

(1) Filter the sample water with a glass fibre filter (Whatman GF/C).
(2) Put an aliquot (usually 20 ml) of the filtered water into volumetric flask of 25 ml.
(3) If necessary, neutralise a solution with dil.NaOH using phenolphthalein as an indicator.
(4) Add 4 ml of mixed reagent for developing the colour.
(5) Dilute up to the mark with distilled water.
(6) Stand for at least 10 min. at 25-40 °C.
(7) Measure the electric resistance value using SP-11.
(8) Convert the value into logarithm.

3) Calibration curve:

(1) Dilute the stock solution (100 µg-P/ml) to the concentration of 5 µg-P/ml.
(2) Put 0, 1, 2, 3, 4, 5 ml of the solution (5 µg-P/ml) into volumetric flasks of 25 ml.
(3) Add distilled water up to ca. 20 ml.
(4) Hereafter, perform the same procedure as the sample water.

CHAPTER 4

ADDITIONAL CONSIDERATION

Munetsugu Kawashima and Sirmsree Chaisorn

4.1 Environmental education class

More than 20 years have passed since the Belgrade Charter stated the excellent objectives of environmental education in 1975 (see Chapter 3). However, environmental education has not achieved these goals so far. Meanwhile, especially in industrialised countries, education has mainly supported the development of science and technology that has brought us mass production and mass consumption. There have been little efforts made to achieve the goal of environmental education up to now. Environmental problems have been more and more crucial.

Many classes are still focused on conveying knowledge one-way to the students. This may also be applied to many other subjects. Especially in environmental education, we should convert the conventional education which has emphasised common knowledge and skill to ability to think, judge and act.

The ILEC Environmental Education Project has studied the environmental education programme based upon the students' experience, in order to nurture the scientific view as well as the power of execution which leads to the solution of environmental problems, the ultimate objective of environmental education. To realise this, we have concluded that, particularly in elementary and junior high schools, it is indispensable to create the environmental education programme that satisfies the students' desire to understand the environmental circumstances and problems in the neighbourhood of their school, and to know more about environment. The teaching materials that we introduced earlier were developed and devised to support the above-mentioned environmental studies. In addition, we would like to actively adopt discussions and role playing conducted by the students themselves. After the studies positively introducing learning by experience on environmental problems, the discussions on the content of what they learned, the way to solve environmental problems, what they can do now or what they will be able to do when they grow up will greatly contribute to fostering the power of judgement.

At present, many countries do not set the independent subject for environmental education, nor do they indicate the systematic contents as environmental education. As it is seen in the report of ILEC in 1996, since the daily classes at school are normally based on the studies guidance outline submitted by the government, there are few possibilities for environmental education to find a niche. Therefore, the

relations between each subject and environmental education become important. The Ministry of Education in Japan stated about the tie-up of each subject in the guidance data on environmental education in 1994, "It is desirable to conduct environmental education in every subject at school; however, the treatment of the phenomenon related to environment should naturally be considered in accordance with the characteristic and the objective of each subject. In this case, the point to be attended to is to manage to link the treatment of phenomenon with each subject in an appropriate manner." In short, it is possible to conduct environmental education as an overall, systematic study within the hours left to the school's discretion. Frankly, though the importance of environmental education is emphasised, the time allocated to this purpose is very limited. Also schools are obliged to depend on the level of each teacher's interest or competence. As a result, many classes of environmental education tend to be a thrown-in type centred on just explaining environmental problems during the class of a different subject, and become one which provides only knowledge to the students. Since environmental education is related to the other subjects, it sometimes gives a wrong idea that it can be dealt with in any subject with any kind of material. For instance, we should keep in mind that science and environmental education stand on two essentially different foundations. Science is based on natural science where natural principle and natural law are clarified. Environmental education is based on environmental science which studies methodology to perceive and solve environmental problems. It is therefore, also linked closely to social science. Also, it is necessary to realise that environmental education is not a mere study about the environment. In this respect, an independent subject like "environmental studies" is expected to be introduced in the future.

Under the current system, we are obliged to carry out environmental education within other subjects, and need to develop a programme which can simultaneously achieve the objectives of each subject and environmental education. Besides, since the class hours are limited, it is important to set a fixed objective of the class.

4.2 Involvement of and feedback to local communities

Environmental education is extremely important for adults as well as for children, and it is naturally regarded significant as one of the modern themes in lifelong learnings. It is adults that have destroyed the environment, and solving environmental problems is a big challenge loaded on adults. However, the warning that should be directed to adults are often given to children. It is often pointed out that children today are not meeting with nature, and have therefore lost recognition, love and sensitivity toward nature. This tends to be regarded as the children's problem. However, it is the society created by adults that has deprived children of the life and the playground, where they have direct contact with nature, and that has compelled them to adapt to the deformed modern society with technological development. First of all, it is necessary for adults to reflect on this fact and to think about global and

regional environment together with children.

The relationship between environmental education at school and the community is important because of the following two points. Firstly, what children learn is expected to increase the opportunity for their whole family and the citizens in the community including adults to study the environment and environmental problems. Especially in the industrialised countries, adults were educated during the period of high economic growth where economic development had precedence, and were never given environmental education about environmental conservation and the solution of environmental problems. It is important for them to be ready to share the results of environmental studies with children.

Secondly, if the citizens in the community help children to study, more fruitful environmental studies will be provided. When outdoor works are carried out, some places entail danger for children alone, or they may find difficult to do research by themselves. For instance, a junior high school in Japan provided a very meaningful environmental study by exploring the shores of Lake Biwa by boat and surveying the quality of water and the bottom sediment. This study was possible with the warm support from the local citizens as well as by the efforts of the teachers. There is another good example found near a bay in Rio de Janeiro, Brazil. The students and the teachers of a junior high school who worried about the disappearance of mangrove forests owing to environmental aggravation called on the fishermen to appeal for the restoration of mangroves. At first, the fishermen refused to cooperate, but steadfast negotiations finally drove them to join reforestation. Now the mangrove forest has been restored. Moreover, with the efforts of the local inhabitants, the water quality of the entire bay has improved too.

The influence of environmental education over the local inhabitants in Ghana should also be mentioned. An element of the general objectives for Environmental Education Project in Ghana is the involvement of the local residents in the identification of solutions to the environmental problems in the communities. During the period of the project, the pilot schools for environmental education were encouraged to promote local residents' participation in the environmental educational activities of the schools. As a result, this gave the residents a favourable influence in terms of realising the local environmental problems. The discussion with the local residents revealed that they have come to recognise the environmental problems in the neighbourhood. The environmental education project involved the traditional rulers and opinion leaders in a number of activities geared towards the maintenance of healthy environments. This motivated many other residents under the heads to join the activities, such as durbars and cleaning exercises, etc., organised by the environmental educational project.

The students started to clean their refuse dumping sites regularly by burning and

burying together with adult residents of the communities. Before the project, more than 80 % of the residents in Ayikai-Dobolo village were suffering from Bilharzia. But the campaign by the pilot schools for environmental education with the support from Noguchi Memorial Research Institute succeeded in decreasing the ratio to less than 10 %. A lot more communities constructed places of convenience to avoid defecating anywhere since the inception of the project. In villages where people were drinking the river water without any treatment whatsoever, the project impacted the idea of boiling the water before drinking. A number of community residents realised the necessity to avoid washing, bathing, swimming and defecating in the Densu River. In some areas, e.g. Ayikai-Dobolo, Nsawam Adogyiri and Domiabra, people are now fined for dumping waste in their water bodies. Some residents organised the regular cleaning exercises to clear choked gutters and waterways to avoid the breeding of mosquitoes and other disease-causing organisms. Moreover, the teachers of pilot schools acted and were considered by the residents as a pressure group on environmental health officers and other environmental protection agencies in the communities concerned. For instance, the project school teachers were introduced by the District Chief Executive (district political head) to the Deputy Minister of Environment, Science and Technology who visited their area as torch bearers of environmental education. However, there is a need for continuous campaign to bring about total attitudinal changes of the community residents, so as to minimise the problems of the environment.

4.3 Training of teachers

4.3.1 Importance of in-service teacher training on environmental education

In-service teacher training, either at teachers' request or as their required experiences, is one of the major methods used to enrich teachers with new knowledge and skills needed for them to work more effectively in their teaching profession. Every school should open up opportunities for their teachers accordingly. In fact, this type of professionalization should be made prominent in school policies. Since environmental education has increasingly become one of the most urgent requirements our world population should have, all schools should take action in adding on or highlighting their curricula or syllabi so that the youngsters of our world are prepared to have environmentally positive behaviours and well-equipped with environmental concepts and concerns needed for meaningful actions. To do so effectively, school teachers should be trained or retrained so they will be acquainted or updated with relevant information and techniques relating to the environment. They can then accumulate new ideas and skills to use in their teaching or facilitating their students' learning activities.

Almost all of our life aspects are influenced by local and global environmental conditions which are more and more deteriorated by all kinds of human acts. Some of the impacts are newly developed from our modern ways of living. No doubt, some

issues and problems are easy to understand but many are complex and need much time and extensive examination to understand them. Environmental understanding means basically concern about nature and natural resources. Throughout the world, some teachers' life styles today are so far apart from the natural world just the same as their students. There is a need for both of them to learn to know and love nature before they can become truly concerned and want to protect the natural environment. Upon this regard, teachers need training on environmental concepts and changing conditions as well as how to appreciate nature. Many environmental principles and problems can be deeply understood only through scientific processes. All these call for training workshops especially at the initial stage of teachers' instructional design task before they do the actual environmental education teaching to their students.

As mentioned earlier, there are many approaches and aspects that could be used for promoting school environmental education. School administrators or the environmental education project committee must decide about these possibilities before giving training to teachers. Below are some examples of questions to be raised.

1. Will all subject teachers in schools be encouraged to infuse environmental education in their own specialised courses whenever appropriate? If so, teachers of all subjects should be in the training workshops, not just science teachers and social studies teachers whose subject areas deal with some aspects of environmental issues directly.
2. Will there be or is there the development of direct environmental education courses in the school curricula? Do these courses emphasise solely a science or social studies content? Or will there be attempts to organise a curriculum that is flexible enough to allow some kinds of interdisciplinary management with cooperation among different subject teachers in such courses or teaching units? If the last approach is to be used, then teachers should be trained on how to cooperate in team teaching styles, for example.
3. Will students be encouraged to cooperatively work among themselves and also with other adults in local communities in promoting environmental understandings and problem-solving?

These types of questions will help in deciding about the training participants, duration of the training, programme schedules and strategies to be used in the training.

From the ILEC project, it is evident that the teachers who participated in the training courses showed more interest and commitment to environmental activities.

4.3.2 Training time and schedules

Time and duration for teacher training vary according to the scope and details of experiences expected for teachers to gain from the training and the available time

they have. If the trainees are already familiar with environmental concepts, they might need only short periods for training in some teaching strategies that are appropriate to environmental education learning or for producing some instructional materials. When should the training be offered? Most teachers of the ILEC environmental education project agreed that training and retraining courses given to them at the beginning of each academic year did raise their sensitivity to environmental issues and help their activity planning. For the piloting project especially, the training time should be before the implementation of the project. Once the project has been started, some additional training and retraining are probably needed in the middle of the programme or the beginning of the next cycle of the programme.

In Argentina, over 20 teachers of pilot schools attended a one-week intensive training course every year for three years during the holiday period preceding the implementation of the project. Experimental activities in Chascomus Lagoon and in the laboratory were repeated in each training workshop. These are the activities they would use with their school students during their teaching. While the Argentinean experience proved one week was adequate for the training of their teachers, the Brazilian project found a 10-day training course for a group of 20-25 school teachers very fruitful. In Ghana, however, 2-day workshops were held for elementary school teachers separately from junior secondary school teachers. Each workshop included approximately 30 elementary school teachers and about 20 junior secondary school teachers respectively. Teachers also found great benefit from the training.

How long the training duration should be, therefore, depends on how much content of training we want to cover and the budget we have for training management. Planners of the trainings have to decide and select the possibilities best suited to each target groups of teachers.

Appropriate training schedules should correspond with instructional plans to be implemented in schools. However, firstly, teachers need to be familiarised with local and regional necessities and also global problems and concerns. In the training schedules, time should be provided for discussion of some prepared data and information. Resource persons from the community, governmental and non-governmental organisations and experts on environmental science and environmental education, therefore, should be invited to expand teachers' visions and experiences. Issues related to peoples' life quality must be selected for discussion.

Skills in problem-solving starting from the ability to identify problems to the ability to find solutions must also be emphasised in teacher training along with how they can play the roles of facilitators in the student-centred teaching/learning atmosphere. Thus, observing, measuring, experimenting, analysing, identifying problems and the like should be discussed and trained. In the training programmes, teachers should

have opportunities to study the watershed system by following through some outdoor activities the way they will use with their students. Use of media and equipments for both outdoors and in classes must be practised.

Teachers in the training workshops should be assigned group-work activities to study those to be used in classrooms, laboratories, and outdoors. In Brazil, during excursions, groups of teachers were assigned to study different subsystems of the Lobo-Broa watershed. One group studied in a natural forest area, while the other went to reforested areas, rivers and wetlands, reservoirs, respectively. Another group was also assigned to examine human impacts like affected areas, visual and scenic change, solid waste accumulation, soil alteration and erosion. They studied air, soil, water bodies, flora and fauna and light. Water samples were also taken to the laboratory for the determination of pH, conductivity, dissolved oxygen and suspended matter.

Some training courses may concentrate on cooperation techniques since cooperation among teachers of different fields to promote the management of environmental education interdisciplinary courses or units has, in practical terms, not been so successful due to limited planning time and the essential understanding each subject field teacher needs to have. In order to do cooperative teaching, teachers should have the concept of team teaching, cooperation and sharing, and be prepared for their vital roles as team leaders or team assistants in different parts of teaching.

To provide teachers with some alternative ideas for integration, a good part of the programme schedules might be used on how to infuse environmental education into existing study areas in school curricula. Each field content may be analysed and guidelines for integrating related environmental content can be prepared for different subjects. Many passages concerning various aspects of nature and other environmental issues can be selected for reading in language classes. Environmental topics can be used for students' practice of writing poems and essays. Drawing or making some products reflecting human living in harmony with nature, or approaches to promote sustainable development can also be very challenging to students. Groups of teachers during their training can brainstorm and put selected ideas in the guideline books or booklets so that they can use them with their students. Training schedules must include both theoretical knowledge and practical experiences for teachers.

4.3.3 Preparation of training

Before each training, besides the general preparation for place and equipments needed, there should be discussion on what teachers actually need to attain from the training workshop. Prior to the discussion, teachers' needs might be surveyed using questionnaires or group discussion method. The training organisers then should set up a priority list of such needed content and skills. After consideration of all the

specified needs and time availability, they can determine training schedules, places to be used in training, resource personnel to contact, materials and equipments to prepare for teachers. The teachers as trainees should be informed ahead of time, for instance, to bring in needed data, cases for analysis or to prepare for outdoor activities.

Training evaluation should also be prepared to collect some ideas and opinions for the effective teacher training in the future. Plans must be taken to give the participants the evaluation forms to fill out at the end and/or to collect photos, slides, video, to observe and record problems, attitudes and behavioural outcomes and change occurred during training activities. Moreover, time after training to put together some useful practical ideas and materials for school use should be taken into account.

4.3.4 Recommended training strategies

Experiences gained from our school projects suggested a variety of promising methods and techniques to be used for teacher training.

1. Using some illustrative media such as pictures, slides, and demonstrations to stimulate lectures in order to provide interesting local and global environmental facts.

2. Promoting outdoor activities, field-trips, excursions, community-based programmes to reach out to the real world just as they would teach their students. Teachers should be provided with "touch-on or hands-on experiences" on environmental conditions in classes, laboratory settings and outdoors.

3. Implementing small group discussion techniques so that teachers can identify the problems and brainstorm about alternatives of solutions.

4. Designing innovative mini-projects or small tasks for groups of trainees to create some kinds of products out of easily-found natural environmental materials.

5. Discussing environmental issues in current news and actual cases.

6. Planning for follow-up activities and close monitoring after training such as classroom visits and conference. These activities would help lessen practical and experimental problems that occur during the project implementation.

4.3.5 Role of universities, colleges or faculties of education in promoting environmental education

Out of the various responsibilities of higher education institutions, the three main ones are those of teaching, researching, and enhancing community development through various community services and use of local wisdom.

Universities are the collective places where all types of experts and scholars belong. In today's comprehensive universities, many faculties or schools may foster environmental understanding in many different ways. Usually there will be specialised programmes that deal directly with the environment such as environmental science or environmental engineering and many other programmes offered within each faculty. Many universities have "environmental studies" as their required courses for the general education part of the programme which is the basic requirement for all students of their institutions.

The Faculty of Education should also take a leading role in promoting environmental education by including such courses in their teacher education programmes. Not only those who are trained to be science or social studies teachers should take the course, but the course should also be opened for other major students. If possible, it should be a required course for all prospective teachers to take. Another popular approach is through co-curricular activities at this higher education level. Students' nature-loving clubs/conservation clubs are usually active. However, the research for and dissemination of essential environmental information the members of the clubs do among themselves and can do for the general public are still limited. These activities should receive more attention.

These pre-service programmes in the universities help build up the awareness of the values of environment in our youth and enhance their environmental friendly behaviours. The behaviour and attitudes of students and other teaching staff as well as surrounding communities can be affected, if the actions of those responsible and interested are taken continuously and sincerely.

Besides pre-service education, the Faculty of Education can give in-service training for teachers who want to upgrade their knowledge and skills in environmental education to be more effective in their teaching. The faculty staff should always scrutinise or do some kinds of research on the topic. They should prepare themselves with contemporary knowledge appropriate for teacher training in environmental education. The centre for promotion of environmental education could be established in the faculty to carry on research study in this field, to collect important and relevant facts and information. More importantly, the centre can be the resource of effective teaching strategies where school teachers can come to study and seek advice. It can be the centre for disseminating and coordinating many environmental activities within the university itself and among schools and the public. For instance, the centre can offer various mini-courses or short training courses for school teachers and the general public. To assure better quality, cooperation among different faculties of the same interests should be promoted so that staff can share their expertise for the in-service training. The Faculty of Education with its direct responsibility of searching for the best ways to provide people with education they need can certainly lead the role of coordinator.

PART II

NATIONAL EXPERIENCES AND CASE STUDIES

EXPERIENCES OF ILEC-PEAEL PROJECT IN ARGENTINA

Silvia Martinez-Bauer, Conrado Bauer and Alberto Calcagno

1. Introduction

The environmental education pilot project in Argentina – *Programa de Educación Ambiental y Ecología Lacustre* (PEAEL: Environmental Education and Lake Ecology Project) – was carried out from 1991 to 1994, with extensions to 1996, as part of the ILEC project, *Promotion of Environmental Education in Developing Countries*. PEAEL aimed at utilising lake environments adjacent to schools as the research and motivation axis for environmental education and promoting an holistic and structured approach to the teaching of sciences and other related disciplines. The project was designed and guided by a Coordinating Committee, comprising ILEC's Scientific Committee members and experts in limnology, educational science, etc.

Five public schools, three for the primary (elementary) level and two for the secondary (junior high school) level, were designated as the PEAEL pilot school where the education programme started in 1992. Training courses for the teachers concerned were held every year.

The project was supported by the National and Provincial Ministries of Education of Argentina, the municipalities of the two cities concerned, Argentine/Urguayan Technical Commission of Salto Grande, several foundations, institutes and private sectors, in addition to ILEC and the Japanese Environment Agency.

2. National Educational System

The Argentine system of education had consisted of five levels, initial, elementary, secondary, tertiary and university, until 1994, only the elementary school cycle (7 years) being compulsory. The percentage of school attendance in 1994 was 88 % for the elementary level (age 6-14) and 43 % for the secondary level (age 12-19). Since the end of 1994, a transformation of the educational system has been adopted nation-wide to meet the demands of the current world. This revision is becoming progressively effective by introducing new concepts into teaching-learning processes and by permanent training and updating of teachers. The outline of the new educational system is given in Table 1.

Main common contents of the curriculum for the general basic education level are grouped in areas as follows: Language, Mathematics, Social Sciences, Natural Sciences, Technology, Informatics with application in different areas, Moral and Civic Formation, Artistic Education, Physical Education, and English.

Before 1994, topics of the environment were basically included in Natural Sciences in subjects such as Ecology and Biology at the general basic education (RGB) level without any interdisciplinary criteria. In the new compulsory RGB curriculum, environmental themes are incorporated in the areas of Social Sciences, Natural Sciences and Technology, and are dealt with transversally across different subjects, including, for instance, such issues as:

- Environment: characterisation and interrelationships
- Population and life quality
- The earth as the source of raw materials: its limitations and the exhaustion of resources
- Renewable and non-renewable natural resources
- Provincial, national and continental environmental problems
- Sustainable development
- Effects of technology on the environment and the society
- Selection of appropriate technologies
- Ethical attitude toward the environment and the society
- Respect to all forms of life

In the polymodal cycle, which is still being organised, one of the five orientations will include Natural Sciences, Health Sciences and Environmental Sciences.

Table 1 National education system in Argentina since 1994.

Cycles	Grades or orientations	Age	Notes
Initial education	*Nursery Kindergarten *Kindergarten	< 3 3 - 5	The last year compulsory
General basic education	*1st-3rd *4th-6th *7th-9th	6 - 8 9 -11 12 -14	Compulsory
Polymodal education	*Humanities & social sciences *Economics & administration *Production of goods & services *Natural sciences, health & environment *Arts	15 -17	Not compulsory: prepares for higher studies and qualification work
High education	*Professional & academic degrees *University and non-university *Institutes of technical education	>18	Not compulsory

3. Objectives and General Scheme

The main objective of PEAEL was to generate environmental concern through the

detailed knowledge of lake ecosystem based upon observation and experiments, to improve the interest, knowledge and capabilities of students and teachers to approach environmental problems, to promote common responsibility for sustainable development and particularly to protect lake environments in cooperation with citizens. It was expected that PEAEL's outcomes and conclusions would be a tool for promoting the interest in environmental education and for improving teaching methodologies in this field.

The implementation of the project was designed to be developed in three levels or course stages, comprising the following core contents.

1992 First stage: Knowledge on lakes (description of the present situation)
1993 Second stage: Changes of lake environments (analysis of symptoms and causes of environmental problems)
1994 Third stage: Lakes and human life; sustainable use and conservation of lakes (prospects and evaluation)

The implementation began effectively in March 1992, along with the start of the school year (March – December). The first year's activities involved 5th grade of elementary schools and 1st-year course of junior high schools. The coverage was expanded to 6th grade and 2nd course in 1993, and finally to 7th grade and 3rd course in 1994, respectively.

4. Teachers' Training Courses

During the three years of the project, a seven-day training course was held annually for about 50 teachers from different schools, levels and specialisation in February immediately before the opening of the annual school cycle. In addition to lectures by university professionals, specialised in pedagogy, didactics, limnology, legal and ethical aspects, and social/community planning, workshops, work meetings, debates, roundtables, etc. were simultaneously organised. Bibliographic materials were distributed to the trainees by the Coordinating Committee.

Limnological contents of the course covered the following topics.

1992 General knowledge of ecosystem. Lake & Reservoir. Plankton & benthos. Taxonomic groups. Sampling techniques. Use of microscope. Identification and abundance counts of microorganisms. Measurements of macrophyte biomass, suspended solids and pigments.
1993 Determination of phosphorus content in water. Treatment of P-rich water samples in the laboratory. Bioindicators of contamination and eutrophication. Visit to a wastewater treatment plant. Application of the saprobien system for assessing pollution of streams. Determination of

oxygen consumption in water samples with different organic matter contents.

1994 Questionnaire survey on environmental problems in the local community. Personal essays on particular human impacts. Evaluation of the course activities.

5. Pilot Schools and Their Environments

Pilot schools of PEAEL were chosen from two districts; Concordia (Province of Entre Dios) and Chascosmús (Province of Buenos Aires) (Table 2).

Table 2 List of PEAEL pilot schools (1992-1995).

Locality	School Name	Total no. of pupils
Concordia	Primary School No. 17 (Dr. Diogenes J. de Urquiza)	1,100
Concordia	Primary School No. 53* (General San Martin)	800
Chascosmús	Primary School No. 2 (Domingo Faustino Sarmiento)	632
Concordia	Secondary Normal School No. 71 (Jorge Luis Borges)	400
Chascosmús	Secondary National Normal School of Chascosmús	650

* Joined the project from 1993.

5.1 Concordia – Salto Grande Reservoir

The city of Concordia in which three pilot schools are located, lies some 350 km north of Buenos Aires, along the Uruguay River that forms the border between Argentina and Uruguay. Riverside plains of sandy soil are covered by citrus (main product) orchards mixed with plantations of eucalyptus and pine. The climate is sub-tropical, the monthly mean temperature ranging between 10 °C and 25 °C. Mean precipitation amounts to 1,560 mm/yr, with positive hydrological balance from April to December.

Salto Grande Reservoir (length 35 km, surface area 783 km^2), the main field for outdoor studies by the pilot schools, was formed by building a binational dam (height 35 m) on the Uruguay River at 13 km north of the city. It serves for power generation, irrigation, navigation, fishery, domestic water supply and recreational uses. The flooding of productive lands and the relocation of residents caused severe social impacts.

Progressive deterioration of water quality has taken place in the reservoir during recent years, in spite of the agreement between the two countries for protecting water quality. Major troubles are: chemical contamination due to pesticide inflow from orchards; eutrophication caused by nutrients and organic loads from orchards, domestic wastewater and solid wastes; and sedimentation due to the deforestation in

the upper reaches of the river. There is no sewage treatment plant in and around Concordia city.

5.2 Chascosmús – Chascosmús Lagoon

Chascosmús city is located 120 km southeast of Buenos Aires. The climate is temperate/subhumid with 950 mm of mean annual rainfall. The prevailing natural vegetation on gently undulating uplands is the grassland of humid pampa type with scattered tree groves. Reddish brown/black soils which developed from silty loess material are highly productive for such crops as corn, wheat, sorghum, sunflower, etc. Eucalyptus plantations are also common. In low lands nearby lagoons, including the city area of Chascosmús, xerophilous peristeppe forests represent original vegetation, but has suffered from gradual destruction.

The city is on the shore of Chascosmús Lagoon, to which almost all of the city's activities are closely related. The lagoon, one of the seven chained lagoons, served for the students of two pilot schools as the field of outdoor observations and studies. It has a surface area of 30 km^2, and an average depth of 1.5 m. The lake water level is regulated by a flood gate. Slightly alkaline freshwater supports the growth of emerged and submerged macrophyte vegetation in the peripheral zone, and offers an optimal habitat for the well-known fish, atherine (local name pejerrey; *Basilichthys bonariensis*). Semi-intensive aquaculture of the fish is carried on, producing more than 100 kg/ha/yr.

Normally, organic pollution is not detected in the lake water. A sewage treatment plant and the gathering/treatment of waste are satisfactorily operated by the municipality. According to the results of observation by the pilot school students, the concentrations of dissolved oxygen, nitrates, total P and N were within normal and acceptable levels, without significant increases during the last five years.

6. Project Activities in the Primary Schools

At the elementary education level, basic principles and proposals presented by the Coordinating Committee were strictly adopted by the pilot schools, though the programme was differently implemented by respective schools. The project was applied to the third cycle pupils (5-7th grades) mainly in the area of Basic Elementary Sciences, but attempts of interdisciplinary approach to environmental themes were also made. Extra-class laboratory experiments and field visits were organised as requested by the scheme of PEAEL. It is worth mentioning that all the pilot schools except one had lacked facilities for laboratory experiments in 1992, but could thereafter develop modest but very active labs, owing to the donation of instruments from supporting institutions.

Primary School No. 17 (Concordia) The curricula for 5-7th grades were

reorganised at the beginning of the project to incorporate required subjects, classes, experiments and visits, although this school had already started environmental education to a certain extent in 1990. The teaching/learning programmes for the third cycle pupils (120 per each grade) were centred on the concepts of ecology, water cycle, water quality, characteristics of Salto Grande Reservoir, differences between various natural water bodies, water pollution and treatments of drinking water and wastewater.

In addition to the reservoir, Uruguay River, ponds and rivers in the vicinity, and a water treatment plant were visited. An integrated work by the pupils, on the environment, pollution and micro-organisms of the Concordia River flowing near the school, was very effective. A small laboratory, set up in the school building with instruments and materials provided by the project, allowed the pupils to discover the wonder of the microscopic world and proved especially useful.

No. 53 School (Concordia) The environmental education programme included studies on the pollution of air, water and soil in relation to peoples' behaviour, and the water quality and pollution of Concordia River.

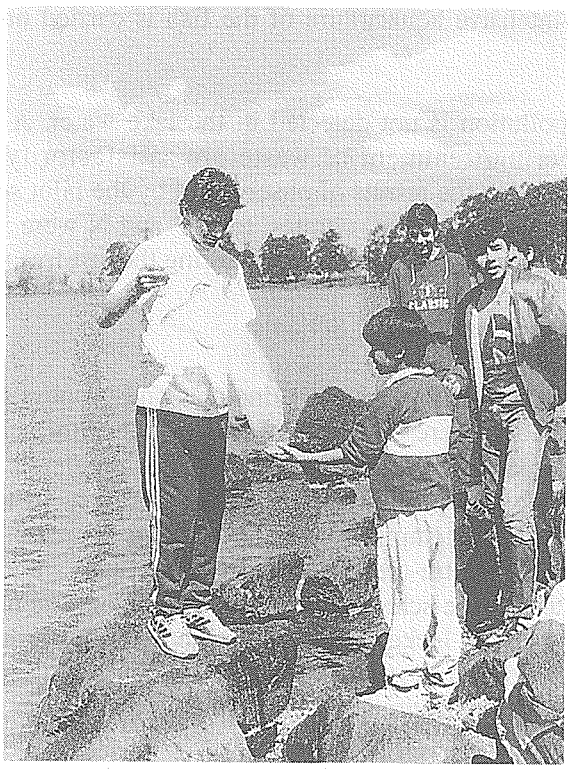


Fig. 1 Pupils of School No. 53 taking plankton sample at Salto Grande Reservoir (1994).

No.2 School (Chascosmús) started PEAEL programme with the ecology and limnology of Chascosmús Lagoon as the core theme. Later, the main theme, *Natural resources in Chascosmús district and their relationships*, was set up through interaction of teachers and pupils, and dealt with in an interdisciplinary way covering different areas of learning (Language, Mathematics, Social Sciences and Natural Sciences). The following were the central topics: soil, water and air and effects of human activities; the use of natural resources in the city; comparison of urban and rural ecosystems; health hazards due to contamination; and pollution of ecosystems and their preservation.

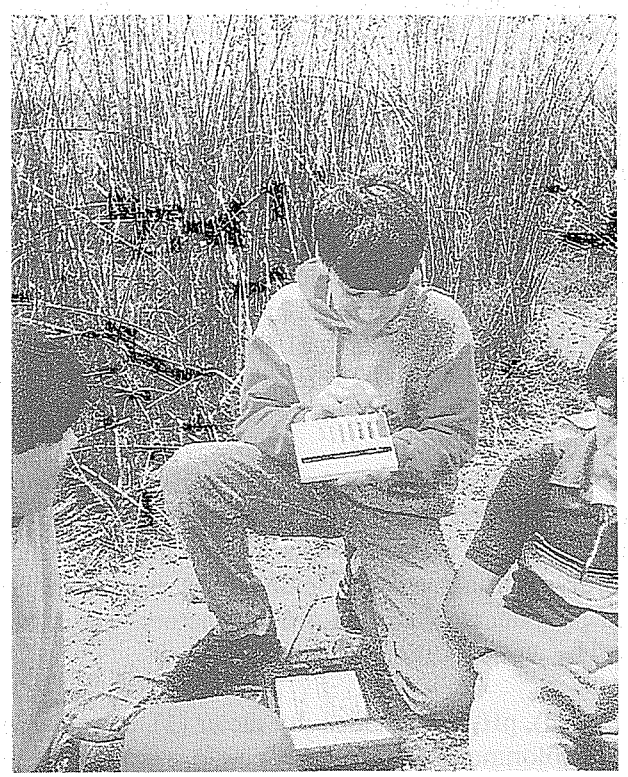


Fig. 2 Pupils of School No. 2 working on the shore of Chascosmús Lagoon with the photoelectric colorimeter and dissolved oxygen meter (1994).

Other activities in the three schools were: preparation of such experimental devices as plankton net and Secchi disc by pupils, holding an environment exposition showing the results of PEAEL, visits to research stations and museums, mutual visits and communications between pilot schools and with nearby normal schools, etc.

7. Project Activities in the Secondary Schools

The secondary schools consisted of the 3-year basic cycle and the 2-year higher

cycle. The environmental education programme was mainly applied to basic cycle students in the form of workshops (not compulsory). Participating students worked in a few groups per class and their number tended to increase with the development of the programme.

National Normal School (Chascosmús) The education programme consisted of a classroom workshop and three modules (equivalent to 6 lecture hours) per week, together with full-day visits. A total of 110 students joined the programme in 1994. They studied the geographical, climatological, physical, chemical and biological aspects of Chascosmús Lagoon by means of field observation, sample collection and subsequent laboratory work, such as the measurement of transparency, viscosity, P-content, dissolved oxygen content, etc. and the observation of plankton. Also the pollution and self-depuration processes were studied in a city stream and experimentally in the lab using aquariums. They organised a questionnaire survey to identify problems and to know the opinion of the general public.

No. 71 School (Concordia) The EE workshop took place once a week between 2 p.m. and 5 p.m. (two periods of 90 minutes) and was attended by 40-45 students of the basic cycle. Its contents were organised by teachers, consisting of the topics from three subject areas, Physico-chemical Sciences, Biological Sciences and Communication Sciences. The pupils were divided into two working groups. Some of them were *veterans* who participated in the same workshop for more than a year.

Studies on the pollution of Salto Grande Reservoir were made by field visits and laboratory work that followed. An on-site laboratory was prepared by the school in the kitchen of a local house, where students worked for observation and discussion. The growth of blue-green algae (*Microcystis*) was experimentally studied in the laboratory to see the effects of certain growth factors. The available instruments (number) provided by the supporting agencies were:

> Thermometer (3), pH and conductivity meter (1), dissolved oxygen meter (1), photoelectric colorimeter (1), microscope (3), suspended solids measurer (1), dissolved O_2 and CO_2 meter(1), phosphate and dissolved O_2 measuring kit (6), glasswares, 286XT computer (3).

The dissemination of scientific knowledge to the public received special emphasis in the PEAEL project of this school. Students were trained in the collection and interpretation of information from various sources and the elaboration of messages for various communication media. They edited a magazine for elementary schools, elaborated slogans and campaign messages which emphasised local ecological problems including the protection of lakeside areas and the prevention of accidents, and created short programmes for radio and TV. Some posters and booklets they produced were printed and distributed by the Technical Commission of Salto Grande

Reservoir. Their participation in an environmental contest was awarded by Concordia Municipality. Among the campaigns they initiated, there stand out those concerning the sorting of waste, the disposal of used batteries and the recycling of cans, besides those directly linked with the reservoir and water.

8. Evaluation of the Achievements

8.1 Evaluation of students

Methods In most cases, written questionnaires were used for individual students or groups of 3-4 persons to assess their progress and achievements (Annexe). Some schools attached more importance to cognitive/comprehensive aspects and the capacity of reflection, while others laid emphasis on their attitudes, sense of values and ability of manipulation. In addition, practical tests were carried out to evaluate the extent of acquisition of manual abilities and possibility of approaching real situations. The observation of students' behaviour by teachers was also useful.

Acquisition of concepts (knowledge) The analysis of evaluation data showed that students assimilated such concepts as lake ecosystem, rural and urban ecosystems, ecological approach, renewable and non-renewable natural resources, pollution, eutrophication, biodegradation, biocides, self-depuration, environmental impact, sustainable development and environmental education.

Operational or procedural aspects (abilities, aptitudes) Students developed the capacity of observation, research and experiment, and the knowledge on laboratory work and procedures of measurements. Considering that generally the students had never experienced the use of such abilities before, this was a particularly meritorious achievement. Many schools had lacked laboratory facilities at the start of PEAEL, but had to prepare one (though rudimental) as a positive consequence of the project. Laboratory work and field visit established the way of organising students into group studies (design and setting up). It was no less important that the students obtained the capacity of using scientific vocabulary (finding appropriate verbal expressions), finding out information sources, learning from observations and experiments, and properly using field and laboratory instruments.

Attitudinal aspects (consciousness, tolerance, cooperation, solidarity) The teachers agreed to recognise that students' sensitivity to environmental matters and life quality, as well as their interests about the conservation of lake ecosystems in their home area, increased as a result of activities in PEAEL project. In all the pilot schools, students developed attitudes to act with growing awareness, tolerance to others' opinions, and to care for group integration and role allotment. Also the sensitivity toward social problems and the appraisal of understanding lake ecosystems were aspects recognised in students' activities.

In general, students received PEAEL programme with pleasure and much interest. They also expected that the EE project would hopefully be maintained as part of the future formal curriculum for all students.

8.2 Evaluation of teachers

In the initial stage of the project, some teachers had difficulties in putting the proposed programme's principles and ideas into operation. With increasing understanding of the programme and students' interest in it, however, teachers became more and more enthusiastic about the proposals realising the importance of the project. The lack of permanent technical assistance was a limitation for some teachers, particularly for those who could not participate in the training course beforehand. This prevented certain topics from being discussed in detail, especially in the initial phase of the project.

It was the results that teachers were obtaining with their students day by day that encouraged their comprehension about the positive implication of incorporating environmental matters in formal school curricula. Many of them considered that they got a greater sensitivity to environmental themes and problems, which would last as long as they feel themselves as leaders and models for their students. They held with the objectives and general scheme of the project, though they felt that practical activities should be further intensified by more supply of teaching material and human resources (such as lab facilities, means of transportation, personnel, etc.).

In the case of secondary schools, the teachers of the subjects not related to EE workshops did not substantially participate in the project. Some of them collaborated in the project from the standpoint of their own subjects, e.g. Mathematics, Language and English, but the interdisciplinary approach was not so fruitful with a few exceptions. This was not a direct flaw of the project, but was due to the situation of the teachers who could not find the ways of implementation due to the lack of time and necessary cooperation.

It must also be remembered that all the activities of PEAEL could not be realised without the good disposition and enthusiasm of the principals and teachers of pilot schools. They accepted unconditionally the proposal from the project and its coordinators and added more responsibilities to the routine programme which was in fact heavily overcharged.

8.3 Extension effects on local communities

During three years of the project, extension effects of the work done by students and teachers emerged, initially within the schools and then in the surrounding community at large. These effects were evident from growing interest and appraisal given to the project by municipal and provincial authorities. The participation of teachers and students in various seminars and courses at local and regional levels also contributed

to the promotion of PEAEL and environmental education.

8.4 Evaluation of the objectives, contents and methods

General objectives The Coordinating Committee for PEAEL thinks that the general objectives of ILEC's International Joint Programme for promoting environmental education at elementary and secondary schools were valid. Through the learning on lake ecosystems, students, teachers and local communities could develop a special care for lake conservation as well as for other aspects of the human environment and bio-physical surroundings.

Contents The contents of the PEAEL programme, which included many innovative themes, caused a certain degree of perplexity in the teachers especially in the initial stage. However, they could increase comprehension by attending training courses and reading bibliography provided by the project.

The contents intended to introduce concepts of environmental education for sustainable development, considerations on positive and negative environmental impacts and their influences on the quality of life. The development of the project has shown that these contents could potentially encourage people to modify their behaviour, take up new values, develop creativity, adopt work modalities with a scientific spirit, and commit themselves to local and regional problems.

Thus the environmental education for sustainable development builds capacities to identify and solve real problems, so that the subjects selected for EE programme should correspond to local and/or regional necessities. This aspect was considered in all the activities planned by PEAEL teachers, and aroused great interest among students, their families and local authorities.

Didactic methods The present project tried to generate a constructive learning process with positive participation of students, emphasising an experimental approach and field studies, and to stimulate solidaristic conducts tending to a better life quality. It was appreciated that the students' motivation was strongly stimulated by the following approaches.

- Important role given to their active and creative participation in the learning process.
- Experimental and constructive methods applied.
- Possible combination of personal inquiry (starting from the direct contact with physical and social environments of their daily scope) with laboratory work and abstract reasoning for drawing conclusions.
- Search and posing for problem solving in their own environment.

To complement scientific methodology, some teachers used the identification and

resolution of existing problems as a working method structured in the following steps.

a. Start from the actual situation.
b. Once the problem is identified, relevant information is gathered from different sources (interview, observation, survey, sampling, experimentation, bibliographical documentation).
c. Propose alternative measures based on the information.
d. Compare and evaluate possible measures and select the most appropriate one (of course within the limitations of an educational institution).
e. Finally, evaluate the supposed consequences of the recommended action, and investigate if it may be effectively carried out or promoted by the school.

The *interdisciplinary methodology* showed greater power for elementary schools. At the secondary school level, it was partially applied by some teachers, especially for integrating such subjects as Biological Science and Communication Science with the learning of corresponding techniques and methods in the Normal School of Chascosmús. However, the teachers of the school considered that this attempt was not successful because it required more training and motivation of all teachers, which was still difficult to attain with regard to environmental themes. Nor the application of *transversality*, viz. application of the principles and fundamentals of environmental education in all disciplines, could be effective for similar circumstances.

Didactic resources were poorly available at the beginning of the project, particularly those necessary for the efficient development of laboratory work and field visits, such as well-equipped labs, instruments, and transportation means to reach the lake. The lack of pertinent bibliography and specialised advisors for frequent consultation also caused inconveniences. Improvements were, however, made with a very good disposition by authorities and teachers. Some schools were significantly benefited by donated microscopes, which the schools had never possessed before. Those microscopes were enthusiastically received by teachers and students. Where there were no laboratories, they were improvised and equipped with instruments donated by ILEC, domestic private companies and a Japanese foundation. With these instruments, the schools have been and will be able to continue environmental education with a higher degree of experimental efficiency. Likewise, it must be pointed out that the use of computers, simulation programmes, and audio-visual and multimedia systems was particularly important for the schools of Chascosmús where appropriate installations had already been disposed.

8.5 Conclusions

In spite of the limitations in the application of didactic methods and of necessary resources, the teachers agreed that the students who participated in the ILEC/PEAEL

project achieved:

- Motivation and consciousness about environmental problems;
- More knowledge about didactic methods and techniques in the fields of Natural Sciences and Communication Sciences;
- Abilities of handling scientific instruments for field and laboratory work;
- Detailed knowledge on lake ecosystems, surrounding ecosystems and their interactions; and
- Comprehension that the knowledge about the components of a system (including microscopic ones) is essential to understand its functions as a whole.

All these achievements generated attitudinal changes of the students, who showed more interest and respect to natural and social environments.

ANNEXE

QUESTIONS FOR THE EVALUATION OF STUDENTS PROPOSED BY TEACHERS AND SCIENTIFIC ADVISERS

Primary school level

* Describe what happens in a lake in different seasons?
* What kind of organisms of a lake (or small stream) can be seen through the microscope?
* What elements are used to know some characteristics of a lake?
* Do you consider that the lake (small stream) you know is in good conditions? Justify your answer.
* What must people do to look after the lake?
* How does a lake become polluted?
* What kind of organisms can be found in all places of a lake and among lake shore plants?
* Which kind of human activities do you consider more damaging to a lake (small stream)?
* Can you tell where water comes from when an inundation occurs?
* Do you know where the water you drink and use at home comes from?
* Is a lake (lagoon or small stream) an ecosystem? Make a sketch of all its parts and components.
* What difference is there between the origin of a lake and that of a reservoir?
* Are there any organisms that indicate if a lake (small stream) is polluted?
* What would you do to improve the water quality of a lake (small stream)?
* Which are the main planktonic organisms? State their trophic relations and draw pictures of some of them.
* Why is dissolved oxygen important for aquatic organisms?

Secondary school level

* What are the main planktonic organisms and how are they identified?
* What methods are used to take samples and measure environmental variables?
* To which degree of deterioration has the water body under study attained?
* What happens to plankton during the year?
* What kind of organisms live in the floating vegetation (*carpet*)?
* What are the principal sources of pollution in water bodies?
* What are the corrective measures to eliminate or mitigate pollution?
* How does the sewage treatment plant work?
* What kind of human activities are carried on in water bodies and what impact on the environment do they cause?

* Where does the water of a lake (small stream) come from? What factors affect its quality?
* Do you consider that the community in your city knows environmental problems related to water bodies? What actions would you take for a better understanding?
* What relation exists between water systems, their terrestrial surroundings and human settlements?
* What do human actions produce with respect to the complexity of ecosystems in water?
* What effect does eutrophication exert on ecosystems in water? What are the principal agents of eutrophication?
* Can organisms be used as indicators of water pollution?
* Why is it important to know the amount of dissolved oxygen in water bodies? What effect can its variation cause?

USE OF THE HYDROGRAPHIC BASIN AND WATER QUALITY IN THE TRAINING OF SCHOOL TEACHERS AND TEACHING OF ENVIRONMENTAL SCIENCE IN BRAZIL

José G. Tundisi, Carlos E. Matheus, Elizabeth G. C. Campos and Américio J. de Moraes

1. Introduction

1.1 Conceptual basis: watershed and water quality

The concept of the hydrographic basin (watershed) has been used as the basis for environmental planning and management in the last twenty years (Van Dyne, 1971). A systematic and integrated overview of the environment can be achieved by the use of this natural unity with its fairly clear delimitation and more or less discrete system of environmental dynamics. The dynamics depend upon climatological factors such as radiation, wind, rainfall, etc., hydrological cycle, soil and vegetation. All these subsystems interact under the influence of anthropogenic forces where biogeophysical, economic and social activities interplay (Ab Saber, 1967, 1977, 1987a & b).

It is proposed here to use this concept as a teaching unity in Science and Geography and as the basis of an updating and in-service training for school teachers. Several authors pointed out that the most creative aspects of science arose from the interfaces between different disciplines. The basin concept is expected to form such interfaces in a real and operational unity based on local and regional realities. It also enables an interdisciplinary overview of the uses and abuses of such natural systems as water, agricultural and forest resources.

On the other hand, the water quality in rivers/lakes, measured in terms of physical, chemical and biological state variables, may serve as a comprehensive indicator of the environmental characteristics of the basin and on-going human impacts. Several measurements of water quality can detect the effects of deforestation and soil erosion, inputs of domestic and industrial effluents and loads of suspended and dissolved substances of terrestrial origin on aquatic systems. The relationship between hydrographic basin and water quality is not only important to environmental planning but also successfully applicable to the areas of environmental sciences and the education in science, geography, biology and ecology as a training component.

1.2 Science and biology teachers as interfaces with the community

All integrated regional developments have to take into account existing environmental problems, since population, resources development and environment are fundamentally interrelated with respect to a wide range of human activities (Hashimoto, 1987). In this context, science and biology teachers form an important

interface between scientists and the community in the decodification and transfer of scientific information. Included therein is not only the transfer to students in a creative way but also the involvement of the general public in environmental matters. This contributes to greater achievements in environmental education, in the elaboration of integrated development projects involving the local population, and in defining conservation priorities.

Science and biology teachers are, therefore, able to implant in students and local population a correct and pertinent system of analysis which will allow a permanent sustainable control of the local environment system (Baxter, 1977; Löffler, 1988; Tundisi, 1988; Nakamura et al., 1989).

2. Teachers Training Project

2.1 Structure and objectives

In Brazil, there is a growing concern about environmental problems. The environmental education for young students and the public plays an important role in stimulating the conservation and rehabilitation of terrestrial and aquatic ecosystems (Tundisi et al., 1988).

The present environmental education (EE) project, carried out by the two institutions of the University of São Paulo at São Carlos, Centre for Water Resources and Applied Ecology (CRHEA) and Centre for Science and Cultural Diffusion, was fundamentally based on the watershed concept. The information and extensive data bank acquired during 25 years of continuous field and laboratory works at Lobo-Broa watershed were adequately used for the training of school teachers. The objectives of the project were:

- To establish an updating and in-service training for primary and secondary school teachers of Science and Geography, on the basis of the watershed concept and the scientific information from Lobo-Broa Reservoir and its watershed.
- To establish and maintain an open institute which is able to receive school teachers and their students for the development of observation, experiment, field excursion and conference cycles.
- To develop a water quality kit with the aim to stimulate the construction of a data bank and enhance technical capabilities of teachers and 1st and 2nd grade students.

2.2 Lobo-Broa watershed

Lobo-Broa watershed is a small basin (280 km^2) in the central part of S. Paulo State where the most detailed and the deepest ecosystem study in the Southern Hemisphere has been made (Fig. 1). This area, including the Lobo River and Lobo-Broa

Reservoir, presents exceptionally favourable conditions for field and laboratory work, due to its moderate size, easy accessibility and the existing infrastructure of CRHEA. The known state variables and the processes studied encompass an enormous range of scientific information.

The research in Lobo-Broa watershed has so far covered the following topics: processes and mechanisms of functioning and linking of climatological, physical, chemical and biological factors over a continuous long term; hydrodynamic characteristics of the reservoir; main interactions in the basin such as the input of suspended material to rivers, the effect of hydrologic conditions on ecological cycles, etc.; the development of ecological modelling techniques and their uses for the management of the whole basin and trainings at various levels, etc.

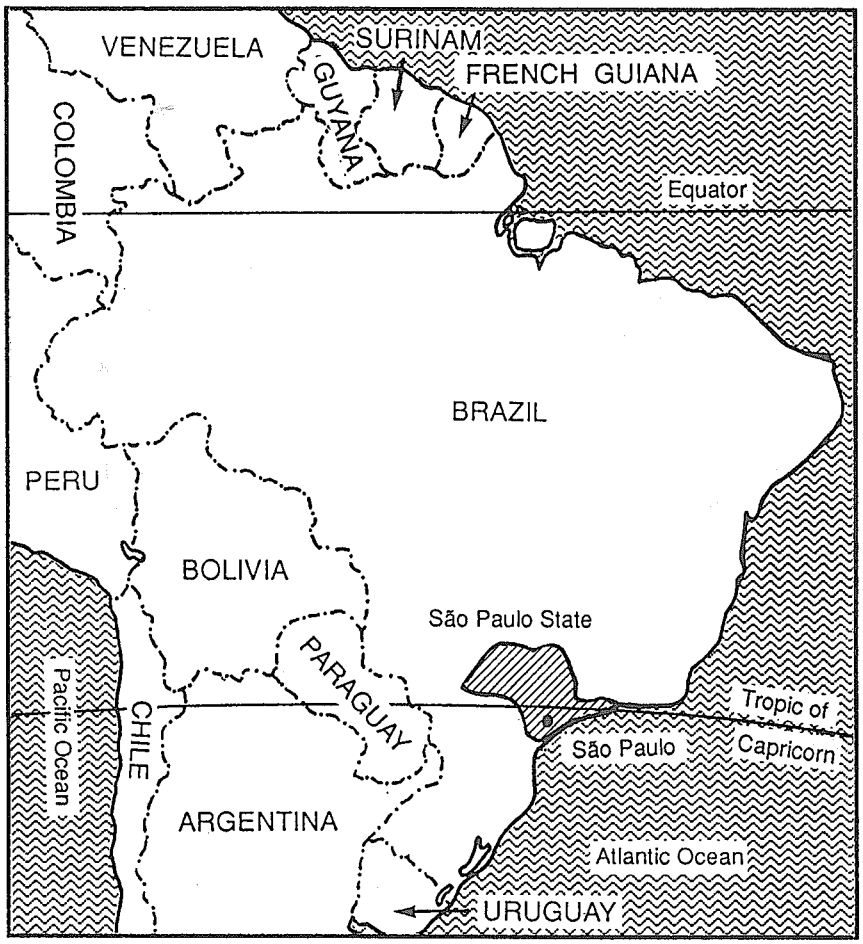


Fig. 1 Map of Brazil showing the location of São Paulo State.

2.3 Methodology and general approach

The conceptual organisation of the updating course reflects an innovation proposal of an interdisciplinary teaching model for Science and Geography. The organisation and setting up of the course are centralised on the following objectives: demonstration, observation, field work, laboratory work and theoretical discussion.

Theoretical Course consisted of:

- Hydrographic basin: theoretical introduction.
- Lobo-Broa basin: scientific data and information available.
- Lobo stream reservoir and Broa Reservoir basin: exploitation system, effects of human activities (agriculture), integrated operating system.
- Identification of main climatic, physical, chemical and biological functioning mechanisms and interactions in the basin.

Examples of the topics presented were:

- The role of wind as an ecological factor in the vertical transport of organisms in water and in the dispersion system in terrestrial ecosystems.
- Food chain in cerrado (savannah).
- Penetration of light into water and riparian vegetation.
- Solar radiation and its importance: radiation spectrum, measurements, effect on photosynthesis.
- Water chemistry: dissolved gases, gas solubility and temperature.
- Water and temperature: water density and thermal stratification in lakes and reservoirs.

Field work Outdoor practices were extensively used as an interdisciplinary updating mechanism, including the following observations and measurements.

- Global observation of the basin from a 860 m height (Fig. 2).
- Riparian vegetation: observation and light measurements (Fig. 3).
- Cerrado vegetation: observation and measurements.
- Observation of small streams and dendritic structure of the basin.
- Transport of organisms and decomposing organic materials in rivers: observation and measurements.
- Measurement of light penetration into water.
- Measurement of dissolved O_2 and CO_2.
- Measurement of water pH.
- Principles of measuring N and P in water and their effects on the growth of organisms.
- Observation of aquatic higher plants.
- Collection of fish, plankton, biological materials and sediments.

- Observation on the main uses of the reservoir and the basin: reforestation, agriculture, tourism and recreation, problem of water-born diseases, water supply system.
- Soil types in the basin: observation and measurements, soil temperature, granulation.
- At the meteorological station: handling of climatic data, radiation, wind, rainfall, regional patterns, microclimate, effects on organisms.
- Aquatic and terrestrial organisms in the basin: form, function, location, interaction with abiotic systems.
- Observation and discussion on the conservation systems used by the local community: water quality, tourism and recreation areas, maintenance of riparian vegetation, aquatic higher vegetation as biotic filtering systems.

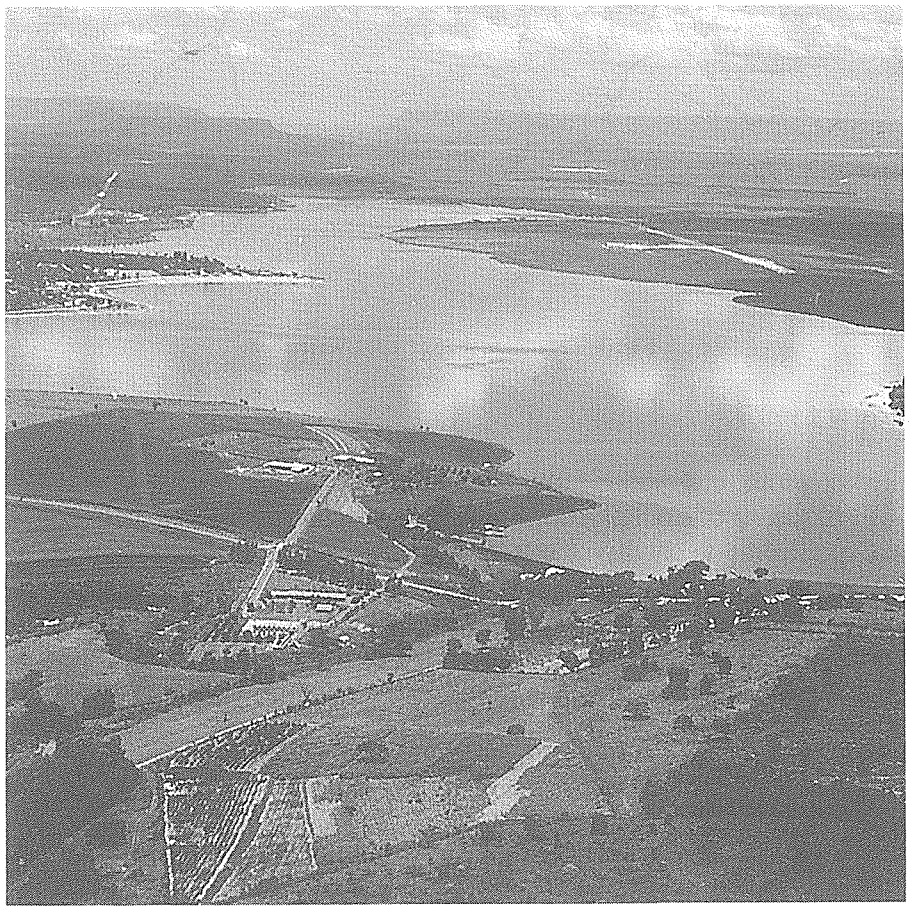


Fig. 2 Aerial view of Lobo-Broa Reservoir and Lobo basin.

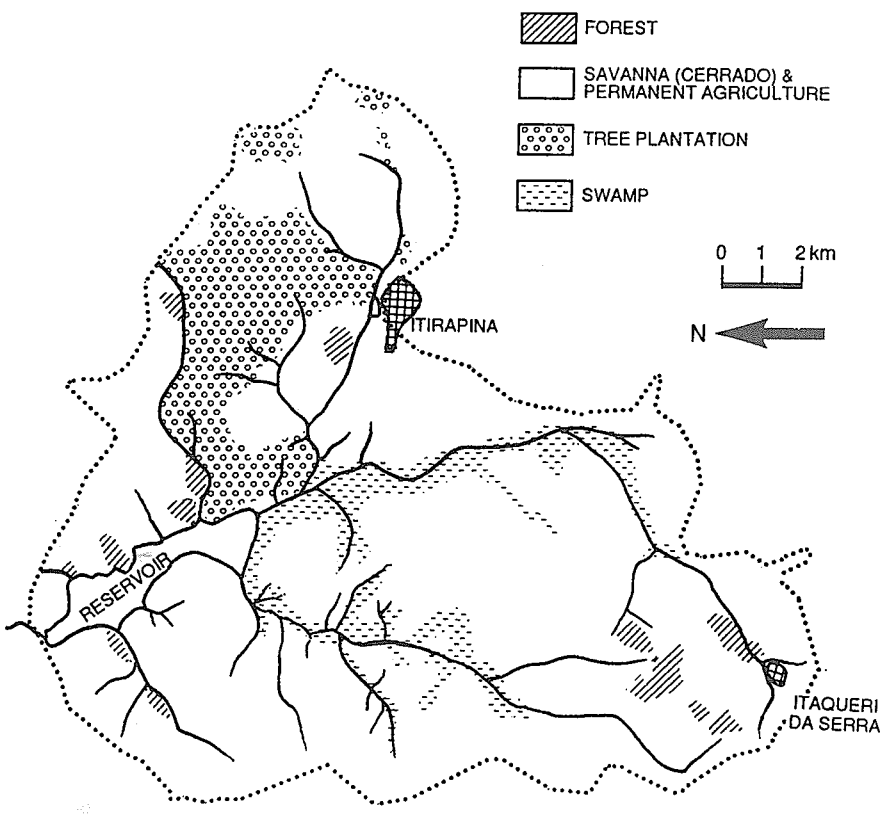


Fig. 3 Vegetation map of Lobo watershed.

Laboratory work:

- Microscopic observations: phytoplankton, zooplankton, benthos (invertebrates).
- Fish: sorting of stomach contents to see feeding composition.
- Experiments on photosynthesis.
- Chemical composition of water and sediments.
- Decomposition of terrestrial plant materials in water.
- Ecological cartography: interpretation of maps, identification of main landscape units and subunits in the basin based on existing maps and aerial photographs.
- Simple experiments with cultured algae and other aquatic organisms.

Theoretical discussion integrated the concepts obtained by the observations and measurements in field and laboratory work. For example, the transmission and absorption of radiant energy in media with different densities were discussed when light penetration in air and water was examined.

In the theoretical discussion, attention was always paid to the interdisciplinarity and unifying aspects by showing various interrelationships. Instead of dealing with a single isolated concept, the basic approach was to consider its function within an integrated system. Applied aspects were also emphasised such as the impacts of human activities, uses of soil and water, the importance of diversity and mosaic structure of ecosystems, the importance of conservation, etc. (Tundisi & Barbosa, 1981).

Not only special but also temporal aspects of the ecosystem and the basin were highlighted in the theoretical discussion, introducing geomorphological notions, the origin of the systems affecting their present status taking human influences into consideration, and special/temporal modifications of physico-chemical factors in the basin and the reservoir. Further, it was attempted to orient the trainees to an integrated view of their home districts in order to enable the choice of appropriate sites for the application of this methodology.

Operation system A 10 day (full time) course was given to 20 teachers annually from 1986 to 1992. All groups of Science and Geography teachers in the region were covered during these years. An Open Institute was simultaneously established.

2.4 Evaluation

The fulcrum of the course's evaluation system was the re-feeding and re-directing of basic concepts through periodical discussions with the teachers participating in the updating work. The validity of the approach employed, the possibility of its local use, the interdisciplinarity of the concepts, and the viability of the model's application were discussed, reviewed, updated and adapted to different districts. Thus the evaluation system served permanently as a functioning mechanism of the courses, allowing the introduction of new ideas and increasing teachers' participation.

Methodological evaluation was done through discussions on the viability of experiments, and the elaboration of equipment and programmes which enables the use of adequate and easily available teaching materials. Leaderships arising during the courses were encouraged by attracting the leading persons to the Open Institute in subsequent courses. The trainees' performance in the course was evaluated by observing their field and laboratory activities and their effective contribution in the discussion for the programme's improvement. They received and answered a questionnaire concerning the use of the developed concepts in their routine classes.

3. Water Quality Kit Project

3.1 Objectives and preparation

The first series of teachers training courses (1986-1992) yielded a new idea to use water quality as an indicator of watershed environments, its uses and the stage of conservation and/or deterioration. This resulted in the production of a water quality

kit for field and laboratory work, which teachers could use in districts where their schools were located to carry out a series of physico-chemical and biological observations and measurements. The data obtained in many places of S. Paulo State and Brazil were compared in various seminars while serving for the assessment of the state of development in a region in the light of scientific information.

Objectives:

- To implant and develop a system of technical/scientific apprenticeship for Sciences and Biology teachers.
- To produce kits to be used for water quality measurements and reforestation with native species, which will be a permanent equipment for 1st and 2nd grade schools in the future.
- To produce manuals, texts and publications with emphasis on the basic concepts and the methodology used, incorporating experiences of the teachers in the project.
- To provide suitable conditions for the development of a local water quality monitoring system, maintained by Sciences and Biology teachers and their students.
- To produce information and data which allow comparative analyses of the relationship between the uses of a hydrographic basin and the quality of its outflowing water as a pertinent material for teachers to understand the multi-disciplinary system (biographical, economic and social basis).
- To prepare teachers for a proper analysis of the inter-relationship between science/technology and the society through their involvement in local environmental problems.

The kit, prepared at the CRHEA/USP workshop and supplied to each group of teachers from the same district, contained (Fig. 4):

- Secchi disc for transparency measurement
- Electric conductivity meter
- Thermometer
- Reagents for dissolved oxygen determination
- Plankton net
- Net for collecting aquatic insects
- Necessary glassware

A technical manual was supplied with the kit.

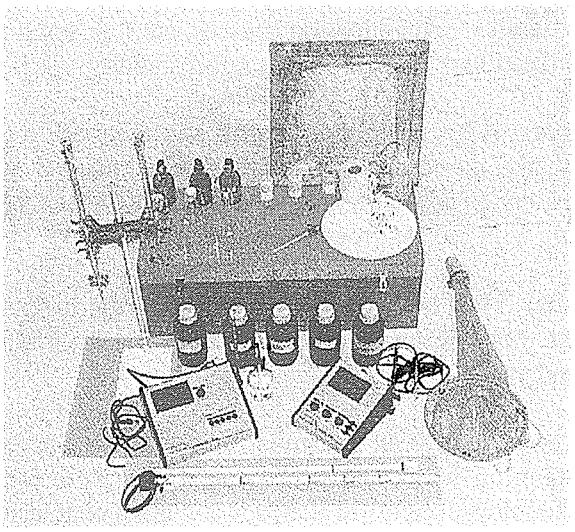


Fig. 4 Water quality kit.

3.2 Operation and results

1st phase The 10 day (full time) apprenticeship consisted of field observations, measurements of physical, chemical and biological variables in rivers and reservoirs, and laboratory practices using the kit. Ample bibliography was supplied to the participants. Of the total of about 80 hours of work, one-fourth was devoted to seminars and meetings and the rest to field and laboratory practices.

Besides technical practices, theoretical information on the following topics was also given: dissolved oxygen, conductivity and other physico-chemical parameters; the importance of aquatic organisms as water quality indicators; deforestation, reforestation and the importance of riparian vegetation in relation to water quality; effects of certain types of wastes on water quality etc.. Techniques of seed collection, planting and reforestation with seeds of native species were also demonstrated during the course.

After the 10 days, the teachers were acquainted with the basic concepts concerned and qualified with the use of water quality analysis techniques as well as the interpretation of the results obtained. They also obtained integrated views in Science, Chemistry and Biology, with water quality as the catalyzer, and on the reforestation as the basis for the recovery of water quality and watershed environments, recognising that this offered a stimulating approach to environmental education.

2nd phase (4 months) After the 10 day course, the teachers used the kits in their own districts for 4 months, collecting water quality data, respectively, in a nearby river or reservoir. Teachers and students worked together on the data, and collected other relevant information (watershed uses, main human activities, types of existing

industries and their wastes, contamination sources, etc.). A small nursery project was also started to grow seedlings for subsequent reforestation.

3rd phase (10 days) After the four months, the teachers returned to CRHEA, discussed and compared the results they brought, and joined a synthesis seminar for preliminary conclusions. In addition, another group of 20 teachers were trained in the same period working with the 1st group of qualified members.

4th phase (4 months) Then both groups went back to the in-service work again for another four months. Forty teachers were thus trained at the end of the 1st year, and another 40 in the 2nd year.

5th phase At the end of the year, a seminar was held with the aim of synthesizing information, exchanging ideas and preparing a complete text by the teachers, containing the methodology, scientific analyses and main conclusions.

The trainees and schools were selected so as to include as many hydrographic basins in S. Paulo State as possible (Fig. 5). This allowed the participants to approach the problems of the basins and to easily compare the results in synthesizing evaluation seminars. Some teachers from other Brazilian states were also invited to act as catalyzers for future development of the project on a national basis.

During the in-service training in respective schools, the teachers were visited by students, technicians and professionals of CRHEA for the follow-up in the districts under study and to standardize data collection and preparation and subsequent discussion.

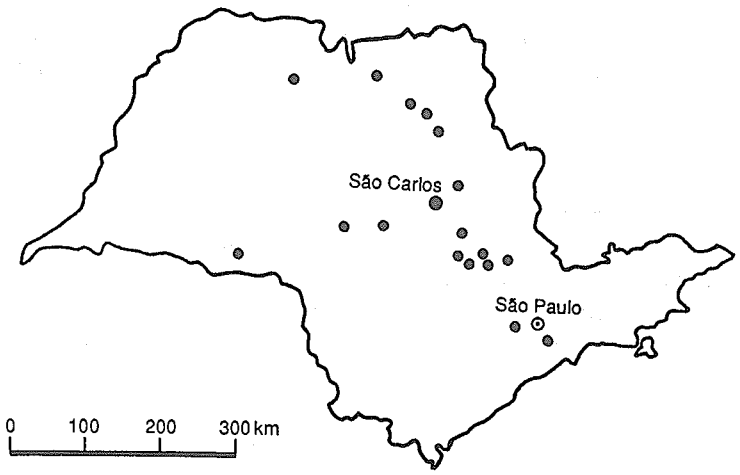


Fig. 5 Distribution of participating school in São Paulo State.

3.3 Critical overview and major achievements

This project includes conceptual, methodological and technical training in Sciences and the interfaces with environmental science and environmental education. The technical training in the use of relatively simple equipment, coupled with the continuation of well-oriented measurements, adds an important aspect to the in-service training for Sciences and Biology teachers. Besides allowing a methodological renewal of the teachers' routine work, it opens new horizons for them, supplying adequate tools to analyze ecological situations correctly through the production of data by scientific measurements.

The quantification of the processes concerned is another important aspect. Precise data collected daily or weekly enables the follow-up of changes in hydrographic basin systems and the cause/effect interactions involved. The use of the basin concept is not only efficient and innovating but also particularly important for the introduction of integrated views in Sciences (Ludwig, 1988).

Recognising cause/effect relations plays a key role in dealing with a hydrographic basin and its rivers, lakes and reservoirs as a functional unit being subject to permanent changes. It must be emphasized that not only biogeophysical, but also socio-economic causes are involved in this approach. Thus the analysis of local environmental problems is done by combining water quality measurements with the survey on uses of hydrographic basins (Chandrasekara, 1987).

4. Improved and Specialised Courses in Environmental Education

With ample experiences obtained during the first series of training courses (1986-1992), and the Water Quality Kit Project (1990-1994), as the theoretical and practical background, CRHEA developed a new series of improved and specialised courses in the last few years, aiming at deepening the information given to school teachers and enhancing the conceptual framework acquired.

4.1 Improved courses

From 1993 onwards, an improved series of 180 hours on the following subjects were implemented to strengthen inter-disciplinary integrated concepts of sciences, ecology and environmental education.

Water quality To create teachers' awareness of the importance of water quality preservation for various water uses and the impacts caused by pollution and contamination in hydrographic basins.

Techniques for measuring water quality To make trainees get acquainted with the main techniques of taking, preserving and analysing water samples as well as correlating determined water quality with basin environments.

Didactics of environmental education To create conditions for investigating theoretical principles necessary for teaching; to make trainees critically visualise the factors which interact under teaching/learning situations; and to extract from various teaching approaches the structural frame related to environmental problems involving teacher/student interactions in and outside the school.

General limnology To give trainees knowledge about the basic functioning of aquatic systems, various interactions among aquatic organisms, research methods used and environmental influences, with the aim of deepening integrative approaches.

Water resources planning To present the principles of water resources planning, which are useful for professionals in a wide range of expertise.

Ecology of fish and impacts on fish fauna To give an overall view of the ecological principles ruling the life of fish in aquatic systems, from the viewpoints of ecotechnology, sustainable development and environmental education.

4.2 Specialised courses

Specialised courses with a total duration of 360 hours were introduced in 1996. Besides the modules described above, the following new subjects were added.

- Conceptual basis for environmental education in a hydrographic basin context.
- Wetlands as a subsystem of hydrographic basins.
- Participation of society in environmental movements.
- Critical overview of theoretical and practical activities for the conservation of the environment.

These two new activities, now forming part of CRHEA's permanent activities, were the outcome of the initial project that started in 1986 as a really new approach to the training of school teachers in Brazil.

5. Summary and Conclusions

1. Eleven years (1986-1996) of continuous activities for the upgrading of school teachers and the education of 1st and 2nd grade students have caused a considerable change in the general view of environmental problems on a regional basis in S. Paulo State, with some effects in other regions of Brazil.

2. The project successfully transferred to teachers and their students the knowledge accumulated by Lobo-Broa watershed studies and decodified the scientific information to the general public. It also stimulated public supports to environmental programmes and integrated watershed management projects.

3. The basin approach, which dealt with watersheds as a unity for research and planning and as a teaching laboratory, introduced a systematic overview of environmental problems as well as an integrated and articulate view of socio-economic problems.

4. The preparation and distribution of the water quality kit enabled schools of primary and secondary levels to develop a technical capacity to measure water quality and look for cause/effect relationships concerned. The equipments of laboratories in these schools and the establishment of a databank were very important results of the project. The kit stimulated the awareness of water problems in the districts where it was supplied, and attracted the attention to rivers and reservoirs as the receiver of wastes from human activities in the watershed.

5. The project trained some 500 school teachers and more than 5,000 students participated in training courses, excursions, laboratory and field work. Several manuals, textbooks and papers were produced to help training activities.

6. The recent development of a permanent specialised level training programme at CRHEA was an important achievement of the project's activities.

7. The inclusion of water quality issues and environmental education in the curricula of elementary and secondary schools was another important achievement of this project.

8. As a perspective for future extension of the project, it is planned to prepare a water manual (*Cartilha da Água*) to be distributed to schools all over Brazil. The manual will introduce water problems in plain language and call attention to the importance of water resources conservation and water quality preservation. It will be used widely in schools, but may also be used for the general public.

9. A wider distribution of the water quality kit is also intended, and is expected to be incorporated in several projects in science education and environmental education which are now being developed in many regions of Brazil.

10. The project stimulated several districts to reformulate their institutional and organisational framework for the conservation and management of water resources.

Bibliography

Ab'Saber, A. N. (1967) Problemas geomorfológicos da Amazônia Brasileira. Atas do Simpósio sobre a biota Amazônica. Geociencias, 1967: 35-67.

(1977) Os domínios morfoclimáticos da America do Sul: promeira aproximacao. Geomrfologia (Inst. Geogr. Univ. de São Paulo), 52: 21.

(1987a) Zoneamento Ecológico e Econômico da Amazônia: Questoes de Escala e Método. 25pp. Seminar on Technology for Human Settlements in the Humid Tropics, CEPAL/IPEA (Economic Commission for Latin America/Caribbean Institute of Economic and Social Planning).

(1987b) Aspectos geomorfológicos de Carajás (Geomorphological characteri-zation of the Carajás region). *Desenvolvimento Econômico e Impacto Ambiental em Áreas do Trópico Úmido Brasileiro*, pp. 201-231.

Barica, J. (1981) Hypereutrophy; the ultimate stage of eutrophication. WHO Water Quality Bulletin, 6(4): 95-98.

Baxter, R. M. (1977) Environmental effects of dams and impoundments. Ann. Rev. Ecol. Syst. 1977: 225-283.

Campos, E. G. C. (1993) *O Estudo do Pensamento Infantil nos Campos da Ecologia e da Educãcao Ambiental.* CRHEA/EESC/USP, 87pp. (digitado).

Chandrasekhara, C. S. (1987) Environmental planning and management for local and regional development; a conceptual framework. UNCRD & UNEP(1987), pp. 23-54.

Hashimoto, M. (1987) Man power development for environmental planning and management. Regional Development Dialogue, 8(3): 181.

Jørgensen, S. E & Vollenweider, R. A. (eds.) (1989) *Guidelines of Lake Management, Vol 1, Principles of Lake Management.* ILEC/UNEP, Otsu & Nairobi, 199pp.

Leal, J. (1989) A gestao do meio ambiente na America Latina: problemas e possibilidades. Caderno Fundap, 16: 7-14.

Löffler, H. (1988) *Hazards and Health Risks from Lakes.* 23pp. UNEP/UNCRD/ILEC Expert Group Workshop on River/Lake Basin Approach to Environmentally Sound Management of Water Resources, Feb. 1988, Otsu & Nagoya.

Ludwig, R. L. (1988) Ecological Effects of Metropolitan Growth on Water Resources. 42pp. Same Workshop as above.

Margalef, R. (1974) *Ecologia.* Ediciones, Barcelona, 951pp.

(1975) External factors and ecosystems stability. Schweiz. Z. Hydrol., 37: 102-117.

(1980) *La Biosfera entre la Termodinamica y el Juego.* Ediciones Omega, Barcelona, 236pp.

(1982) Instabilities in ecology. Casa Vasquez, J. & Lebon, G. (eds.): *Stability of Thermodynamic Systems*, pp. 295-306. Springer Verlag, Berlin.

(1983) *Facts of Life not to be Overlooked in Preparing School Books for Our Grand Children.* Univ. of Barcelona, 12pp. (manuscript).

Nakamura, M., Hashimoto, M., Tundisi, J. G. & Bauer, C. (1989). Planning for sound management of lake environments. Jorgensen & Vollenweider (1989), pp. 115-134.

Swanson, G. (1979) Geomorphology and ecosystems. Waring, R. W. (ed.): *Forests – Fresh Perspectives from Ecosystem Analysis; Proceedings of 40th Annual Biol. Colloquium*, pp. 159-170.

Tundisi, J. G. (1978a) *O modelo Broa; a Comunidade Vegetal como Unidade Bio-lógica, Turística e Econômica.* Publ. Acad. Cienc. Est. São Paulo, 15, pp.99-113.

(1978b) O Ecossistema como Unidade Ecológica. Ibid., pp. 3-13.

(1979) *Projeto Integrado de Pesquisa nas Estaçoes Ecologicas para o Brasil.* IBILCE/UNESP, 18pp.

(1986a) Ambiente, represas e barragens. Ciência Hoje, 5 (27): 49-54.

(1986b) *Local Community Involvement in Environmental Planning and Management: Focus on River Basin Management -- the Lobo-Broa Reservoir Case Study.* 29pp. UNEP/UNCRD/ILEC Expert Group Workshop on Environmental Planning and Management for Local and Regional Development: Focus on Training Aspects derived from Studies of Inland Water Management, 1986, Otsu & Nagoya.

(1988) (ed.) *Limnologia e Manejo de Represas.* Série Monografias em Limnologia, EESC/USP/CRHEA/ACIESP, 1 (Tomo 1 & 2), 946pp.

Tundisi, J. G. & Barbosa, F. A. R. (1981) *Impacto das Obras Hidráulicas nas Bacias hidrográficas; Interfarcies, Escitos e Documentos.* IBILCE/UNESP, 27pp.

Tundisi, J. G., Schiel, D., Diniz, R. E., Santos, M. J., Rigolin, O., Santos, B. & Eler, M. N. (1988) A uttilização do conceito de bacia hydrografica como unidade para atualização de professores de ciencias e geografia: o modelo Lobo (Broa), Brotas/Itirapina. Tundisi, J. G. (ed.): *Limnologia para Manejo de Represas --Série: Monografias em Limnologia,* Vol. 1, EESC/USP/CRHEA/ACCESP, pp. 311-355.

UNCRD & UNEP (ed.) (1987) *Environmental Management for Local and Regional Development, Part II, Developing Countries' Perspectives,* Nagoya & Nairobi, 315pp.

Van Dyne, G. N. (1971) Implementing the ecosystem concept in training in the natural resources sciences. Van Dyne, G. N. (ed.): *The Ecosystem Concept in Natural Resources Management.* Academic Press, London, 383pp.

THE DANISH ENVIRONMENTAL EDUCATION / SCHOOL PROJECT, EXPERIENCES FROM THE PERIOD 1990-1995

Sven Erik Jørgensen

1. Introduction: Environmental Education in Relation to the Danish School System

The Danish school system is based upon a frame legislation, which implies that the schools independently can assess themes, which are given a particular profound treatment in the education. It is common to use multidisciplinary projects as such themes. Environmental issues are strongly recommended as multi-disciplinary themes or projects by the ministry of education.

No grading of the pupils takes place before the eighth grade, which creates a particular relaxed atmosphere. This is used generally by Danish teachers to create team and group work and encourage the use of multidisciplinary projects to the benefit of environmental education as an integrated component in Danish school activities.

An integration of environmental issues into the current "learning process" takes place mainly, not surprisingly, in the scientific subjects (Biology, Chemistry, Physics and Geography) and Danish, where essays on various actual topics including environmental topics are applied. Recently, a subject called Science (in general) was introduced into the Danish school system. Two hours per week is devoted to this subject from the second to the fifth grade. This has facilitated the introduction of environmental issues into the education, as "pollution of your own environment" and seems to be a particularly appropriate topic to focus on in this context.

It may be concluded that the Danish school system seems particularly well fitted to an integration of environmental issues into the general education in public schools. As Denmark has many lakes it will furthermore be very relevant to exemplify the environmental topics by application of lakes.

This chapter gives the results of ILEC's environmental education programme on the application of lake environments in Danish schools as object for a more general education in environmental topics. The experience gained covers a wide range of grades and is entirely obtained by integration of the programme into existing subjects. After a presentation of the experience gained, the discussion centers on which components of the programme it would be beneficial to use more generally in environmental education to be able to give general recommendations on this type of education.

2. An Overview of the Activities in Seven Danish Schools

The school project in Denmark has involved seven schools: The Seven Stars School in Værløse, a suburb of Copenhagen with about 20,000 inhabitants, Marie Kruse School in Farum, a suburb of Copenhagen with about 20,000 inhabitants, Vestervang School in Esbjerg a town with about 100,000 inhabitants in the Western part of Jutland. Esbjerg is a North Sea harbour with fishery, fishery industry and offshore oil exploitation in the North Sea. The Oak school, also situated in Værløse, Bagsværd Boarding School and Gymnasium, Bagsværd, a suburb of Copenhagen with about 50,000 inhabitants and Fladstrand School a village close to Frederikshavn, a major harbour in the Northern Jutland with about 40,000 inhabitants. The last last three schools joined the lake project in 1995, while the Vestervang School and The Seven Stars School have been very active from the beginning of the reporting period throughout the entire period 1990-1995.

In 1988 it was decided at the Danish Ministry of Education, that Science should be introduced as a subject in the Danish Schools, from third to fifth grade (later grades 2 to 5 grade), in addition to the traditional scientific subjects Biology, Geography, Physics and Chemistry which were taught mainly from the sixth grade. The two school adopting the ILEC lake educational programme were starting up with this new subject among the very first schools in Denmark. It gave a unique possibility to test the environmental lake programme launched by ILEC.

In the four schools: Marie Kruse's School, Bagsværd Boarding School and Gymnasium and Fladstrand School, the application of the lake project is mainly limited to integration of lake examinations from adjacent lakes in the topic science in grades 3 to 5 grade, although the bird life at lakes was also included in Biology in the seventh grade at the Fladstrand School.

The Oak School is a small school with only pupils at the tenth grade. In this class the pupils can choose among several lines: a sport line, a creative line, a practical line or a natural scientific line. In the last line (about 20 pupils) is the lake project now integrated as one of the possibilities the pupils could choose for a more profound examination within the subject area of Natural Science. For the pupils who have chosen this possibility, mainly water quality examinations of the adjacent lakes were carried out using the ILEC-developed spectrophotometer as a useful tool.

Details on the implementation of ILEC's lake educational programme in the two schools, The Seven Stars School and the Vestervang School, which have adopted the lake project for the longest period are given below. The presented programme has in both schools been adopted as scheduled activities after the successful implementation of the lake educational programme as an integrated component in several subjects.

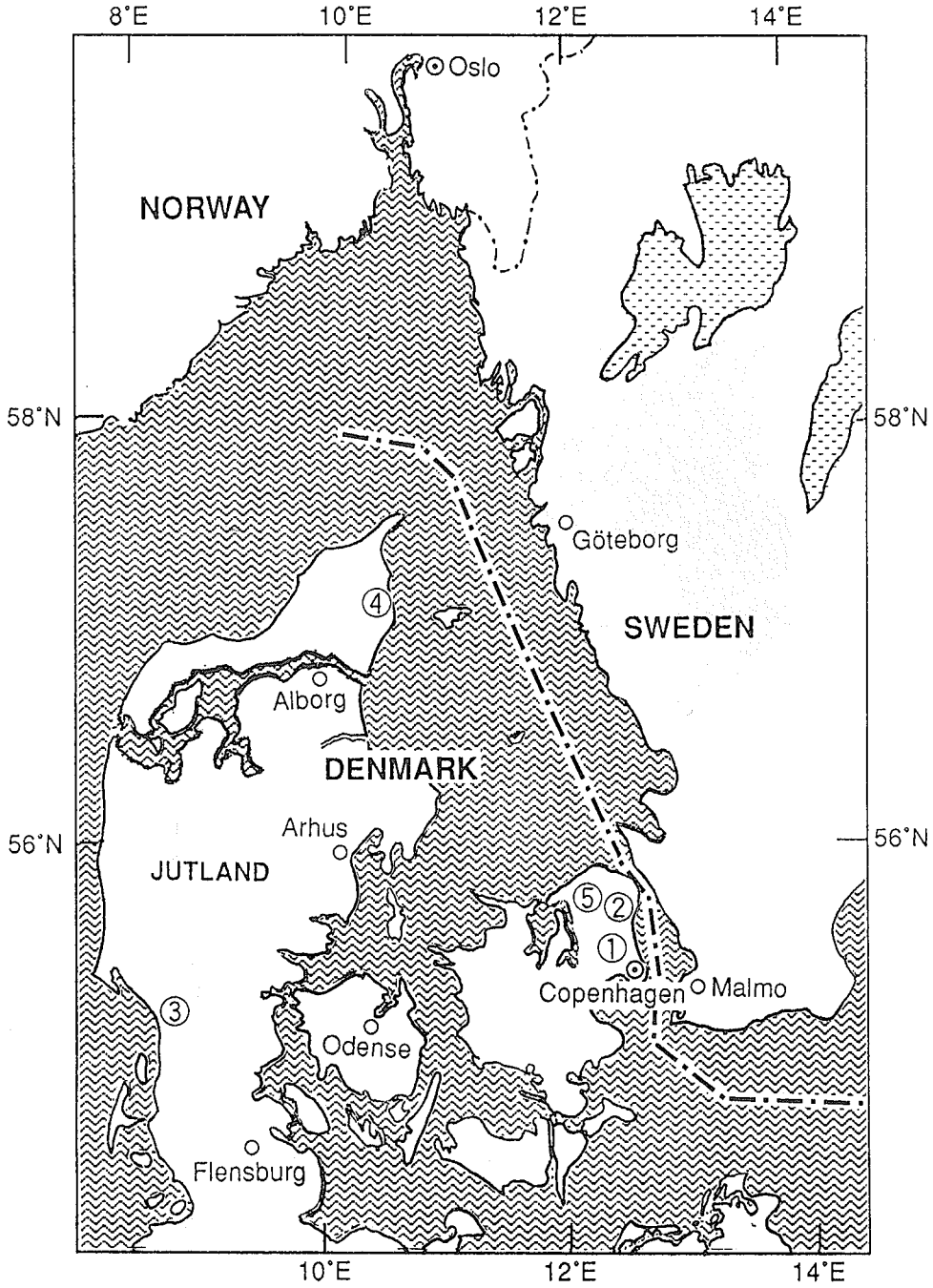


Fig. 1 Location of pilot schools. ①The Seven Stars School ②Marie Kruse School ③Vestervang School ④Fladstrand School ⑤The Oak School

3. The Experience Gained at the Seven Stars School

The Seven Stars School was one of the first schools to start the new programme in Science, mentioned above, in Denmark (in 1988). When the school lake project started, Science in the third, fourth and fifth grades was considered an experimental education, which was carried out at the Seven Stars School parallel to a small (selected) number of schools in Denmark. The experiment of introducing Science in grades 3 to 5 was so successful that Science in the second, third, fourth and fifth grade is now a fixed part of the syllabus in all Danish schools.

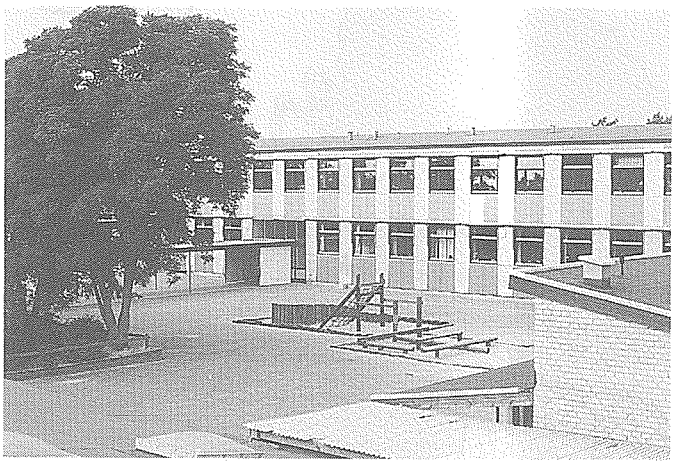


Fig. 2 The Seven Stars School.

The lake educational project (the ILEC project) has now been integrated at the Seven Stars School in several classes and some details about this integration are given below.

1. In the first three grades (grade zero, one and two) exhibitions of drawings focusing on specific environmental issues are a general annual event. The (peculiar) properties of water and water as resources are discussed in these grades.

2. The lake project has from the very beginning of this programme and up to today been an integrated part of the educational programme in Science for the third, fourth and fifth grade. Environmental education is mainly concentrated in these three grades and in conjunction with the education in Science, although other activities in other grades are also related to environmental issues. It was therefore considered natural for the Seven Stars School to continue this successful activity. Three major projects are generally applied:

A. 4-6 excursions to the adjacent (large) lake, Lake Fure, for sampling of phytoplankton, zooplankton and water analyses. The temperature, pH and transparency are measured. The results are used to assess the level of eutrophication and to illustrate the seasonal variations. The observations are discussed later in the classrooms: the seasonal changes, why is the lake so green? Do you like to swim in green water? the food chain (what do zooplankton eat? and who is eating the zooplankton?) What is eutrophication (= too much nutrients)? Why is the water warmest at the surface during the summer? What can we do to improve the water quality? Different types of pollution.

The data are also treated in the mathematics by the use of graphical plots, which is taught in the third grade. All the observations were plotted on graphs and the results were discussed once more now by the use of their graphs with relation to seasonal variations of temperature, transparency, pH and nitrate.

B. Discussion of the water cycle, associated with visits to a drinking water plant and a sewage plant. This project is generally an activity in the fourth grade. In the class room pupils discuss the details of the water cycle and why water is a resource, that we have to care about. The relation between our water consumption and the pollution. How can we reduce our water consumption? What will it imply, if we are able to reduce the water consumption? Why the water quality is still unacceptable in spite of the proper waste water treatment is also discussed? (The retention time of the lake is 20 years and the sediment has stored phosphorus from previous lack of proper treatment (until 1974)). It is furthermore discussed, what would have happened if the proper waste water treatment had not been introduced in 1974? The water consumption calculation are carried out in mathematics. The physical, chemical and biological

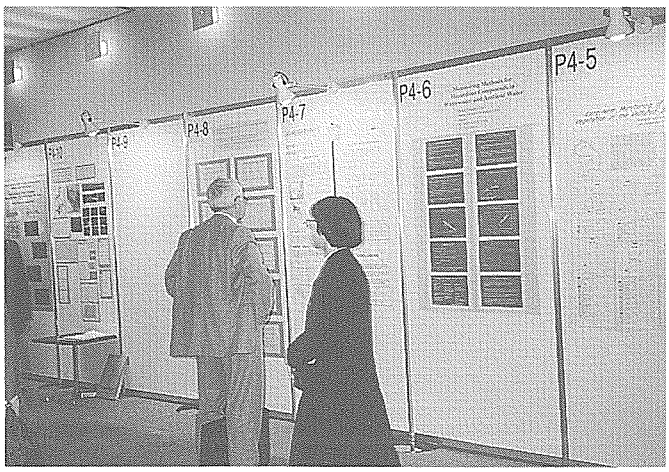


Fig. 3 Poster session at the Kasumigaura Conference.

properties of water in general are discussed. Analyses of rain water are carried out. In the case of Lake Fure, the waste water treatment has since 1974 been by an effective three-steps treatment (since 1992 a four-steps treatment including nitrification and denitrification), where the phosphorus concentration was reduced to a very low concentration ≤ 0,25 mg/l.
The pupils produce also posters covering their observations of the various life forms in the lake and at the lake shores. The class is divided into five groups focusing on the birds, the fish, the zooplankton and the phytoplankton, the amphibians and the mammals in the adjacent forest. The first generation of posters were presented at the Fourth International Conference on the Conservation and Management of Lakes in Hangzhou, China, 1990, while 1995-posters were presented at the Kasumigaura Conference in October 1995.

C. The lake model software, developed by ILEC, is used in computer science, which is taught in the fifth grade.

3. The lake educational activities continue in the sixth grade, where the class is divided into five groups, focusing on five different lakes. Lakes as ecosystems and resources (for recreation, water supply etc.) are discussed. The pupils realise through this study, that lakes are an ecosystem with some similarity but also with differences. The five lakes are: Lake Fure (the previous studied lake). This lake is the largest of the five lakes, has an average depth of about 20 m (maximum depth 38 m) and has therefore thermocline during the summer; Lake Farum (a shallow lake upstream of Lake Fure which is, relative to its shallowness, less eutrophic); Lake Sønder (a shallow lake used for drinking water production to the community of Copenhagen – it has never received waste water and has a very good water quality); Lake Bagsværd (a shallow lake that is more eutrophic than the other

Fig. 4 Lake Farum.

examined lakes); and a forest lake (with a brown colour due to its high content of humic acid caused by the presence of allochtonous material). The pupils take photos of the lakes and discussed their water qualities, differences and similarities. Some of the slides taken by the pupils were shown by Inge Egelund (teacher at the Sven Stars School) at the Kasumigaura Lake conference in 1995. The impact of the climate was also discussed in relation to lakes at other latitudes.

4. Analysis of nutrients in lake water is also used as a general example of chemical analysis in chemistry, which is taught in the seventh grade, and the biology of freshwater fish and lake birds are now regularly included in biology simultaneously, i.e. in the seventh grade. In conjunction with topics in chemistry and biology, a one-day excursion to the adjacent lake is a regularly scheduled during the spring.

5. It should finally also be mentioned, that the school has a one week theme every year, where the entire school (all classes are involved) is active round one focal issue. Environmental issues were often selected as the focal point for these activities, for instance town-ecology and the rain forest.

4. The Experience Gained at Vestervang School

This school has for over ten years had environmental education as a general component of several multidisciplinary projects.

The school has its own (small) artificial lake, which is widely used in biology and for water analyses. The ecology and the water quality of the lake is followed by all classes currently, as the lake is situated on the site of the school.

In the period 1993-95, the school has had five different environmental projects, which have been repeated at least two times during this period.

The entire school was involved in the energy project, which focused on energy consumption in the school and what could be done to reduce this consumption? what are the consequences of the huge energy consumption in the industrialised countries? the green house effect and acid rain.

The second project concentrated on freshwater angling, the use of green hobbies as for instance angling, angling and water quality, and the conflict between the environment and green hobbies. This project was carried out as group work in a few classes. This project is closely related to ILEC's programme.

The third topic was "nature" in general. The entire schools went on a one week excursion in a camp. The idea was to let the pupils be in close contact with nature 24

hours round the clock, and give them "experiences of nature". Views of nature and views of the environment were discussed among the pupils. A number of pupils wrote about this excursion in the school journal.

The fourth project focused on rivers and streams. The water quality of an adjacent stream was monitored by the pupils of several classes and gave also inspiration to a theatre performance called the "blue river". It was concerned with the view of nature and environment and was a parallel activity in many Danish schools during the fall of '93. Consideration is now being given to expand it to other Nordic countries in the coming year, where an increased exchange of experience from environmental educational projects is foreseen. This project is also closely related to ILEC's programme.

The fifth project was concerned with the internal environment – the school itself, and how a nice and clean environment influences your every day work and your health.

5. Discussion of the Educational Results, obtained by ILEC's Lake Educational Project

The pupils have with enthusiasm participated in the programme probably because they were confronted with real life problems: pollution, conservation of nature which the adults also talked about, and because they could use both their hands and minds, and even do it outside the class room in nature. There is no doubt that the pupils had a much better understanding of how nature functions, what pollution is, how nature uses recycling and that water is a precious resource after they have been through the entire programme described above.

The lake project was also able to integrate several subjects. The pupils had small textbooks of an appropriate level about nature, lakes, water and simple analytical procedures for each of the grades which of course forced them to read and write Danish. The linkage to mathematics and computer science in the fourth and fifth grade, mentioned above, was very beneficial for these two subjects as it increased the interest of the pupils for these two subjects. The relation of the lake project to Biology is very obvious.

Generally, the Danish school systems has the possibilities to integrate multidisciplinary projects into the school programmes, as the teachers have a wide freedom to select their own methods and the focal topics particularly in the first seven grades, as there are no examinations and grading of the pupils.

It should also be mentioned in this context that all school children in Denmark have a bike, which makes them very mobile in the neighbourhood of their school. It is therefore very easy for the teacher to arrange excursions in nature to for instance

adjacent lakes without extra costs for the school.

6. Recommendations Based upon the Gained Experiences

It is attempted to extract the experience gained at the Danish implementation of ILEC's educational programme with reference to what could be applied in developing countries and what could be applied in industrialised countries. The facilities in the schools of the developing countries are usually very limited, which on the other hand makes the outdoors activities more attractive. Danish schools have approximately 600 dollars per pupil and per year for books and equipment, which makes it possible to buy, for instance, book material as basis for the studies of lakes and the environment. Some equipment can be made with very little resources, for instance a Secchi desk and a water sampler, while chemical water analyses almost always require more expensive equipment.

The experience gained at the Danish school project is summarised below in several points and classified as follows.

A. Observations/results of general interest for schools in developing and industrialised countries

A1. It seems very successful to attempt to integrate the environmental education in as many relevant subjects as possible to apply this education to show that real life is not fragmented in several different subjects. The pupils found mathematics more interesting, when they used their own lake data as basis for calculations and they wrote Danish essays with more enthusiasm when it was about their own experience at the shoreline of a lake and at a water work. It seems of great importance to demonstrate to the pupils that the different subjects are coherent when it come to their application "outside the school".

A2. It seems of great importance, particularly for children in large cities, to get acquainted with "real" nature and to understand how nature is functioning as a unit, but also to accept that nature is vulnerable. The use of lakes as objects for environmental education gives a paramount opportunity for the pupils to meet "real" nature.

A3. The lake educational programme gives a unique opportunity to present to the pupils their immediate environment, man's interactions with his environment and to show how the environment follow the seasonal rhythm. It is therefore of utmost importance to include in the programme visits to the lake and its environment at all seasons.

A4. It is most probably of importance to integrate the lake educational programme

into several grades. The pupils make different observations and have different emphases at different ages. Different aspects should therefore be included in the programme at different grades. It will be an impossible task to teach I) water cycle, II) water pollution, III) seasonal changes, IV) the role of flora and fauna V) water quality VI) water treatment and water consumption VII) the system properties of ecosystems VIII) the recreational value of nature in one grade. The 8 topics mentioned here represent probably a right sequence of topics to be applied in the programme from grades 3 to 7.

A5. The relation between observations and assessment of quality (in this case may the transparency, the concentration of nutrients, the temperature, pH, the fauna and flora in the lake be observed) can hardly be demonstrated more clearly than in lake studies. The discussion around the interpretation of the observations is therefore extremely important for the pupils benefits of the lake programme. If the equipment for the entire list of possible observations are not available, it is not important. It is, however, important to have some observations for discussion and interpretation.

A6. Use of posters, drawings and other (simple) means to activate the creativity of children seems to give an incredible interest particularly by small children for the environment.

B. Observations/results mostly of interest for schools in industrialised countries

B1. The lake programme gives a unique opportunity to integrate biology, physics and chemistry, because the chemical and physical analyses of the water are compatible with the biological observations of the flora and fauna. The necessary equipment for this integration of different types of observations and analyses is usually prohibitively expensive for developing countries, but should indeed be considered in the industrialised countries.

B2. It is also recommendable to use electronic media in environmental education in industrialised countries. Use of computer programmes (ILEC has, for instance, a lake educational software which is a little too difficult for pupils in the seventh or eighth grade, but they can still benefit from the programme in this age, anyhow), calculations of the data on a spread sheet software, use of video films about lakes etc. There are many possibilities to use electronic media in environmental education, although the work in the class room can never replace the work in nature.

7. Conclusions

Lakes seem to be an excellent theme for multidisciplinary integrated school projects,

giving the pupils the opportunity to make observations in nature, understand the concepts of pollution and the processes in nature and simultaneously illustrate the practical application of reading, writing, mathematics and biology. Properly planned, a lake environmental school programme can touch many important topics such as the various life forms, ecosystems as a concept, the variability and adaptability of nature, the water cycle (and elements), resources, pollution, seasonal changes, use of graphs, computers as tools, use of a manual etc.

The Danish school system may be particularly fitted to multidisciplinary projects, particularly with the new subject science in grades 2 to 5. The Danish experience gained by the ILEC lake educational school programme strongly emphasise the particularly educational benefits that can be obtained by implementation of a lake environmental programme as a multidisciplinary project.

The results of the ILEC lake educational projects are summarised in 6 general recommendations, A1-A6 above, and 2 recommendations, B1-B2 above, for the industrialised countries.

The recommendations are in short:

- integrate the programme into many subjects,
- make it thereby multidisciplinary,
- use it to show the important relationship between man-nature and to understand how important nature is for us,
- use different parts of the programme in different grades to illustrate different aspects.

8. Continuation of the School Project after 1995

The Seven Stars School will most probably continue its activity and from time to time launch an environmental multidisciplinary project within the framework of environmental education.

The Vestervang School has shown a particular interest in environmental educational activities, and it will be interesting to follow the many challenging projects, that the school will currently undertake.

The five schools which have recently adopted ILEC's educational lake project will most probably be able to offer some additional activities in the coming years, which will be followed closely.

Several books and booklets are available in Danish to support environmental education. They are generally used as additional activities to the more general school

agenda and curriculum. The books cover a wide range of environmental issues from biology of lakes and streams to water and air quality analyses and actual environmental issues such as the green house effect and the ozone layer. They are widely used in the subjects of Biology, Chemistry and Science. It is also common to use English books for seventh grade or above, which implies that the books are used simultaneously in English and another subject for instance Biology, Geography, Physics and Chemistry.

GHANA'S ENVIRONMENTAL EDUCATION PROJECT

Michael Tsiagbey and Nii Boi Ayibotele

1. Introduction and Background Information

1.1 Development of the EE project

According to Ghana's Environmental Action Plan, the country is to raise the level of public awareness of environmental issues to the point where individuals, groups and organisations can fully assume responsibility for safeguarding the environment. The environmental education (EE) issues in Ghana emphasise the need to support both formal and non-formal programmes in environmental education by way of developing additional training materials and resources that are appropriate to the situation in the country. Ghana will therefore embrace projects or programmes whether local, national or international in dimension which support EE efforts of the country.

ILEC's Pilot School Project on Environmental Education was introduced to Ghana in 1991 by the director of Water Resources Institute at that time who served as a member of ILEC's Scientific Committee. Then Ghana's EE Project was implemented under the auspices of the Ghana National Committee for International Hydrology and Water Resources Programmes.

1.2 Present state of the country

Croplands account for 19 % of the total land area of Ghana, permanent meadows and pastures for 22 %, and the rest is mostly covered by forests and woodlands. Whereas urbanisation is going on rapidly, about 65 % of the national population is rural. The rate of population growth is very high (3.0 %/yr for 1990-1994). The GNP per capita was the least among the six countries involved in the ILEC EE project, while the mean annual rate of inflation for 1984-1994 amounted to 28 % (cf. Appendix at the end of this volume).

The distribution of population, water resources and land use poses a particular set of environmental and water resource management issues. Power production is largely determined by the hydropower capacity of the Volta scheme. High rates of population growth are placing considerable demands upon water use. Water supply, power production and irrigated agriculture are the major consumers. Urbanisation in particular is placing pressure on the energy and water sector whilst also causing considerable degradation of aquatic environments.

1.3 Water resources and water use

Sources of water The climate is sub-humid to humid, with annual rainfall ranging from 2,160 mm in the southwest to 1,015 mm in the northeast and 890 mm in the

coastal southeast. Rainfall is seasonal, with two peaks (July, October) in the southern half and a single peak (September) in the northern half.

The country is drained by three main river systems; Volta River, Southwestern River and Coastal River (Fig. 1). The Volta River system covers 70 % of the total country area, and its basin is shared with Burkina Faso, Mali, Togo and Benin.

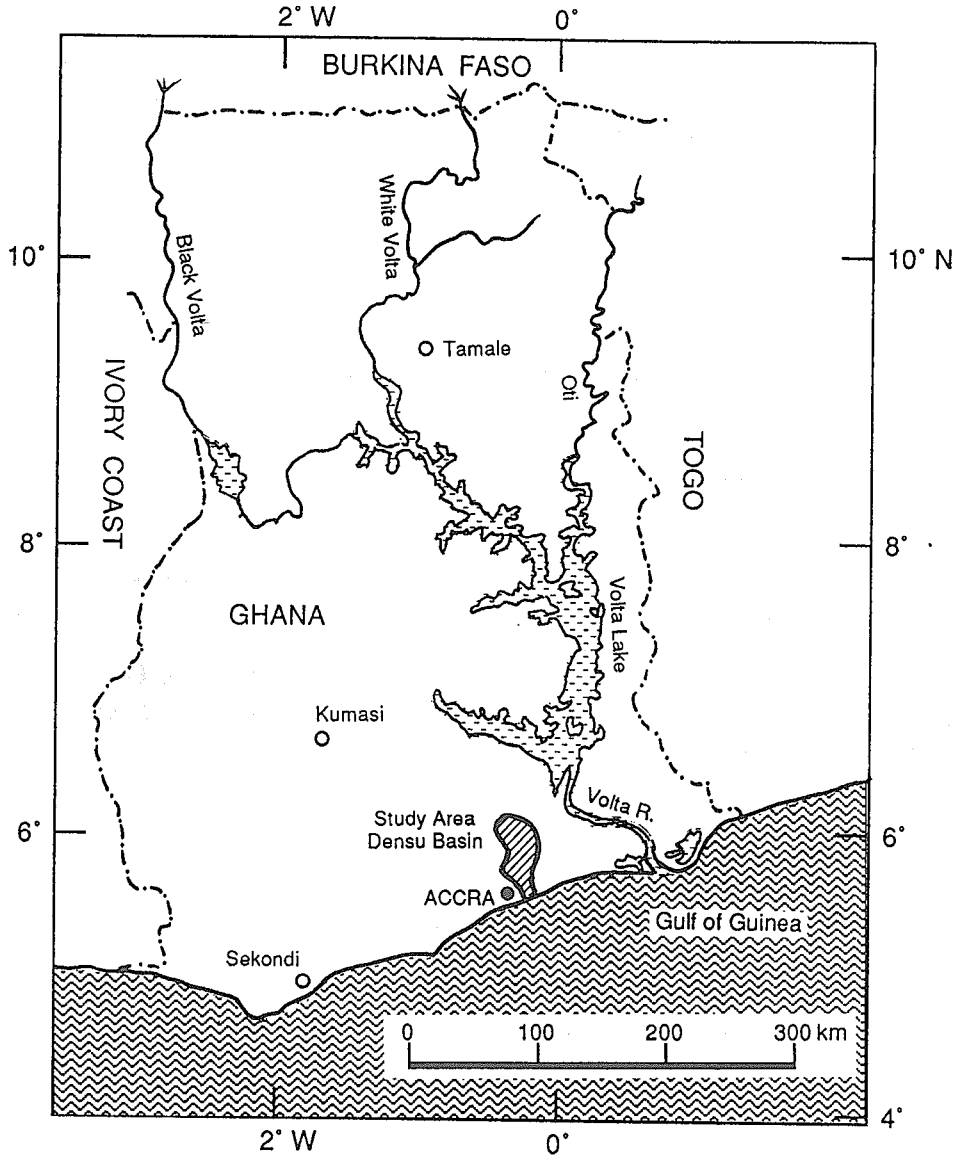


Fig. 1 Map of Ghana showing the location of the Densu River Basin.

Around 10 % of the mean total surface runoff water (55,000 million m^3/yr for the whole country) is used for consumption. Goundwater occurs in weathered and fractured crystalline basement complex as well as in sedimentary formations. Boreholes are normally 10-60 m in depth, and yield water of good quality except in certain areas where iron and fluoride concentrations are high.

Potable water in urban sites is supplied by 208 reticulate systems covering main towns with a population of over 5,000. In rural areas, about 10,000 boreholes and 60,000 hand-dug wells serve for water supply, in addition to traditional spring and stream sources. There are many communities and peri-urban zones where no centralised water supply network exists but the concentrated population (over 2,000) is too large to rely upon wells, springs and rivers.

Water uses Consumptive use in agriculture is supported by 12 major irrigation systems, but only a small portion of permanent croplands (22 % of the potential area) are irrigated. Rain-fed agriculture accounts for over 98 % of the food production in the country.

Non-consumptive use is limited to two hydropower systems and transport on lakes. Presently, 40 % of the hydropower potential of 2,000 MW have been developed, and are shared with the neighbouring countries. Waterborne transport on Volta Lake in 1989 served for 42,340 passengers and 47,257 tons of cargo.

1.4 Main environmental issues

Location-specific issues are commonly related to industrial and mining activities or to human settlements. Air, water and noise pollution due to industries and mining cause localised impacts, but have not yet assumed very serious dimensions. The quantity and diversity of industrial wastes and emissions have increased over the years.

Resource-specific issues include those affecting land and water resources and coastal zones. Land degradation represents the most serious environmental problem facing the country in terms of their economic impact and the area and number of people affected. It includes two inter-related processes; the degradation of soils through erosion and loss of structure and fertility, and that of vegetation through deforestation and overuse. The most densely populated coastal zone with urban and industrial centres is of particular concern. There is only limited capacity to cope with the human and industrial wastes generated there, constituting a threat to fragile coastal ecosystems.

Current issues related to water resources are driven by the demands of socio-economic development, population growth and changing rural/urban mixing. These developments and changes are causing particular concerns in Ghana's water resource

base, integrity of aquatic environments and institutional capacity to manage the resource for sustainable development.

There is little, if any, effort to conserve water resources. Uncontrolled discharge of wastes poses significant threats to human health in both urban and rural areas. Surface water supply impoundments suffer from silting as a result of erosion in their catchments arising from land clearing. Raw water quality degradation occurs in the wet season when large amounts of sediments are brought into rivers. In addition, the pollution of rivers and lagoons near or around all the urban towns causes major environmental problems.

Water shortages often occur in the dry season due to climate variability as in the drought years 1981-1984, making drinking and irrigation water supply and hydropower systems unable to meet the demands on these works. The monitoring of water resources and the regulation of their uses are hindered by declining regular budget for the authorities concerned.

Difficulties also arise from the lack of overall water policy to give basic direction to water resources development and management, and the fragmented legislation which are difficult to access. Institutional weakness arises from the top-heavy organisational structure, administrative difficulties, inadequate professional/managerial manpower, poor financial resources, and from limited community participation.

2. National Educational System

The country has adopted the 6-3-3-4 system of education since 1987. Nine years of basic education, made up of six-year primary school and three-year secondary school, are followed by the three-year senior secondary school programme and four-year university or tertiary education in turn. The basic education is compulsory for all children of school-going age. As at 1993, 70 % and 83 % of females and males, respectively, were enrolled in primary education. For secondary education, 28 % of females and 44 % of males were enrolled. Adult illiteracy in 1995 was 36 % (47 % for females and 24 % for males) in Ghana.

2.1 Basic education

The Basic Education is the first nine years of schooling, free and universal for all children normally 6-15 years in age. Leavers from junior secondary school may enter into apprenticeship to prepare for employment for life or continue schooling by entering senior secondary school or post-basic training institutions.

Primary school aims at giving children basic numeracy and literacy and, in addition, developing inquiry, creativity, manipulative and life skills, sound moral attitudes, healthy appreciation of our cultural heritage and identity, constructive

adaptation to changing environment, and good citizenship as a basis for effective participation in national development. These objectives are incorporated into a national curriculum comprising the following subjects: Mathematics, Science, Social Studies, Cultural Studies, Ghanaian Languages, English, Agriculture, Life Skills, and Physical Education.

Junior secondary school In addition to the objectives for primary schools, the junior secondary school curriculum is designed to provide opportunities for students to acquire basic pre-technical, prevocational and scientific knowledge. The performance of students in primary and junior secondary schools are assessed by the continuous assessment method. Junior secondary school students are finally graded on a 40 % assessment based on their cumulative records and a 60 % external examination conducted by the West African Examination Council.

2.2 Secondary and tertiary education

Selection into senior secondary schools is based on the final assessment at the end of basic education. The senior secondary school refers to five types of 3-year course that constitute terminal points of the pre-university education; viz. Secondary Technical, Senior Secondary Vocational, Senior Secondary Business/Commercial, and Senior Secondary Agricultural.

The tertiary or higher education is made up of University, University College of Education, Polytechnics and Post-Secondary Teacher Training College. The latter trains teachers for the basic education system. Provisions are made for 25 % of senior secondary school graduates to enter tertiary institutions.

2.3 Current state of environmental education in schools

Some environmental and related topics have been incorporated into the syllabuses of various subject areas in schools of primary and secondary level. Environmental education is not taught as a separate subject but rather through the interpretation of the syllabuses. In the basic education, EE topics are integrated in Science, Social Studies, Cultural Studies, Agriculture and Life Skills. In the senior secondary school, the concept and function of ecosystems, for example, can be explained in the teaching of relevant aspects of Agriculture, Geography, Biology, Chemistry, Physics, etc.

The Environmental Protection Agency of the government recently (1994) launched a book on the EE strategy for Ghana. The strategy in the formal system involves the intensification of in-service training courses for teachers of primary and junior secondary schools, holding workshops to produce pilot teaching/learning materials, organising competition and awards in the schools, and assisting environmental clubs in schools and colleges.

At the level of university education, general EE curricula have not developed. In third cycle institutions, however, specialised curricula for ecology, agriculture, medicine, applied sciences and engineering have been created to train middle level and specialist personnel in various sectors of resource management.

3. Implementation of the Project

3.1 Overall goal and objective

The overall goal of the Ghana EE Project was to establish and strengthen environmental education in the primary and junior secondary schools' curricula so as to increase the knowledge and concern of young people regarding environmental problems and to prepare them to assume responsibility for the protection of aquatic environments in the future.

The objective of the project was to develop curricula for the schools, and, by means of testing in some selected schools, increase the coverage of environmental education, and make the youth concerned with environmental problems and instrumental in protecting the environment.

3.2 Progress of the project

The project was implemented in two phases: Phase 1 June 1991 – March 1993 and Phase 2 April 1993 – March 1996.

- An Implementation Committee was established in August 1992, consisting of the representatives of the Water Resources Research Institute, the Institute of Aquatic Biology, the Ministry of Education (Curriculum Research and Development Division), the Environmental Protection Agency, and the Ghana National Commission for UNESCO. A representative of the Ghana Water and Sewerage Corporation was invited to join the committee in March 1993.
- The Densu River Basin and Weija Reservoir in the basin were selected as the object area and the study site (Figs. 1 and 2).
- Three primary schools and three junior secondary schools in Densu Basin were designated as pilot schools for the project.
- The Implementation Committee developed the syllabus and curriculum for the schools in May 1992.
- A list of teaching aids and other facilities required was compiled.
- A two-day training of pilot school teachers took place in October 1992, respectively for primary and junior secondary level, to ensure effective teaching of EE subjects mentioned in the developed syllabus.
- A field visit to Weija Reservoir, its treatment plant, and water pollution and land degradation sites was organised for all pilot school teachers.
- Retraining workshops were organised in October 1993, assessed the project's achievements, and also enriched the knowledge and skills of those involved in

the project implementation.
- The Implementation Committee designed a reporting format to be completed termly by all the pilot school teachers.
- In an effort to promote citizen participation, the project organised a durbar (formal reception) for the residents of Nsawam, a town in Densu Basin.

3.3 Project area and pilot schools

The Densu River Basin is located to the immediate east of the national capital Accra and has the advantage of easy accessibility and available information on its characteristics worked out by earlier studies. The river is 116 km long and has a drainage area of 2564 km^2. Mean annual rainfall is 900-1,200 mm. Its southern part is the low coastal plain, while the northern part consists of the dissected plateau 240-300 m in altitude. The existing vegetation is characterised by strand vegetation, mangroves, scrubs and grasslands towards the coast, while the upper reaches are essentially the area of moist deciduous forest which has now mostly turned into secondary forests due to intensive farming.

The Weija Reservoir was formed by a dam commissioned in 1977 at Weija 16 km west of Accra. It is 33.6 km^2 wide and has a mean depth of 10.5 m and a capacity of 5 million cubic metres. It supplies water to Accra at a rate of 318,000 m^3/day, stores irrigation water for potentially 1,400 ha of land, and supports fisheries.

About 2,000 persons who were resettled due to the dam construction, as well as immigrants from other parts of the country, set up villages on the shores of the reservoir, and led to the introduction and prevalence of bilharzia. The catchment areas are intensively cultivated for various crops. There are some poultry, pig and livestock farms. Most farmlands are rainfed, but a few irrigated commercial farms pump up water from the Densu River. Two fruit cannery industries discharge wastewater directly into the river. Most households also use the river for waste disposal.

Pilot schools and the number of students enrolled are shown in Table 1. The schools focused EE activities on environmental problems in Weija Reservoir basin, especially the water quality degradation. On an average, four periods (40 minutes/period) per week were devoted to EE topics, which were taught under or integrated into such subject areas as Social Studies, Cultural Studies, Life Skills, General Science and Agricultural Science.

The teaching/learning was supported by the use of aid material prepared by students themselves and teacher/students together. Posters, e.g. on pollution and water-borne diseases, were mostly prepared by students. Other handmade aids were sand box, sun dials, rain gauge, etc. Generally laboratory sessions were not efficient due to the lack of adequate facilities, but the schools depended on local resources and improvised

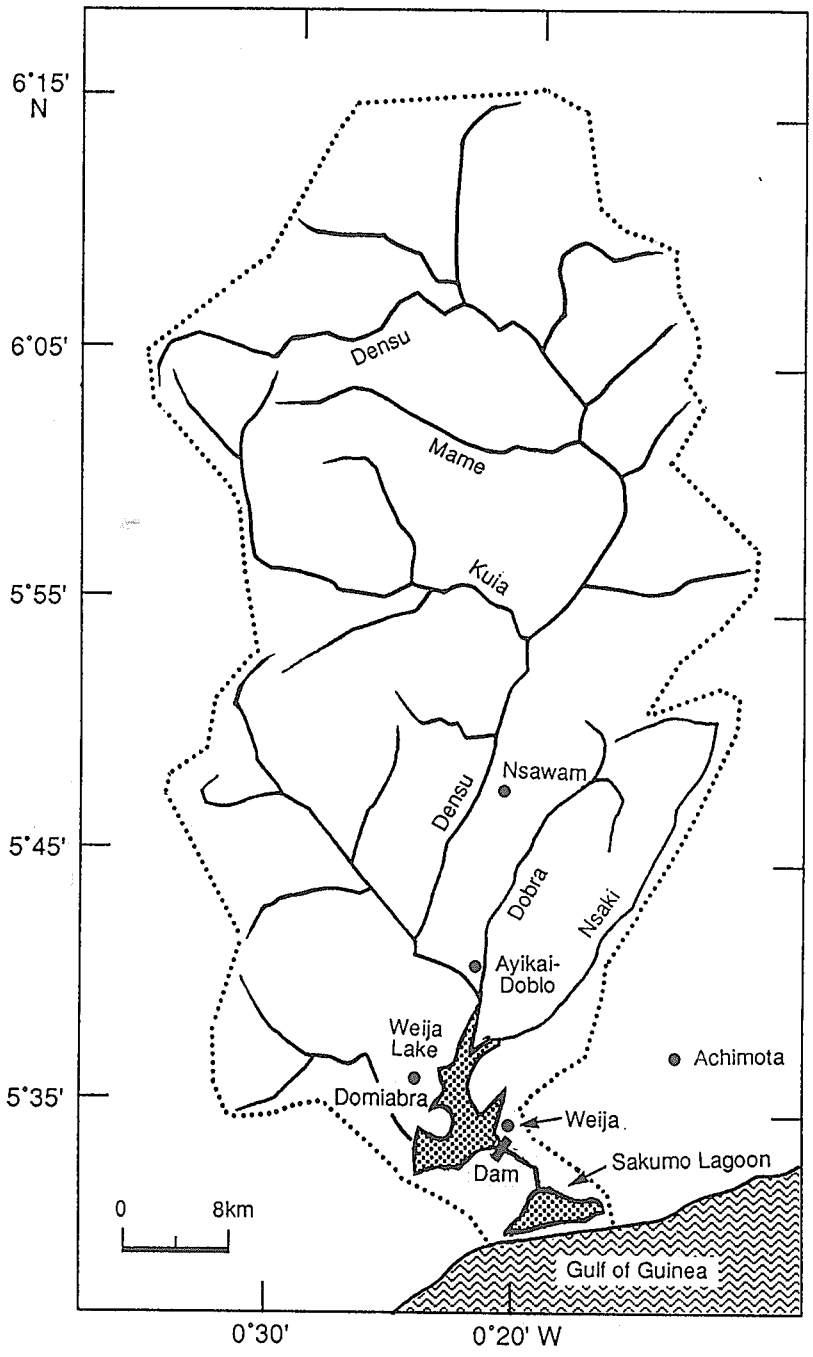


Fig. 2 Densu River Basin. The location of pilot schools is marked with black dots.

material for laboratory work, such as gravel filter, calico filter and simple boiling for water quality study. Almost all the schools made visits to the reservoir and its water treatment/supply plant, although the expense of transporting students was a great limiting factor for field visists. Some schools also visited sites of environmental concerns, e.g. refuse damping sites near river banks.

Table 1 Pilot schools and the number of students enrolled. The location of the schools are shown in Fig. 2.

Schools	1991-92	1992-93	1993-94	1994-95
Primary				
1. Achimota	-	383	390	396
2. Nsawam Anglican	382	577	608	589
3. Domiabra Methodist	248	225	244	264
Junior secondary				
4. Weija	297	308	292	280
5. Achimota	-	157	165	168
6. Ayikai-Doblo	120	109	102	86
Total	1047	1759	1801	1783

4. Evaluation

The evaluation of the project's achievements was made, by means of interviews, observations, questionnaire survey, testing, and review of reports, with respect to the curriculum (syllabus, teaching methods, learning environment, learning activities), student learning and impacts on local communities.

4.1 Curriculum/syllabus

In the workshop for reviewing the syllabus/curriculum adopted in the project, the primary school teachers agreed that there was little to be changed in the syllabus. They confirmed that all the topics in the syllabus were of relevance and the objectives specified were clear and understandable, though they found difficulties in teaching certain topics. The teachers complained about the lack of basic scientific equipment and other teaching material which prevented effective demonstrations, group work and field visits, as well as about excessive numbers of students in a class.

The teachers of junior secondary schools came up with similar comments on the adequacy of the syllabus. Further, the teachers requested assistance from the project in organising campaigns for changing the attitudes of community members towards environmental issues and problems.

The syllabus was found to have acceptable standards by comparing its quality with what was expected from the curriculum proposed by UNESCO/UNEP

Environmental Education Programme.

4.2 Teaching methods and learning activities

The teaching methodology advocated in the project was the *Education for Change Method* of Teaching, which is also referred to as the *Participatory Approach.*
This was the learning through participation and student-centred approach to environmental education, and allowed students to discover that they could be as good as their teachers and anyone else. They also learned to cooperate rather than compete in order to gain approval. The teachers ensured that they did not put ideas into students' heads but drew ideas out, being facilitators rather than authoritarians.

The teachers fully adopted this student-centred method of teaching, which was proved very appropriate for teaching most EE topics. Varied teaching/learning strategies such as field trip, project work, experiment and discussion enhanced the students' mental skills. Mental processes such as observation, analysis and measurement took place during field trips. The observation of aquatic life, human settlements and activities, and their effects on water quality improved the students' ability of analysis, while the projects such as making of rain gauge enhanced data collection ability. Action-oriented projects such as tree planting were undertaken by some schools after the students had identified deforestation as a problem in their communities.

It can be said that the learning activities in pilot schools yielded positive results in creating action-oriented students with awareness and understanding of environmental problems. The training and retraining of teachers contributed to raising the level of their knowledge and skill. A look at their lesson notes revealed that almost all of them had no problem in planning their lessons to include clear objectives and well-sequenced activities.

4.3 Learning environment

The EE project took place in many settings – classroom, school site, community and beyond. The project encouraged the use of such different environments to enhance learning. In spite of the teachers efforts to improve classroom settings and efficiency and effectiveness of learning, there were very little achievements in this regard owing to unfavourable economic situations. All the pilot schools suffered from inadequate furniture and instructional resources. The use of audio-visual system did not exist in the schools.

Nevertheless, the creation of friendly atmosphere in the classroom made students get involved seriously in their learning. The teachers emphasised the contribution of psychological factors to the congenial atmosphere for learning rather than physical factors.

Outdoor lessons for experiencing some examples of environmental degradation, e.g. poor location of waste disposal sites causing objectionable odour in homes, offered the learners skills for identifying and evaluating environmental problems. School projects with the joint participation of community members proved very supportive in the learning experiences of students, though EE field projects suffered from community apathy at the beginning.

4.4 Student learning

The students were very enthusiastic during EE lessons, and participated actively in the classroom and field sessions. They confirmed that they found most of their lessons real and stimulating.

Knowledge and attitudes At the lower primary level, the EE syllabus laid much emphasis on building up the knowledge base about the environment, especially the bio-physical environment, with less emphasis on the socio- cultural environment, while focus was placed on students' acquisition of attitudes and behavioural skills to protect the environment and solve problems at the upper primary to junior secondary level.

Assessment with pencil and paper tests indicated that the students had acquired expected knowledge base. Unobtrusive observation of a cross-section of school children through their performance of various sketches (drama) showed that they had the attitude to share their knowledge with community members. The involvement of communities in certain outdoor activities, e.g. clean-up exercises to keep the community environment free of wastes, demonstrated their attitudes to work together with adults to cope with environmental problems.

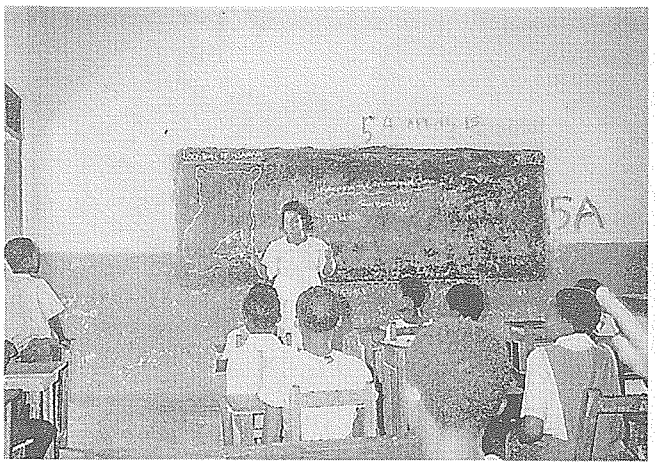


Fig. 3 Classroom session in one of the EE schools.

Thinking and action skills The problem-solving approach is a distinguishing feature of environmental education. To solve the problems, one needs first to know and understand the environment and associated problems and then to apply necessary thinking skills in application, analysis, synthesis and evaluation in order to take required actions. In the syllabus prepared for the project, appropriate action verbs were used to describe what the students could do to demonstrate the skills they acquired.

In the 3rd class, for example, one of the lesson objectives was to identify those behaviours which protect and those that degrade the environment. This needs the skill of analysis, or the ability to break down human activities into two groups either harmful or beneficial to the environment. In the 5th class, a lesson objective required the students to link a water-borne disease with its vector and causing organisms. Here the skill of synthesis, or the ability to put parts and elements into a unified whole, is needed. The pilot school teachers reported that their students strongly developed thinking skills in the areas of application and analysis, but were weak in synthesis and evaluation areas.

These deficiencies could be addressed by providing appropriate teaching aids and improvements in behavioural objectives for identified topics. Though the lack of teaching aids is one of the serious setbacks of the Ghana EE project, the students demonstrated admirable action skills in the production of visual aids (models), field projects and making presentations through varied means to community members about the need to keep the environment clean. The participants of the project displayed their action skills by persuading community political leaders, environmental health administrators and residents (mainly along river banks) to get involved in environment improving activities of the schools. The EE project made impacts on the students' ability to deal with environmental problems in their communities realistically.

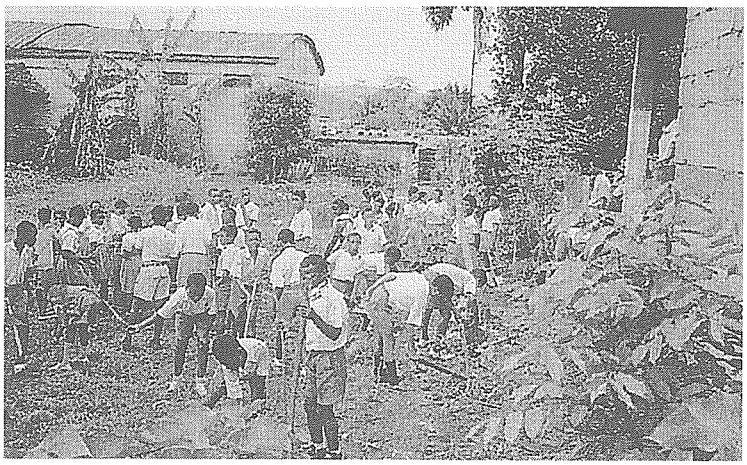


Fig. 4 EE school children involved in a clean-up exercise.

4.5 Impact of the project on local communities

Involving community residents in identifying and solving environmental problems was an element of the general objectives of the EE project in Ghana. Termly reports submitted by the pilot schools were used to gather information on the types and frequency of action for promoting citizen's participation. Also the project implementation team observed some of the joint school/community activities. Discussions with selected community members revealed that residents were aware of environmental problems in their community, but that the majority of them were yet to show willingness and commitment to initiate actions against those problems.

The EE project involved traditional rulers and opinion leaders in many activities geared towards the maintenance of a healthy environment. The fora organised by the project such as durbars, cleaning exercises, etc. were attended by a large number of residents including traditional leaders. The project made positive impacts on community residents in creating their awareness of environmental problems. Residents understood the causes of those problems to a considerable extent through the project activities, identifying human activities as the major cause of water pollution problem. However, there is yet a great deal of work to be done to bring about attitudinal changes of the residents so as to minimise problems of the environment.

5. Reflections

5.1 Constraints

Identified major constraints to the development of environmental education and the recommended remedies are as follows.

1. At the basic education level, educational materials are currently organised around disciplines and not much emphasis is laid on problem-solving approach. There is a need for the educational sector to adopt this non-traditional approach in the environmental education in schools and out-of-school situations.

2. Another constraint is the shortage of classroom teachers who are prepared to effectively integrate environmental education into the school education system. It is needed for the country to embark on training a cadre of teachers, whose role is not to lecture about the environment but to guide students to the development of an environmentally literate citizenry.

3. Teachers are loaded with crowded school curricula and have difficulty in dealing with extra EE work. Efforts should be made to integrate environmental matters with other subjects so that the existing curricula are enriched without creating additional teachers' work.

4. There is a lack of appropriate teaching/learning materials. Materials to be developed should include EE textbooks, visual aids and basic scientific equipment and tools.

5. Other constraints encountered were the lack of funds to provide transport for educational visits and resistance and apathy on the part of communities.

5.2 Lessons from the project

In the course of the EE project, some lessons which may guide the design of future EE projects have been gathered.

A. For effective environmental education, the basic understanding of humankind is as important as that of the environment per se. While environmental education is concerned with bio-physical environments and associated problems, it is ultimately concerned with human life.

B. Education is a process, not a product. The training of teachers should aim at assisting them to inculcate in students how to think rather than what to think about the environment.

C. At present EE subjects are not examinable in the country. There is a need for those subjects to be made examinable, because this will encourage and assist teachers to monitor and assess the impact of teaching/learning effectively.

6. Conclusions and recommendations

6.1 Conclusions

One can conclude that the EE project in Ghana achieved its objectives which included:

- the development of a curricula for primary and junior secondary schools;
- testing the use of the curricula in pilot schools by way of trial teaching; and
- making the youth more concerned with environmental problems.

The project has not yet increased the coverage of environmental education in the formal school system, but the cooperation between the Ministry of Education, the Environmental Protection Agency and the present project laid down necessary steps for infusing EE-related topics into existing disciplines.

The EE project was implemented in Ghana for five years and the evaluation report stemming from accumulated observations, discussions, tests and unobtrusive assessments arrived at the following conclusions.

- The project improved the knowledge and understanding of pilot school students regarding the environment per se and the cause of environmental problems.
- The Education for Change Methodology or Participatory Approach adopted by the project was of relevance and worth adopting in all EE endeavours in the country.
- The schools involved were groomed to see environmental problems in their communities with a sense of concern and became more ready to assist in resolving the problems.
- Community members around the pilot schools became more aware of the EE activities. This resulted in serious concern about environmental problems such as water pollution caused by the disposal of household wastes into streams in the communities.

Also the following points were evident from the evaluation study.

- The EE syllabus prepared could be integrated with the national basic education syllabus in identified subject areas.
- The preparation of teaching/learning aids was the most costly aspect of environmental education adopting participatory approach, but this constraint could be overcome by motivating teachers to be innovative in developing the aid material from local resources.
- The project laid the foundation for the youth to be instrumental in protecting the environment.

6.2 Recommendations

Based on the results obtained, the followings are recommended.

- Establishment of a dedicated multidisciplinary committee to develop and implement the project, and to facilitate communication between the project and decision-makers, community leaders and politicians.
- Establishment of a committee including community leaders and educational authorities at all levels to implement EE programmes within the educational system of the country.
- Formation of a coordination research group to provide necessary theories of learning, teaching and attitudinal/behavioural changes which serve as guiding principles for managing the project.
- EE projects should have well-planned monitoring and evaluation system so that feedbacks from the assessments will improve and enhance teaching/learning activities. The pre-evaluation is as essential as the post-evaluation for any EE project.
- EE curricula should be developed with the participation of experts in order to establish measurable behavioural objectives to be achieved, and in a way that

students obtain cumulative knowledge and skills, with emphasis on the affective (feeling) domain in early stages and on the cognitive (knowledge) domain in later stages.

- The local environmental situation must be screened so that EE curricula can reflect real local issues. In order to develop an EE programme expected to improve local environments effectively, the school system should organise simple projects in cooperation with residents.
- EE projects must be designed in a way that the process can be sustained by local initiatives after their termination. The long-term sustainability is imperative since any educational programme aiming at changing attitudes takes longer time than the project period. The projects should be continued to allow time for them to move to the phase of national adoption.
- Preparation of comprehensive reports for use by educational authorities, and its presentation at national workshops.
- Publication and wide distribution of a guideline book.
- Financial sources should be sought both nation-wide and internationally to support diverse strategies of EE projects.
- Funds and resources should also be mobilised for the capability development of the teachers for EE projects.

SHIGA PROJECT FOR ENVIRONMENTAL EDUCATION 1989-1995 - A CASE STUDY IN JAPAN -

Munetsugu Kawashima

1. Introduction

Many lakes in the world suffer from such environmental problems as declining of water level, rapid siltation, acidification, contamination with toxic chemicals, eutrophication, and resultant disintegration of aquatic ecosystems and loss of bio-diversity as reviewed by ILEC (1994). The deterioration of lake environments has been caused mostly by the increase and change in human activity. In order to preserve a lake's environment, it is essential to take into account all such activities, industrial, agricultural and daily-life over its whole watershed. People need to understand the relationship between their activities and the environment in order to lead a more environmentally sensitive life.

"The Shiga Project for Environmental Education" was organised as part of the ILEC Environmental Education Project. The Executive Committee for the project, consisted of a university professor, the director of the Environmental Section of Shiga Prefectural Government, section chiefs of local boards of education, schoolmasters of elementary schools and principals of junior high schools, and was responsible for framing the general policy, annual implementation programmes, and financial budget, and for preparing annual reports. According to the policy, the Research Group, organised mainly by teachers of pilot schools, usually had meetings to study environmental education programmes and teaching materials every month and applied developed materials in classes four or five times a year. Two elementary and two junior high schools in Shiga Prefecture were annually selected as pilot schools for the Shiga Project for Environmental Education and one elementary school was added later in 1994. These pilot schools were chosen from both urban and rural areas.

2. Backgrounds

2.1 Brief history of environmental education in Japan

Environmental Education in Japan has its origin in anti-pollution education. Since 1950, human health hazards caused by environmental pollution, including Minamata Disease and Itai-itai Disease, occurred frequently in the country, and Japan was sometimes called an "advanced nation with respect to pollution". In 1964, a national research organisation for pollution control started investigations on the degree of injury of elementary and junior high school students due to pollution and its origin.

The National Environment Agency was established in 1971. In the same year, the course of study for school was partly revised by the Ministry of Education according to the revised "Basic Law for Environmental Pollution Control" (1967). The national guideline for the subject "Social Studies" clearly stated that it was very important to protect people's health and life from industrial pollution.

Since the beginning of the 1970's, groups of conservationists became more conscious of the education for protecting natural environments. The courses of study for elementary and junior high schools (both compulsory education) were revised in 1977 and for high schools in 1978, to incorporate the study of the environment and natural resources in almost all subjects. Further, a new course was notified by the Ministry of Education in 1989, adopting the new subject "Life Studies" in the first and second grades of elementary school, and the contents of such subjects as Science, Social Studies, *etc.* were more strongly related to environmental issues for all grades of elementary and junior high schools. In 1991, the Ministry of Education announced the guideline for environmental education, in which global environmental problems such as acid rain, global warming, water pollution and so on were dealt with in related subjects. The new course of study started in April 1992 in elementary schools, in junior high schools in 1993 and in high schools in 1994. All the schools were obliged to adopt the new course of study.

2.2 Backgrounds in Shiga

Geographical and Social Features

Shiga Prefecture is located in the centre of Japan's main island, Honshu, at about 500 km west of Tokyo and 10 km east of Kyoto. Lake Biwa, the largest freshwater lake in Japan, is situated in the centre of the prefecture and occupies one-sixth of its total area.

Residents of Shiga had lived mainly on agriculture, forestry and fisheries before World War II. However, the prefecture experienced remarkable economic growth and industrialisation since the 1960's, and is now one of the important inland industrial areas of Japan. Its population has also increased significantly owing to the immigration from nearby big cities such as Kyoto, Osaka and Kobe. At present, about 50 % of the prefectural area is occupied by forest, 19.9 % by Lake Biwa and other inland waters, 15.3 % by farming land (mostly wet paddy field) and 13.5 % by other uses (mainly housing land).

The catchment area of Lake Biwa accounts for 79 % of the total area of Shiga Prefecture. More than 400 streams, large and small, originating in the surrounding mountains flow into Lake Biwa, while the lake water is drained into Osaka Bay through the Seta River, only one natural outlet, and supplied to Kyoto through the Biwako Canal. Lake Biwa is the largest freshwater source in Japan, supplying water to fourteen million people in Shiga, Osaka, Kyoto and Kobe, and is also valuable for

recreation, fishery and scientific research.

Eutrophication of Lake Biwa

The water quality of Lake Biwa has been degraded continuously since the end of the 1950's due to eutrophication. The progress of eutrophication caused many troubles such as the clogging of filter beds in city water supply plants, decline of certain benthic fauna, over-growth of exotic waterweeds, freshwater red tide (since 1977), blooms of blue-green algae (since 1983) and picoplankton (1989), *etc.* The local government, in corporation with residents, has made great efforts to prevent further eutrophication. For example, the Prefectural Ordinance Concerning the Prevention of Eutrophication of Lake Biwa was enacted to reduce nitrogen and phosphorus loads in 1981 and prohibited the sale and use of synthetic detergents containing phosphorus. Nevertheless, the eutrophication of Lake Biwa is still advancing as shown by the gradual increase of COD, for example.

We are now realising that environmental problems cannot be solved by legal and administrative measures alone. People's understanding of the relationship between themselves and the environment and their participation in coping with the problems are indispensable. Thus, environmental education is becoming increasingly important.

Environmental Education Programmes in Shiga

Shiga Prefectural Board of Education has put various programmes of environmental education into practice in formal education systems since 1971, focusing on aquatic environment in Lake Biwa because of its immense economic and scientific value. There are two important programmes being conducted for environmental education in the schools of Shiga Prefecture.

1. An overnight school on board a study boat, called "Uminoko" or "the Floating School", on Lake Biwa is offered for all 5th grade students of elementary schools since 1983. Through this programme, students gain a wonderful experience which can be rarely obtained in classrooms. Since the available space of the boat is limited (for 240 students at a time), a new alternative programme is now under consideration.

2. The Shiga Education Board developed sub-textbooks for environmental education programmes, which contain a lot of pictures, figures and tables and easily understandable for students. All the schools from elementary to high school level in Shiga Prefecture are using these textbooks in classes of Science, Social Studies, Moral Education and Special Activities. Ten hours per year is spent on environmental education in each grade. Currently, however, most teachers are just providing general information on environmental problems to their students in the classroom without giving any experimental or on-site experiences. Extensive

improvements of teaching programmes are therefore necessary to stimulate students' interest and active consciousness.

In addition to the two programmes mentioned above, 15 elementary, 10 junior high and 5 senior high schools in Shiga Prefecture were designated every year since 1980 to specially promote environmental education. Study results and experiences obtained in these schools contributed to further environmental education implementation. Since many schools had experienced to practice environmental education, this system was completed in March, 1995 and Shiga Prefecture started a new system in which schools join to promote experience learning of students. Many schools are expected to develop and promote environmental education programmes following this system.

The problems that took place in Lake Biwa have spurred Shiga Prefectural Government to take the lead not only in the protection of aquatic environments but also in the promotion of environmental education in Japan. As the results show, advances have been made in the teaching about aquatic ecosystems and teaching study methods for environmental education, though many difficulties still remain to be overcome.

3. Activities of the Shiga Project

Questionnaires to pilot school students showed that present-day children spent little time playing outdoors and had little contact with river and lake water. After school, they usually spend their time watching TV, reading magazines and studying in private schools. Taking these situations into account, the Project members considered that outdoor studies would be very important as an effective method for environmental education.

On the other hand, when environmental matters are introduced into class work in schools, a greater part of teachers usually teach the knowledge alone without giving students any personal experience concerned. We considered that such classes were not sufficient for the learning of scientific thinking toward the solution of environmental problems. After discussing about these situations, we began to study environmental education programmes and teaching materials with the basic belief that students should have as many opportunities as possible 1) to contact and realise natural and social environments, 2) to understand scientifically the phenomena through experiments, and 3) to enjoy the study of the environment through "scientific eyes". Consequently, it was essential for teachers to understand the state and problems of the environment near their schools and make environmental education programmes that satisfied their students' desire to learn more about their neighbourhood environment in depth.

The Shiga Project selected "Eutrophication of Lake Biwa and the conservation of its watershed" and "Acid rain" as two basic themes for environmental education. Needless to say, the eutrophication of Lake Biwa is the most important local problem in Shiga Prefecture, while acid rain is a major problem from a global viewpoint. Although it was somewhat difficult to introduce global environmental problems in school education especially for younger students, acid rain was considered to be one of the more easily handled subjects because students could directly touch rainwater, collect sample water and measure pH and other components.

3.1 Development and application of simple instruments for water quality analysis

It is essential to develop appropriate instruments for the measurement of water quality in order to help students scientifically understand aquatic environments. The members of the Shiga Project have developed several instruments and tried to apply them to environmental education classes in elementary and junior high schools. As described elsewhere in this book (Part 2), such aid instruments as the simple transparency meter made of plastic tube, simplified colorimeter for measuring phosphate content, filtration apparatus utilising a squirt gun, etc. proved sufficiently convenient for the use by students since the principles of them were very simple.

3.2 Teaching materials in the floating school

In the floating school on Lake Biwa, most elementary schools adopted eutrophication as the subject for learning, and usually the students measure the transparency of lake water and observe phytoplankton and zooplankton with microscope. However, these are not sufficient for the teaching of eutrophication, because the two types of experiments are not consistently related to each other. Therefore, the Shiga Project tried to prepare new materials which help to teach that the decrease of transparency in Lake Biwa was due to the increase of phytoplankton. After the students filter the lake water with the simple apparatus mentioned above, they observe the colour of suspended solids on the filter paper and microscopically observe the filtrate. Through these experiments, the students learn that the turbidity in Lake Biwa originates mainly from phytoplankton. In the floating school of the Odani, Sawayama, Daiho and Ishibe Elementary Schools, this way of teaching was actually applied and proved to be fruitful. The teachers then prepared an instruction manual for use in other schools.

Other materials included the dissection of fish for teaching food relations in the lake ecosystem. In the floating school of the Daiho Elementary School, this operation was repeated with large-mouth bass and bluegill under the guidance of an expert of fish. It seemed difficult for students to study the internal organs of fish individually, but they could understand the food chain by investigating the stomach content of fish, that is, the food. The Shiga Project proposed to introduce this teaching methods to other schools.

3.3 Field trip to Lake Biwa

Every summer from 1989 to 1994, a field trip on Lake Biwa or to nearby rivers was performed by the Shiga Project members and pilot school students. The main purpose of this trip was to study how the students could learn about the water quality of Lake Biwa and the rivers using the instruments developed by the Shiga Project. Obtained data are effectively used in environmental education classes in schools.

3.4 International exchange programmes

Every year ILEC holds a Group Training Course in Lake Water Quality Management for trainees from developing countries in cooperation with the Japan International Cooperation Association (JICA). The Shiga Project offered opportunities for pilot school students to talk with ILEC/JICA trainees, in which the trainees visited environmental education classes at work and enjoyed discussion on aquatic environments, singing and playing games with the students. The trainees in 1994 mentioned the importance of experiment-supported environmental education in their reports. Also the members of ILEC Scientific Committee sometimes visited Shiga environmental education classes. The pilot school teachers also joined discussion with those international visitors after the classes.

4. Examples of environmental education classes in elementary schools

Daiho Elementary School

Daiho Elementary School joined the Shiga Project in 1989-1992, though a teacher of this school remained as a member of the Research Group working to develop environmental education curricula. In this school, the environmental education programme named "Nakanoigawa gakushu" (learning in and around the Nakanoi River) was carried out for all students from the first to the 6th grade and experiments were performed using materials collected in and around the school and the river. The teachers of each grade have made annual environmental education programmes and gave classes in accordance with the developmental stage of the students. The curriculum was designed so as to enable the students to learn about their immediate environments and then global environmental problems. These classes were incorporated in subjects such as Life Studies, Social Studies, Science, Japanese, Moral Education and Special Activities.

In the classes, the students often went out to the river to catch fish, look for aquatic insects and inspect water quality using simple instruments. They enjoyed studying the environment through direct experience and learning about the complex structure of nature. They learned about the origin of pollution of the river receiving industrial, agricultural and domestic effluents, and then about the water quality of Lake Biwa into which the river flowed. Thus, they came to understand the relationship between the water pollution of Lake Biwa and people's life.

The main title of "Nakanoigawa gakushu" for each grade was:

1st grade: Let's familiarise ourselves with wildlife.
2nd grade: Let's make friends with living things.
3rd grade: Let's discover something in the Nakanoi River.
4th grade: Let's explore the Nakanoi River.
5th grade: Let's learn about the environment in Lake Biwa.
6th grade: Let's learn about the global environment.

Sawayama Elementary School – "Now, the water quality of Lake Biwa is getting worse" The 5th grade students learned the term and concept of eutrophication in the Floating School. Based on their experience on board Uminoko, this class was designed for the 5th grade students to learn the relationship between the pollution of rivers in the school area and the eutrophication of Lake Biwa.

This class consisted of the following four lessons, dealing mainly with the Seri River passing near the school and flowing into Lake Biwa. The river serves the school children of all grades as a playground and is a suitable site for environmental education. They have often observed in environmental education classes water-weeds, aquatic insects and fish as well as cast cans, rubbish, dead plants, bubbles in water, *etc.*, and became gradually interested in the deterioration of water quality and causes of pollution.

Lesson I (1 hour): "Let's make a map of the Seri River and its watershed"
The students investigated from where and how small streams flow into the River.

Lesson II (2 hours): "Let's search for the cause of river pollution."
The students made an excursion to the Seri River and its vicinity in order to look for the cause of river pollution and speculated as to the origin of pollution.

Lesson III (3 hours): "Let's consider how to protect Lake Biwa against pollution."

Part 1 (1 hour): The students observed the concentration of phosphate ion in domestic wastewater qualitatively using simple reagent following teacher's instructions.

Part 2 (1 hour): The students carried out experiments such as the culture of algae in the water of Lake Biwa added with domestic wastewater for about two weeks. In this class, they learnt how nutrients promoted algal growth, and were surprised to find out that the increased growth of algae was due to the wastewater from their daily life.

Part 3 (1 hour): They discussed the results of the experiments and considered how to protect Lake Biwa from water pollution in the future.

The students often think that the pollution is caused by muddy water originating from soil erosion, but they should know that muddiness is fundamentally different from eutrophication. Furthermore, it is important to learn that dissolved components also cause the pollution of rivers and lakes. Exactly understanding the mechanism of eutrophication may be too hard for students of elementary school, but the experiments can help them to understand at least part of the eutrophication process. After the experiments, all kinds of wastewater were collected together in a bucket and some students who watched the colour of the mixed water said that this water showed the condition of Lake Biwa. From these impressive words, the teacher felt that the students had a recognition that their life was closely connected with Lake Biwa.

Ishibe Elementary School – "Can we preserve Lake Biwa?"
Ishibe Elementary School is located in Ishibe Town, a small rural town surrounded by paddy fields, in the south-eastern part of Shiga Prefecture near the Yasu River, one of the major tributaries of Lake Biwa. Ishibe Elementary School served as a pilot school of the Shiga Project since 1993.

The goal of environmental education in this school aims at "developing students' love of nature to let them actively participate in creating a better environment." It was intended to raise students' awareness in putting what they learned in their studies into practice, in addition to increasing knowledge and promoting their understanding. The ultimate objective is, therefore, not only to give a good knowledge about the mechanism of eutrophication, appearance of algal bloom, or kinds of sewage containing phosphorus and nitrogen, but also to make them think of the ways to apply the knowledge to their everyday life.

The teachers tried to prepare an environmental education class for 6th grade students on the eutrophication of Lake Biwa, attaching importance to the self-learning of students and problem-solving study provided through experiences. This class of 9 hours consisted of the following five lessons.

Lesson I (1 hour): "Lake Biwa."
The purpose of this lesson was that students should be made aware of the relationship between Lake Biwa and their life. The students recollected their experiences in and around Lake Biwa and considered how to use Lake Biwa water. The teacher presented some pictures of Lake Biwa.

Lesson II (2 hours): "Eutrophication of Lake Biwa."
They learned that the pollution of Lake Biwa was caused mainly by eutrophication which resulted in the occurrence of red tide and blue-green algae bloom. Some pictures and graphs of red tide were presented.

Lesson III (3 hours): "Let's examine our domestic effluents."

Those who live in Ishibe Town must know the relationship between the eutrophication of Lake Biwa and the effluents from our daily life. The students studied various subjects such as domestic effluents, passways of water, water quality and water quantity. In the classroom, they examined the concentration of phosphate ions in water samples from rivers and ponds in Ishibe Town and various other sources such as dish-washing wastewater, drinks, etc.

Lesson IV (2 hours): "Let's present the results of our investigation."

The students prepared and presented reports on the results of their investigation. They also learned the reports of other students and then discussed ideas born from the results.

Lesson V (1 hour): "What can we do to prevent the eutrophication of Lake Biwa?"

The students discussed how to tackle the problems of river pollution and eutrophication of Lake Biwa.

Sawayama Elementary School – "Properties of aquatic solutions and acid rain". Students may become interested in global environmental problems such as ozone layer depletion, global warming, acid rain, deforestation, desertification and marine pollution through TV and other mass media. However, they feel that these problems are only distantly related to their everyday life. There are also difficulties for the students in understanding the properties of aquatic media around them.

Teachers designed a class of 18 hours for 6th grade students, in which the acid rain problem was incorporated into the Science class under the title mentioned above. This class consisted of four lessons as follows:

Lesson I (5 hours): "Classification of aquatic solutions."

The students classified many kinds of solutions into acidic, neutral and alkaline using litmus paper. They also examined the solutions such as juice, liquor, vinegar and others in their houses, and learned how to use pH indicators such as BCG in order to determine pH in detail.

Lesson II (5 hours): "The solution which dissolved gas."

The students learned what was the gas coming out from carbonated water and how much carbon dioxide was dissolved in water. They examined pH of the water in which car exhaust and smoke from fossil fuels was dissolved.

Lesson III (4 hours): "Aquatic solutions and metals."

In this lesson, the following four themes were treated.

a. Is it true that acid rain can dissolve concrete and metals? The colour change of pH indicator after dissolution of the surface of concrete and metals by acid rain was displayed in the class.

b. How does the metal change in diluted HCl?
c. What the metals change to?
d. What solution other than HCl can dissolve metals?

Lesson IV (4 hours): "What happens when acidic and alkaline solutions are mixed?"
The following three themes are treated.
a. Why is lime put into acidic lakes and applied on paddy fields?
b. How do acidic and alkaline solutions react when mixed?
c. What can we do to prevent damages from acid rain?

The students' understanding of acid rain would be insufficient if they merely classified solutions using only litmus paper. In this class, the students learned to measure pH, a new scale, so that they could take quantitative interest in acid rain. They examined pH of rain samples they collected near their houses and schools. They also made water samples which dissolved car exhaust gas. Then they performed an experiment to observe the colour change of BCG indicator while the concrete was put into the sample water. These experiments helped the students to understand the damage by acid rain, which they had only known by watching a video.

5. Examples of environmental education classes in junior high schools

Classes on aquatic environments in Moriyama-kita Junior High School (1992 – 1994)
The educational objective of this school is to develop strong and open-minded students, and the teachers are making efforts in every field to attain this. They planned an overall curriculum of environmental education, taking advantage of the characteristics of the school area and utilising familiar materials. "How can teachers lead students to have a deep understanding of their environment and to foster a co-operative mind and a practical attitude so that they can lead a life in harmony with nature and the environment?" was the school's motto for environmental education.

In 1992, the study themes were set as "Environments familiar to us" and "Aquatic environment and our life" and put into practice with 1st grade students. In the environmental education class, the students examined the colour, smell, transparency and COD of water samples from Lake Biwa and nearby rivers. The measurement of transparency and COD was the first experience for the students. They found that there was a great discrepancy between the measured values and their sensory estimations and that it was difficult to judge the quality of river water from sensory indexes only. They also learned that the water quality of rivers was strongly related with their life from experience, even though they had a knowledge that wastewater from their houses was one of the causes polluting rivers and Lake Biwa.

In 1993, the class for 2nd grade students was taken forward by introducing an experiment which enabled them to understand that one of the causes of

eutrophication of Lake Biwa was the phosphate ion, a nutrient salt, contained in wastewater from houses. Firstly, the application of the reagent to detect phosphate ion made the students notice that most of the foods we eat contained phosphorus. Then, they learned that wastewater from their houses contained a great deal of phosphorus, which was carried through rivers into Lake Biwa. Secondly, they carried out the experiment to remove phosphate ion in tea by adding soil and learned that some kind of soil had a strong property to absorb phosphate ion.

To review the series of study, the sub-textbook "Lake Biwa and Its Environment" published by the Shiga Prefectural Board of Education was used so that the students could learn the reason why we should try to reduce the amount of phosphorus entering into Lake Biwa and the importance of collective conscious efforts in our daily life to prevent further eutrophication.

Judging from the reports written by the students after the class, the teacher inferred that they could understand the relationship between the eutrophication of Lake Biwa and their daily life. Some students wrote about the talks with their families regarding environmental problems and were going to do something to prevent environmental deterioration with families.

New subject "Environmental Studies" in Kohoku Junior High School

In 1989, this school was designated as a pilot school of the ILEC Project. The school is located near Lake Biwa and the students live near its shores, but they had little direct contact with the lake water and seemed to have little concern in water pollution and the value of the lake itself. Thus the teachers placed emphasis on direct experiences of the students for learning about the environment. Certain teaching materials were created and environmental education classes were given so as to lead the students to enjoy the classes, get strong impressions on what they had learned and have a deeper scientific understanding. Special classes on the aquatic environment for 1st and 2nd grade students were set by making use of discretionary hours in the curriculum and an elective subject for 3rd grade named "Environmental Studies" was also started. The subject was divided into three parts on natural (Course Ia, Ib and Ic), social (Course IIa and IIb) and familiar environments (Course III). In 1994, all the 3rd grade students selected one of the six courses. The title of each course was as follows:

Course Ia: Familiar nature
Course Ib: Acid rain
Course Ic: Function of reed communities
Course IIa: Study about prefectural ordinances
Course IIb: Fishing methods and tools
Course III: Rubbish, wastewater and recycling

For example, the purpose of Course Ic was to lead the students to be interested in the present condition of Lake Biwa and the function of reed communities through experience and experiments near the shore, and to act for the protection of natural environments with scientific understanding.

Class plans:

Lesson I (1 hour): Orientation.

Lesson II (6 hours): Basic training for field work and experiment.

The students learned about the food chain, photosynthesis and process of decomposition by lecture, and were trained in the basic techniques of investigation such as the measurement of pH and transparency and filtration. They also learned about the species of waterweeds.

Lesson III (6 hours): Field work, Part I.

The students subsequently investigated aquatic environments around Okunosu, a small sand bank in Lake Biwa, e.g. water quality, functions of reed zone as a habitat for fish and birds and the damage on reeds by floating wastes such as cans and rubbish. Then, they interchanged the results of their study and discussed about natural environments.

Lesson IV (2 hours): Report of the ILEC summer training course.

Every summer since 1989, a field trip to Lake Biwa has been carried out by the Shiga Project members and pilot school students. The main purpose of this trip was to study how students familiarised themselves with the quality of water and sediments of Lake Biwa. Several students of Kohoku Junior High School participated in this trip.

Lesson V (6 hours): Field work, Part II.

Groups of students investigated aquatic environments respectively pursuing their own object, which included investigations of aquatic weeds, animals and plants in the reed zone, bottom sediments, drifting rubbish near shores, etc.

Lesson VI (6 hours): Summary of field works.

The students summarised the results and prepared posters for exhibition at the cultural festival in the school. They also found new questions and planned experiments to solve the questions.

Lesson VII (6 hours): Experiments in the classroom.

The students did experiments concerned the relations between the chemistry of water and the distribution of organisms and sediments.

Lesson VIII (2 hours): Summary of the class.

The students summarised and reviewed the results of field works, lectures and experiments.

Outdoor activities brought a lot of discoveries and surprises to the students. This made them learn actively and enthusiastically. It was most significant that they experienced practice by Lake Biwa, which existed nearby but was getting less and less familiar to their life. Also the teachers were able to learn much.

6. Discussion and Conclusion

Despite the world-wide pressing demand for establishing the concept and practice of environmental education in the last few decades, its methodology is still evolving. In view of the urgency of environmental problems, all school teachers who have direct contact with the younger generation should make every effort to develop pertinent methods and teaching materials for environmental education. However, there are still many teachers who are poorly concerned with environmental education, simply because they had no chance to learn about the environment during their school and college days. In this respect, the members of the Shiga Project played a significant role by helping the retraining of the teachers in each pilot school. The retraining of teachers is prerequisite to the success of environmental education.

Even if environmental education programmes have already been provided, the lack of information exchange system among schools may disturb environmental education development. In the Shiga Project, the exchange of information covering educational programmes proved very useful. As the environmental education is a new subject, preparing a database of teaching programmes and materials will be effective for extending environmental education. The Shiga Project is now editing an environmental education guideline book for Japanese teachers based on its experiences.

The Shiga Project have developed curricula whereby the students could experience the natural and social environment and understand environmental phenomena scientifically by experimentation. Formerly there was an idea that environmental education could be attained by such activities as cleaning public space, growing flowers, moral education, *etc.* but the target is hardly reached without scientific education. The pilot school students said in their reports that, after the environmental education classes, they could enjoy the Science class and feel wonderful natural environments. We realised that environmental education classes gave new discoveries and impressions to the students and encouraged their positive attitude. In conclusion, it is very important for the promotion of environmental education to prepare curricula and teaching materials which are based on the locality concerned, encourage students' participation and satisfy their desire to learn more scientifically about the environment in depth.

The ILEC project was completed in March, 1996, but the spirit and products of the Shiga Project are inherited by The Center for Environmental Education and Lake

Science, which was established in the Faculty of Liberal Arts and Education, Shiga University in April 1995. The main purposes of the center are 1) to make inter-disciplinary and collective study about environmental education using Lake Biwa and its watershed, the associated farm and forest attached the university and 2) to foster co-ordinators for environmental education who have practical ability, theory and knowledge enhanced through a lot of experience. Although the organisation of the Shiga Project changed, many teachers who participated in the ILEC Project are still studying environmental education as guest researchers of the center. We are going to make efforts to continue the environmental education programme that encourages the students to understand phenomena scientifically, then judge and act by themselves.

A GUIDELINE FOR ENVIRONMENTAL EDUCATION FROM CHIANG MAI UNIVERSITY (THAILAND) –ILEC EE PROJECT

Sirmsree Chaisorn

1. Backgrounds of the Project

1.1 Socio-economic background

Thailand is one of the rapidly developing countries of Asia in terms of both socio-economic and modern technological advancement. However, a large portion of its population of about 60 million is still struggling for sufficient life quality. More and more younger generations are leaving their farmlands in rural areas to seek other types of work in towns or cities. This trend has caused many cultural and societal problems. Farming is, however, still the main occupation of the Thais in most parts of the country, although the first-rank exports from Thailand are not agricultural products any more. The gap in life quality between groups of people with high and low income still remains as one of our serious socio-economic problems.

1.2 Forests and rivers in Chiang Mai Province

Chiang Mai is the largest province of northern Thailand. Its central city, Chiang Mai, has been the socio-cultural and economic centre of the North for 700 years. The total population of the province is about 1.5 million, of which about 200,000 are hill tribe people belonging to at least nine different ethnic groups. They live in the mountains north and west of Chiang Mai city, cultivating hillsides for agriculture. Plain areas in river valleys are used as rice fields and for other crops by lowland farmers.

Chiang Mai is among the nine northern provinces favoured with vast forest areas. Forest-covered mountains of the North are the sources of four main rivers, which flow southward joining together into the Chao Praya (Menam) River, the largest and most important river of central Thailand. The Ping River flowing through Chiang Mai city is the westernmost of the four rivers (Fig. 1).

The forest vegetation on watershed mountains consists mostly of mixed deciduous forest and hill evergreen forest. Deciduous dipterocarp forest, a drier type of open woodland, also spreads all over the northern provinces. The elevation of mountains surrounding Chiang Mai ranges between 500 m and 2,565 m, while Chiang Mai plain lies at about 300 m above sea level.

1.3 Environmental problems

Deforestation still remains as one of the critical environmental problems in Thailand. The forest area in Thailand was reduced from about 50 % of its total land in 1961 to only 20-23 % at present. Although northern provinces maintain a higher

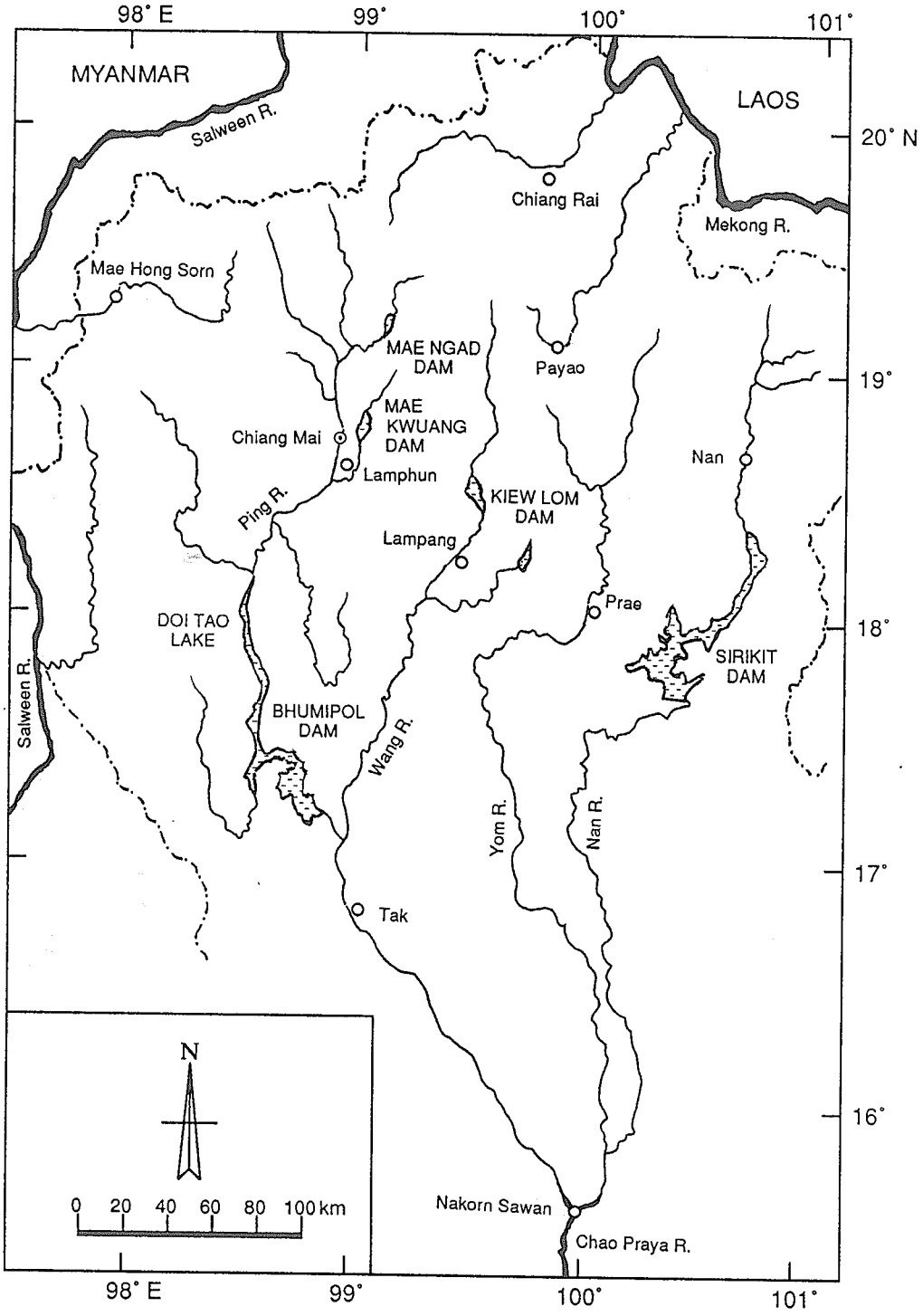


Fig. 1 River system in northern Thailand.

percentage of forests than other regions, topics on illegal cutting of big trees deep in the northern forests are always found on the front page of Thailand's leading newspapers.

Drought and flood The Ping River, like other northern rivers, dries up during every summer. People are then provided with water from reservoirs. On the other hand, Thai people suffer from flood disasters in some provinces all over the country. Flood has become a critical problem only during these couple of years.

Governmental as well as non-governmental agencies are putting forth great efforts to campaign for watershed conservation and reforestation. As a result, many groups of people from all walks of life, including school and college students, are participating in reforestation activities. The 1994 data indicate, however, that reforestation can cover only 160-480 km^2 per year whereas forests are being continuously destroyed at an average rate 1,600 km^2/yr.

Water pollution Water resources in rivers and canals in and outside the city area are getting progressively polluted with household wastes. Mae Kha Canal which flows through Chiang Mai city to the Ping River has been dark-coloured for many years. In spite of the trial of various countermeasures by the municipality, the problem still remains unsettled since it is quite difficult to find appropriate ways of wastewater treatment for the old residential quarter where people have lived like that for such a long time.

The Ping River water is very turbid due to soil erosion caused by the change of forest vegetation in certain areas. Another source of pollution is the use of large amounts of insecticides, pesticides and chemical fertilisers by farmers to increase their agricultural products.

Waste Chiang Mai city discharges 250-300 tons of waste each day, though the city's disposing capacity is only about 200 tons/day. The present site for landfill waste disposal will be filled up in one more year. The municipal office is struggling to find new sites. People need to be much more careful and responsible for their own waste, while the waste collecting system should be improved to help people behave in a more responsible manner to their surrounding environments.

1.4 Needs for sustainable development plans and environmental education

Every citizen's care and concern for the well-being and survival of natural environment, of people other than themselves, and of all living things should somehow be urgently emphasised for better living both in rural and urban areas. More actions from all sectors of the society to make economic development harmonious with the environment. Environmental education should respond to these needs more vitally and immediately. It seems that environmental education for

people, especially for younger generations, is the best alternative for our future survival.

In 1992, Thailand's Government, through the Ministry of Science, Technology and Environment, enforced a new national law for the promotion and conservation of environmental quality to replace the former laws of 1976, 1978 and 1979. Under the new law, master plans and action plans for environmental quality management are being fostered at the provincial level. Both governmental and non-governmental sectors in each province propose projects focusing on four areas; awareness and consciousness promotion, monitoring and prevention, rehabilitation, and action research. The National Environment Committee examines and make decisions on all kinds of projects and activities.

2. Outline of Thailand's National Education System

The school system consists of the following five levels.

- Kindergarten level (1-2 years). Non-compulsory.
- Elementary level (6 years). Compulsory.
- Lower-secondary level (3 years). Campaigning to make this level compulsory.
- Upper-secondary level (3 years).
- Higher education level (college level) (4-6 years).

Elementary school education There are five experience areas in the elementary education curriculum; Life-Experience, Skill (mathematics and language), Character Development, Work Education, and Special Experiences. Life- Experience area curriculum prominently attempts at integrating Science, Social Studies and Health Education subjects. In most schools, however, science is taught separately so that children receive more training in this topic. Thailand is proud of the high percentage of elementary school attendance (almost 100 %) though the question of adequate education quality is often raised.

Secondary school and higher education More than 80 % of elementary school students now go to the lower-secondary level. After that, they can continue either to the upper-secondary level or to vocational schools. Then, all can proceed to the college level. There is also non-formal education for those who want to receive their elementary and secondary education out of schools. Furthermore, there are open universities along with other governmental or private universities which are distributed in many provinces all over the country.

The subjects in secondary school curriculum are more specialised. Thai Language, Social Studies, Science, Work Education and Health Education are required for all students. After 1996, English Language has been added to required courses

throughout elementary and secondary levels.

3. Environmental Education in Existing School Curriculum

3.1 Stated principles and guidelines

The initial parts of the national curricula now being implemented in elementary and secondary schools (issued in 1978 and revised in 1990) contain curriculum principles, aims for the education, and guidelines for teaching/learning. Although these are meant for all the subjects or subject areas concerned, they respond perfectly to environmental education concepts. Environmental education should be integrated wherever possible and be studied in depth in any subjects or subject areas. Its provision and enhancement depend on schools and teachers. They are expected to creatively promote instructional and student activities, though teachers often teach their subjects without studying the master curriculum.

Examples of stated teaching guidelines For example, the guidelines for elementary schools states:

- Curriculum and instructional media should be based on local situations and developed locally;
- Instruction should be learner-centred and relevant to learners' interests and actual lives;
- Instruction should foster integration within and among subjects areas as much as possible;
- Emphasis should be laid on learning processes, reasoning and creative thinking processes, and group process; etc.

The guidelines for lower-secondary schools also emphasise similar approaches:

- There should be a variety of learning activities for students to choose;
- Instruction should combine knowledge and actual practices with the emphasis on learning processes, reasoning and group processes; etc.

These can be used as the principles for environmental education. However, due to many limitations, school experiences are still far from actual life experiences of students and communities.

Since environmental problems have become serious both locally and globally, there are now more attempts to promote environmental education in schools and also in out-of-school projects. EE curricula for both elementary and secondary schools in Thailand are being worked out by certain institutes. There is also a strong tendency to add a new course on environmental science to the basic required courses.

3.2 Environmental topics in some subject areas

In the current curricula, environmental contents are found in many subject areas. There are, however, basic questions which those who are concerned with environmental education keep raising still; how much of the contents are extended to reach students' local environments and whether all students learn about them or not?

Elementary level In Life-Experience subject area of elementary school curriculum, students have to learn, for instance, Unit 3 (Our Surroundings) through all six grades. For Grades 5-6 students, additional units and small texts (for Grade 6) for reading are provided. The following three texts deal directly with the environment.

- Man and Environment deals with animal life, relations among organisms, ecological system, national park, water pollution, and conservation of natural resources.
- Physical and Mental Health Learning about local environment, community public health, home and community sanitation, and water pollution.
- Economics and Occupations Natural resources, water, irrigation, dam, reservoir, waste disposal, pesticide, and problems related to people's irresponsibility for other beings and society.

Other subject areas and required activities, such as boy scouts training, also emphasise awareness of the environment. In Character Development (arts and moral education) subject area, for example, pupils are expected to form learning enthusiasm by observing nature and environment and drawing relevant pictures.

Information given in school texts usually does not cover all necessary details, but provides general statements of concepts. For students to be able to apply those principles in the texts to their surrounding environments, teachers should organise meaningful learning activities for them. Informal interviews with some teachers and supervisors showed that most learning activities occurred within classroom walls.

Lower-secondary level The aims of lower-secondary school curriculum (Grades 7-9) are almost the same as those for the elementary level, except that the former stresses students' ability to analyse community problems and to suggest ways to solve the problems. Two secondary level subjects, Science and Social Studies, which deals directly with environmental education, respectively contain a few target items specified to serve environmental concerns.

The first level (Grade 7) students of lower-secondary schools are required to learn about *water* in the first semester. The official Science text for this period contains a big chapter called *Water for Life*. In the second semester, the students learn about plants, animals and ecological systems. Grade 8 students study electricity, water force and natural resources in water. They have to do some experiments on water quality.

As for the required Social Studies subjects, only Grade 7 students learn about the environment of Thailand under the theme "Our Country". The Social Studies curriculum also offers Environment Education as an elective course for lower-secondary school students.

The teachers of Science and those of Social Studies belong to two different school departments, and usually never plan their teaching together, even though their subject contents are quite repetitive in many parts. The Science textbooks poses some questions for students to think about their own environmental problems, but most schools do not organise definite activities or projects that make students understand their surroundings thoroughly, actualise their own roles and responsibility, and aware of the local or official organisations they should be acquainted with.

4. Project Implementation

4.1 Preparatory stage

The ILEC EE project at Chiang Mai was planned and organised by the staff of Chiang Mai University (CMU) with the cooperation of four pilot schools (2 each from the elementary and lower-secondary level). A project committee was organised with CMU staff and a representative of the pilot schools. The first year (1992) was devoted to the collection of relevant information (especially of water resources and water quality in northern Thailand), discussion with specialists in water quality management, survey of youngsters' consciousness of environmental issues, and the determination of the curriculum unit title, *Water and Life*, and its scope/focus for classroom use.

In 1993, two workshops were organised, with invited resource persons from CMU Faculty of Science and the Department of Forestry, to strengthen project teachers' concepts on some environmental principles and related scientific processes and to write up 12-hour teaching plans on Water and Life. Curriculum materials and instructional media for the unit were also collected or produced.

4.2 Project activities

Unit: Water and Life Details of instructional plans of the unit Water and Life are shown in the appendix. The unit consists of the following three themes,

Theme 1: Water – the most important thing for all forms of life,
Theme 2: Our Nam (water) – Fa (sky) – Pa (forest) – Khao (mountain), and
Theme 3: Problems, development and conservation, focusing on Thai people's social responsibility, problem-solving and process skills, critical thinking and experimental learning.

Classroom work The instructional unit Water and Life was planned for team-

teaching approach. At the secondary level, Science teachers and Social Studies teachers taught students together. Classroom activities included, besides lectures, discussions and analyses through maps, slides, pictures, charts, video-tapes, and other materials.

Field trips Students went on a one-day field trip to Mae Ngad Dam and its hydroelectric power plant, water supply unit and CMU wastewater treatment unit; 80 elementary students from two pilot schools went on Saturday, and Sunday was assigned for 80 secondary school students. Another weekend was spent on nature walks to study the relationships of forests, plants, animals, soil and water.

Workshops for students Two pilot schools promoted students' understanding of local water resources by inviting local authorities and experts to talk to students on various topics such as water relations and beauty of forests, underground water and wastewater treatment. An example was the workshop on *Local Water Resources and Forestry* held in 1995, which emphasised the contact of students with local figures responsible for water/forest management and students' expression through verbal and artistic work.

Teaching media Each school received the following media.

1. Forty copies each of two supplementary reading texts prepared by CMU staff, entitled Our Northern Nam-Fa-Pa-Khao and Thailand's and Northern Water Cases. Illustrated maps and final note attached at the end of the text helped students' understanding. Suggested activity sheets were also prepared for teachers.
2. One set of 220 slides on Water Resources and Environmental Problems in Chiang Mai.
3. One commercial video-tape, On the Search for the Origin of Ping River.
4. An expense of 1,000 Baht (US$ 40) to buy simple material for Science experiment required by the instructional plan.

Revision of lesson and activity programmes was planned in 1995 for use in 1996-1997. The plan included:

- More integrated activities,
- Further development of experiential learning of local environments,
- Production of various learning materials necessary for the better understanding of local environments,
- Expansion of co-operative efforts among school teachers, and
- Enhancement of inquiry processes for learning surrounding environments.

5. Proposed Guidelines for School Environment Education

Environmental education is a process aimed at helping individuals or groups to learn about the environment so that they understand appropriate environmental concepts, are able to analyse environmental issues, and become aware of the inter-relation between the issues of different scales. It must attempt to educate people to value thoughts and practices that are constructive to the environment, and behave with consciousness and commitment to improve the quality of their own surrounding environment and of larger-scale environments whenever possible.

Here are some suggested ways for giving environmental education to school students.

1. Teach the concepts directly in traditional courses or units designed specially for environmental studies. This can be done in such different subjects as Science, Social Studies, and Agricultural Education, for example. However, some overlapping of contents are certainly found between these subjects, particularly between Science and Social Studies with respect to geographical environments and natural resources. Students' direct experiences may be promoted in teaching/learning of such subjects.

2. Promote conceptual and actual experiences in student activity organisations (co-curricula activities) under close supervision of teachers. Students usually want to organise Environmental Conservation Club, Nature-loving Activity Club, Community Studies Club, etc., where they can be led to have hands-on and real-life experiences in many aspects. With mutual cooperation, they will expand their science and social process skills as well, perhaps even more than they usually get from course studies.

3. Adopt integration approach in designing certain units or the whole course to reduce overlapping and repetition among subjects. This is quite difficult for schools and teachers under the traditional system of education. Schools and also curricula are usually organised according to the staff's specialisation. There have been no efforts to look across subject boundaries, against the world's trend of closer interchange in all aspects including information and a greater part of knowledge.

This approach calls for team teaching and would enhance cooperation among teachers to organise students' learning experiences more relevant to environmental needs. Students will realise the inter-relation of the subjects they learn in schools and thus see the importance of school learning more than they ever do. The ILEC EE project at the CMU Faculty of Education attempted to encourage pilot school teachers to use this approach. The interdisciplinary unit illustrated here (Fig. 2) is a sample for them to study. Environmental issues, and hence environmental education also, are interdisciplinary by their own nature.

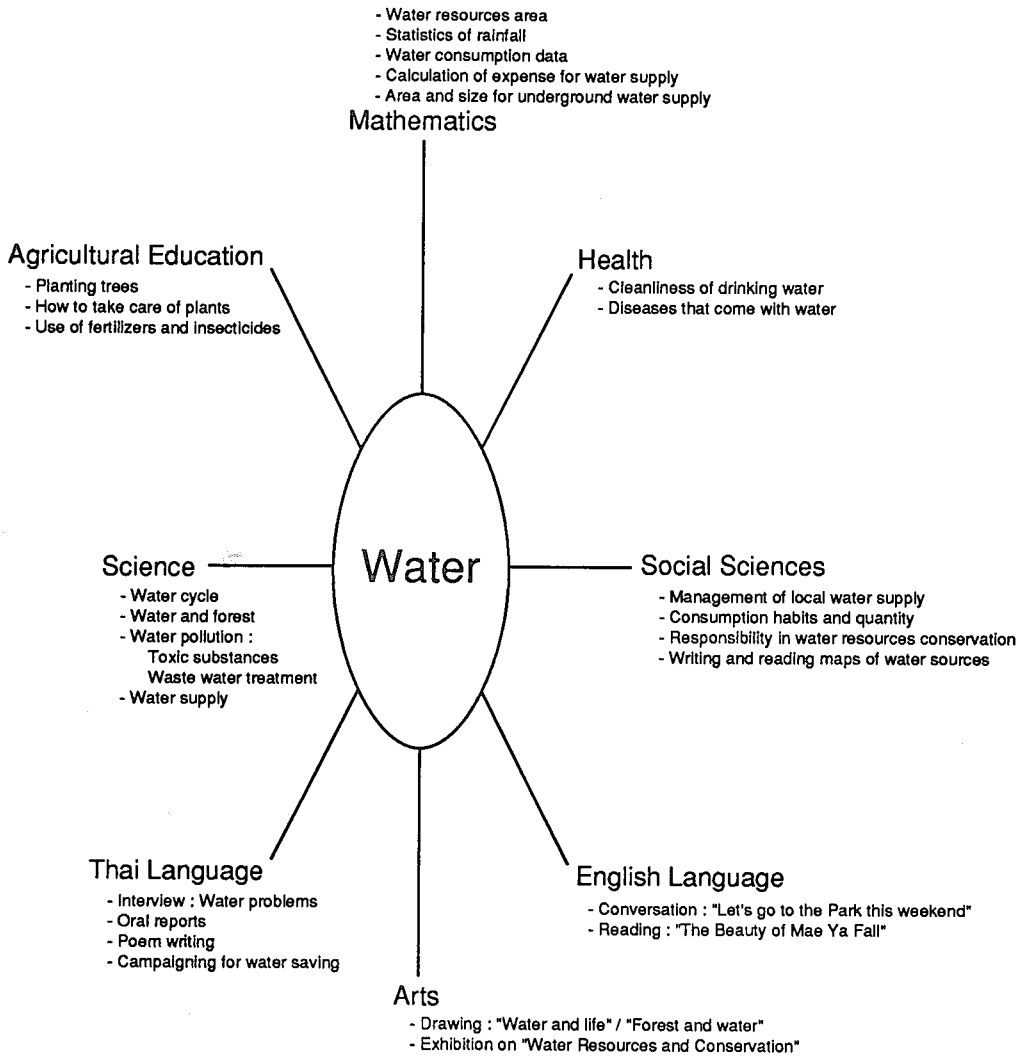


Fig. 2 Scheme of a proposed interdisciplinary unit, Water and Life.

The problem turned out in the CMU/ILEC Project was that teachers had no time to work or plan together. They must follow their own subject plans that are rarely flexible. According to the later analysis by our project committee, the real problem might be that the teachers themselves did not feel the real need of such an approach, and lacked understanding of its theoretical background. When they worked together in our project, nonetheless, they said they have learned more by working with their colleagues and enjoyed it.

4. Teachers' handbooks on how to organise general learning experiences for students must be prepared. Teachers should at least be invited to participate in specifying scope of contents and topics related to their school, local and broader environments. The handbook should give examples of various questions, the where-, what-, why-, who- and how-, on each topic to be used to stimulate students' inquiry. The questions should guide the ways to explore students' surrounding environments, and to study or probe into nation/world-wide environmental problems that have impacts on their communities and their own lives. Some examples of the questions are:

   - Where do your water resources come from?
   - Why should we save the water when we are having so much rain?
   - Where does the water in this river flow?
   - Who supplies your tap water? How to provide public water supply? What are the expenses?
   - How should we dispose of broken glasses and bottles, batteries?
   - How exactly do people use the water from this reservoir?
   - Why do we say that plants are the great producers of our world?
   - Why do we find bits and pieces of waste along streetsides? What can we do to solve the problem?
   - What are the effects of polluted water, polluted air on living things?
   - Why are we facing more severe floods in our rainy season?

Other teaching/learning techniques, such as getting students to collect news of local and global environmental problems/issues, can also be included.

5. Teaching resource units on separate topics should be designed so that varieties of teaching/learning resources are collected and suggested. Ideas for instructional strategies such as different types of hand-on experiences, problem-solving methods, critical thinking, etc. would be listed. Artefacts and media, for teachers to select for their students or for students to study and begin their inquiry projects, would also be collected or produced for particular topics for which the teaching resource units are designed.

6. Training and designing local curriculum and affective learning should be planned together with specific methods of environmental studies. Training keeps teachers updated on environmental situations. It would assist teachers to be more confident in teaching their students to be more skilled in project planning, investigation, experimentation, communication, and understanding environmental situations.

Environmental problems are our problems, the problems of our communities, the problems of our world. We as teachers should be more concerned and contribute to the understanding of environmental problems – adjusting the content or learning

activities in all subjects, so that they build up students' conscience and commitment to make our environment and thus our lives better.

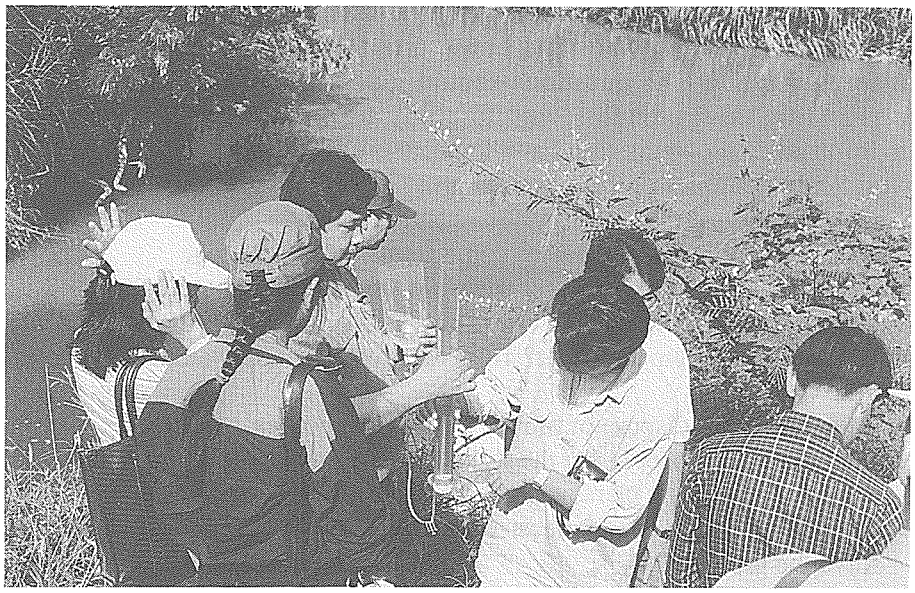


Fig. 3 Training of teachers on the riverside.

ANNEXE

DETAILED PLAN OF THE UNIT, WATER AND LIFE

Topic 1 Water : The Most Important Resource
(Time: two class periods)

General Objectives	Learning Activities	Grouping	Resources	Integration	Evaluation
1. Awareness of the necessity of water for all forms of life especially human beings.	1. List daily-life activities using water, from waking up in the morning to bed time. 2. From students own experiences and additional pictures, discuss in groups about the necessity of water for existence of human beings, animals, and plants, and report to the whole class. 3. Write short essays or poems or draw pictures illustrating how important water is. Display on boards.	Whole class Small class Individuals	1. Pictures that give various concepts of water necessity	Social Studies Language Art	Observing students' participation in class activities and evaluate the products of activity 3.

Topic 2 Water Cycle and Ecological System
(Time: one class periods, one-day field-trip, one-day nature walk)

General Objectives	Learning Activities	Grouping	Resources	Integration	Evaluation
1. Understanding of water cycle. 2. Realisation of water as the basic resource in the ecological system. 3. Better understanding of the interdependence among resources and living things in the natural environment.	1. Take field-trip to see a multi-purposed dam, watershed, visit Chiang Mai University Water-supply unit and Waste-water Treatment System. 2. Study water-cycle chart, identify factors that cause or affect the cycle (heat, wind, animals, humans, and plants). 3. Carry on simple experiments on "Water from plants: When and How? 4. Join nature walk activities to study about inter-dependence of lives and nature in the ecological system, followed by art and language activities. 5. Answer teachers' oral or written questions about the water cycle and the ecological system.	Whole class Whole class Small groups Whole class Individuals	1. Real places and resource personnel at each place. 2. Water-cyclecharts 3. Simple equipment for experiments 4. Recording forms for nature-walk activity 5. Equipment and utensils for language and art activities at the nature sites.	Science Social Studies Language Art	- Observing students' participation - Evaluate outcomes of the experiments - Check for correct answer to the questions at the end.

Topic 3 Our Water Resources in the North
(Time: two class periods)

General Objectives	Learning Activities	Grouping	Resources	Integration	Evaluation
1. Better acquaintance with important water resources in the North, especially in Chiang Mai Province and nearby. 2. Ability to survey and report on local community water resources and usage.	1. Identify the names of the important rivers and dams shown in the outlined maps. 2. Study supplementary materials (Our Water - Sky - Forests and Mountains of the North) to learn about the origins of each river and its paths, especially the Ping River. 3. View a video tape on "Searching for the Origin of the Ping River" 4. Read a documentary pocket book to learn about the environment around and along the Ping River, a main source for Chao Praya River. 5. Discuss positive and negative effects of building dams and reservoirs using authentic cases. 6. Report individuals' survey of natural or constructed water resources that affect his/her living. After teachers' feedback, display on boards.	Whole class Individuals Whole class Some individuals (to read and report to the class) Whole class Individuals	1. Outlined maps of the North and surrounding areas. 2. Supplementary reading material: Our Water - Sky - Forests and Mountains of the North, (prepared by the Committee) 3. One hour video tape on "Searching for the Origin of the Ping River" (made by the Pacific Communication Company) 4. A book on "The Origin of the Chao Praya River" (by Theeraphap Lohitkul) 5. Local Areas 6. Survey Report Forms	Social Studies Language	- Check for correct identification on maps - Evaluate the quality of discussion and survey reports

Topic 4 Quantity and Quality of Water
(Time: two class periods, out-of-class activities)

General Objectives	Learning Activities	Grouping	Resources	Integration	Evaluation
1. Concern and care for quantity of water consumption and water quality in Chiang Mai communities. 2. Realisation of the needs of people's responsibility and cooperation to prevent and to solve water and other environmental problems.	1. Study recent cases dealing with eater resources and quality in Thailand especially in northern provinces. 2. Viewing slides showing environmental problems. 3. Discuss and analyse people's habits of over consumption, social irresponsibility, selfishness, and ignorance which cause water shortage and pollution. 4. Observing plants, animals, and water quality in rivers, canals and ponds. 5. Experiment on water quality using water samples from communities.	Small groups Whole class Whole class Small groups	1. Selected water cases (prepared by the Committee). 2. 12-15 slides depicting environmental problems. 3. Equipment and materials for water quality experiments.	Social Studies Science	- Consider the breadth of discussion and the ability to carry on the experiments.

Topic 5 Action for Problem-solving, Development and Conservation
(Time: three class periods)

General Objectives	Learning Activities	Grouping	Resources	Integration	Evaluation
1. Awareness of water quality problems in the local communities and their causes. 2. Ability to plan for water or other related environmental improvement, development, and conservation so as to enhance the quality of family and community lives. 3. Taking active roles in implementing the plans to increase environmental quality.	1. Study sample cases concerning environmental problems especially those relating to water. 2. Analyse cause-effect factors from the cases. 3. Interview local authorities and peoples. 4. Plan for action on various group projects initiated by students themselves. 5. Report the procedures and results of the project activities through exhibitions. 6. Revise the plans or write up the proposals for more action in the future.	Small groups Small groups Small groups Small groups Small groups	1. Selected water cases (prepared by the Committee and other cases found in local areas or newspapers. 2. Local communities 3. Local resource persons and people connected to problem-sites.	Social Studies Language Art (designing exhibitions)	- Evaluate the plan for actions

RESULTS OF THE ENVIRONMENTAL EDUCATION PROJECT CARRIED OUT AT PATTANI, THAILAND

Kanok Chantong

1. Introduction

An environmental Education Project was carried out, as part of the ILEC's Project covering six countries, in Pattani Province of southernmost Thailand. It was initiated in May 1991 and its implementation started in August 1991 when a working committee consisting of the staff of the Faculty of Education, Prince of Songkhla University and the pilot school teachers was formed at Demonstration School in Pattani Campus of the above university.

The objectives of the project were:

1. To study the state of environments in the Pattani River and its basin,
2. To produce teaching materials for the purpose,
3. To work out the programme of activities in pilot schools, and
4. To exchange ideas and experiences about environmental education among the participating countries.

The Working Committee nominated one pilot school each, respectively from the elementary and secondary level. The project continued for 64 months until September 1995.

2. Brief description of Pattani River basin

2.1 Pattani Province

Pattani Province is a small province (1,940 km^2) in the southern peninsular region of Thailand about 1,100 km south of Bangkok. The province is bordered by the Gulf of Thailand on the north and the east, by Yala Province on the south, and by Songkla Province on the west (Fig. 1).

There are four main rivers flowing northward through the province to the Gulf of Thailand, of which the Pattani River is the largest. The town of Pattani lies on the low flood plain at the mouth of the Pattani River. Coastal plains extend to the northwest and the east of Pattani.

Pattani Province has a tropical rain forest climate. As influenced by the southwest and northeast monsoon, Pattani has only two seasons, summer and wet winter. Annual mean temperature is around 27.5 °C. Mean precipitation amounts to 1,663 mm/yr, with the heaviest rainfall in November-January and the driest season in

February – April.

The natural vegetation consists mostly of undisturbed rain forest containing many economically important plants such as dipterocarps and rattan. The area around river estuaries and sea coasts support species-rich mangrove forests.

The predominant land use is for agriculture. The agricultural area is about 152,000 ha. Main crop plants are rubber tree, rice, coconut and fruits (rambutan, durian and longan). Domestic animals include cattle, buffalo, goat, sheep and chicken. Industries are limited to a few places. There are 150 ha of general industrial area and additional 90 ha is for small (semi-clean) industries. These areas contain 782 plants engaged in fishery industries, canning, freezing, drying, etc.

The population of the province is about 530,000. Their main protein source is freshwater fish (catfish, white puntius, etc.), but they also eat brackish water products such as seabass, karang and black tiger shrimp.

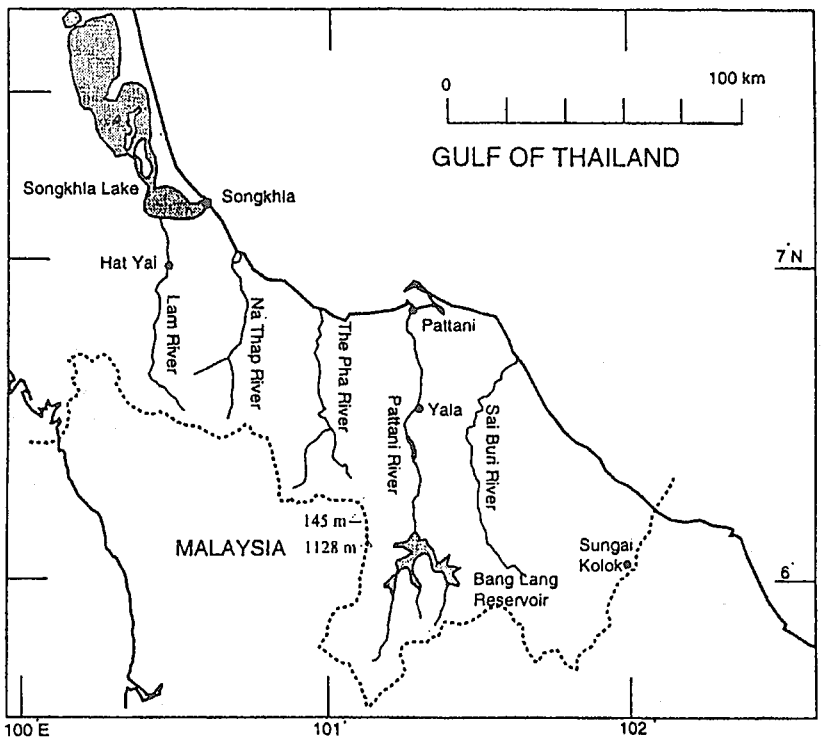


Fig. 1 Map of the southernmost part of Thailand.

2.2 Pattani River

This river has its origin in Bentong District of Yala Province and flows northwards for about 190 km, reaching the Gulf of Thailand at Muang District of Pattani Province. The uppermost part of the river basin in Yala Province is generally mountainous and narrow valley flats are only partly found. The middle reaches run through flood plain. Near its estuary, delta and flood plain develop offering suitable sites for agriculture. The water of the Pattani River has pH values of 6.7-7.5. Water temperature is 25-28 °C. Dissolved oxygen concentration is lowest (4.9 ppm) at the river mouth.

Dams There have been two development projects in the Pattani River basin; the Upper and the Lower Pattani River Basin Development Project. Bang-lang Dam was created by the former project and Pattani Irrigation Dam by the latter. The Bang-lang Dam intercepts the river near Bang-lang village in Bannangsta District of Yala Province. This rock-fill dam measures 85 m in height, 422 m in length and 10 m in width, and can store up to 1,420 million m^3 of water. The dam was inaugurated in 1981 for the main purpose of hydroelectric power generation. Three generators produce 200 million kwh/yr of electricity.

Pattani Irrigation Dam is a concrete structure across a 800 m span of the river at Taseh village in Yala Province. Its role is to diverge irrigation water to farmlands of about 38,700 ha. Besides being an irrigation dam, it also serves to reduce flood damage on farmlands and foster fish resources.

2.3 Environmental problems in Pattani

As with other big cities, Pattani suffers from environmental problems. It is necessery to solve them before the situation gets worse. Prevention being better than a cure. The main problems are as follows.

Destruction of mangrove forests This is very serious in recent years, owing to the expansion of black tiger shrimp farms in this region. Mangrove forests are increasingly destroyed day by day in many coastal districts. It is an alarming problem because it exerts serious damage to the rich source of aquatic animals and plants which may result in the decrease of marine products in the future.

Water pollution is apparent in the lowermost part of the Pattani River over a distance of 2-3 km near the town of Pattani and a nearby industrial area. Main sources of pollutants are wastewater and solid wastes from the community of Pattani town, industrial factories and the fishery port of Pattani which enter the river without any treatment.

Air pollution The only one source of air pollution to be mentioned is the bad smell

emitted from many factories near the Pattani River estuary.

3. Environmental education in the current school system

Today, Thailand's national curricula for both elementary and secondary schools include environmental concepts in several subject areas. Two subjects, Social Studies and Science, deals directly with such concepts which are incorporated in both subjects for all grades.

On the elementary school level, Social Studies, Science and Health Education are united into a subject area called Life-Experience. Life-Experience is required for elementary school children of all grades (1-6). Its contents are divided into various units on all levels such as:

Unit 1: Living things,
Unit 3: Our surroundings,
Unit 4: Thai nation,
Unit 6: Energy and chemicals,
Unit 7: Universe and space, and
Unit 9: Population.

Students of Grades 1 and 2, for example, learn about the natural environment and its effects on human life in Unit 3. In Grades 3 and 4, they are taught about plants, animals, forest and conservation in Unit 1, and about water cycling and soil in Unit 3. The concepts of natural environment, ecological system and environmental conservation are studied in Unit 3 and about pesticides in Unit 6, by Grades 5-6 students. Thus environmental concepts are apparently scattered among various teaching units. Only basic concepts are provided in the texts, but most of them are only briefly mentioned.

In the junior secondary school curriculum (Grades 7-9), Science and Social Studies are two independent subjects, in which environmental matters form part of the contents. Aside from the required subjects such as "Our Country" (Grade 7) and "Our Continent" (Grade 8), Social Studies have a few elective courses directly related to the environment such as Population and Environment and Environmental Studies, but these are not pursued by all students.

It may be said that general environmental concepts are provided in the curricula, but that the required courses do not cover details of local environmental conditions, issues and problems. Unless teachers have the possibility to learn such aspects, students will not obtain a deep understanding of environmental matters, especially those of local concern.

4. Pilot schools

Two schools located near the town of Pattani were appointed as the pilot school for the ILEC EE Project: Ban Sabarang School for the elementary level, and Demonstration School of Prince Songkla University for the junior secondary level.

Demonstration School is one of the departments of Faculty of Education, Prince of Songkhla University. It is in the Pattani Campus of the university, located on the left bank of the Pattani River 1 km away from the sea. The school was founded in 1970 to serve as the teaching laboratory for the students of Faculty of Education. In 1995, it had 561 students, including 259 of junior high school level (Grades 7-9) and 308 of senior high school level (Grades 10-12), and 54 teachers. The education in the school is carried out following the curricula issued by the national Ministry of Education.

Ban Sabarang School is one of the elementary schools in Pattani Province, located on the left bank of the Pattani River at Sabarang, Muang District near the town of Pattani. The school was founded in 1946. It has 1,212 students of Grades 1-6 and 46 teachers in 1995. Most of the students come from the same district.

5. Implementation of the project

5.1 General scheme and preparation of EE programme

The environmental education programme focused on encouraging students to think about how to conserve the environment of the Pattani River and its basin as the main theme. Main topics selected to meet this purpose were:

- Environments of the river and its basin,
- Study of mangrove forest,
- Disposal of wastes and waste,
- Study of acid rain, and
- Study of natural resources in school surroundings.

These contents of environmental education were integrated in the curricula for both elementary and secondary school levels. On the elementary level, scientific knowledge about the environment was inserted in Life-Experience subject, while environmental matters were integrated in Science, Social Studies, English and Thai Language on the secondary level.

Preparation of teaching materials The following teaching aids were prepared.

- Some 80 slides showing the Pattani River basin.
- A video-tape (21 minutes) on the Pattani River basin.
- A picture book on the Pattani River basin for students' supplementary reading.

- A teachers' manual, which offers supplementary reading for teachers on the Pattani River basin, water pollution, wastes and waste, forest and wildlife.
- Posters depicting existing environmental problems to promote classroom discussion on how to conserve the Pattani River.
- Scientific instruments were provided by ILEC: pH meter, conductivity meter, rain gauze, phosphorus test kit and detergent test kit.

5.2 Lesson plans and activities

1. **Survey of mangrove forest** Grade 9 students of Demonstration School made this survey by setting up four study plots each in three mangrove forest stands and observing soil and water pH, water salinity and other conditions in each plot. Obtained data and findings were discussed and synthesised in the classroom.

2. **Drawing competition** Contests of drawing on the conservation of the Pattani River were held twice in both schools (Grades 6 and 7 students) in order to make students become aware of the importance of the river, to know how to make the river clean, and to realise the importance of cooperation in coping with environmental problems. Pictures submitted by the students were examined by teachers for artistic beauty and creativity. Prizes were awarded to excellent works, some of which were exhibited at the schools and at the 5th World Lake Conference held in Italy (1993), etc.

3. **Study of acid rain** This study was a group activity planned for Grade 5-6 students of Ban Sabarang School and Grade 7 students of Demonstration School. Students collected rainwater twice a month and measured pH and conductivity continuously for two years. The records were discussed in the classroom every 3 months, 6 months and one year.

4. **Study of water quality in the Pattani River** This was conducted by the cooperation of Grade 5-7 students. Water temperature was measured and water samples were taken weekly for about two years at three different sites to measure pH, conductivity and phosphorus content. Results were presented monthly for interpretation.

5. **Exhibition on the Pattani River basin** The exhibition was held at Demonstration School throughout the second semester (November 1993 – September 1995). Grade 7 and Environmental Education Club students worked in two groups respectively responsible for different items, which included stream sources, forests, wildlife, domestic animals, crop culture, fishing, air/water pollution, wastes/waste, etc. Displayed items were changed weekly.

6. **Lesson on the Pattani River basin using a video-tape** A video-tape (22

Fig. 2 Study of acid rain at Demonstration School.

Fig. 3 Study of river water quality at Ban Sabarang School.

minutes) was produced to show the river's water sources, landscape, forests, wildlife, mining, agriculture and fishery in the basin. After the lecture and video presentation, students wrote essays on the value of the river. Excellent essays were presented in the class.

7. **Lesson on the Pattani River basin using a picture book** This lesson (2 periods) was included in Unit 3, Our Surroundings, of the subject Social Studies for Grade 5 students at Ban Sabarang School. A picture book on the Pattani River basin was used for students' reading, discussion and free drawing.

8. **Lesson on the conservation of the Pattani River** Lectures (100 minutes) on the significance of the river for local communities, existing environmental problems and measures to prevent or solve the problems were given to Grades 5-6 and 7-9 students using the picture book as an aid. Students were later asked to create slogans for the river conservation campaign.

9. **Lesson on water pollution** Grades 5-9 students attended a 100 minutes lecture on wastewater sources, and effects of and countermeasures for water pollution. Several pictures illustrating the pollution of the river were shown by teachers. After the lecture, students joined a brainstorming in small groups on the prevention/solution of water pollution problems.

10. **Campaign slogan contest** Demonstration School students tried to work out slogans that highlighted the benefits of protection and conservation of the Pattani River and the necessity of "joining hands" for keeping the river clean. The EE Club screening committee selected the best ones for awarding and announcing in the school.

11. **Study of natural resources in the school's surroundings** This activity was intended to make Grades 5-6 students of Ban Sabarang School get basic knowledge on the school's surroundings, with emphasis on natural resources such as soil, water, air, plants and animals, and learn how to conduct simple field surveys. It took two months for surveys, data collection and evaluation.

12. **Lesson on wastes and waste** The lesson (100 minutes) is given to Grade 5-7 students dealing with sources of wastes/waste and waste problems. Pictures of wastewater and waste inputs to the Pattani River are shown. Students discuss in small groups afterwards and a representative of each group presents the result of discussion to the class. This programme has not yet been carried out.

13. **Study of natural resources** In order to enhance the understanding of the role of natural resources by on-site experience, the students of EE Club and the teachers of Demonstration School visited Bang-lang Dam in August, 1995.

Summary of the activities 1992-1995

1992-1993	Studies of the EE methodology, the collection of basic information on the watershed and estuary of the Pattani River, and the preparation of teaching materials.
1993	Lesson/activity Nos. 1, 2, 3, 4, 5, 6-8.
1994	The Environment Day, Nos. 2, 3, 4, 5, 6-8.
1995	Nos. 2, 3, 4, 5, 10, 11, 13.

6. Review of the project

6.1 Evaluation

The activities in the EE project at Pattani were mostly concerned with the environmental conservation of the Pattani River and its basin, and successfully enhanced understanding of the environment and developed good attitudes toward environmental issues in students, teachers and related people.

At student level, the two pilot schools provided some 1,800 students with the opportunities to obtain knowledge on the environment of the river and its basin, to have right attitudes toward environmental conservation, to join activities for protecting the river in their daily life, and to transfer their knowledge and experience to other members of their families.

About 15 teachers were responsible for teaching in this project, while an additional 100 teachers also joined their students by taking part in such activities as exhibition, Environment Week events, campaign slogan contest and drawing competition.

One target of this project was to let students bring their knowledge and experience back to their families and share them with family members. If this continued, many people in local communities would also gain more knowledge on and right attitudes to environmental conservation.

The activities were mostly confined to the pilot schools because of limited resources. However, if the project would have enough financial support to extend it to the whole district, province and educational region, it would offer a great opportunity to develop and disseminate environmental knowledge and consciousness which will be very useful to our country.

6.2 Difficulties to overcome

Although the EE project at Pattani was successfully carried out due to the good cooperation by the two pilot schools and the project staff, there were some difficulties encountered during the five years of its implementation.

1. There was no specific course for environmental education in the current school curricula, so that the project activities had to be incorporated in the teaching of existing subjects, Science, Social Studies, Thai and English.

2. The project was under the control of the officials in Demonstration School, which was no more than a small public organisation, without any authorisation by the government. This caused trouble in running the project.

3. Not all the planned activities could be put into practice because of the shortage of funds.

4. All the staff members of this project were volunteers, who nevertheless had to take great effort and responsibility. Therefore, only a small number of them were available.

Every member of the project committee realises the benefits for students which the project offered and wishes to go on to find additional financial support to cover all necessary expenses. Though we have not yet been successful in this effort, we still keep trying.

6.3 Future plans

We would like to realise two main plans in the future. For the short term, we expect to hold some sort of exhibition about environmental education which will be displayed in every elementary and secondary school in Pattani Province. In the long run, a target will be set to ensure financial sources for providing teaching materials to all schools in the province and further in the whole south region, with the aim of arousing environmental consciousness in the mind of every member of the society.

7. Recommendations

1. The cooperation of six countries in the promotion of environmental education proved very useful. Such efforts should be strongly encouraged to cover other developing countries.

2. The experience gained from this project's activity, including our own, should be applied as a model in other parts of the world to help the development of environmental education pertinent to respective communities.

3. Most developing countries have financial problems for the time being. ILEC and other international organisations should help them in ensuring more financial support to such kind of environmental education efforts.

4. The availability of good, responsible and devoted cooperators should be

increased to successfully establish environmental education in developing countries.

5. The development and production of teaching materials for environmental education and their supply to schools other than the pilot schools should be encouraged.

APPENDIX

Some basic statistics of six countries involved in ILEC's environmental education project (Based on the Japanese edition of World Resources 1996-97 – A Guide to the Global Environment (eds. WRI, UNEP, UNDP & The World Bank), 1996, except for Ghana). Data for Ghana (1994 and 1995) were supplied by M. Tsiagbey and N.B. Ayibotele.

		Argentina	Brazil	Denmark	Ghana	Japan	Thailand
Area of Territory (1,000 km)		2,737	8,457	42	239	377	511
Population (1995) (million)		34.6	161.8	5.2	16.6	125.1	58.8
Population density (1995) (per km²)		12.6	19.1	122	69.5	332	115
Rate of population increase (1990-95) (% / yr)		1.2	1.7	0.2	3.0	0.3	1.1
Infant mortality rate (1993) (per 1000 cases)		27	63	7	74	6	33
Life expectancy at birth (1990-5) (yrs)		72.1	66.3	75.3	58	79.5	69
GNP per capita (1993) (US$ / yr)		7,220	2,930	26,730	410	31,490	2,110
Literacy (1990) (%)	Female	96	81	103	53	99	91
	Male	96	82	99	76	99	96
Primary school attendance (1993) (%)	Female	107	109	99	70	102	97
	Male	108	117	98	83	102	99

POSTSCRIPT

Sven Erik Jørgensen

It is the scope of ILEC to disseminate globally the knowledge and the concern about the environmental quality of lakes and reservoirs and their associated watersheds. It has therefore been entirely in the spirit of ILEC to launch a project that aims toward a better understanding and appreciation of lakes and reservoirs by school children through an introduction of lakes and reservoirs as an important issue in environmental education at all levels in the schools. The deterioration of the global environment during the last few decades has been terrifying. It seems to be the only hope to build on the future generation for a better understanding of the importance of environmental issues. It is therefore understandable that this project of environmental education has been one of ILEC's core project during its duration, 1989-1996.

In 1991, the Environment Agency of the government of Japan started a five year project to support environmental education in developing countries and committed the project to ILEC, taking their achievement hitherto into account. The results during these five years make the core of this guideline book. Several reports have already been published about this project, an exhibition has been held in Otsu, Japan and information material has been distributed about this project and its results to the school children in the six countries. This guideline book attempts to make a final conclusion of the most important experience that has been gained by the project in the hope that the experience that the project has given us can be utilized by many other schools around the world.

This guideline book could not have been published without the financial support from Voluntary Postal Savings for International Aid of the Japanese Ministry of Posts and Telecommunications, Heiwado Foundation, AEON Group Environment Fund, Japan Fund for Global Environment, Nihon Seimei Foundation and Biwako Bank's Fund for Greenery and Water. ILEC would like to acknowledge its sincere appreciation of this indispensable financial support.

ILEC would also like to use this opportunity to thank all who have contributed to the EE activity: ILEC staff members, who have been enthusiastically involved in this school project during its entire period, the many enthusiastic school teachers involved in the project in the various schools in the six countries and last, but not least, all the thousands of school children who have participated in the project with their unspoiled enthusiasm.

Chairman of ILEC's Scientific Committee
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