A STUDY OF CHEMISTRY TEACHING WITH ENVIRONMENTAL ISSUES AT NHATRANG UNIVERSITY OF FISHERIES

by

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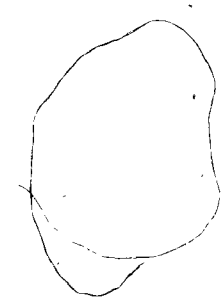

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Abstract

The themes of science, technology, and society (STS) and their interrelations are the focus of this study of science teaching in Vietnam. An "environmental approach" was developed and investigated in a chemistry course to further our understanding of the problems and challenges of science curriculum development in Vietnam.

In recent years, the use of the STS curriculum emphasis in teaching has been adopted widely throughout the world. This study represents an early attempt at doing so in Vietnam. The study investigates three aspects of STS education in need of further development and clarification in Vietnam: curriculum, course content, and teaching methods. The environmental approach was developed as a means of addressing all three aspects, aiming to assist students in developing knowledge of, and ability to think critically about, chemistry as it is related to environmental issues, and to develop positive attitudes toward the study of chemistry.

The study focuses on a unit of environmental chemistry that was developed for a class of fifty-one science students (forty-four males and seven females) from five different faculties of the Nhatrang University of Fisheries in Khanh Hoa province. It is a technological University with five faculties: the Faculty of Sea-processing Product, the Faculty of Sea-Exploitation, the Faculty of Sea-Economics, the Faculty of Aquaculture, and the Faculty of Ship-mechanical Engineering The unit was taught over a six-week period in the summer term of 1996.

Data for the study include field notes taken throughout the teaching period, together with recorded interviews with a colleague acting as "participant-observer." In addition, students were surveyed to gain some insight about their attitudes toward chemistry, the environment. A questionnaire was given to the class at the beginning and another was given at the end of the unit. Once the unit had been completed, students wrote a final essay telling of their experiences with this "new teaching method."

The results indicate that the integration of environmental issues motivated students to learn chemistry. Students enjoyed the learning activities, they acquired awareness of, and sensitivity

to, environmental issues, and they exhibited responsible attitudes toward acting on environmental issues. Students had opportunities to reinforce and expand their knowledge of global environmental issues, they thought deeply about concepts and principles in chemistry, and they had little difficulty in adjusting to a "student-centred" approach in teaching.

In general, the study shows that the STS curriculum emphasis in environmental chemistry seems to facilitate the development of positive attitudes in learning, the development of skills in solving problems, and an increase of knowledge about chemistry and environmental issues.

Dedication

To the memory of my father.

To my beloved husband for your encouragement, support, and for taking care of our children, to my mother in-law for taking care of my little son, and to my beloved children for patience and missing me during my three years at Simon Fraser University in Canada.

To my uncle, Chuck, who encouraged me when I was living abroad.

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I would like to express a special thanks to the Board of Nhatrang University of Fisheries for helping to implement this study, to the Dean of the Department of Sea-Product Processing, to the Chairman of the Department of Chemistry and instructors for helpful observations and lab work.

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Chapter 1
The Problem

Educational system in Vietnam

After reunification in 1975, control of the Vietnamese educational system changed from the South to the North. The organization, structure, and curriculum of this system were rebuilt.

At the beginning of the north educational system, there were three separate ministries controlling education in Vietnam: the Ministry of Education, which controlled basic and secondary education; the General Department for Vocational Training, which administered vocational and trade training; and the Ministry of Higher and Secondary technical education, which was in charge of universities, colleges, and secondary technical education. In 1987, the General Department for Vocational Training and the Ministry of Higher and Secondary Technical Education combined to form the Ministry of Higher Technical and Vocational Training. In 1990, the Ministry of Higher Technical and Vocational Training and the Ministry of Education joined to form one ministry, the Ministry of Education and Training.

The Vietnamese educational system has undergone structural changes as well. For example, the educational system now includes elementary school, grades 1 to 5; lower secondary school, grades 6 through 9; upper secondary school, grades 10 through 12; and higher education, covering undergraduate studies.

All students must take courses under a standardized grading system. After students have completed high school, they must take a national examination. Students who want to pursue a higher education must pass this exam to be admitted to a university.

Curriculum has also been overhauled. In elementary schools, science is integrated with other subjects. In lower secondary school, concepts from earth science, biology,

chemistry, and physics are taught as a combined science. In upper secondary schools, the science curriculum is divided into biology, chemistry, and physics. All students must receive a standardized grade in these courses as a prerequisite for taking the national examination. All students entering the universities must follow this procedure.

University curriculum was also reformed, but these changes did not happen as quickly as at the high school level. In general, these reforms concentrated on reorganizing the structure of universities and course curriculum to follow the rational order.

Despite these changes, most Vietnamese educators and parents said the quality of education had declined sharply over the past decade. In 1989 Vietnam began upgrading its curriculum, putting greater emphasis on vocational training and technical and scientific skills.

In 1990, post-secondary science education was restructured in Vietnam, with the formation of a consortium of eleven universities to guarantee science curriculum development and teacher education. The main goal of the plan is to establish a "University Credit System", which includes two training phases for undergraduate science students. The first phase is a "basic science" component that will prepare students for the second phase of their education in science specialization, such as fisheries, agriculture, computer science, and so on.

The purpose of restructuring science education in Vietnam is to increase access to basic science education and improve the scientific and technological literacy of the Vietnamese citizenry. There are many problems and conditions that have helped to shape the specific nature of the impending reform.

In November, 1993, a new system of education reform was introduced, based on doi moi (renovation). This reform aims to improve scientific literacy, train man power, and support bright and talented individuals, while broadening the scope of education and improving the overall quality and results.

The higher education system is becoming more flexible one, allowing students, in terms of ability, to move from one component to another, through the introduction of three main factors (MUCIA, p. 3):

1. Dividing the undergraduate education process into two stages, general higher education (3-4 semester) leading to the education (2-4 years) leading to the diploma of higher education.
2. Using the credit system and establishing education modules.
3. Diversifying educational environment options and establishing appropriate links between them, including full time/part time; long term/short term; formal/informal; and distance education.

One of the major issues at the seminar on "Higher Education in the 21st Century", held in Hanoi on July 31 - August 1, 1995, was to debate the quality and effectiveness of educational reform in improving curriculum design and evaluation procedures, and in preparing new degree programs in higher education.

The above projects are only the first step of educational development at the University level. One of the most important recent developments in education around the world is to integrate Science-Technology-Society (STS) in all levels of curriculum. In Vietnam, this has yet to be done. From 1975 to 1995, the University curriculum had not integrated the social issues-technology component into the curriculum. The upgrading of Science-Technology-Society Education that has been studied by North American educators is just being considered now in Vietnam.

Background of the study

For twenty years, Vietnam has endured economic difficulties and scarcity of financial and technical resources. Because of this, the higher educational system has faced serious problems. Among these has been the declining quality of education and training (Le Thac Can, 1991). There have been serious shortages of educational equipment and

facilities. Few scientific materials have been translated into Vietnamese. The quality of education from elementary school to secondary school has been very poor. "The quality of students arriving from secondary school is very poor. They don't have enough background to enter University", says Dao Cong Tien, the rector of Ho Chi Minh City's Economic University (Hiebert, 1991, p. 20). Effective methods for teaching science have been lacking.

Curriculum for every school level is set up and controlled by the Ministry of Education. Text books have also had to conform to these standards. Teachers are accustomed to accepting a written curriculum from the Ministry of Education and therefore rarely try to produce their own teaching materials.

Present teaching methods rely heavily on students memorizing course material. The limitations inherent in learning by memorization are exacerbated by students' lack of practical experience related to the principles and concepts of science. Smith and Goode (1984) critisized this trend in science education by saying:

> If the goal of a science education is to develop problem solving skills of students, instruction must be devoted to problem solving. Unfortunately, many science students receive instruction where the only learning strategy is that of rote memorization and recall (quoted in Pizzini and et al., p. 525).

From this point of view, rote memorization of information or rote understandings which are often forgotten before students leave the classroom, or one or two weeks later, does not improve the problem solving ability of the students.

The science education curriculum has not sufficiently addressed the issues and problems that students encounter in their daily lives. It also has not reflected the growing concern regarding pollution and the detrimental effects of industrialization on the environment. Issues of resource use, pollution, and environmental degradation have not been included in lower secondary to higher education.

The Vietnamese government is now making an enormous effort to rebuild the educational system at all levels. A close analysis of the purpose of a science education is

essential in instituting these reforms. Science curriculum that reflects the true nature of the scientific enterprise and the inter-relationship among science, technology, and society must be developed.

In harmony with these developments in education across the country, Nhatrang University of Fisheries, is making efforts to construct and develop the new training, as well as studying ways to further improve the university's curriculum. The goals of the university are to promote and assist the intellectual, human, social, and vocational development of students. In this situation I, as a member of Nhatrang University of Fisheries, would like to change my teaching strategies.

Nhatrang University of Fisheries is located in the maritime province in a beautiful coastal town in central Vietnam. The area has miles and miles of crystal-white sand beaches and turquoise-blue water with abundant natural resources such as lakes, rivers, mountains, ocean and forest. The area is rich in aquacultural and agricultural industries and the population is highly concentrated.

Most of the university teachers have never been trained in teaching methods or philosophy of education. So the teachers teach what they studied in the university themselves, inheriting the liabilities of their former teachers. Whereas the contents for teaching only "pure" science is followed in the curriculum and is controlled by the Ministry of Education. The aims, goals, and objectives of the learning activity as well as the quality of instruction have not been given full consideration.

I was accustomed to teaching by traditional methods. In the processes of teaching I seldom brought real life into my teaching. Teaching chemistry without concern for social issues was a shortcoming in my teaching.

In considering the general world trends of development in education and in the spirit of the conference on "Higher Education" in Hanoi, and in the process of studying in the Faculty of Education at Simon Fraser University in Canada, I think there is a need to apply the STS approach in teaching science in general and in teaching chemistry in particular at

Nhatrang University of Fisheries so that science, and its applications in technology, can help to improve the quality of people lives. Science and technology are socially useful activities with which we should expect students to become familiar. The objectives of chemistry in STS are to broaden and enrich the knowledge of students. Moreover, it is also intended that the students realize that chemistry, environmental chemistry in particular, is especially crucial to understanding and solving today's environmental problems.

According to McClaren (1994) the organization and planning of curriculum should follow an overall pattern of moving from the general to the specific. The general goals or aims of education are identified. A clear philosophical understanding of what is being attempted, a conception of the purpose of the curriculum, and a theory of education are essential part of these general aims or goals. Objectives provide a guide to curriculum decisions and set expectations of content and behavior. But the newly developed curriculum has to function within the Vietnamese economic, historical, and culture context.

The upsurge of concern in recent years for environmental problems led to the development of a considerable number of courses in environmental chemistry in North America. Environmental education shares a commitment to nurturing both the acquisition of new knowledge and the development of new ways of thinking. Because of this, I believe that Vietnamese curriculum needs to be modified to include environmental problems in science courses that will acquaint the student with basic scientific principles, the processes of science, and social issues related to science.

Topics can be clustered in terms of their national and local connections, vocational connections, and global connections. Each topic contains issues important to students, their community, or to the world. Flexibility is built in through the use of different types of activities. Core activities are intended to achieve specific learning outcomes. Extension activities offer interested teachers and students an opportunity to further explore the topic or issues.

Using Nhatrang University of Fisheries as an example of vocational connections, an engineer of sea-product processing needs to understand how industrial waste and chemical treatment relate to the natural environment and human health. An engineer of marine aquaculture needs to understand how to protect water resources including rivers, lakes, ponds, and ocean environments to ensure long term production. An engineer of exploitation of sea products needs to understand how oil, gasoline and diesel spill from the ship to cause sea pollution.

Pressing environmental problems are part of the national and local connections. As in any place, people in Vietnam are attracted to cities for economic, educational, and health reasons, as well as for the quality of life available there. Most economic growth occurs in or near cities because of the efficiencies found there. Industries are located near cities because of the better infrastructure, communications and an educated, plentiful work force. But industries bring pollution. Vietnamese cities face several environmental problems because of their highly concentrated productivity, consumption, and population.

The high concentration of population, with the accompanying aquacultural and agricultural industries, causes several kinds of pollution because of food processing factories and industrial waste discharges. The industrial portion of waste water is increasing each year. These waste water systems pollute nearby rivers which are the main sources of drinking water. Domestic and industrial wastes have contaminated the shoreline ecosystems of the coastal cities, affecting the quantity and quality of seafood and reducing tourism income.

Most Vietnamese cities have serious air pollution problems, much of it caused by motor vehicles. The number of motor vehicles has increased in recent years. The use of leaded gasoline and diesel fuel containing sulfur causes pollution. Lead pollution raises the incidence of hypertension and heart attack.

The importance of controlling environmental pollution and treating industrial wastes is recognized by the government and environmentalists, but these concerns are not widely

known. This consciousness has not reached into the schools at all levels. Educators and teachers have not brought environmental education into the classroom. This is the main reason for this thesis – I am interested in teaching environmental chemistry.

In regards to the global connection, one example of a global concern is the introduction of carbon dioxide into the atmosphere through the burning of fossil fuel. Many environmental educators are interested in global environmental problems such as world climate changes causes by greenhouse gases, and ozone depletion in the atmosphere.

According to Mayer (1990), today's students must understand our interrelationships with people around the world and how our collective daily activities affect our planet and its resources. Thus, it is wise to include this concern in teaching about the applications of scientific information so that students will realize how these applications can benefit or damage our lives.

STS curriculum should provide balance in emphasizing the following aspects:

1. The nature of science (the epistemology of science technology ought to be treated as problematic).
2. Social issues (e.g., pollution and nuclear war but also smaller scale local controversial issues that schools can engage directly).
3. The content of science discipline. How science influences social life and is itself influenced by the imperatives of social life (quoted in Hart and Robottom, 1990, p. 579).

STS education reform should provide the opportunity for students to increase their understanding of science, especially environmental issues, because science is defined as an activity of human beings. Science is a continuing process of seeking new knowledge, new explanations, and deeper understanding. New discoveries tend to generate new questions which call for further observation and more experimentation. Therefore, science is an intellectual activity which arises from personal experience and takes place in the minds of human beings (Golstein & Golstein, 1978).

The goal of any STS course should include the development of positive attitudes toward science and technology and the fostering of confidence in using scientific and technological information to make judgments about science related issues. Vietnamese education should enable students to understand the relationship between science, technology, and society. Students should be encouraged to relate their learning to social problems and to pay attention to the needs of society and individuals in order to cultivate their understanding and concern for the public interest.

STS is an inter-disciplinary course of study and its contents are intended to serve society. The content is based on such considerations as learning outcomes, based, in part, on educational theory, purpose, and philosophy. Students are first presented with a knowledge base which appears to contain all the information needed. They are then encouraged to modify their original insights for additional information.

Looking at the benefits of the STS approach, I believe I need to incorporate information about STS in my teaching, by designing some topics that are concerned with environmental issues, for the following reasons:

- The STS approach is in agreement with the purpose of educational reform at the University
- The use of the STS approach is of international concern.
- Through studying specific local pollution problems as well as global environmental issues, I hope the students will develop their scientific thinking and look for new trends. I hope these cognitive skills will continue to develop not only when they study chemistry but also in other academic disciplines such as physics and biology.

Why teach environmental chemistry?

Daily, there are references in newspaper and magazine articles and radio and television stories, concerning environmental issues such as global warming, depletion of

the ozone layer, environmental pollution and the like. The investigation and analysis of these problems in terms of environmental and chemical concepts will provide students with opportunities to experience and investigate the relationships linking individuals, societies, and natural surroundings.

Environmental problems have not been yet woven into Vietnamese curriculum yet from primary school to higher education. Maybe we have neglected many opportunities to involve students directly in that learning, and missed the chance of offering a environmental chemistry program that will prepare students to live and operate in the future.

Environmental teaching is developed with the belief that students should understand how and why the environment has an impact on their daily lives, and how those daily lives have impact on the environment. It is hoped that students will come to understand how their action affects both local and global environments. In this way, it is hoped that students will begin to realize how they can take personal responsibility in creating a more environmentally sustainable way of life.

Some topics are selected in environmental chemistry for students who are not majoring in science and would like to learn what the science of chemistry offers in explaining common chemical phenomena. Students are also curious and motivated to understand the relationship between science thinking and every day events.

The purpose of the study

The study aims at applying the Science-Technology-Society approach to the traditional curriculum in a way that will expose students to new ways of thinking about science in general and chemistry in particular. In that spirit, the environmental approach is selected to integrate into teaching in the second year chemistry course at Nhatrang University of Fisheries. In this study I designed several chemical topics with an appropriate environmental approach to assist students in learning basic concepts, improving problem solving skills, and developing positive attitudes towards chemistry and the environment. In

general, I am interested in environmental issues that might help students learn second-year chemistry. How do students relate their chemistry knowledge to national and global environmental issues when learning the chemistry course with an environmental approach? Can STS instruction, especially environmental chemistry, improve students' attitudes toward science in general and environmental chemistry in particular?.

Significance of the study

I hope that this study will give students and teachers a real picture of applying the STS approach in chemistry teaching. Simultaneously, through environmental issues that are integrated into chemistry, the study will help students develop a way of thinking about science in relationship with environmental problems that impact Vietnam and the global community.

This study represents the first time a chemistry course designed from the STS approach and taught using a student-centered model has been implemented at Nhatrang University of Fisheries. It will be a cornerstone for developing future science education studies based on STS approaches, and where the learning environment shifts from a teacher-centered to a student-centered model.

Chapter 2

Review of Related Literature

In this chapter an overview of the literature related to this study is presented. This literature includes justifications for the study of science, technology, and society and environmental education. The literature review also explores various the teaching tools, the SSCS cycle of Pizzini, and methods of problem solving method and their rationale. Finally, this chapter reviews some literature relating to the environmental context in Vietnam.

Review STS approach

Rationale for the STS curriculum

STS is the acronym for Science-Technology-Society Education. Some understanding of science, technology, and society, and how they relate to each other, can be found in a statement by Hurd (1975):

> Science provides knowledge, technology provides the way of using that knowledge, and our values and concepts guide what we ought to do with both. (quoted in Kumar and Berlin, 1993, p. 73)

From this quotation there is a basic difference between science and technology. Technology has always generated devices and procedures, often exhibiting creativity. Science is concerned with the search for knowledge and understanding of the physical world. Therefore, STS means using technology as a connector between science and society (Bybee, 1985, cited in Kumar and Berlin, 1993).

How science, technology, and society relates to education is stated in a position statement of the National Science Teachers Association (NSTA) in 1982. The NSTA Board of Directors proclaimed,

> The goal of science education during the 1980's is to develop scientifically literate individual who understand how science, technology, and society influence one another and who are able to use

> this knowledge in their every decision making. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual net works and process skills which enable the individual to continue to learn and to think logically. This individual both appreciates the values of science and technology in society and understands their limitations. (quoted in Deboer, 1991, p. 178)

From this perspective, an STS theme has to demonstrate a clear understanding of the nature of science, show its relationship with technology, and demonstrate its effects on society and the effects, in turn, which society has on research and the development of new technologies.

If education is to help to produce a scientifically and technologically oriented citizenry, science and technology must be included in the curriculum because science is more and more closely related to social life, the social economy, and different areas of advanced technology.

If science education is to provide for the needs and continued development of schools, where students engage in science education and fulfill the requirements and expectations for developing society, then STS is a logical choice for science education.

One of the most significant curriculum developments in school science today pertains to the interface between science, technology, and society. It starts with problem identification, proceeds to problem resolution, and involves the student in decision making. Central to the STS approach is a focus on individual learners as a part of a society. Because the approach focuses on problem identification, it is a multi-disciplinary one. Moreover, STS focuses on real-world problems. The National Science Teacher Association has offered the definition of STS:

> STS is the term applied to the latest effort to provide a real world context for the study of science and the pursuit of science itself. It is a term that elevates science education rhetoric to a position beyond curriculum and the ensuing debate about scope and sequence of basic concepts and process skills. STS includes the whole spectrum of critical incidents in the education process, including goals, curriculum, instructional strategies, evaluation and teacher preparation performance. Once can not "do" STS by adding certain topics and lessons to the curriculum, course outline or textbook. Students must be involved with goals setting, with planning procedures, with locating information and with evaluating

> them all. Basic to STS efforts is the production of an informed citizenry capable of making crucial decisions about current problems and taking personal actions as a results of these decisions. STS means focusing upon current issues and attempts at their resolution as the best way of preparing people for current and future citizenship roles. This means identifying local, regional, national and international problems with students; planning for individual and group activities which address them; and moving to action designed to resolve the issues investigated. Students are involved in the total process; they are not recipients of whatever a pre-determined curriculum or the teacher dictates. There are no concepts and/ or processes unique to STS. Instead STS provides a setting and a reason for considering base science and technology concepts and processes. It means determining ways that these basic ideas and skills can be seen as useful. STS means focusing on real-world problems instead of starting with concepts and processes which teachers and curriculum developers argue in terms of usefulness to students. (NSTA in press, quoted in OST and Yager, 1993, p. 282)

Wraga & Hlebowitsh, (1990) state that

> The STS approach seeks to develop in students the ability and inclination to apply knowledge from the sciences and skills from the social studies toward the resolution of science-and technology-related social issues. (Heath, 1992)

STS is science that goes beyond the limits of textbooks and into the real world. The goal of an integration of a STS theme into curriculum is to achieve scientific and technological literacy for all. By involving learners in experiences and issues directly related to their lives, we empower them to make informed decisions and take responsible action (Yager, 1987; Rubba, 1990).

Therefore Science-Technology-Society education has been one of the major foci of current science education reforms in the United States. Patrick and Remy (1985) report that STS issues present ideal cases for analysis, using models that can help students acquire basic concepts relevant to improving their understanding of the dynamics of science and technology in modern society (Remy, 1990).

The analysis of STS issues can help students develop some rudimentary factual knowledge about key, enduring issues such as pollution, energy production and consumption, and the like. Whereas the social studies curriculum is the place where

students can learn about the social context and consequences of science and technology. Indeed, a recent study of science educators indicates that the STS issues they identify as most important are of similar interest to social studies educators. These include world-wide hunger, depletion of water resources, and so on (cited Yager, 1990).

Yager (1984) defined science education in the following way:

> Science education is defined as the discipline concerned with the study of the interaction of science and society i.e. the study of the interaction of science upon society as well as the impact of society upon science. There interdependence becomes a reality and interlocking concept for the discipline. Research in science education centers upon this interface. (cited in Bybee, 1987)

Yager's definition above is almost exclusively in regards to the social context of science education.

The integration of the STS issues into the science curriculum aims to achieve scientific and technological literacy in learners for the experiences and issues directly related to their lives, empowering them to make decisions and take responsible actions. Thus, Roy (1983) proposed that the ideas, concepts, principles, and theories of science should be presented in a societal framework that has meaning for most students. In 1985 Roy said,

> Science and technology are an integral part of our culture, and it is their connections to society - its economy, values, religions which make science and technology relevant, important, and worth remembering. (cited in Heath, 1990)

From this perspective, an STS curriculum requires integration of content, particularly in courses that deal with issues, providing a knowledge base that allows students to develop the capabilities to act responsibly and effectively as members of local, national, and global communities.

The guidelines for teaching science related social issues include choosing a topic in which learners are encouraged to develop an understanding of STS as pertaining to interdependent aspects of society, and society as a responsible agent within the natural ecosystem. In addition, the National Science Foundation (1990) announced new guidelines in 1990 that aim to boost scientific literacy and citizen understanding of science related

issues. At every educational level "science instruction" must deal with improving critical thinking and habits of mind, developing better understanding of the contributions of science to the lives of individuals and societies, and generating stronger student commitment to positive value systems and ethical conduct (cited in Kumar and Berlin, 1993).

In the spirit of the National Science Foundation guidelines cited above, STS means focusing on the best way of preparing people for current and future citizenship roles. To achieve this kind of relevance the STS approach starts with the students, with their interest, and with what is relevant to their lives. It builds on local resources, and in doing so offers the teacher the role of "decision maker" with respect to the curriculum structure and the instructional approaches used. This departs from traditional science teaching, in which all attention is directed to acquiring information determined to be important by larger jurisdictions. It is common for both school curricula and teachers to enhance the importance of considering science processes.

The appraisal of STS approaches

STS education is dependent on teacher awareness and preparation. This is also critical to the successful implementation of STS because teaching and learning are social activities. Student/teacher interaction should develop in the best possible environment all.

The spirit of STS is dynamic teaching and learning. Effective science classrooms can not be passive environments where students go over information that will be tested on examinations. The STS approach depends on the relevancy of the curriculum to the world of students.

A major gap exists between teachers' expectations for their students and their actual teaching practices. This gap makes students appear not to have developed abilities to think rationally, use and evaluate knowledge, develop curiosity or creativity, or pursue further knowledge (Kumar, 1993).

According to Mc Cutheon (1985), the gap between theory and practice is a function of conventional approaches to educational reform that deny the existence of teacher's theories of action. Moreover, many science teachers are reluctant to incorporate STS education into their practices due to

a) a lack of class time in an already crowded syllabus

b) inadequate knowledge of the facts surrounding debatable issues, and

c) a lack of usable materials in print (quoted in Kumar, Berlin, 1993).

According to a paper "A review of science education: Past failures, future hopes" by Ogens (1991), traditional methods of teaching science that focus on textbook instruction and didactic teaching (telling-listening) have failed. The instructional pattern typically consists of reading the text, followed by answering factual questions posed by either the teacher or the text.

Teachers can not continue teaching scientific courses in exclusively verbal form as is currently done. The "chalk board classroom" should be abolished as the only means of conveying knowledge. It is necessary to teach students to love nature, to use it as it ought to be used, to enjoy it. Therefore units of study built around student investigations of current science and technology related topics are a means of achieving this goal.

Tanner (1990) states that

> Because the social problems and issues of our lives are so pervasive and interconnected with science and technology, they may well serve as focal points for school science. (cited in Heath 1990)

STS curricula are interested in outcome learning in terms of the development of decision-making skills, attitudes toward science in general, and boosting scientific literacy. Wrage et al. (1989) state that STS education stresses the interaction of personal and social goals within a problem-focused framework. The curriculum of STS should address a broad range of environmental, industrial, technological, social and political problems. This brand of science education aims chiefly at preparing citizens for life in a democratic society.

An STS orientation would mean research and development of curriculum and instruction for the following:

> 1. Presentation of science knowledge, skills, and understanding in a personal social context.
>
> 2. Inclusion in the curriculum of knowledge, skills, and understanding relative to technology.
>
> 3. Extension of inquiry goal to include decision making.
>
> 4. Clarification of the knowledge, skills, and understandings relative to the STS theme that are appropriate to different ages and stages of development.
>
> 5. Identification of the most effective means of incorporating STS issues into existing science programs.
>
> 6. Implementation of STS programs into the school systems (Bybee, 1987, p. 679).

According to Rubba and Wiesenmayer (1988), learners are mostly to become active in the resolution of STS issues if the STS education they receive includes the study of issue investigation skills and strategies that can be applied toward the resolution of STS issues along with the opportunity to apply them.

Environmental education is an important aspect of the STS program. Science is seen as a vehicle for promoting environmental education, sometimes as the central activity and sometimes as a component of the science course. Environmental education may therefore provide an organizing theme in science courses based on STS approaches and intentions.

Environmental education

Aims and rationale for development of environmental curriculum

A conference hosted by the United Nations at Tbilisi, U.S.S.R, developed a definition of environmental education.

> Environmental education is an integral part of the education process. It should be centered on practical problems and be of an interdisciplinary character. It should aim at building up a sense of values, contribute to

> public well being and concern itself with the survival of the human species. Its force should reside mainly in the initiative of the learners and their involvement in action and it should be guided by both immediate and future subjects of concern. (UNESCO-UNEP, 1977, p. 3)

The integration of the STS objectives in chemistry curriculum is widely endorsed. As science and technology have gained greater influence over our daily lives, citizens' ability to make responsible decisions and to take action have become desirable capacities for effective citizenship.

Human action is changing the environment, and has become the major force in the transport of solid earth materials. Chemical by-products are changing the hydrosphere and the atmosphere, altering earth's life support systems so that all living things are threatened with disaster or extinction.

For human survival, improvements in social and economic conditions are needed. Development must continue to be promoted in both industrialized and less developed countries, but people must find a way of creating a balance between the utilization of natural resources, economic growth and technological progress that brings benefits to many people while lessening the environmental consequences.

Science and technology have often been used to foster development which leads to exhaustion of natural resources and the deterioration of the environment. The main characteristics of environmental education outlined in Unesco's Tbilisi Conference on environmental education are:

- a problem-solving approach
- an interdisciplinary educational approach
- the integration of education into the community
- education as a life-long process

It is crucial, from the standpoint of enhanced self-images and a meaningful life for students, to know basic facts about the environment and their relationship to it. Students

should have the capability and inclination to act in a positive manner toward environmental protection.

School must thus equip students with the knowledge and ability necessary for acting in the future. Today many nations in the world, especially less developed countries, are faced with a new social needs to which education must respond. It is the need to survive in the face of environmental pollution, problems of personal health and nutrition, and other science related pressures that will affect their lifestyles.

The topics listed below are perceived to be most important from the surveys of Bybee (1987, p. 680).

Air quality and atmosphere	Hazardous substances
World hunger and food resources	Land use
War technology growth	Nuclear reactors
Water resources	Extinction of plant and Animals
Energy shortages	Mineral resources

STS programs are being developed and implemented in Canada. Towler (1980) concluded that environmental education is varied and diverse across the country. In his belief that environmental education will grow in importance, quality, and popularity across Canada, he speculated about the preparation of the teacher who will be expected to teach environmental education in the years to come.

Environmental education includes such topics as acid rain, deforestation, energy, nuclear proliferation, toxic waste disposal and solid waste management. These topics have been increasingly appearing in Canadian curriculum over the past twenty five years.

Kirk (1980) discussed environmental education in the United Kingdom. The integration of environmental education in schools in the United Kingdom has occurred since 1965, with topics covering both national and international environmental problems.

Educators contend that environmental education has enriched the quality of education in schools throughout the country. Students enrolled in schools throughout the United Kingdom leave with a much better understanding and appreciation of environmental problems facing their country, and their world.

According to the paper entitled, "Let environmental chemistry enrich your curriculum" by Parravano (1988), environmental chemistry has been woven into the general chemistry course at the State University of New York. The weaving of environmental chemistry into the introductory chemistry course for science majors has greatly heightened student interest in the course.

In China the STS program started in the spring of 1992. Yoong (1994) developed a course in social organic chemistry to replace organic chemistry. He reported that students found his lectures enlightening and were enthusiastic throughout the learning process.

Yager (1990) stated that STS has flourished as a focus for school science. More than 1000 teachers, especially in grades 4 -9, have developed and introduced STS modules into their science classrooms. The STS movement received unprecedented support in the 1980's.

At Simon Fraser University, the Department of Chemistry devised three Environmental Chemistry courses, including Analytical Environmental Chemistry of the Aqueous Environment, and Chemistry of the Atmospheric Environment.

STS in general, and environmental education in particular, has become a major curriculum emphasis in many parts of the world from secondary schools to universities. Public awareness is essential for the improvement and maintenance of environmental quality. However, environmental education has been neglected in schools in Vietnam. We missed many opportunities to provide students with knowledge about environment.

Global Education

Generally speaking, educational goals are what the school aims to accomplish for its students and for society. For students, such goals include an increase in knowledge, basic skills, social skills, self-concept and vocational competence. These vary a great deal from country to country, and indeed from school to school. A recent goal for education is to cultivate in young people a "global perspective" and to develop in them the knowledge and attitudes to live effectively. Global education has been defined by Hanvey (1976);

> Global education involves learning about those problems and issues that cut across national boundaries, and about the interconnectedness of systems - ecological, cultural, economic, political and technological. Global education involves perspective taking-seeing things through the eyes and minds of others - and it means the realization that while individuals and groups may view life differently, they also have common needs and wants. (cited in McClaren, 1995, p. 11)

From this definition global education recognizes the importance of commonalties among humankind. It is also concerned with the differences among people and nations. Among the obstacles in achieving an international understanding is the difficulty of language and culture.

According to Pinar (1995), global education aspires to provide models of interconnectedness, interdependence, and interrelationship of world culture in an effort to promote cooperation and progress. Science continued to be recognized as a source of knowledge that can be used to improve our living standards. However, knowledge can be used in different ways for the long-term benefits of all, for short-term political gain, and for destructive purposes. There is a need for dialogue and understanding among people of different languages and cultures; global education, running through science curriculum, is seen as a means to achieve these ends.

Educational objectives in outlining awareness, knowledge, skills and attitudes are all necessary to deal effectively with environmental issues. It is hoped that students will

find science content, especially chemistry, to be more meaningful and relevant with an STS approach.

The next section presents literature related to aspects of STS teaching and STS development in North America, with a view for developing STS in Vietnam. STS instruction is a very desirable approach to bring to my teaching. Through this investigation, I hope not only to help my students gain more knowledge, but also to help other teachers approach the STS emphasis.

Problem solving method

A rationale for the problem solving method

Chiappetta and Russell (1982) stated that problem solving as a goal of science education is problematic, that is, there is not a commonly accepted definition of problem solving. Problem solving has been defined as a method of learning as well as on outcome of learning (quoted in Pizzini, 1989, p. 523).

From this view, science has always been a part of a student's experience in school. Students must have a hand in identifying problems and determining their actions concerning them. Science subjects help students gain a functional understanding of the concepts and principles linked with real-life situations, acquire science skills, as well as scientific attitudes and values needed in solving everyday problems pertaining to health and sanitation, nutrition, food production, and the environment.

What is problem solving ?

According to Mills and Dean (1960) the problem solving method is a "way of thinking." They say that thinking occurs only

> When there is a need for it , when the situation is baffling or unsatisfied, or when the situation presents a difficulty that can not be met by other means. (P. 3)

For example, it is a paradox that people have been known to suffer from nitrogen deficiency disease even while breathing air which contains about 78 percent nitrogen. Why is this a paradox? What is the problem here? How we can find out the solution? The answers connect to the conceptual realm of chemistry as "free" nitrogen is not in the molecular form needed: amino acids. The nitrogen in the air must be "fixed" in the form of nitrates and then converted into plant protein. Later the plant protein is consumed by animals, digested and converted into their proteins which in turn may be consumed by other animals.

Novak (1977) indicated that problem solving requires a reorganization of information stored in memory to reach a special goal, the solved problem, and that if the problem requires new information, it then requires a search process (cited in Pizzini).

Presseisen (1985) noted that in any problem solving model of instruction the first order of learning is the recognition of a problem, the determination of information needed to solve the problem, and where to obtain the information (cited in Pizzini).

According to Mills and Dean (1960), the problem solving method is only one way of learning and teaching, and must be related to other methods in practice. Lectures, discussions, demonstrations and assignments in the classroom remain desirable to develop students' understandings and skills.

Mills and Dean (1960) said:

> Of more importance is the development of a sound approach to critical thinking, and a knowledge of how to proceed in arriving at conclusions that are defensible. (p. 10)

The ability to work with problems varies from student to student. Problem solving processes may be improved with more experience in a variety of problem solving contexts. STS issues in social studies can help students develop problem solving skills and flexible, but organized, ways of thinking about social decision making.

In the process of teaching about STS issues in environmental chemistry, a teacher can use a "tool" to help structure problem solving experiences that follow the SSCS

problem solving cycle of Pizzini (1989). SSCS is the acronym for Search- Solve-Create-Share. This cycle consists of a four step cyclical model to allow for reentry into the various states of the model during the problem solving process.

The "Search" phase of the SSCS model is taken from the model of problem solving instruction which includes the recognition of a problem, and the determination of information needed to solve the problem. It is very important where information is found. Resources for problem solving include demonstrations, magazines, newspaper articles, textbooks, and field trips. These resources facilitate students in identifying researchable questions.

The "solve" phase focuses on the specific problem refined by the Search which requires students to generate and implement their analysis for finding a solution.

The "Create" phase requires students to create a product that relates the problem or solution. It is very necessary for student to check and compare the data to the problem, draw generalizations and, if necessary, to modify the data. The "Create" phase also enables students to evaluate their own thinking processes.

The "Share" phase involves students in communicating their problem solution. It requires that they interact, share their own ideas, receive and process feedback, reflect on and evaluate solutions, and generate potential research questions.

The aim of the teacher is not only to help students develop their problem solving abilities and skills, but includes their acquisition of knowledge, accurate concept formation, and understanding of theories and principles for creating meaningful learning. In solving any problem, both the conceptual knowledge and information needed for arriving at a solution (content), and the procedural knowledge of how to execute a problem solution, and the reasoning that goes toward the solution (process), are important factors (Zoller, 1987).

In general, the problem solving model of Pizzini is integrated into a teaching strategy that focuses on environmental issues. Moreover, the teacher should view various

models of teaching as ways of accomplishing a wide variety of purposes. Because no single teaching strategy can accomplish every purpose, the teacher will master a sufficient repertoire of strategies to deal with the specific kinds of learning problems he or she faces (McClaren, 1994). In the process of learning activities, students can be encouraged in a debate, discussion, and presentation or investigation of learning activities and lab activities. Discussion is well suited to help students develop skill in reasoning, problem solving, and critical thinking, as well as in communication. Discussion also brings students into closer contact with the instructor. In addition, students will give the instructor useful feedback on what students are learning. Students learn to use scientific and technological knowledge to solve problems which are relevant to their lives.

Problem solving methods provide students with the opportunity to select and pursue problems of concern and interest to them, and thereby to increase their motivation, persistence, and determination to learn.

Review the environmental situation in Vietnam

Vietnam is a predominantly tropical country bounded on the North by China and on the west by Lao and Combodia. Its coastline borders the South China Sea on the east and the Gulf of Thailand on the south. Vietnam has a population of approximately 70 million concentrated in the Red River Delta in the North, The Mekong River Delta in the South, and the central plains. The intensity of population growth is increasing. Moreover, Vietnam is surrounded by developed and developing countries that have the potential to influence the Vietnamese environment. This is a matter of great concern.

The country's water resources are showing signs of heavy pollution due to industrial and chemical wastes. Pollution is at hazardous levels in many areas, partly due to the industrial plants and lack of water-treatment facilities.

Pollution in the work place has led to an alarming rate of increase in occupational disease among workers. But most environmental pollution comes from the textile, energy,

chemistry and mining industries. Most wastes from these activities are buried without any pre-treatment and the effect on under-ground sewers is adding to the industrial pollution, already at a record high (Thao, 1995). Moreover, there are more and more motor vehicles in the cities and exhaust fume has become one of the major sources of air pollution in Vietnam.

Vietnam has been burdened with the problems of environmental pollution since the Vietnam war (prior to 1975). American planes sprayed herbicides on 10 percent of the country, destroying 8 percent of the croplands, 14 percent of the forests, and 50 percent of the mangroves.

Nietschmann (1990) says that,

> The war in Vietnam left in its wake extensive impoverished grasslands instead of forests, widespread erosion and dust storms, major declines in freshwater and coastal fisheries, and severe losses of wildlife, especially from the forest canopy_ wounds from which the land may not recover for a hundred years. (p. 35)

Quy (1990) concluded from Anthur Westing's work on the ecological effects of the war in Vietnam that when mangroves are destroyed, because mangrove forest is a transition zone between land and sea, as happened in South Vietnam. Mangrove invade the new soil and hold it against the erosive action of wind, wave, current and tide. The coastal shores are not readily recolonized. He concluded that sustainable recovery can take more than a century.

During peacetime, mangrove forests of Vietnam are important source of seafood, as well as tannin for tanning leather and charcoal for cooking fuel. The destruction of the mangrove forests depleted population of various aquatic animals. One species of mollusk may be been placed in the extinction by Agent Orange. The residual effect of herbicides destroyed mangrove ecosystem. The many species of crabs that in or visit these forests may be a threat to the final fate of the disturbed mangrove environment.

Some evidences from society were cited, such as the high ratio of patients with a particular of cancer, a lot of barren women, and many cases of mental disorder dealing with detrimental effect of Agent Orange found in regions contaminated by Agent Orange

For ten years, beginning in 1961, about 20 million gallons of chemicals were sprayed on south Vietnam by a variety of aircraft. More than half these chemicals consisted of Agent Orange, an herbicidal mixture of 50 percent 2,4-D and 50 percent 2,4,5-T. Herbicides are chemicals that either defoliate or kill plants. Although these particular herbicides have been used throughout the world, the amounts applied in Vietnam were far greater than those legally permissible in the United States (Pfleiffer, 1990).

I think that environmental issues (Acid rain, greenhouse effect, and depletion of ozone layer) represent a good subject for an STS approach to science education that trains decision-making skills and emphasize the social aspects of science and technology. The integration of environmental issues represents contemporary issues that can illustrate the STS connections because Volk (1984) and Disinger (1986) suggested that environmental education is, in fact, STS education. They contend that there is a body of literature in environmental education that has direct implication for STS education. (Rubba and Wiesen Mayyer, 1988).

Students, as future citizens, should be able to make decisions about personal and social issues based on relevant scientific knowledge. I used STS approach by integrating environmental approach into science teaching because the relation between teaching and learning is a social activity that implies an interaction between the teacher and students.

Many countries in the world, as introduced above, have incorporated environmental chemistry topics into school curriculum. Many educators, in north America, reflected that environmental education has enriched the quality of education and helped students better understand environmental problems facing their country, and their world.

In order to improve the quality of chemistry teaching and modify chemistry curriculum with more effective interactions between teaching and learning, this study makes

efforts to combine environmental issues and tools such as the cycle of problem solving of Pizzini in teaching. The researcher would like to pose questions or create situations that emphasize paradoxes, dilemmas, and discrepancies that students attempt to resolve. In order to enhance the development of thinking skills in solving problems, I attempt to place emphasis on applying what students have learned to real problems.

Vietnamese students need to be alert to environmental protection. Many educators, in the world, have been interested in environmental issues in schools for many years. Environment, therefore, is a part of every subject in school curricula. Environmental issues were chosen for the course as the subject due to science, technology, and society interaction involved. Environmental education must develop grater sophistication by fostering global thinking about environmental issues and personal actions (McClaren, 1995).

As introduced in Chapter One, a close analysis of the purpose of a science education is essential in instituting educational reforms in Vietnam. Appropriate science curriculum that reflects the true nature of the scientific enterprise and the inter-relationship among science, technology, and society must be developed.

Vietnamese educators, therefore, should integrate current issues which would help learners to increase the scientific literacy of citizens with global thinking. Moreover, literature of STS education offer support for integrating environmental issues into chemistry curriculum for Vietnamese students.

In summary, environmental pollution is a pressing problem in Vietnam that makes up to date information in schools necessary. The integration of environmental issues into the curriculum is compatible with the purpose of science education reform of the Ministry of Education and Training in Vietnam, and match the benefits of an STS approach.

In this approach students have opportunities to be familiar with a variety of environmental phenomena in the country and in the world, to understand the close relationship of science, technology, and society. Moreover, students have opportunities to develop an awareness of environmental issues and to develop the knowledge, skills,

attitudes, and motivations required to solve current problems. Students will have the opportunities to build confidence in their ability to interact with the environment and to communicate with others about pressing matters.

Chapter 3
Research Method

The study aims at examining how environmental issues are integrated into a chemistry course, and how effective they are for developing positive attitudes towards chemistry and the environment, improving problem solving skills, and for understanding the basic concepts and principles in the chemistry curriculum.

The context of the study

The setting

Nhatrang University of Fisheries, located in the Khanh Hoa province, has been introduced in Chapter One as a technological University. Across the country there is only one university that includes faculties such as the Faculty of Sea Product Processing, the Faculty of Aquatic Maritime, the Faculty of Sea- Economics, the Faculty of Ship Mechanical Engineering, and the Faculty of Sea Exploitation. This University provides human resources for enterprises and factories across the country.

Nhatrang University of Fisheries provides students with different careers paths, such as engineering of sea product processing, maritime aquaculture, exploitation of sea products, mechanical ship, and sea- economics. A degree in engineering of sea product processing is sought by the factories that deal with food processing and frozen sea products. A degree in engineering of maritime aquaculture is sought by the Maritime Aquaculture Institute, fish farming or shrimp farming. A degree in engineering of exploitation of sea products is sought by the boat and ship mechanical factories that deal with the exploitation of sea products.

1000 to 1100 students enroll every year from all across the country. They study full time for four and a half years.

The curriculum, which is similar to other universities, consists of two stages. The basic stage comprises the first two years of study with courses in mathematics, chemistry, physics, and some elective courses. The students recieve a general degree after taking four main semesters and satisfactory completion of at least eighty, to a maximum of ninety-two credits. The students have to pass a transfer examination before they can enter the second stage, in which they take more intense courses relate to their future job. At this level students study five more semesters to complete 125 credits.

Each academic year has three semesters: semester I (September-January), semester II (February-June), and an additional semester III (July-August) in which students choose elective courses. Then the students prepare for the entrance examination to the second stage.

Chemistry is a vital discipline for students, so they are required to complete the chemistry curriculum in the first stage before continuing to the next stage, and must pass the exam. Hence, students in all five faculties have to attend two-hundred and fifty hours of lecture with lab in inorganic chemistry, organic chemistry, and analytical chemistry. In recent curricula of chemistry there are a lot of changes, mixing inorganic chemistry, organic chemistry, and some environmental problems, that make teachers confused in their teaching. Most teachers impart knowledge to students through lectures. The curriculum focuses on reactions, chemical laws, and the principles of pure science.

Participants

Fifty-one students who attended the study were divided into five self-selected groups. These students came from five Faculties of the University, in which there are forty-four males and seven females, their ages ranging from nineteen to twenty-three years. This class was the first class taught at the university that included environmental issues. Normally, students had to attend class with other academic discipline thirty-five hours per week. In addition, most of the students had to prepare for the transfer examination that

allows them to enter the second stage. The participants in this study came from all parts of the country, which includes coastal areas and highland areas. There were three students who came from Combodia. About one-third of the students were those who had performed very well in the national exam while two-thirds of the class had a satisfactory performance in the national exam.

The overall design of the study for collecting data

The data collection for the study included:

- Observation of the class activities
- A survey on students' attitudes
- Students' essays
- Midterm exam and final exam
- Informal interview with cooperating teacher

Observation

- Observation of the class is because of an interest in how students learned.
- Observation of students' behavior.

Observation was conducted by the researcher (the teacher) and the cooperating teacher from the beginning of the class to the end of the class. This was given in the form of a hand-out (Appendix C). Observers sat at the end of the classroom to observe what happened in the class, joining the class activities when the researcher or the cooperating teacher felt it is necessary. The observers played the role of catalyst persons or initiator persons to help students solve problems in chemistry as well as in environmental issues, without constraining or forcing the students to present their views.

It is believed that the participation of observers did not influence student activities in the class because the researcher and the cooperating teacher always maintained a harmonious atmosphere. All of members in the class had to respect others' ideas. Observers listened to students' ideas in the class discussions and presentations. The data collection is based on the observers' field notes, exchange of ideas from the observer participant, and my diary notes. Simultaneously, in order to collect a high concentration of data from observation, the observers focussed on one group of eleven volunteer students.

A questionnaire of a survey on students' attitudes

The survey, a multidimensional instrument, was used as the very small quantitative portion of this study. This survey was administered to the class A2 in the final week.

The survey that consisted of 20 items was taken from Gogolin and Swartz (1992) and Talton and Simpson (1986), Likert-type instrument comprising seven subscales with different items per scale. Attitudes toward chemistry with environmental issues are measured in six dimensions and another dimension of knowledge. These subscales are attitudes toward chemistry, attitudes toward chemistry with environmental issues, attitudes toward the environment, the perception of the teacher, anxiety of chemistry, physical environment of the classroom, and understanding knowledge. Students were asked to respond to the forced-choice system (strongly agree, agree, undecided, disagree, strongly disagree). Items were scored (5, 4, 3, 2, 1 respectively). Higher scores represented more positive attitudes, except for the anxiety scale. Lower anxiety scores were considered to be the positive attributes.

Mid-term exam

The researcher wanted to find out how students understood what they learned. The researcher used the format of multi-choice questions for the midterm exam and final exam. The researcher used the results of the exam to evaluate students' knowledge. Thus, in this

study the researcher does not present the specific result of the final exam. Instead a reflection of the results was generated from the Chairman' ideas and my own.

Essay for the whole class

The purpose of the essay was to determine students' feelings about what they thought of the new learning environment, such as the teaching strategy, class activities, and the new content. In order to avoid bias by the researcher, students were asked to use an alias.

Informal interview

The purpose of informal interview was to acquire feedback from the cooperating teacher's classroom observation and his evaluation for the " experimental teaching course".

Data analysis procedure

The reflection of open-ended questions is generated to compare partly with students' attitudes towards chemistry. The results of the questionnaire survey were determined by the mean and the percentage of students responses for specific items in every subscale. These results were analyzed for each item.

The informal interview included notes, the interviewee read the Vietnamese summary and commented on its accuracy. The conversation between the researcher and cooperating teacher was expressed under the descriptive format, including his evaluation.

The students' essays were coded and presented in the different themes.

The mid term exam was coded and presented in a percentage; analysis and interpretation of the data was obtained under the descriptive format.

In this study a questionnaire survey was used as a very small quantitative approach in the study. Most of the data collections in the study were applied to a qualitative approach; the study was conducted in a small sample of fifty-one students that led the researcher to

obtain the insight results, presentation and interpretation of how students involved in the study viewed environmental issues.

The result of this study may provide a cornerstone for further of the integration of environmental issues in the curriculum of chemistry. The study may provide students with an awareness of the environment, and to take personal responsibility in action and realize the close relationship between science and life. It also encourages teachers to bring their own materials to date on information that relates to studying science teaching, and then teachers can realize that potential of an STS approach, with environmental issues, in the syllabus.

Chapter 4

Instructional design and development

This chapter consists of two sections: (a) The rationale for the development of a curriculum is presented, including criterion for choosing topics and designing learning activities, in which the outlined steps are based on the instructional stages of curriculum development designed by McClaren (1994), together with objectives of general environmental education consistent with a STS instructional approach, (b) The implementation of a designed plan, including learning outcomes and a teaching approach for every topic is presented.

Rationale

The following statement foreshadows the development of a chemistry curriculum for the university level in Vietnam:

> The environmental problems arise as a result of activities in various fields of human endeavor, especially in specific and technological fields. Others arise as a result of natural forces at work. Since these problems are the result of multi-faceted activities, both man's and nature's, their solution must be based an inter-disciplinary approach. (Rugumayo, 1987, p. 29)

As the above quotation asserts, environmental problems require an inter-disciplinary approach. Chemistry plays a vital role. Environmental chemistry is concerned with chemical phenomena that occur in the natural environment, transformation of matter in nature, and chemical changes that affect the natural environment.

Environmental chemistry also focuses on the structure and interaction of matter as it relates to problems and current issues, and with the facts, concepts, laws, theories, and processes for obtaining this knowledge. Environmental chemistry is developed within a social context, and awareness of a global context is helpful for understanding the complex interrelationships between environmental chemistry, its technological applications, and society.

As argued in Chapter One, the study of environmental chemistry at the university level can help to prepare students to be informed decision-makers in an increasingly technological world. A knowledge of chemistry helps to give students confidence in being able to understand and control their actions in the natural environment. A core of fundamental chemical knowledge in environmental chemistry is central to this understanding.

The following criteria were addressed for designing learning activities in this study:

1. Curricular criterion

An environmental approach should cover basic concepts which could be best taught in the field of chemistry. The environmental approach relates to current environmental issues around the world as an integral part of the curriculum in developing society.

2.Objectives of criterion

- Awareness: to help students gain an awareness of, and sensitivity to, current environmental issues.
- Knowledge: to help students acquire a basic understanding of environmental problems, interconnectedness of humans and nature, basic science concepts, and take responsible in action in the natural environment.
- Attitudes: to help students acquire strong conscious feelings of concern for their environment, as well as an enjoyable attitude towards science.
- Skill: to help students acquire the skills for solving environmental problems.

3. Educational criterion

The environmental approach should be a learning experience in reality. In order to make an environmental approach more educational and as an integral part of curriculum, a

teacher should develop learning materials that prepare students for solving problems and guiding them through studying problems.

In order to meet the three above criteria, and to respond to the purpose of STS approach, the following instruction for designing is presented as follows:

a. Choice of environmental issues for learning

Environmental issues should be chosen according to the understanding potential of students, involving related chemistry concepts, and acquiring the criteria of objectives. Environmental issues should be as close as possible to their action in daily life, and to their job in the future.

b. Matching curriculum concepts

Environmental issues contain chemical concepts included in the requested curriculum. An example of this is using the concept of a redox reaction to explain how sulfur is oxidized in the atmosphere in the topic of acid rain.

c. Development of teaching/learning aids and tool for solving problem

In order to answer the educational criteria and criteria of objectives the package of instructional design should include aids such as:

- Learning aids for students, such as video-tapes and up to dateness of problems in particular articles from scientists' pros and cons which directs students develop thinking.
- Teaching aids, such as transparency color to help the teacher stimulate students to explain observations or help the teacher to explain the problem.
- Tool (SSCS cycle of Pizini) for teaching helps students develop communication skills and deeper thinking, solving problem.

d. *Learning activities should be a learning experience in reality.*

In order to answer the educational criterion above, learning activities should be a learning experience in reality. For example, classroom experiments that give students an understanding of controlling carbon dioxide (CO_2) atmospheric levels, or by comparing the

CO_2 content of the exhaust of several motor vehicles. Through a very simple activity of identifying CO_2 students realize that the presence of CO_2 in the atmosphere provides a real experience that encourages immediate scientific problem solving. This lab can provide students with the opportunity to develop their creative and critical thinking skills, when activities are based on the real-life problems. Environmental labs enable students to understand current science issues and develop positive attitudes about the field of chemistry.

e. Learning activities should educate students to be aware of high occupational action

As introduced in chapter one, the study is applied at the Nhatrang University of Fisheries, that is located in the maritime province. A goal of the University of Fisheries is to develop human resources for breeding and growing, as well as exploiting, shrimp, fish, and shellfish in rivers, lakes and the sea. So learning activities should acquaint students with local or national problems that help students take personal responsibility to avoid the spilling of fossil fuel onto the surface of water to ensure long term production. For example; the topic of oil pollution is concerned with the harvesting of crustacean and molluscan shellfishes and fish, because the oil that coats the shorelines may persist for a long time, depending on the characteristics of the hydrocarbons that cause different levels of oil pollution damage.

g. Learning activities should provide students with a broader view toward global environmental issues

Learning activities should aim to educate students to understand our interrelationships with people around the world because humans are changing the environment, their chemical by-products are changing the hydrosphere and the atmosphere. Learning activities should offer global perspectives on the relation of science and technology to society. So learning activities should exhibit logical science, technology and

society problems, for example; topics of acid rain. Through video-tape students can visualize the effects of acid rain on environment.

The implementation of designed plan

Prior to my decision to integrate environmental issues in my chemistry teaching, I contacted the Chairman of the Department of Chemistry at the Nhatrang University of Fisheries about my study. I planned to teach environmental chemistry, using acid rain, the greenhouse effect, and the depletion of ozone layer as topics.

During the time prior to this study in Vietnam the Chairman tried to convince Nhatrang University of Fisheries to integrate environmental problems into the chemistry curriculum, but his suggestion was not implemented. When he heard about my study with environmental issues, he encouraged me and asked me to collect materials, video-tapes and textbooks that are concerned with environmental problems for my teaching, and keep them for the Department of Chemistry.

Two weeks after I returned to Vietnam the Chairman organized a meeting. I presented the purpose of my study, after which he asked one of the teachers to participate in teaching and to observe the class with me. He also asked a technician to help me prepare laboratory experiments. In addition, the Chairman asked me to prepare two more topics covering oil pollution and pollution caused by pesticides, herbicides, and agent orange. The Chairman gave me a course syllabus in which there is one chapter of environmental chemistry for students who are not chemistry majors. The syllabus was as follows:

1. The distribution of elements on the earth.
2. Environment and pollution.

- Effects of pollution on the atmosphere (ozone hole and greenhouse effect).
- Effects of pollution on the hydrosphere (water pollution and waste-water treatment).

- Effects of pollution on the lithosphere.

The Chairman of the Department of Chemistry introduced the new teaching method, and new content to the class A2 in advance and then I presented the overall plan of my study to the students. They were told that the purpose of the program is to improve the quality of curriculum, as well as new teaching methods, in Chemistry, with the goal of helping students gain a basic knowledge and awareness of environmental issues. I told them my hope was that they would come to understand that the knowledge of chemistry is not separate from human life, and that they would be able to take part in solving daily problems.

The students were told that the class would be centered on group discussions, student presentations and solving problems. They were encouraged to express and share their ideas freely in the class.

I provided the students with an introductory letter in which was included the expectations and activities required of each student (Appendix A). They were invited to sign a consent form if they agreed to participate in the program (Appendix B). After that, the cooperating teacher and myself team teaching the course with me provided an overall framework of the course, and explained the evaluation criteria for the whole " Experimental teaching course", which included thirty hours of lecture and lab experiments.

The researcher gave them an open-ended question to elicit the student's free response concerning their attitudes towards environmental protection, knowledge of related problems that they were in the process of learning, and their general attitude towards chemistry. The questions follow:

- Do you like to study chemistry?
- Have you ever been interested in environmental protection without pollution?
- Have you ever heard about acid rain, greenhouse effect, and the depletion of ozone layer?

More than sixty minutes passed in active discussion between teachers and students concerning course instructions and tasks, as well as students forming self-selected groups.

After that students signed the consent form to participate in the program. This was the first time the class A2 studied in this kind of learning environment, with the new content, so students needed some guidance for group discussions. This was given in the form of a hand-out and researcher explanations (Appendix D).

The plan for teaching

Week	Time (hour)	Learning activities
1	5	Acid rain Video tape: A visible threat
2	5	Depletion of ozone layer
3	5	Greenhouse effect Video-tape: Greenhouse effect
4	5	Oil pollution
5	4	Lab: Influence of acid on different rocks.
6	4	Determining the CO_2 content of different samples (ambient air, human exhalation, nearly pure CO_2, motor vehicle exhaust).

Acid rain

Learning outcomes

Students should be able to

- describe the environmentally important oxidation states of sulfur.

-2 oxidation state in H_2S

+4 oxidation state in SO_2, H_2SO_3

+6 oxidation state in SO_3, H_2SO_4

- understand concepts of chemistry as redox reaction, acids and bases, and the pH scale.

- realize that besides two main components of acid rain as HNO_3, H_2SO_4; HCl is also a component of acid rain, snow, drizzle or fog.

- explain the simplified diagram of biogeochemical sulfur cycle.

- understand the environmental impact of acid precipitation of acidic emission on vegetation, forests, living things in the water.

- realize that natural causes such as volcanic eruptions are the first source that causes pollution and human's activities are the second source of pollution.

Teaching approach

Two teachers were teaching together with a class of fifty one students from the five different Faculties at Nhatrang University of Fisheries in Vietnam. Most of the students had already studied the concepts of redox reaction, acid and base as well as the concept of the pH scale. That is an advantage for teaching environmental issues. However, sometimes the cooperating teacher also repeated basic chemistry for the students involved. The class had been studying a section of acid rain that was based on "Student resource 1, 2, 3 and 4" (Appendix L).

Students were asked to move from the classroom to the television room for watching the video-tape "Student resource #1 with Acid rain: A visible threat". The teacher

asked the students to look for specific information or details of what they saw. This helped break passive viewing habits, and focused students' attention on requested problems such as recording their responses while viewing. Students recorded normal rain has pH of 5.6, ammonia has pH of 11, orange juice has pH of 2.4 and soda has pH of 9, and distinguished some areas where the pH was smaller than 5.6. Simultaneously, students also observed the phenomenon of toxic fish with heavy metals of Alumina, and understood the effect of a pH of 4.9. Aluminum toxicity damages the fish's gills, and this can result in their death. Fish egg are unable to survive in the acidic water with a pH of 4.5-5.5, especially pH < 4.5, all fish are dead, pH of 4.5- 6.0, number and diversity of species decrease rapidly. Bacterial decomposers at the bottom of the lake die. Plankton starts dying out. Toxic metals (aluminum, mercury, lead, calcium, tin, beryllium, and nickel) are released from sediments or leached from nearby soil.

After that the students were asked to explain why normal rain water is slightly acidic. We had students answer that because of the formation of a weak solution of carbonic acid when rainwater dissolves some of the naturally occurring carbon dioxide in the atmosphere, as in equation below,

$$H_2O + CO_2 \text{ -------> } H_2CO_3$$

Then the students were asked to explain why the surface of buildings and monuments lost the details on the surface. We had students' explanation that limestone and marble are two types of stone used in the construction of buildings and monuments and in the creation carved stone statuary. Both rock types are composed of calcite, the stable variety of calcium carbonate ($CaCO_3$).

Most of carbonate materials are sensitive to acidic deposition, erosion of marble and limestone surfaces, and loss of detail on the statuary is caused by a natural acidic environment.

$$CaCO_3 \text{ (s)} + H_2CO_3 \text{ (aq)} \text{ -------> } Ca^{2++} \text{ (aq)} + 2HCO_3^- \text{ (aq)}$$

After a ten minute break, the teacher had been reading the paper "Student resource #2" with the title, "A threat of environmental acidification" from a Vietnamese magazine in which the author translated an episode concerning the loss of lakes and ponds that are acidificated in North America and in Europe. There are 20,000 (over 90,000) acidificated lakes in which there are 4,000 lakes without fish; in Norway 13,000 lakes have "died"; in Europe 14 percent of the forest is acidified, in German 52% of the forest is affected with acid rain etc. China uses 460 millions tons of coal for burning per year and every year factories put 17 million tons of H_2SO_4 and 23 million tons of smokes and particles in to the atmosphere. In general, pollution of the atmosphere is caused by areas of high population and developed industry.

In Canada, acid rain has already damaged 14,000 lakes, rendering them almost fishless, and another 150,000 in peril. Some 20% of Sweden's lakes are said to have been damaged by pollution, and much of Norway's fish population has been exterminated.

After ending the reading of fifteen minutes, students asked the teacher, "Has acid rain appeared in our country?" (Vietnam) Actually, at that time, I was vague with my answers, because I did not know the exact pH level, but I was able to explain that in Vietnam some monuments, tombs and temples have been damaged by erosion due to an acidic environment. In actuality, there is no bulletin of this phenomenon on public communication and this is also not serious problem in Vietnam now. However, the erosion of carbonate stone is caused by the carbon dioxide in the atmosphere which combines with moisture, to form a weak solution of carbonic acid. Thus, Vietnam has a slightly acidic environment. The teacher hinted that at the moment Vietnam does not has serious acid rain problem, but the problem will increase as the population increases, everyday. The power plants are under construction and more and more motorcycles are used in Vietnamese cities. All of these are causes of acidic rainwater.

Acid rain a serious problem in China , Vietnam is adjacent to China. This phenomenon may influence Vietnamese environment in the future because emission of air

pollutants from mining industries or power plants are brought far away downwind. It is environmental issue that cut across the national boundary.

Before ending the class the teacher provided every student with a copy of the material "Student resource #3" concerning acid rain, and students were asked read the paper at home.

The second day of the topic; "acid rain" the teacher asked students in self-selected discussion groups for a discussion with "Student resources #4". Students moved from the class to another place around the classroom or outside the classroom. Forty minutes later the students came back to class and discussed the topic with the whole class. In the process of debate and discussion we elicited the following conclusions from the students:

- Acid rain causes a leaching of heavy metals from the soil into lakes, ponds and rivers. These toxic metals are assimilated into the tissues or gills of fish that serve as food for people. Acid in water can also leach copper and lead from pipes, into drinking water.

- Lake acidification is the pollution of a lake from acid rain. Reduced pH levels in a lake affect the living organisms under water. If the water in a lake has a very high acidity, no living organisms will survive.

In order to help students understand more about the relationship between chemistry and the natural environment and human activities, students were asked to explain a simplified diagram of the biogeochemical sulfur cycle, with sulfur entering the atmosphere as H_2S, SO_2, and sulfate salt from sea pray. Water droplets transport sulfuric acid and sulfate salts to the Earth's surface (Figure 3). The teacher asked the students to construct the sulfur cycle. The students were asked to identify the source of the sulfur which enters the atmosphere. After ten minutes students prepared and solved this cycle and we put students' solution on the diagram at the black board.

A large proportion of sulfur reaching the air from natural biological decay goes through the intermediate compound, hydrogen sulfide.

- Hydrogen sulfide (H_2S) smells like rotten eggs, H_2S is oxidized by anaerobic conditions in soil water to form SO_2 and H_2O from the anaerobic decay of organic matter in swamps, bogs, tidal flat and active volcanoes.

  $2H_2S + 3O_2$ ------> $2H_2O + 2SO_2$

- Sulfur dioxide (SO_2) comes from active volcanoes.
- Sulfate salt is like ammonium sulfate from sea spray.
- Sulfur enters the atmosphere from human sources.

Sulfur dioxide reaches the atmosphere from human activities when sulfur-containing coal and oil are burned to produce electric power SO_2 comes from industrial processes such as petroleum refining and the smelting of nonferrous metals with sulfur-containing ores. Sulfur impuries react with oxygen gas in the atmosphere to produce sulfur dioxide as.

$S + O_2$ ------> SO_2

And some of sulfur impuries react to form sulfur trioxide.

$S + 3/2\ O_2$ ------> SO_3

Within some days most of the sulfur dioxide in the atmosphere reacts with oxygen gas:

$2SO_2 + O_2$ -------> $2SO_3$

And then sulfur trioxide reacts with the vapor in the air or on the ground to form droplets of sulfuric acid.

$SO_3 + H_2O$ -------> H_2SO_4

Some of the sulfuric acid droplets can react with ammonia gas (NH_3) in the atmosphere to form solid particles of ammonium sulfate: $H_2SO_4 + 2NH_3$ ------> $(NH_4)_2SO_4$. These particles fall to the earth as dry deposition or dissolve in rainwater. Small particles of these sulfates provide plants with an essential nutrient.

In actuality, the oxidation of SO_2 in the atmosphere is very complex, because oxidation can occur by three ways: catalytic oxidation or photooxidation or by oxidation radicals.

The depletion of the ozone layer

Learning outcomes

Students should be able to

- distinguish between spherical layers of atmosphere characterized by abrupt changes in temperature due to the difference in the absorption of incoming solar energy.
- understand how ozone is formed and destroyed in the atmosphere.
- understand the nature of substitute mechanism of radical chain reactions.
- know "the rule of 90" for finding the specific formula of Freon and students can write the formula of CFCs (Freon) when they know the code number of Freon and students also can write the specific formula of Halons.
- explain how ozone-depleting agents (CFCs) attack the ozone layer.
- realize the role of ozone is bad in the lower atmosphere and good for human when ozone is presence in the atmosphere.
- realize the fate of ultraviolet (UV) radiation to reach the earth's surface to cause cancer, cataracts.
- understand that besides CFCs there are other industrial pollutants such as carbon tetra chloride (CCl_4), and methyl bromide (CH_3Br), and natural pollutants such as nitrogen oxides from volcanoes, chlorine ions from sea salt.

Teaching approach

Before coming the class the students were asked to prepare and read the paper in advance "Student resource # 5" . As a rule, the cooperating teacher reviewed the concept of electromagnetic radiation and wavelength that students had already studied in the last

semester. For more than forty minutes students sat quietly listening to the problems related to chemistry and then the teacher used the overhead projector and transparency with figure (4). The teacher asked students as "Explain the significance of the earth's atmospheric layers as why the temperature of the atmosphere reduces in the troposphere and mesosphere and increases in the stratosphere and thermosphere, what is the fact?" Then we had students explained with modifying from the teachers below.

The temperature of the atmosphere is governed by the following factors: absorption of energy received from the sun; heat production in the interior of the earth; and loss of energy by emission from the earth acting as a blackbody radiator. While the highest intensity of incoming solar energy occurs in the visible, the highest by the much cooler Earth occurs in the infrared. The atmosphere plays a vital role in warming the Earth' surface.

In the troposphere, the temperature decreases as altitude increases both because some of the infrared radiation has already been absorbed at a lower altitude by carbon dioxide and water vapor with the traces of different chemical species, and also because as the altitude increase, the pressure is decreasing, there is fewer molecules available for absorption. This decrease continues until the tropopause, beyond which altitude ozone and oxygen concentrated in the stratosphere, especially the presence of ozone is predominant, the conversion of solar radiation to heat via the O_2/O_3 system outweighs the cooling trend.

In the stratosphere, almost all the chemical species are molecules. Chemical processes in the stratosphere involve the conversion of the solar radiation in the range 200nm-300nm into heat. The processes of reaction occur below,

$$O_2 \xrightarrow{\lambda < 20nm} 2O$$

$$O + O_2 \xrightarrow{M} O_3$$

$$O_3 \xrightarrow{\lambda < 320nm} O_2 + O$$

As altitude increase the temperature rises from a minimum of about -60°C at the tropopause to the stratopause with near O°C. This is explicable as follows. As the concentration of molecules of O_3 and O_2 rises in the stratosphere, absorption in the range 200nm-300nm becomes more efficient and so the temperature rises. The maximum at the stratopause in the temperature reflects a heating process high in the atmosphere due to the absorption of solar radiation in the near ultraviolet region by a bandy ozone.

In the mesosphere, the temperature falls again as altitude increase because the pressure is decreasing the concentration of molecules is very low, especially near the mesopause the chemical species are ions. Fewer photons are therefore converted into heat and the temperature drops until the mesopause is reached.

In the thermosphere, the temperature rises from a minimum of about -60°C at mesopause to 120°C at the altitude beyond 90km. The temperature rises more due to the absorption of solar rays in the far U-V region by atmospheric gas, principal oxygen. The atmospheric air of this layer is very thin, pressure is smaller than $10^{-8\ atm}$. Highly energetic photons of wavelengths well below 200nm are absorbed by both molecules and atoms (students explained the relationship between wavelength and frequency of light is given by: $\lambda = c/\nu$ where λ is the wavelength, c is the speed of light and ν is the frequency). These photons have energies sufficient to cleave molecules into atoms, and even to ionize both atoms and molecules. The thermosphere is warmed by the conversion of very short wavelength solar radiation into heat. The thermosphere is the only region of atmosphere in which the predominant chemical species are atoms and ions rather than molecules.

After a ten minute break, the teacher asked students questions about Freon formula. Freon is known as the trade name of chloroflurocarbon (CFCs). Two CFCs often used are Freon-11, a propellant now banned in several countries, and Freon-12, still used in refrigerators, air conditioners and freezers.

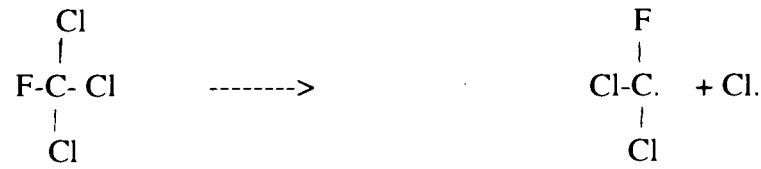
Freon is a type of compound in which some or all of the hydrogen atoms of a hydrocarbon (alkane) have been replaced by chlorine and fluorine atoms. Then the teacher asked students to apply the role of 90 for giving the formula in the case of Freon. We had students answer, "by adding 90 to the code number". If students looked at a Freon-11 or Freon-12, what are specific formulas? Students were vague about the formulas of Freon, although students will meet these substances or these terms in their subsequent courses that relate to their job in the future. Because most of the students who were present are majoring in the Sea-product Processing, they will go to the frozen food factories or enterprise after obtaining their degree. Even some teachers who teach about Freon do not know the specific molecules of Freon. Hence, the teacher helps students to know "the rule of 90". For example; a correct answer in the case of Freon 11 is:

Use the code number of 11 + 90 = 101. The three digits one, zero, and one are the numbers of carbon, hydrogen, and fluorine atoms in the molecule. The rest of the atoms that fit carbon valency must be chlorine. Hence, the specific formula of Freon-11 is $CFCl_3$. Another example such as Freon -141 is 141+90 = 231, Three digits mean $C_2H_3FCl_2$.

Next the teacher helped the students to understand what halon is. Halon is obtained by replacing the hydrogen atoms of a hydrocarbon by bromine along with other halogen atoms, but a code number of four digits is necessary in order to number the carbon, fluorine, chlorine and bromine atoms in the molecule. Any atoms not accounted for are supplied by hydrogen. For example, H1211 means CF_2ClBr; H1301 means CF_3Br.

After that students had a ten minute break and then the teacher used a color transparency with the pictures in the figure (4) and asked students to write the formula of Freon, and write the reaction for ozone destruction in the atmosphere. After that many students wanted to solve the diagram and we had students answer.

In the picture (1) in figure (5), Freon-11 (Trichloro mono fluromethane) are broken up by ultraviolet radiation in the stratosphere, breaking off an atom of chlorine.



In the picture (2) the free chlorine atom attacks an ozone molecule, breaking off one of ozone's three oxygen atoms form one chlorine monoxide molecule and leaving one oxygen molecule.

$Cl. + O_3 \text{ -------> } ClO + O_2$

In the pictures (3) and (4) the chlorine monoxide molecule reacts with a free oxygen atom, produced during the natural mixing of oxygen and ozone, the oxygen atom breaks up the chlorine monoxide molecule and combines with the oxygen atom, forming a new oxygen molecule, and leaving behind a free chlorine atom. The newly free chlorine atom can continue to destroy ozone molecules for many years.

$ClO. + O \text{ ----------> } Cl. + O_2$

$ClO. + O_3 \text{ ---------> } ClO_2. + O_2$

After students had written their answers on the blackboard the teacher gave a hint that a single molecule of free gas can eliminate many thousands of molecules of ozone because this kind of reaction is a free radical mechanism. Hence, the overall rate of the chain reactions depends on the rates of the initiation and termination reactions. This is because the average number of stages of propagation depends on the balance between the rates at which the chains are initiated. Since most of the initiation reactions are photochemical, their rates depend on the intensity of sunlight, and thus their rates fall to zero at night.

Before leaving the classroom students were asked to discuss "Student resource# 6" and "Student resource #7" and after that students compared the ideas between the pros and cons from articles in order to begin decision making. All of them were ready to believe what scientists have discovered and then they went on to make the decision that HCFCs (Hydro chlorofluorocarbons), and HFCs (Hydrofluoro carbons) are greenhouse gases and

must be banned by law. However, some students were concerned about the present situation in Vietnam, where most of the air conditioners, refrigerators, or freezers in use are old fashioned and we reuse second-hand appliances without labels. This makes it difficult for Vietnamese people to check the composition of chemicals in those appliances.

The detrimental effect of CFCs on the atmosphere will continue, Vietnamese citizen haven't realized the fate of CFCs because environmental issues are not educated in the school. Students should know that the effect of technological development on society is a positive or negative nature. Some of which may not be apparent for many year. CFCs are still use in Vietnam. Knowing the properties of chemicals can help us to make a good choice and control our action in daily life.

In order to avoid emission of greenhouse gases into the atmosphere we should check regularly for CFC leaks and repair air conditioners and refrigerators when necessary.

After reading the paper " Student resource # 6 with what you can do to help protect the ozone layer" students were happy to learn about more chemicals that are toxic to their health and deplete the ozone layer, and they realized that they should stop using aerosol spray products which release propellant chemicals into the air, using roll-on and hand-pump products in their place.

In order to help students to understand more about the depletion of the ozone layer the teachers asked them to look at the picture of the ozone hole in the upper stratosphere over the Antarctic region (Figure 6). When students saw that the depletion of the ozone layer decreased more and more from 1979 to 1992 their faces showed their worry about life on the earth being threatened by the depleting chemicals. After that the teacher asked, "Is ozone a bad or good thing for us?" Students answered that the role of ozone in the atmosphere depends on which layer the ozone is present. Ozone is a noxious pollutant near the ground but in the stratosphere it forms a protective blanket, the ozone layer, which shields all forms of life on earth from over exposure to lethal ultraviolet radiation from the sun. Hence, a depleted ozone layer allows more UV radiation to reach the earth's surface

causing animals to suffer serious burns and develop cancer and lethal mutations. Humans would be especially vulnerable and plants would suffer as well.

In addition, students were provided other sources that detailed depletion of the ozone layer being caused by supersonic transport (SST) and military jets releasing nitric oxide (NO) because they fly between 20km and 30km above the earth's surface, where concentration of ozone is the highest. The details of supersonic transport are as follows:

Supersonic transport ----------> NO

$NO + O_3$ ---------> $O_2 + NO_2$

$NO_2 + O$ ---------> $NO + O_2$

$NO_2 + O_3$ --------> $O_2 + NO_3$

$NO_3 + h\sqrt{}$ --------> $NO + O_2$

After all, students reached the conclusion that the problems of the depletion of the ozone layer cannot be solved by cutting back slightly on CFCs, but CFCs had to be banned altogether.

The greenhouse effect

Learning outcomes

Students should be able to

- understand what the greenhouse effect is.
- understand the concept of electromagnetic radiation, the relationship between frequency and wavelength.
- discover that human activity is contributing increasing amounts of greenhouse gases into the atmosphere from different sources.

- be aware of things needed to sustain their life that have greater or lesser effect on the atmosphere.

- to get a conscious feeling of environmental issues.

- know which aspects of their lifestyle they would be willing to change to support a sustainable society.

Teaching approach

Before beginning the topic "The greenhouse effect" the teacher investigated students' interest in global environmental issues as "what the greenhouse effect is and whether or not they have ever seen a greenhouse?" At that time nobody had visualized the greenhouse because in a tropical country greenhouses are not widely seen. So we explained that the metaphor of a greenhouse is used because a greenhouse uses covered glass to limit the escape of the warmth from the inside of the structure. The video-tape " Student resource # 8: "The greenhouse effect" was shown. Most of the journalists and environmentalists who in the video-tape of greenhouse effect discussed the greenhouse gases, focused on carbon dioxide (CO_2). The teacher thought that it may not be necessary for students to view the video in its entirety. Hence the teacher used stop and pause buttons frequently to highlight some segments, such as the view of the greenhouse, and asked students to look for specific information or details from what they saw on the tape. Students observed the lab demonstration from Bob Mc Donald that presented the typical North American landscape, in order to help students understand the analogy of the heat trapping skin of the greenhouse with the growing envelope of CO_2 around the earth. This also helped students avoid the common misconception that our atmosphere is heated directly by the sun.

What actually happens is sunlight shines through the atmosphere and is absorbed by the ground. The ground gets hot and gives off heat in the form of infrared radiation. Moreover, Bob also presented the picture of factories and houses that use oil heat. All of them burn fossil fuels and therefore are adding CO_2 to the atmosphere. At that time students

realized that CO_2 has a different way of reacting with infrared radiation. Then Bob explained that there is a balance in the amount of radiation that is coming into the earth's atmosphere and is raditating out. These two processes should balance each other, with an equal amount of radiation being absorbed and being released, but human activities are putting too much CO_2 in the atmosphere and disturbing this balance.

CO_2 absorbs infrared light so that the atmosphere can be heated directly. What happens when the radiation that is coming out can not escape, the temperature begins to rise, because it is being trapped. This is the greenhouse effect. At the same time the teacher used pause buttons to break passive viewing habits and asked students what happens to the dome when the temperature goes up? Other questions considered were, a inside the dome "what did the students see? and what role do the clouds play?"

The students responded that the clouds play a role of an insulating barrier around the earth, and contribute to the build up of heat, reflecting light back out into space before it even gets to the surface. The temperature is rising and reach a new equilibrium. As result, the earth becomes a little bit warmer.

Next the teacher questioned students about what is the damage to humans when trees and forests are cut. Many students had ideas because everyday there are references on the radio, television, and in the magazines dealing with the damages as people cut down trees for fuel and wood. Far more trees are getting cut than are being planted. Hence, every winter heavy rains cause flooding in low-lying regions that causes damage to people and property. People die after every flood. After that the teacher turned the video-tape back on and students watched pictures of forests being cut down and burned. Forest are continuing to be cut and burned in the third world to provide farmland for crowded populations. Students watched for fifteen minutes more. Then the teacher presented the question, "Why do we need to keep trees and develop forests more?" and "Can you explain the relationship?" Some of the students answered and explained the relationship that trees use

CO_2 during photosynthesis as they breath and take carbon to make the wood, they breath out oxygen which is very useful for us.

Students then had a ten minute break. After the break, the teacher wanted to check for comprehension and clarify details in the video-tape, such as, "What is the role of the ocean?" Some students responded to this question by explaining that the tropospheric CO_2 gas is taken up by the ocean, where a complex series of equilibrium converts CO_2 (g) into $CaCO_3$ (S).

$$\overset{}{} \qquad \overset{H_2O}{} \qquad \overset{-H^+}{} \qquad \overset{-H^+}{} \qquad \overset{Ca^{2+}}{}$$

$$CO_2\,(g) \rightleftharpoons H_2CO_3\,(aq) \rightleftharpoons HCO_3(aq) \rightleftharpoons CO_2(aq) \rightleftharpoons CaCO_3(s)$$

After break time students were asked to discuss the "Student resource # 7" In order to help students understand the teacher asked, "How do these gases affect the balance of energy? What role do these pollutants play in the atmosphere?" Then the students came to explained. As we know that the incoming ultraviolet, visible, and infrared energy has a max intensity, at the earth's surface around 483nm, while energy reemitted from the earth is only in the infrared region with a maximum intensity around 10,000nm (this is explainable to be based on Wein's law, one can calculate the peak wavelength of the rays given off by a hot body by dividing its absolute temperature into a constant number, 2,900,000. The solar spectrum peaks at 483nm, giving an estimate of the temperature at the surface of the sun of about 6,000°K. The earth, of course, is much cooler than this. If we take the average temperature to be an estimate of the temperature to be about 290°K a peak wavelength is expected about 10,000nm). If this energy was lost to the atmosphere the temperature of the earth's surface would be around -20°C to -40°C. At this temperature the earth would be cold, the life on earth does not exist. However, the atmosphere plays an important role in warming the earth's surface, some of the infrared radiation is absorbed by water vapor and carbon dioxide in the air and reemitted in all directions, some of which returns to produce an average temperature of around 14°C.

But because we are putting more pollutants into the atmosphere, these pollutants, CO_2, N_2O, CFCs, and halons allow some heat to flow back into space, absorbing and reradiating some of it back toward the earth's surface. This is the reason more heat is radiated to the earth and the balance of energy can be upset. These pollutants rise, more heat is radiated to the earth, causing the atmosphere to warm.

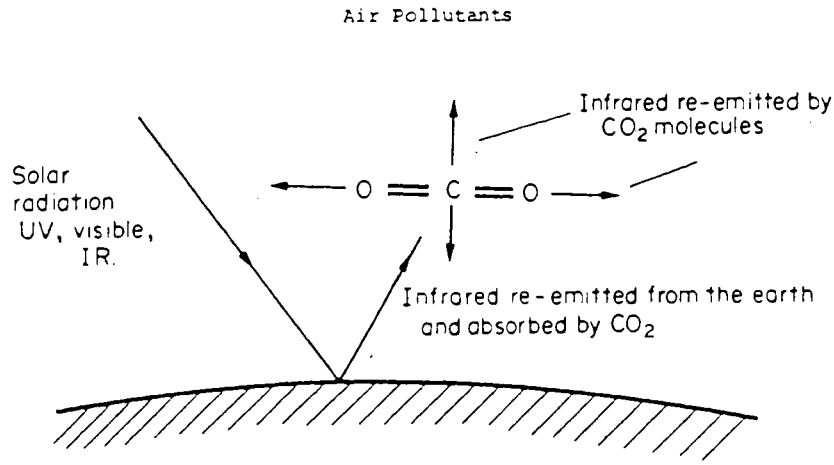
Then the teacher read the "Student resource # 9" with students, in which the capacity of trapping heat of different chemicals were presented, especially the molecules contain chlorine atoms. They are not only to destroy the formation of ozone in the stratosphere but also they trap heat with thousand of times more than carbon dioxide. Throughout the "student resource #9" the students realized that a threat of the warming Earth is caused by not only carbon dioxide gas but it also included CFCs .

Students were asked to discuss questions "Student resource #10" as " Explain, why Nitrogen and oxygen that are the major air constituents, do not absorb infrared radiation in the atmosphere? Before students went to discuss and debate, the cooperating teacher reviewed the dipole moment concept. After that the teacher used a metaphor about vibration of the molecules such as in the molecules, the atoms behave much as if they were balls connected by the springs, the spring being the chemical bonds. The resistance of the bonds to stretching or bending determines the stiffness of the springs. The stiffer the springs, the greater is the frequency of vibrations. Then, the students continued to explain this phenomenon with assistance of the teachers and we had the solution shown below.

While absorption of visible and ultraviolet radiation is associated with electronic transitions in the molecules, absorption in the infrared region is associated with vibrational transitions. Light may induce molecular vibrations when its frequency matches vibrational frequency. The absorption of light depends on both the frequency of light and the dipole moment of the molecule during the vibration. Nitrogen and oxygen do not absorb infrared radiation because they are two identical atoms in the molecules, produce no charge separation, so their dipole moments are equal to zero. If the atoms in the molecule are not

the same as carbon monoxide and nitric oxide has dipole moment, then the vibrations absorb infrared light, but there are very small traces of these gases in the atmosphere.

Figure: A schematic drawing illustrating the greenhouse effect. Infrared radiation from the earth absorbed by CO_2 molecules is re-emitted in all directions returning some back to the earth's surface.



The water and carbon dioxide are polyatomic molecules. For polyatomic molecules, the dipole moment of a molecule containing three or more atoms depends on both bond polarity and molecular geometry. To have a dipole moment, a polyatomic molecule must have polar bonds. However, even if polar bonds are present, the molecule itself might not have a dipole moment. But CO_2 is a triatomic molecule and its geometry is either linear or bent.

linear molecule (no dipole moment)

resultant dipole moment

bent molecule

(has a dipole molecule)

The arrows denote the flow of electron density from the less electronenagative atom (carbon) to the more electronegative atom (oxygen). In each case, the dipole moment of the entire molecule is made up of two bond moments, that is, individual dipole moments in the polar C=O bonds. The measured dipole moment is equal to the sum of these bond moments. These dipole moment, like the bond moment, is a vector quantity, that is, it has both magnitude and direction. It is clear that the two bond moments in CO_2 are equal in magnitude. Since they point opposite directions in a linear CO_2 molecule, the sum of dipole moment is zero. On the other hand, in a bent CO_2 molecule, the two bond moments partially reinforce each other, so that the molecule would have to have a dipole moment.

H_2O and CO_2 consist of different atoms in within their molecules and absorb infrared radiation, because their vibrations, which stretch the bond between atoms, produce charge separation. The main infrared absorbers in the atmosphere are water and CO_2.

The teacher asked students to read the "Student resource #11" and think about it with the teacher's question of "Do you believe the theory of the greenhouse effect is true? If so, what will you do from now?" About two third of the students said that the theory of greenhouse effect is not true because when the earth warms up, the evaporation of water from the lakes and oceans is faster, and condensation is formed to produce more rainfall. Rain cools the land and subsequently cool the air over the land. While the rest of the class debated that it is a good way to protect the earth without it warming up as "prevention is better than cure". They compared the concentration of CO_2 in the atmosphere has risen from about 274 ppm to over 340ppm. While just since 1958, the concentration of CO_2 have increased from 315 ppm. With the a increased level of concentration of CO_2 and then concentration reach 550 ppm would occur. Certainly, theory of greenhouse effect will become reality. Subsequently, ice-cap and glacial melting will increase the sea level that causes convection currents in the atmosphere and fierce storms.

After break time students were asked to consider question three "What can you do to prevent global warming?" Most of the student gave the same ideas, that they never know

the atmosphere was full of CO_2. They just thought simply. Certainly, there is a pollution increase where there are crowded people and automobiles. They never thought that all human activities have an effect on the global climate. Students realized that what they could do towards preventing global warming is to use energy efficiently in appliances in order to save money and reduce CO_2 and SO_2 emissions into atmosphere, plant more trees to reduce of carbon dioxide from the atmosphere, and reducing the harmful effect of deforestation, and refrain from buying air conditioners, refrigerators, or freezers that use CFCs as the cooling fluid.

Before ending the topic of the greenhouse effect the teacher showed the figure (7). The picture of figure (7) helped students understand the whole concept of the greenhouse effect more.

Oil pollution

Learning outcome

Students should be able to

- distinguish among of hydrocarbon such as saturated hydrocarbons, unsaturated hydrocarbons, and aromatic hydrocarbons.
- understand the concept of isomers.
- understand commercial damage as well as public health risks from oil pollution.
- be aware of the fate of oil to the ecosystems of land and sea.

Teaching approach

In order to cultivate the interest of students with national and local connections, the teacher provided students with the "Problem of oil pollution" and asked them to find out the recent oil spills in Vietnam, and where the spills occurred, the cause of the spill, as well as

the impact of the spill on living things and the shoreline. These requests encourage students to do research and collect information related to the problem of pollution. Then we had students do their presentations of oil spills that occurred between 1993 and 1994. In this period of time there were three oil spills, such as on the twentieth of September in 1993, there was a collision between two ship from Singapore, and Vietnam. A total of 40 tones of oil and goods were lost during the incident, and the oil spill spread out on the surface of the water in Ba Ria, Vung tau. On the morning of 8 May 1994, a Vietnamese Transco-01 ship was in conflict with Uni Humanity. The collision occurred at Tac Roi, Can Gio, where over 100 tones of oil spreaded out on the surface of the river water. On the third of October, 1994, a Singapore Neptune ship was in conflict with the harbor of Saigon petrol factory damaged over 1, 000 tones of oil spilled into river. The accident has had an impact on the marine environment and the aquatic river environment. There is evidence that oil coated the shorelines and spread out to form a thin layer that impeded the exchanges of gases with the water, and reduce the dissolved oxygen in the water that caused plankton and it poisons surface organism. Shorelines and the bottom of rivers were contaminated with oil and embedded in marsh to cause to die the bottom biological system. The effects of oil pollution on plants living close shorelines, canals were died.

After students ended their presentation about oil pollution in some areas in Vietnam, the teacher asked students to give a definition of gasoline and an explanation of the phenomenon of isomerism, as well as distinguish the difference in structure of cyclic, branched chain, and straight chain hydrocarbons in regards to boiling points and melting points.

After a ten minute break, the teacher asked students to read "Student resource #12" with the teacher, and after that students moved on to "Student resource #13" Before students had a discussion the teacher provided students with the "Student resource #14" for acquire more evidence of the fate of living thing from oil pollutions as well as the methods used to clean up oil spill.

After forty minutes for a group discussion, students' ideas presented in the class. A representative member of each group presented the solutions. They had the answer for the question #2 below,

Oil can affect organisms in the water, clogging the gills of fish, and respiratory passage ways of other marine organisms. Shellfish can die or become contaminated with hydrocarbons. Birds are particularly vulnerable to oil spills, and when their inner feathers are coated with oil, insulation is lost and they may die of exposure.

Oil that coats shorelines may persist for a long time, depending on the characteristics of the hydrocarbons, especially crude oil and tar residues that may remain embedded in beach sands or encrusted on rocks for months or even years. However, contamination of organism and products of commercial fisheries at sea have been transitory.

After this discussion the teacher gave the hint of the Vietnamese situation. For example; from the oil spill of the third of October, 1994, the damage of oil pollution caused 1, 787 hectares of rice fields and rice paddies to die. 11,000 ducks were coated with oil and died immediately after five days from the oil spill, and fisherman also reflected that the harvesting of crustaceans, molluscan shellfish and fish has been reduced from the effects of the oil spill. Throughout the discussion students realize that the oil pollution has influenced the long term production of crustaceans that concern with their life, especially students of engineering of sea-exploitation became more aware of the dangers of loading or unloading of oil from ships. In general, students understood that the oil spill disasters have affected not only the ecology and economy but also have been aesthetically disturbing.

Finally, students presented and discussed in the active classroom atmosphere the question #3 below.

Some methods used to clean up oil spill are skimming devices or absorbent materials of straw, ash, or plastic shaving, and detergents used to try to emulsify the oil. Most of the students disagreed with the use detergents for cleaning up because the

detergents are water soluble and toxic, and they caused the death of marine plants and animals in the areas of the spill. Moreover, detergents are used with larger massive quantities, so they can't afford to spend this on the oil spills. But students also studied and understood the way of cleaning up oil spills that Vietnamese people often do such as under the effects of temperature, evaporation, wind, bio-decomposition, concentration of oil in the water reduce more and more in consecutive days. However, the process of self-cleaning will occur over a long time, so people need to apply some suitable techniques for decreasing the concentration of oil in water as soon as possible such as mechanical treatments, physical-chemical treatments, and biological methods.

Lab activity #1 *Carbon dioxide*

To illustrate influence of the greenhouse gases to the global warming, the lab focuses on the carbon dioxide.

Student Objectives

Through a lab's activity, students can detect amount of carbon dioxide in the different samples by phenolphthalein indicator and measure the amount of carbon dioxide in the samples. This activity help students identify the presence of CO_2 in the atmosphere. This lab make concepts of greenhouse effect to become real and students can measure the CO_2 content that encourages immediate scientific problem solving.

Lab activity #2 *Acid rain*

Student objectives

Lab's activities give students an opportunity to compare the erosion of limestone and granite by acid and understand more the pH concept of solution.

Evaluation

Student comments make a valuable contribution for us to make improvements in both the material and teaching methods, and the evaluation of the study from formal and informal sides.

- Informal evaluation is recognized by its dependence on a casual observation of students' behavior, especially observation of small volunteer group discussions, class discussions, and presentation. Moreover, evaluation for the processes of learning and teaching also was reflected by the observer participant.
- Formal evaluation is recognized by its dependence on achievement tests of learning outcomes, the effectiveness of the environmental approach through reflection of students' essays, and assess the effect of environmental issues on students' understanding and attitudes change, a questionnaire survey provided feedback the result. This evaluation is presented in the next chapter.

Chapter 5
The results and analysis

This chapter presents the results of the study and analysis. The present results are five fivefold: (a) reflection of students' attitudes toward chemistry and interest in the environment before the class started, (b) to investigate attitudes toward chemistry with environmental issues and absorbed knowledge after learning, (c) presentation of results of mid-term test, (d) to examine how effective when environmental approach was integrated into curriculum chemistry throughout the reflection of students' essays, and (e) presentation of reflection and evaluation throughout the informal interview from the cooperating teacher.

Consideration was focused on attitudes toward the course because of their relationship to students' behaviors and learning achievement. If a student has a negative attitude then he or she would probably achieve less and his or her capacity to solve problems in chemistry with environmental issues may not develop.

Classroom observation, students' essays, and informal interviews from participant observer are also implemented for getting more evidence about students' attitude change and understanding level of knowledge change. Attention was also focused on academic achievement (midterm-exam with multi-choice question) because this would give feedback on application of environmental approach in teaching. If students achieve good results then the environmental approach should be paid more attention to in chemistry teaching.

Reflection of students' attitude and interest in environment at beginning of the classroom

I have investigated the students' responses before my teaching started as follows:

For chemistry: Some students like to study chemistry because chemistry plays an important role in the daily life, but most of students gave the same ideas that they do not

like to study chemistry very much. They explained that they studied chemistry because they had to study it for completing requested credits and they feel that chemistry does not stimulate them in learning because the principles, laws and the series of reactions and facts have to be memorized in a short time and that chemistry is a pure science.

For interest in environmental protection: and global issues

Two-third of students said that daily, there are reference on the television and radios as well as newspapers concerning the problems of pollution in the country, but in actuality they have no understanding of where pollution comes from. When answering how they could reduce the pollution, they responded that the simplest way is to just reduce garbage on the street and stop dumping the rubbish in the river and sea only.

Students heard from the radio and television that people have to protect our planet with clean air and with green color forever, but they think no longer about it. Students said that it is difficult to protect the environment because industry and agriculture is developing, motorcycle use continues to increase, and the population is expanding. These hinder efforts to protect the environment, while in the schools problems of environmental pollution have not been taught.

Students did not show an understanding of acid rain, greenhouse effect, and depletion of ozone layer. Some of students gave ideas of ozone depletion as having heard the ozone layer is being destroyed and is obtaining holes that in the ozone layer are occurring over the Arctic and ultraviolet radiation reaches the earth's surface that causes cancer for human beings, but they did not understand why ozone is destroyed.

To investigate attitudes

Fifty-one students participated with this survey. In questionnaire survey, students were told that they were allowed to answer with their alias. In order to avoid response bias, the seven scales were mixed together (Appendix E).

A questionnaire survey consists of the seven subscales below,

- Attitude towards chemistry.
- Attitude towards chemistry with environmental issues.
- Attitude towards environment.
- Attitude towards perception of teacher.
- Attitude towards anxiety of chemistry.
- Physical environment of classroom.
- Understanding knowledge.

The analysis of each specific item for every proportion of subscale (in percent) (Appendix F)

One way to look at the data is to combine the "strongly agree" and the "agree" categories to determine the percentage of students who agreed with a statement, and to combine the "strongly disagree" and the "disagree" categories to give the percentage of students who disagreed with a statement.

Attitude towards chemistry

Item # 3: A greatest proportion (96.1%) of students indicated that most of students realize that chemistry is a worthwhile and necessary subject in the school.

Item # 9: The result shows that students appeared to be more feeling toward chemistry after learning. Further investigation compared with at the beginning of the class, students appeared to show changes in attitude toward chemistry. However, there is 19.6 percentage of students who are ambiguous.

Attitude toward chemistry with environmental issues

Item # 13: The result of this statement shows that students have positive attitudes towards environmental chemistry, and they realize that this course is really necessary for everybody.

Item # 5: Comparison of the percentage of students exhibited more variation in the response patterns of students. This result indicate that 39.2% of the students do not realize that this course with environmental issues is not easy to learn. However, there is a smaller percentage of students that indicate that this issues course is easy.

Attitude toward environment

Item #1: The result shows that 96.1% of students have an awareness of environmental protection and they feel that it is pressing problems nowadays, however, only 3.9% of students are undecided in their action towards environment.

Item #2: Comparison of this result shows more variation in the response patterns of the students. When the "undecided" are 50 percent of students, this response reflected their real thinking, and it is difficult to say because students feel scared when life environment is polluted, but they are ambiguous in their action. It is difficult to stop their style of life because in Vietnam motor vehicles are popular in transportation. And there was 31.4 percent of the students disagreed the statement.

Item #6: This result may indicate that students are becoming aware of environmental issues that relate to human life. But 15% of students' responses exhibited their ambiguous feelings about statement, or, perhaps, they simply have not yet formed any opinion about environmental issues in magazines.

Item # 10: 74.5% of students' responses agreed with the statement. However, there is 19.6 percent of students who are ambiguous about the statement, perhaps the ambiguous actions reflect the real situation in Vietnam. Students have no power to close industries that

cause environmental pollution. But there is still 5.9 percentage of students who strongly disagree with the statement.

Attitude toward anxiety of chemistry

Item # 12: The result shows that there is variation between the responses given by students. It can be seen that more than 50% of students have a positive response, while 25.5 percent of students are ambiguous in thier decision, and about one-fourth of students' responses indicated that chemistry course make them feel scared.

Item # 16: 56.9 percent of students' responses about chemistry test do not make them nervous, the result suggests that these students felt comfortable and self-confidence in test exam. However, 37.3% of students were unable to make a choice. They may have ambiguous feelings about the statement, or, perhaps, they simply have not yet reached a decision, while there is 5.9 percent of students' responses which agree "Chemistry tests make me nervous".

Item # 20: Examining the percentage of students who chose the "disagree" and the " strong disagree" response, it can be seen that in the process of learning, students exhibited deeper thinking about studying problems, while 82.3 percentage of students' response disagreed with the statement. But the small proportion of the scores falling in the "undecided" response may indicate that the students are not sure how their mind is thinking about the statement of item.

Attitude toward perception of teacher

Item # 4: Only a very small percentage of students (5.9%) reflect feelings of ambiguity toward the statement and 92.2 percentage of students' responses agreed with the statement "My teacher listens to what I have to say". The result shows that the teacher expected that students wanted to share their ideas, and respects students' ideas.

Item # 7: The 86.3 percentage of students suggests that most students really pay attention when the teacher provides information. There is still small percentage of students (11.8%) undecided their behavior in the classroom. This percentage of students may indicate that they felt that sometimes they neglected to pay attention to what teacher asked them in the processes of learning or have not yet concentrated on what the teacher presented to them.

Item # 11: The result of 94.2 percent of students' responses shows that most of students agree the statement. This indicated that teacher behaved whole heartedly with her students, while fewer than 6% of students did not agree with the teacher's plan. This indicates that the teacher has a short coming in specific plan.

Item #18: The result shows that 100% of the students' responses agreed their teacher is waiting until students receive good information. This waiting is proper with student's ability in the process of learning.

Physical environment of the classroom

Item #15:The result of the 90.2% of students' response indicates that students agreed that the class atmosphere is attractive to them and they felt comfortable with new learning environment.

Item #17: 95.3% of students agreed that in the classroom there were enough valid resources for learning, but in fact there is a shortage of equipment for teaching. It is because this was the first time students have seen the overhead projector and copies of materials with environmental issues.

Understanding knowledge

Item # 8: The result of 72.6 percent of students shows that students agreed with the statement, while there are still students who did not agree with their increased knowledge of

environmental issues, but this is somewhat surprising given the result of 19.6% of the students were undecided about their knowledge increase or decrease.

Item # 14: Responses to this statement indicate that environmental issues helped them understand more basic concepts of chemistry. And item's response also shows that students are receiving information about environmental issues in their mind.

Item # 19: The result shows that 100% of students agreed that their knowledge exhibited an increase. Moreover, environmental problems helped them to understand the impact of chemistry on environment and they realized that chemistry is not separate from daily life.

Figure A: presents the mean for every specific item below.

Item	Mean	SD
1	4.51	.579
2	2.94	1.02
3	4.51	.644
4	4.37	.692
5	2.90	1.06
6	3.88	.952
7	4.29	.756
8	3.88	.931
9	3.88	.711
10	4.03	.894
11	4.15	.703
12	2.66	1.08
13	4.05	0.56
14	4.49	.579
15	4.25	.627
16	2.37	.774
17	3.90	.431
18	4.49	.505
19	4.58	.497
20	2.00	.600

Attitude toward chemistry

The mean scores of item # 3 tell us that the scores of distribution cluster highly around the mean of the scale, and that students agreed with the statement "Chemistry is a worthwhile and necessary subject". The statement suggests that chemistry plays a role in society. The mean scores of item # 9 are 3.88, indicating that the mean scores of distribution are somewhat dissipated around mean. But students still exhibit positive feelings towards chemistry.

Attitude toward chemistry with environmental issues

The distribution of scores of item # 5 do not cluster around the mean score, indicating that the study of environmental issues is not easy, while the mean score of item # 13 tells us that the distribution of scores clusters around the mean scale, indicating that students have the highest positive attitude.

Attitude toward environment

These mean scores of item # 1 and item # 10 tell us that the scores of distribution cluster around the mean, and that the students had more positive or "friendly" attitudes towards awareness of environmental issues, while the mean score of item # 2 of students exhibits that they are ambiguous in their actions. They may think that it is absurd to stop driving motor vehicles to move places. The scores of distribution dissipate, while the mean score of item # 6 has a little higher score, showing that they are less positive in attitude towards interest in magazine and articles that relate to the environmental issues. It is not a surprising response. In actuality, there is a shortage of materials that contain valid environmental issues.

Attitude toward perception of teacher

The difference in mean scores were not noticeable for "Perception of teacher" scale. These mean scores are very similar, indicating that students had quite positive feelings about teacher in general. These mean scores clustered around the positive mean.

Attitude toward anxiety of chemistry

The mean total scores for the "Anxiety toward chemistry" scale of students in item # 12 and item # 16 are basically the same, showing that the students feel confident in learning, and item # 20 indicates that students are more positive towards the study of environmental issues. This reflected that most students are always thinking about environmental issues.

Physical environment of classroom

This distribution of mean scores of item # 15 clusters around the mean, indicating that the students have higher positive attitudes toward chemistry. While the slight downward mean scores of item # 17 also exhibits the distribution of the mean score cluster around the mean, indicating that this scores also exhibited high a mean score.

Understanding knowledge

These mean scores are similar, suggesting that, throughout, environmental issues helped students to understand the concepts of chemistry and understand the relationship between chemistry and daily life. The students' understanding knowledge increase through the mean scores of item # 14 and item # 19 is basically the same. In addition, the mean score of item # 8 tells us that the distribution of the scores cluster less around the mean of scale.

Presentation of result of mid-term test

The test is administered as multi-choice questions (Appendix G) in which some questions were taken from Aron and et, al (1994), Leeming, and et, al, (1995), and the researcher. The test aimed at increasing evidence that proves that the reflection of students exhibited an increase after learning. The test consists of fifteen questions. The test was given after students learned three topics such as acid rain, greenhouse effect, and ozone hole. The test was a measure of background knowledge of learned environmental issues.

Figure B: The mid-term test results in which 49 students participated.

Question	Percentage of students that answered each question correctly
1	91.83
2	8.16
3	38.77
4	100
5	61.22
6	97.96
7	100
8	77.55
9	95.91
10	81.63
11	100
12	89.79
13	100
14	91.83
15	95.91

A list of the percentage of responses above indicates correct responses. Test scores generally confirmed that environmental issues went to students' mind and simultaneously, it reflects the existence of problem misconceptions. For example; answers to the third question revealed an interesting case which showed that responses were aware that most pollution of our water source is caused by human and animal wastes and emissions. Yet only 19 students chosen correct answer.

Looking at the result, I realize that any question that relates to the studying topics was correct such as:

Answers to question #1 showed 91.83 percentage of students chose correctly. Yet 8.17 percentage of the students chosen wrong answers, theses students do not think that burning coal for energy is problem of CO_2 emission into the atmosphere.

The responses to question #2 showed that a majority of student incorrectly assumed that phosphates are harmful in sea water because they cause cancer in fish. Only 8.16 percentage of students chosen the correct answer.

Question #4 revealed that the oxide responsible for causing acid rain is SO_2. 100 percentage of the responses answered correctly. Obviously carbon dioxide is not a main component of acid rain although rainwater always exists with this oxide (CO_2).

Question #5 indicated that 30 students answered correctly. Yet there were still 19 students aware of that greatest threat to the Earth's environment is nuclear power plant.

Questions #6 and #10 exhibited that students that understood most air pollution in the big cities comes from car and most of the lead in our air is caused by cars.

Question #7 revealed that 100 percentage of responses agreed that environmental problems of pollution are a threat to all living things in the world.

Question #8 revealed that a majority of students responded (77.55%) correctly that high octane gas do not reduce the pollution by motor.

Answers to question #9 showed that 95.91 percentage of students were aware that the non renewable resource is petroleum.

Question #11 deals with the greenhouse effect and revealed that students understood the concept of the greenhouse effect. 100 percentage of responses answered correctly.

Question #12, 13, and 14 deal with the concept of acid rain. Nearly 100 percentage of responses answered correctly, indicating that students understood the background in the topics.

Question #15 deal with "the rule of 90" for CFCs. 100 percentage of the students answered correctly, indicating that students had noticed the formula of Freon.

To examine how effective environmental approach was when integrated into chemistry curriculum

The effectiveness is reflected throughout students' essays which provided evidence for the study. Students were asked to write a 30 minute essay with the form of the hand-out (Appendix H) in the class on the last day to express their feelings about the new learning environment such as teaching method, attitude toward environment, a basic understanding, etc. Forty-three students attended the study, and eight students were absent. Throughout the students' essays the researcher looked for the students' feelings exhibited below

- Attitude toward environment
- Teaching method
- Attitude toward the teacher
- Knowledge
- Atmosphere of the classroom
- Students' suggestions
- Resource

Teaching method

In a traditional classroom environment, the teacher studies the materials, and organizes what is important in materials or textbooks, makes notes, finds examples and then presents information all on the blackboard. The students' role is fundamentally passive. Students' involvement is sometimes unnecessary as they sit more or less still, more or less paying attention to the teacher's presentation. Students feel constrained, bored in their attitudes in the traditional classroom. Sometimes students complain about how fast the teacher writes, and they complain that they don't know whether to try to keep up with copying what is on the blackboard or just quietly sit back and try to understand what the teacher presents, while the other students busily copy information into their notes.

That was how I taught before. Over the last term I have changed my pedagogy to a more student-centered approach, with a much greater emphasis on student activities. After teaching we found that most of the students liked to study under a student-centered model. Students realized that the new method helped them gain greater insight and knowledge not only into chemistry, but also into real-life environmental problems. In their own words:

> We like these this teaching strategies very much because we discussed and debated the problems in the middle of the class and commented on some ideas that related to problems. It is very interesting for me but I regretted that this course hasn't been integrated into the required University course curriculum. I realize that the materials and textbook are limited.
>
> I hope this course will be rapidly integrated into the curriculum because this course explains the causes and effects of environmental pollution. Before I myself haven't yet understood about global environmental issues but now, because of the opportunity Mrs. Nhi gave us by teaching these problems of environment, I have a basic understanding and I am very interested in these problems because it helps me how to protect environment without pollution.

Another student reflected that his results were better as compared with the old teaching method that had been used in previous courses:

> I realize that these new teaching strategies are important because this teaching method brought many interesting things into learning. I believe this

method should be applied throughout the school to promote better education.

Some of the students said that they also feel that they were free to exchange ideas and they also increased their knowledge, but the short duration of the class did not provide enough time for them to adapt to the new style. They are accustomed to teachers' notes and they suggested the teacher should give a summary of the answers to the problems presented in class that is easy to remember. One student writes:

> In the new learning environment I am really out of my element, and I think that it was the way of learning that made me nervous and worry. But this was only my first impression and after a few days I became familiar of this way. We realize that this learning environment was very good.
>
> Classroom discussion is the good way for everybody to participate because students can be free to give their ideas and debate the problems to come to solution. I realize that through discussions our ability to perceive and understand the problems was improved. I think class discussions should be maintained but in the classroom we also need the teacher to play the role of arbitrator for discussion and to the sum up discussions' ideas into a short summary for the students to get important knowledge of the topics.

We found that most of the students liked to learn with discussion because they realized that their ideas became clearer as they discussed them in class. Discussion helped them develop more confidence and exploit and absorb information from their classmates more effectively:

> Learning through discussion made me gain more knowledge from classmates and helped me realize the gaps in my own knowledge. On the first day I was embarrassed, shy and not bold but in the continued days I presented my ideas in the middle of the class, felt more confident, and I believed in my presentation more.

Attitude toward environment

At the beginning of the class most of the students did not yet know about global environmental issues, but after the course students acquired a basic understanding of environmental issues and understood the impact of chemistry on the environment. The

students appreciated the materials concerning environmental problems that were available to the class and expressed the need for these kinds of materials to be available to everyone, so that we all might understand the causes and effects of pollution. One student reported:

> This summer I registered for the chemistry course and I felt highly honored and very lucky to be taught with the new teaching method employed by Mrs. Phan thi Nhi. On the first day I felt comfortable when the teacher explained to us what environmental chemistry is and the new ways of learning. Before if I wanted to study chemistry course with good results I had to find my own materials. Textbooks in chemistry are difficult to find and there is a shortage of textbooks. But when I attended this course I had many learning resources such as written materials, video-tapes, and many pictures that pertained to the problems I had been studying. With this way of teaching we can discuss and understand right away in the classroom. In actually, the environmental chemistry I had been learning did not relate to the knowledge to prepare for my examination in the second year stage, but the knowledge concerned with environment was very important because it helped me understand more about the environment in which I am living. I understand the threat of pollution to the environment and I have an awareness of environmental issues that I did not possess before I took this course. I am really interested in environment and I enjoyed studying this course very much.

Some of the students studied environmental pollution but they didn't understand thoroughly the pollution causes for our living environment and how pollution is formed. Now they can explain those problems. In addition, students do not like to study alone any more. As one student reported:

> For long time some teachers taught about environmental issues in biological perspective but I just roughly understood. I hadn't yet understood how the environment is contaminated and the consequences of pollution brings to humans and the environment. For example, take the problem of acid rain. I knew it is oxides combined with water vapor to form in rain and fall down on the land, but I did not understand that this process of reactions occurs with every oxide released into the atmosphere! Through the new method from the teacher I realize that our learning had a good result. I felt comfortable every time I went to class. I think the most interesting activity was all of the students who discussed, exchanged ideas together and got to make scientific conclusions. It is not like before when every student studies by himself. That made me feel uncomfortable in learning. The discussion and debate helped us to exchange ideas.

Some students expressed that studying chemistry integrated with environmental issues helped them understand the relationship between chemistry and their daily life. Their awareness of the environment changed as a result:

> After I studied this course I realized that this course was not only to study the problem of chemistry related to the daily life but also to study the impact that chemistry has had directly and persistently on human existence. By studying chemistry with environmental issues I understand more about environmental protection, and understand that pollution is a visible threat to life in the present and in the future.

Another student said:

> The course in environmental chemistry provided me with necessary information about the damage and effect of environmental pollution. I and my friends tried to find out more other related problems and especially we are interested the causes and effects in order to find the best way to reduce the pollution that is one of the pressing problems we now face.

Teacher

The researcher and observer participant, in their roles as instructors, helped students understand how to solve problems, and helped them develop their own understanding of the problems in the environment and in chemistry. Teachers always addressed the problems that the students were having with topics of environmental issues, by clarifying and explaining, providing examples, or whatever else the teachers could do to help. In addition, we thoughtfully considered how to create a classroom environment with the repertoire of teaching strategies to stimulate and challenge the students to think and ensure an atmosphere where students felt free to express their ideas. Because this was the first time a chemistry course was taught, that was designed to integrate science-technology-society approach with environmental issues and new style of teaching strategy, we were very concerned with establishing a good rapport between the teacher and students in the classroom. Students felt free without fear of failure. The students also did not feel as much pressure to achieve, and did not worry about the result of their achievement. Moreover, the teachers always

respected the students' ideas and listened to student ideas. Sometimes the teachers could not only listen, but also mirror the ideas back to the students for more understanding.

The teachers' enthusiasm for teaching combined with the researchers' thirst for outcomes, as well as the effectiveness of integration of environmental issues in teaching, was evident in our reflections . The students reflected that they wanted to express thanks to the teacher for the whole-hearted help they received. As a student said:

> This is the first time the environmental issues were applied at Nha trang University of Fisheries. It was very attractive me, the researcher and cooperating teacher were enthusiastic and gave whole-hearted help to the students. I still liked the way of discussion, because I obtained more knowledge from my classmates as well as exchanged ideas with others. But after the debate the teachers should explain more.

Another said:

> Throughout the period of learning I was very happy. Thanks very much to the teachers who obtained the course of experimental teaching for us to attend this class. I would like this teaching method and integrated content to be used throughout the university system. I am highly honored to thank to the person who designed this new learning approach.

And some of the students said that they were very lucky to learn about these problems. Because many different students had not had a chance to learn about these topics, the students exhibited many thanks to the teacher:

> Last time we had a chance to absorb completely new knowledge that is very helpful for us. I think that there are still many Vietnamese students who have not had an opportunity to learn and read these articles. We thank you very much for providing information about the environmental problems around us and thereby increasing our understanding of these problems.

Students' suggestion

From the whole of the essays we realized that most of the students would like schools and universities to integrate environmental chemistry into the curricula of chemistry in order to equip students to live and operate in the future. Moreover, environmental

problems of pollution should be communicated to people who can reduce possible pollution, and they can stems home waste and from industrial waste from their activities. As students wrote:

> The problems of environmental pollution are important and of interest to the world. I think that we should integrate the program of environmental chemistry into teaching from high school to universities to educate and increase our sensitivity to environmental issues.

During the course, the time for teaching and learning activities was short. The students felt the need for more time for discussion and watching video-tapes that illustrate the problems. As one student said:

> I think that the new teaching strategy with environment increases the students' understanding but I have some ideas for improvement, namely to make more time for discussion and view more video-tapes. I also think that everybody needs to be aware of the problems of environmental pollution so they can reduce their actions that cause pollution. Vietnamese educators should print many books that are easy to read, everyone can be aware of environmental protection.

Classroom atmosphere

Classroom atmosphere is one of the important elements for stimulating student learning. As teachers of this course, we expected students to learn by reading the material, sorting through it, digging out what is important, and working on problems. After making notes of their difficulties in solving the problems, the students were expected to participate in classroom discussions on the questions to create their own dynamic learning. Because there are different degrees of attention among individual students and different behaviors toward the class activities, the teacher' role is also important too in encouraging student learning. The teacher's manner toward the students needs to be friendly and inviting, reducing student nervousness in the new learning environment. Students expressed in their reflections that the warm and friendly classroom atmosphere made them feel comfortable

and have self-confidence in front of classmates and the teacher. They commented on the lack of a heavy atmosphere that is common in the first days:

> In the classroom I felt that the classroom atmosphere was not heavy between teacher and students as before. I participated in more dynamic discussions, and all of the members in the class respected each others ideas. The teacher also participated in the discussions with us, which supported the comfortable atmosphere. Although at the beginning of the class the repertoire of teaching strategy such as discussion, presentation and debate seemed to me unsightly, it was only my sensation of the first day. The new learning environment helped me get more knowledge, that I understood better and remembered longer.

Another said:

> Before I passively absorbed knowledge from my teachers by listening. Sometimes I would like to say something in class but I was afraid or felt embarrassed because the teacher play important role as the center of the class. But at this moment I studied in the comfortable learning environment I saw that we are really the center of the classroom. I can present my own ideas in front of my classmates without shyness. That improves my ability to communication and to further my studies in the future.

Another student reported:

> Throughout the new learning environment I realized that the classroom atmosphere was comfortable and stimulated all of the members in the class because with this classroom environment the students were not passive, sitting quietly to receive information from the teacher. It was not a classroom environment where the teacher provides knowledge and students absorb it without finding anything out for themselves, but the opposite. In this course the students were active in learning and discussion and gave their ideas because this class was centered on the students, instead of teacher-centered. The role of the teacher was to act as a guide or facilitator.

Resources

Most of the students commented that video-tapes and over-head transparencies illustrated lively pictures of the problems that make them more stimulated to learn. They did not feel bored with familiar chalk and blackboard as before. Students also reported that students realized that through special equipment students find useful information of the problems in front of them for easy reference.

Obviously, a lively picture with colored transparency paper and video-tapes are necessary. Students reported that video-tapes and providing photocopies of topics helped them understand more. As a student said:

> Learning with video-tapes and overhead projector with transparency color paper helped us understand more real problems and perceive what was inherent in the textbook. Many of pictures in the video-tape and illustrations were easy for us to remember, and made a greater impression in my mind.

Another student said:

> The materials that presented the problems of acid rain, the greenhouse effect, the depletion of ozone layer, and oil pollution contained new information that was helpful for us. Before I learned chemistry with a little bit of environment but I did understand the nature and significance of the problems. These materials and the color transparencies stimulated me to understand thoroughly the problems in chemistry. Although I learned this course in a short time, I realize that my knowledge of chemistry in particular and other problems in society in general have improved very much as compared to before. And I think that this teaching approach should be applied more in schools.

As I introduced in Chapter One, I was accustomed to teaching in a traditional teaching environment in which students see schools as competitive. Grades are given comparing which students' scholarship are best, so students must compete with others. I would like to change this learning atmosphere. Students in the environmental chemistry course operated well in group discussions and presentations in order to achieve a learning goal. This result made me reconsider my teaching method all the more because these participants were the students who came from different faculties at Nhatrang University of Fisheries.

At first, I wondered if the teacher should always assign students to heterogeneous groups or should the students be allowed to choose their own groups. And then I decided to give my ideas to the classroom and we analyzed the advantages and disadvantages when students learn in different classes. After all, students said that they felt more comfortable working with those they already know, and this was the first time they operated in this new

learning environment. They wanted to be comfortable with the members of group that they would have to give their presentations to. I realized that the students preferred to work with their friends, and they may have refused to participate in a group that included some one they do not like. But the students also understood that they needed to exchange their ideas with all of the other students in order for us all to understand more. Near the end of the learning activities the students discovered that they can learn with and from many people, even those who seem very different from themselves, and the students also agreed that they have more knowledge or success in learning from other groups experience. As one student said:

> The discussion and presentation of every group was restricted but when the class concentrated on five discussion groups I liked this atmosphere very much because some problems that I and some my friends in my group had not found and had not understood other groups had already showed and modified.

Understanding knowledge

Learning activities consisted of reading articles and materials, discussion groups, class discussion, class presentation, and solving problems that were aimed at helping the students use their chemistry knowledge to solve related problems that closely connected with the student's life, along with helping students' understand more basic science concepts. Through the new approach the students developed communication skills, and were able to solve scientific problems as well as debate on the pros and cons related to a particular article. We hoped that through learning with different activities students would reinforce a positive attitude towards science in general and towards chemistry in particular. I was also hoped that integrating environmental knowledge would increase their ability to apply scientific principles to real life situations and increase their understanding of the basic concepts and principles of chemistry overall. Most students expressed in their reflections that their knowledge had increased about the environment and chemistry:

> Before attending this class I did not know environmental concepts such as the causes and effects of acid rain, the warming of the earth, and the depletion of ozone layer. There was some body who asked me, why does the temperature of the earth seem to increase? At that time I did not know how I could explain it to them but now I can answer that question. Depending on the environmental issues, I have got a basic understanding of that question as well as of global environmental issues.

Another student said that this knowledge is very valuable for students and they hope that this knowledge can be used in the future:

> Although when I began this course I had a little bit of knowledge about environment when I studied these topics that helped me accumulate lots of knowledge about environmental pollution, depletion of ozone layer, greenhouse effect, and acid rain.
>
> Everybody is interested in these problems because they are a visible threat to human life. For me this is valuable knowledge that I need to know and I need to consider in my life. I see that in the process of learning and living I will use this knowledge with a useful and effective result.

Participant observer's reflections and evaluation

After finishing the course on environmental teaching, the researcher and cooperating teacher had an informal interview. These questions were given in the form of hand-out (Appendix I), but in actuality, the researcher wanted to know how an environmental approach is evalued by the observer participant, as well as his feelings on this approach and his ideas on how to improve the course.

The conversation we had was relaxed and comfortable. I asked if he was excited about teaching these topics and he said that he was interested in the greenhouse effect very much because he had already read in Vietnamese magazines about this problem, but he still did not fully comprehend it. He could not visualize the word "greenhouse" and why scientists used this word. As he had never seen a greenhouse, he did not understand the concept.

Throughout the video-tape he saw a greenhouse and then understood why they used that analogy. Every topic covered in the course has different features because these topics concern global environmental issues and reflect phenomenon that occurs around us. He said that we should integrate environmental issues into universities and schools because environmental protection is not only environmentalists' responsibility but also teachers' too. We do not have up-to date information because there is a shortage of magazines, newspapers, and textbooks for up-to-date teaching. For example "the rule of 90" is very interesting and an easy rule to apply for CFCs, but there were his colleagues who asked him about the formula of Freon-12, and at that time he did not know how he could explain the chemical. He thought that in the process of teaching, it is good if we integrate the curriculum with problems that relate to real life.

The researcher also wanted to know how the observer felt when he participated in the class and taught basic chemistry with environmental issues. He said that during the first few days of the class he felt that students and himself were not familiar with the classroom climate and procedures, although the researcher presented the designed model of learning and teaching. But students and even the researcher were initially perplexed with class activities. As the course progressed students became familiar with this atmosphere and the researcher was able to be a good facilitator and students exhibited enthusiasm, and were actively engaged in class discussions.

He said we had an advantage in teaching this particular class because these students had a basic knowledge of chemistry that enabled them to understand more, and students were able to apply this knowledge of chemistry to understanding aspects of environmental issues. During the course, the researcher empowered students and the class became more student-centered model, and the students were more able to complete their learning activities.

Certainly, he realized that students exhibited an awareness of environmental issues, understood the concepts of chemistry and principles in chemistry and especially, they knew

how to use their knowledge of chemistry to explain the impact of chemistry on the natural environment.

In addition, students exhibited an increase in their ability to study independently. After every break time students said to him that throughout this course they received a lot of valid information and understood the nature of the phenomenon of acid rain, the depletion of the ozone layer, and the greenhouse effect. Students also reflected that if most teachers used the different teaching strategies, incorporating real life information with teaching, the students would be excited to learn and there would be more active learners as well.

However, students were still somewhat dependent on the old teaching methods of a teacher-centered classroom. For example, students wanted the assistance of the teacher in summing up the ideas after the discussion or the presentation. Also, there were still some students also did not respect others' ideas when their classmates debated.

And then, I wanted to know whether or not he would include environmental issues in his teaching, and would include real-life problems in his course curriculum. He said that this approach could be a cornerstone of his teaching. He felt there were many teaching strategies that would be relevant for him in his teaching. He also said that although this was the first time the environmental approach was used in an "experimental teaching course" we had been considering integrating environmental issues into the curriculum already because it is one of the pressing problems facing Vietnam today. Everyday radio, television, and newspapers cover environmental issues.

He thought that this presents a good opportunity to teach environmental issues in schools and universities. This integration coincides with the spirit of educational reform in the chemistry curriculum. He would like to recommend this course to everyone who studies chemistry. However, in order to institute a course in environmental chemistry he would like to suggest some more topics, such as treatment of discharged water from the sea-product processing factories and enterprises. He was especially concerned with the waste water treatment for rivers, lakes, and pools so fish and shrimp will not be adversely affected by

pollution. These concerns relate to students jobs in the future. However, he mentioned that lack of time is one of the obstacles of implementing environmental issues into the university curriculum.

In addition, the researcher wanted to know whether or not this repertoire of teaching strategies had influenced the observer's teaching strategies and also wanted to hear his comments on the teaching method used in this course. He said he applauded the teaching strategies I used, and believed I was successful because the learning environment was shifted from a passive one to an active one. He observed that students were really able to cooperate with each other and a friendly rapport was established between the teachers and students. Throughout the learning activities he realized that students liked the discussion groups as well as class discussions, and the debate resulted in an increased problem solving ability of the students solving problems. According to him, the strategy of discussion enhanced the basic knowledge that students acquired in the chemistry course, and helped students to avoid misconceptions. Simultaneously, students thinking skills and problem solving ability were developed, as well as their ability to work as a teamwork. Throughout this observation he was moved to change in his pedagogical approach and believed that this would improve the chemistry curriculum. He went on to observe that the students exhibited an increase every day in their communication skills and deeper thinking.

The researcher then wanted to know how valid he believed the resources were that were taught to students. Was it enough information, did it need to be updated and expanded? After that he said that these global environmental issues were completely new information in curriculum and a new area in education, but that I exploited useful and wonderful problems of environmental pollution that were up to date at that moment in Vietnam. Simultaneously, I knew to link learning and teaching science with real life. However, the model of discussion or presentation of the whole class would be convenient for a class of fifty students or less, but in a class over fifty it would be difficult to organize the class activities and be difficult to manage learning with a good result. In the process of

cooperative teaching we realized that students understood a knowledge of chemistry in issues much better now than students did before. Students thought patterns about the science of chemistry were changed through the real-life problem solving aspect of the class, and students left with a sense of being educated with the relevant purpose of studying environmental issues.

The researcher enabled students in this course. My teaching strategies and educational materials, such as the overhead projections with lively color pictures, were stimulating and made students want to learn chemistry more, the observer reflected.

In order to draw experience for teaching, I wanted to get more ideas for completing a separate course in the future for my teaching as well as for my colleagues, and suggestions of more topics that would be necessary and relevant. He said that he would like to suggest that we should collect and integrate more problems, such as hazardous household wastes and indoor air pollution into the topics presented and include field trips. Field trips stimulate student learning and are recognized as a teaching tool in education, and field trips can help students to fill in the gap which exists between lectures and real life. We should be familiar with the outdoors as a learning environment for understanding environmental issues more.

The summary of findings from the reflection and evaluation above

One of the data collections in conducting this study was a observer participant's reflection and his evaluation across the "experimental teaching course" with environmental issues.

Throughout the informal interview above, the different patterns of strength and weakness shown by the cooperating teacher correspond to the general evaluation and conclusions about the knowledge absorbed by students and pedagogical skills of the teacher.

Using the environmental approach helped to increase students' knowledge and awareness of chemistry of environmental issues as well as increasing students enjoyment of learning scientific concepts, and descriptive properties of chemical reactions.

When integrating the teaching of chemistry with the environmental approach, the teacher's behavior and pedagogical skill is the key to successful instruction. The teacher transferred knowledge and managed learning activities as a model by not only stimulating the thought processes of students but also by changing students' attitude towards the science of chemistry and towards environmental issues.

In general, the attitude and motivation of teachers and students are crucial. The attitude of the teacher was central to the success of interactions with students. Our motivation in the process of teaching was reflected in what we designed and taught.

Throughout his reflection, the pedagogical skills of the teacher were sufficiently well developed to enable the teacher to plan successful classroom activities, although planing was a very time consuming task. The problem of time is also one of the barriers to this approach. Findings from this reflection and evaluation exhibited the effectiveness of the environmental approach, the cooperating teacher confused the term greenhouse effect. He was surprised why scientist use this term. His curiosity was right because according to Miller (1982), the term of greenhouse effect is misleading, a greenhouse, or a closed car on a sunny day, not only trap heat energy, but also keep the warmed air from blowing away and carrying with it the added the warmth. Even though technically inexact, the use of this term is widespread.

- Students perceived the impact of chemistry on the natural environment and understood human's responsibility to the environment.
- Students understood the basic concepts in chemistry and the mechanism of chemical reactions that occur in the natural environment.

- Students improved their attitude toward environmental pollution and toward the science of chemistry.
- Students exhibited the dynamic learning activities and exchanged ideas together and erased the competitive atmosphere in learning, and exhibited a friendly atmosphere with teachers and classmates.
- The environmental approach provided a good opportunity for learning and teaching. It seemed to improve the quality of education.
- The articles, materials, and video-tapes selected from Canada were evaluated highly and were up to date, but there was still a lack of Vietnamese situations of environmental issues.
- The field trip for outdoor learning is a good teaching strategies and in the future is necessary to combine and develop as an integral part of the science curriculum.

In general, students, as well as the participant observer, welcomed the global environmental issues and the new teaching style very much, although there were restrictions in the teaching activities, as discussed above.

Teachers' role

In order to help the students not only achieve learning outcomes, but also develop problem solving skills as well as communication skills, the role of the teacher is very important. The teacher can be a model which students imitate when they do the work or solve the problems. Hence, the teacher's role differs with every class activity, but the teacher is responsible for creating a proper learning environment for students.

The teacher had to have unique strategies to develop classroom activities with problem solving overtones that would promote the learning outcomes. Some of the students reflected that group discussion was more effective than whole class discussion in promoting learning, while most of students realized that they liked to participate in the class

discussion because their classmates could present explanations or solutions that are embedded in the problems. But one of the more important roles the teacher provides is to stimulate students, keeping them active in problem solving and in developing the dynamics of the class activities. These are the reasons that made the teacher to be very careful to pose questions of the right difficulty, so students would not be too discouraged or confused and give up, yet still be stimulated to develop their problem solving abilities and actively participate in the class activities.

In fact students came into the class with various levels of knowledge. This made the teacher consider this problem in teaching. Although this decision was difficult, the teacher did not separate the scientifically gifted from the less interested students in the class. But fortunately, most of the students who participated in this study were volunteer students, so the students already had the ability to study independently. About a haft of the students took the environmental chemistry course to complete their credits.

The reflections from students showed that the classroom atmosphere was attractive and comfortable for them. In their feedback, students especially wanted the teacher to sum up the main ideas of the class discussions, as well students suggested that the teacher tell students the right or wrong, and the pros and cons, from the particular articles.

However, understanding of the students was not the same, not all students participated or were engaged in learning activities, and there were also students who did not focus on learning activities or seemed to not be comfortable with the new learning style. Some students kept quiet and did not share their ideas. The teacher responded by patiently encouraging students more, and gradually students became aware of their roles as learners. But the teacher seemed to be aware that most of students who were used to being assisted by teachers did not learn from books or materials without the assistance of the teacher.

Moreover, this was the first time environmental issues were integrated for students who were not chemistry majors. The teacher presented a plan that followed a format that

provided in the process teaching objectives, lesson outlines with the procedures, a list of resources, and sections for student evaluations of the class, and self-evaluation as well. The teacher guided students in determining which problems must or should be dealt with first, and in learning which methods could give the best solutions.

The teacher and cooperating teacher always encouraged students to ask questions and to express their ideas. Most students reflected through their essays that their communication has increased and their knowledge increased. However, some of the students felt less confident when they communicated in the middle of the class, but their feelings appeared on the first days only. In actuality, some females were still shy and felt a lack of confidence when they were involved the discussion.

Some of the students said that this was the first time they had studied in a learning environment with an overhead projector with many colored pictures which that helped them understand more and stimulated them in learning. I think that this reflection is true because most teachers rarely use that equipment for teaching.

I received feedback from the students that this course helped them to acquire an awareness of environmental protection and they believed would help them in their future jobs, such as an engineer of sea exploitation, to be more aware of how pollution is toxic to living things under water, harming the fish and shrimp resources; students intending to become engineers of sea product processing acquired an awareness of environmental pollution that is caused by waste discharges from food processing factories. Students especially developed an awareness of using coolants such as CFCs in freezers and refrigerator, and students studying to become engineers of marine aqua culture acquired awareness of water pollution that influences sources of fish, shellfish and shrimp.

In addition, the observer participant (cooperating teacher) commented that "student resources" were valid for teaching but he thought that there were not enough for the course and if I collected more resources concerning environmental issues and video-tapes that use Vietnam as a setting that would stimulate the students more. He was also said that as these

were the first students involved in a student-centered class, students exhibited the dynamics of learning and were excited to learn, although there were still some the students who had not yet changed.

In addition, students complained that the time given for learning activities was not enough. In an average week the students had to learn thirty hours without lab work and they had to prepare for the entrance exam at the second stage. They said that in a period of short time they had to digest much information, but fortunately, with the new learning environment they understood the curriculum more readily in class, rather than just reading articles and preparing at home. And students said that if the teacher gave assignments or exercises in chemistry to them, they may not be able to finish this work for the teacher because there was no extra time for learning and preparing.

In summary, throughout the results of the data analysis students exhibited positive attitudes toward science after learning chemistry with environmental issues, and an enjoyment in learning as they were very active in discussion groups, and class discussion. Throughout the activities, students had the opportunity to relate their knowledge of chemistry to explain or to solve real life problems. Students felt that they were playing an important role in a student-centered model. The "experimental teaching course" provided students with the opportunity to select and pursue problems of concern and interest to them, increasing their motivation and persistence to learn. As the learning environment shifts from a teacher-centered to a student-centered classroom, the role of the teacher changes as well.

Chapter 6

Conclusion, discussion, and implications

This study started from the purpose of rebuilding the educational system in Vietnam with high quality and effective educational innovations in curriculum. The Ministry of Vietnamese Education aims to improve the scientific and technological literacy of the Vietnamese citizenry. The researcher was interested in integrating environmental issues in teaching chemistry because at the moment environmental issues are pressing problems in Vietnam. The researcher realized that science education today is being urged to produce a citizenry informed and alert to the problems of environmental science. Although teachers in the Department of the Chemistry reflected upon integrating environmental issues in chemistry courses, they would prefer a separate course of environmental issues. Objectives include transmitting essential characteristics of particular discipline, connecting the subject matter to environmental issues, and providing a foundation for further study in the field of chemistry.

STS education is occurring in schools in the north America. It aims to help learners develop the capacities needed to participate as capable citizens to resolve STS issues that we face as individuals and as members of society. As indicated in literature review learners are most likely active in the resolution of STS issues.

The educational goal is what the school aims to accomplish for students and society, but today's students need to understand the interrelationship between people and that of daily activities that affect our planet and its resource. Knowing knowledge and its application can extend our capacity to alter what nature has created and also directly the way we live.

However, the global issues have not been recognized by Vietnamese educators in schools yet such as greenhouse effect, acid rain, and ozone depletion. Citizens feel difficult when facing issues arising from the interactions of science, technology, and human

activities every day of their lives, in areas such as environmental quality, waste management, energy consumption, AIDS, overpopulation. As a member of Vietnamese society, I realize that the integration of STS education, especially environmental education in Vietnamese schools at this moment is "better late than never."

The integration of environmental education in schools was examined as parts in the world were relevant to integrate into Vietnamese curriculum. I feel that the efforts has been successful through the result that will be discussed later.

I hope that this "experimental teaching course" can serve as a catalyst for instructors to initiate curriculum restructuring. Because the chemistry course for non-major science students involves a lot of information that is difficult for students to memorize in a short time. Students feel chemistry is difficult and they do not enjoy chemistry or see its value in their lives. With an environmental approach, however, students can better understand the concepts and principles of chemistry in the context of environmental issues that occur around them. In this study students were active and dynamic in a variety of learning activities, such as group discussion, class discussion, presentation, debate and problem solving.

Students were provided four topics of environmental chemistry and two lab sessions that concerned environmental issues in daily life. The goal of this approach is to develop students' critical thinking and problem solving skills raise their level of confidence in what they can accomplish, enabling them to take a broad view of environmental issues.

I attributed the results of learning activities included in this study to several changes in students' "active learning" of environmental issues.

First, the level of in-class participation increased from twenty students on the fist day to fifty-one students on the third day. This course became a selected course for students who wanted to complete their credits and for students who were eager to learn about environmental issues.

Second, although students perceived this approach to learning as a demanding course, they thought it was beneficial to combine relevant applications in the curriculum.

Third, students, faced with a problem, tried to tackle immediately the task of constructing a solution. They spent little time beforehand developing a description of the problem or planning a solution. Furthermore, they spent little or no time afterwards to assess whether the solution they found was correct. Nor did they try to extract from a solution knowledge that might help them to deal with problems. Students still tended to place a great emphasis on remembering and using various facts without trying to think more deeply about the problems. Accordingly, students may be able to answer questions with assistance of teachers. But throughout the processes of learning activities students gradually became accustomed to using related knowledge to plan a solution or check whether a solution made any sense.

In trying to solve problems, students paid much more attention to the solution than to the process. Thus, students were mostly interested in the answers to problems. After all, students gradually understand that the most important aspect of problem solving is the decision processes which leads to good solutions. Moreover, students were not accustomed to asking the teachers when they had difficulties or confusing problems and they revealed that small group discussion and class discussion motivated them more.

Finally, students' acquired knowledge improved through discussion and debate, although it was clear that students' problem solving skills were rather primitive. Students reported repeatedly that they preferred this teaching approach. Their improvement may have resulted from several factors, such as teaching strategies used by the teacher, new information of global environmental issues, video-tape and valid resources, classroom atmosphere, and the teachers' manner. Certainly, they were getting more help and practice in solving problems. Not surprisingly, students became more willing and able to tackle tough problems.

In general, this study reveals that problem solving ability is an important but difficult aspect of the chemistry learning process. Its acquisition depended not only on the knowledge possessed by the students but also on other relevant intellectual abilities. Problem-solving depends on both the knowledge required to solve the problems and problem-solving strategies.

The objectivities of the teaching approach were for students to acquire a basic understanding of environmental problems, interconnectedness of human and nature, basic science concepts in chemistry, and to take responsible action in the natural environment. The result in the survey revealed that 96 percent of the students indicated that environmental issues helped them to understand basic concepts of chemistry and the nature of problems in chemistry, and that environmental problems helped them to better understand the relationship between chemistry and daily life. Students understood the concept of redox-reaction, the rule of 90 for CFCs, the concept of the greenhouse effect, and how ozone depleting agents attack the ozone layer. Moreover, in the traditional teaching method, carbon dioxide is detected in the saturated calcium hydroxide as a precipitate of calcium carbonate from burning organic chemicals. The environmental approach helped students recognize the importance of carbon dioxide to life as we know it, as a small component of the atmosphere, but how in greater amounts it is threatening to life. CO_2 is also one of greenhouse gases. From the lab activity for determining the amount of CO_2 in air, students could identify a variety of environmental problems related to atmospheric CO_2. Throughout the lab activity, knowledge of chemistry helped them understand the relationship between the human and natural environment, and between theory in the discipline of chemistry and environmental issues.

Students' essays reveals that they were enjoying the class more and that their interest and enthusiasm for the subject had increased.

To asses the impact of the environmental approach on students' abilities to master concepts and develop critical thinking skills, mid-term and final examination results were

examined. The multi-choice questions revealed that students peformed well on the mid-term test, with little evidence of student misconceptions. The final examination was formed by the Chairman of the Department of Chemistry and myself. We concluded that students explained the questions with deeper thinking and were able to focus on specific problems to generate and implement their conclusions. The learners constructed their understanding, linking new ideas to what they already knew. In the written paper of the final examination, students showed that they could express their reasoning logically and carefully in developing solutions and drawing their own conclusions. The same was observed during class sessions, when debates were enthusiastic, and students were deeply involved.

It is important to know whether the environmental approach has a broad influence on student's attitudes toward environmental protection, or whether its influence is limited to the material covered class the findings for this objective were based on students' essays and the percentage of responses on the questionnaire survey. The result indicated that 96% of students agreed that they are interested in environmental protection. This is not surprising, because during the data collection period, there were daily references on radio, television, and in the newspaper concerning environmental pollution.

Simultaneously, from the essay students reflected that the environmental approach helped them realize causes and fate of pollution to the living environment, and that this approach has influenced their view of responsibility in action. About 75% of students expressed an interest in reading newspaper and magazine article related to environmental issues. It was surprising, however, that under one-third of the students indicated they would ride a bicycle to do their part in reducing atmospheric pollution. Indeed, most of the students felt it was wrong to ask someone to do this.

Students' essays revealed that topics such as "global warming" and the challenge of reducing the greenhouse effect were useful in educating students about responsible action and in developing awareness and sensitivity to current environmental issues. In general,

attitudes toward environmental issues were positive, and then the integration of environmental issues improved students' awareness of environmental protection.

At the beginning of this study, students declared that they studied chemistry because they had to learn for completing credits; chemistry did not motivate them because in the short time they had to remember many facts, principles and reactions. But through a period of one and a half months with the environmental issues approach and lab work, students changed in their attitude toward science. This conclusion was based on the results and the students' essays, which indicated that they were enjoying the class more, that their interest and enthusiasm for chemistry had increased, that they did not think of chemistry as a dry, boring course any more but realized that, with its real-life applications, was to motivate them in learning their studies were particularly exciting when they had debates and discussion. These reflections indicate that the role of students had changed. In this environment students were not passively to absorb knowledge, or rote learning with principles or laws. Instead, students were really dynamic and active in their role, such as reading articles, and identifying the researchable questions in solving problems.

The students' essays, the questionnaire survey, and the interview with the participant observer all indicated that the environmental approach had positive influences on students' attitudes toward science. Moreover, students also reflected in their essay that they were very lucky to learn about environmental issues and they would like to recommend this course to many science students because the environmental protection is not only environmentalists' responsibility but also every ones.

This study also investigated whether or not teaching strategies such as discussion and problem solving influenced students' abilities, and understandings in science. Observations of class sessions and student's essays revealed that students explored different approaches to solving problems and made their own decisions about the best way to approach the problems and environmental issues that relevant to their own lives.

Students became familiar with the discussion format in accordance with the problem solving method of Pizzini, as throughout every topic, students generated various questions and tried to find the evidence to convince and argue as well as defend their own ideas.

Although students still needed some assistance from the teacher, the finding show that new teaching method with discussion and debate appeared to be successful for learning about and discussing evironmental decision making. It also gave students an opportunity to practice scientific analysis of relationships and causes in a situation. Over 90% of the students indicated that they thought this teaching approach was very good, and they expressed their gratitude to me for designing the activities.

Finally, this thesis raised the question of whether or not the topics of global and local environmental issues have motivated students in learning and are valid resources in the current curriculum. The findings from the informal interview with the participant observer and students' essay revealed that these topics were evaluated highly in term of their educational characteristics. The resources used, such as video-tapes, were seen to be useful and valuable tools for teaching.

The chosen topics were in accordance with curriculum of chemistry. Only recently curriculum deliberation in Vietnam has included concern for environmental issues, and this study represents an "early attempt" to weave environmental issues into a university course in chemistry. These topics are aimed at educating today's students to understand our interrelationships with issues around the world and how our daily activities affect our planet and its resources. Over 95% of the students agreed that there were enough valid resources for learning about environmental issues in the Vietnamese context. Moreover, the cooperating teacher and other colleagues in the Department of Chemistry suggested that there could even be a separate course on Vietnamese environmental education.

Limitations

The researcher was the instructor of chemistry course in which this study took place and main observer. This may have affected students' behaviors in the processes of learning, and resulted in a bias in students' responses to their essays and a questionnaire survey (although in the questionnaire survey students were asked to use their alias for avoiding bias from the teacher). Most of questions in questionnaire survey were taken from Talton and Simpson (1986) and Gogolin and Swartz (1989). Only three questions of understanding knowledge scale were constructed by the researcher but these items were not pilot tested.

It would be interesting to examine the pretest survey of attitudes on a large scale to test its reliability, but this study has not collected sufficient data for this purpose.

It is very difficult to find appropriate resources in Vietnam for the study of environmental issues, even in the university and public libraries. Video-tape and other resources used in this study translated from English into Vietnamese for showing and reading. This is considered to be a minor limitation of the study.

In this study the student's attendance varied, only forty-four students agreed to sign their name in the consent forms for attending the class. However, in the questionnaire survey the number of the students was fifty-one, the number of students in mid-term and final examination was forty-nine, and only forty-three students wrote the essays to express their ideas in the classroom. This inconsistency in students'participation may have had a limited effect on the result of the study.

Finally, the study was conducted in a very short period of time. With more time, further information could be collected about particular environmental problems facing Vietnam.

Implications

Throughout this study students exhibited interest in and thirst for learning environmental issues.

It is desirable to integrate the study of environmental issues into the curriculum of chemistry, and to help teachers find out new approaches required for successful environmental education.

It is important to help students acquire awareness of environmental issues, to nurture as well as develop students' attitude toward chemistry, and to provide students with challenging learning experiences. In order to protect the sources of sea from pollution, and to avoid the risk of waste discharge from industry, I would suggest that a course on environmental issues be developed as an integral part of the chemistry curriculum. An environmental chemistry course should include other topics such as sewage treatment, indoor air pollution, hazardous industrial wastes, and hazardous household wastes. Perhaps such as a course would help students understand the relationship between chemistry and societal issues, as well as to further their understanding of concepts in chemistry, such as chemical quantities, the states of matter, and such practical activities as analyzing the presence of heavy metal in water or detecting cation concentration in the sea water.

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Appendix A

Instructional letter from researcher

Fellow students,

I am doing my Master's degree at Simon Fraser University in Canada on Science Education. I am interested in improving the quality of curriculum and new style of teaching and learning in a traditional teaching.

You will take some topics of environmental issues that consist of thirty hours of lecture including lab experiments. I will provide related materials concerning environmental issues.

The topics as acid rain, depletion of the ozone layer, greenhouse effect and oil pollution in which human activities are contributing to environmental pollution.

Through these topics science concepts, principles, and laws of chemistry will be presented and you will need to understand them in order to solve the related environmental issues.

Learning activities consist of reading articles and materials, discussion group, class discussion, and class presentation. The purpose of teaching and learning activities is to help you use your chemistry knowledge in order to solve related problems that closely connect with your daily life, and also for you to learn the basic science concepts. In addition, through new approaches in learning activities, you will develop communication skills, be able to solve scientific problems and debate the pros and con in the particular articles. Moreover, you are also expected to debate and to clarify your ideas and defend them.

These issues will help you to better understand human activities and their impact on atmospheric pollution.

In the belief that you can make good decisions when you use scientific knowledge to solve daily difficulties, your think of science will change after you have finished this course.

Whether my study that is successful or not depends on your contribution and your effort. I would like you to participate with me in this study.

I am looking forward to receiving your feedback from the questionnaire, expressions of your opinion, participation in active discussion which are designed in appendix.

Data will be obtained from your contribution and the effort you make in learning will reflect the effectiveness of the curriculum, and simultaneously, will effect the teaching strategies for science students learning.

Thank you very much for your contribution. I hope that you will be fruitful in your learning.

Nha Trang September, 1996.

Phan thi Nhi

Appendix B

I. Consent form for attending the study from students

I am pleased to participate in the study with the title "A study of chemistry teaching with environmental issues at Nhatrang University of Fisheries is conducted by Ms. Phan thi Nhi.

I understand that the purpose of study is to apply and evaluate a new teaching and learning model in higher education in term of its effect on students. The researcher presented to the participant as:

The participant will remain anonymous and the identification of the research data will remain confidential.

- The participant can request a copy of the study results from Dr. Allan Mackinnon at SFU (604-291-3432).
- If I have any concerns or complain can be forwarded to Dean Robin Barrow, Faculty of Education (604-291-3395).
- And Ms Nhi presented that in the study participation is voluntary and that the participant can with draw at any time during the study without consequence.

I am pleased to participate class activities as teacher's outlines consist of group, class discussion, presentation and debate in the classroom and I am ready to participate what I can do for her research.

I check blank below in my position.

* I agree to let my teacher takes the class activity's picture. ☐

* I agree to let teacher take the group discussion pictures . ☐

* I am ready to answer the questionnaire survey in the instructional outline. ☐

I also understand that this study is to make an atmosphere in which the rapport is established between teaching and learning and between teacher and students. I understand that I can contact with teacher if I do not understand. If I have any question without making sense I are encouraged to ask questions or suggest related learning problems to the study. Moreover, I understand the data that obtained relates to exact information. I also understand that If I do not want to participate any more I can withdraw from the study.

Signature of the attended student Date

Signature of the teacher Date

Appendix C

Classroom guideline of observation.

A framework for a class observation in following questions:

Classroom atmosphere:

1. How does the teacher make some the rapport to be established between the teacher and the students when the teacher conducted learning activities and lab work?
2. How does the teacher organize the class into group discussions with comfortable teaching and learning activities that are suitable with SSCS tool of problem solving method?
3. Is it informal classroom? Do students feel free and comfortable when they attend the class? Is it friendly atmospheric classroom?

Role of teacher

1. How does the teacher guide the classroom activities?
2. How does the teacher help students when students are still too shy or are not bold enough to give their ideas? How does the teacher give the overtone and encouragement?
3. How is the teacher's attitude when students have suggestion or ask questions? Does the teacher listen and respect students' ideas when they speak?
4. After students finished their class discussion, the teacher summarizes and analyzes what they debated and clarifies for helping students understand more?

Attitudes and Behaviors of students in learning

1. How does student listen his or her teacher and his/her classmate?
2. Students help to each other when his/her friends without immediately understand the issues? Is it right under the team work? And how do their attitude present their ideas in term of self-confidence, communication skill?
3. What is related information that students present their point of view? Do students always use the materials for inference of the problem?

Appendix D

Guideline for discussion

You are always reminded that issues that are debated in the processes of discussion concerned with studying topics and you are always encouraged to give the wrong or right answers on scientists' articles with pros and cons.

You are really encouraged to give your ideas to the class. You are always filled with enthusiasm to investigate studying environmental issues in yours local or your interested issues to outline. Moreover, you are encouraged to discuss under class activities with team work for solving problems in lectures and lab by SSCS cycle. Simultaneously, you should investigate opinions that may be concerned with the trend: social science and issues concern national boundaries as the basic information that sustain to make decision, or choose the best solution for issues in your point of view.

Procedures in solving problems to go making-decision.

1. Recognition of issues.
2. Assemble facts and determine the needed information for making-decision.
3. Identify where can obtain the information (newspaper, magazine, and from the media).
4. Analyze and evaluate received information with different perspective in order to make decision.
5. You will be involved in group, class activities, and lab activities with discussion. You are encouraged to express your own ideas and exchange your ideas freely in the class.

Appendix E

A questionnaire survey

Items of a questionnaire survey for students' Attitudes toward environmental protection, science, class, and teacher, physical environment of classroom, anxiety toward chemistry and understanding knowledge after learning with environmental issues.

Please, read each question and decide to what extent your agree with it by giving score each item.

5. If you strongly agree.

4. If you agree.

3. If you undecided.

2. If you disagree.

1. If you strongly disagree.

I hope that your responses will help me to understand the way you are thinking about environment and related things as well as absorbed knowledge.

	SA	A	U	DA	SDA
1. I am interested in environmental protection because environmental pollution is one of pressing problems in our country now.	❑	❑	❑	❑	❑
2. I would be willing to ride bicycle, to move places in order to reduce air pollution.	❑	❑	❑	❑	❑
3. Chemistry with environmental issues is a worth while and necessary subject.	❑	❑	❑	❑	❑
4. My teacher listens to what I have to say.	❑	❑	❑	❑	❑
5. Students consider this course with environmental issues easy.	❑	❑	❑	❑	❑
6. I often read articles and magazines about environment.	❑	❑	❑	❑	❑

7. Most students in this class really pay attention what the teacher is saying. ❑❑❑❑❑

8. My knowledge has increased about global environmental issues. ❑❑❑❑❑

9. I have good feeling toward chemistry. ❑❑❑❑❑

10. Industries that produce air or water pollution is affecting the health of humans or animals should be immediately closed and should remain closed until a way is found to stop the pollution. ❑❑❑❑❑

11. My chemistry teacher makes good plan for us. ❑❑❑❑❑

12. It scares me to have to take a chemistry course. ❑❑❑❑❑

13. Everyone should learn about environmental chemistry. ❑❑❑❑❑

14. Environmental issues help me to understand more basic concepts of chemistry and nature of problems in the chemistry. ❑❑❑❑❑

15. I consider our chemistry classroom attractive and comfortable. ❑❑❑❑❑

16. Chemistry test makes me nervous.

17. Our environmental chemistry classroom contains a lot of interesting equipment and valid resources. ❑❑❑❑❑

18. My teacher expects me to get good information of environmental issues. ❑❑❑❑❑

19. Environmental problems I am studying make me to understand more the relationship between chemistry and daily life. ❑❑❑❑❑

20. My mind goes blank when I am learning environmental course. ❑❑❑❑❑

Appendix F

Proportion (in percent) of the class A2. Choosing each response option of the survey.

Variables	SA	A	U	DA	SDA
Attitude toward chemistry					
3. Chemistry is a worthwhile and necessary subject.	56.9	39.2	2.0	2.0	
9. I have good feeling and enjoyment toward chemistry	13.7	64.7	19.6		2.0
Attitude toward chemistry with environmental issues.					
5. Students consider this course easy.	9.8	15.7	35.3	33.3	5.9
13. Every one should learn about environmental issues.	5.9	94.1			
Attitude toward environment					
1. I am interested in environmental protection because environmental pollution is pressing problem in our country now.	54.9	41.2	3.9		
2. I would be willing to ride bicycle, to move places in order to reduce air pollution.	11.8	7.8	49.0	25.5	5.9
6. I often read articles and magazines about environment.	25.5	49.0	15.7	7.8	2.0
10. It upsets me when people dump garbage in the rivers or ocean.	35.3	39.2	19.6	5.9	

Attitude toward anxiety of chemistry					
12 It scares me to have to take a chemistry course/	5.9	17.6	25.5	39.2	11.8
16. Chemistry test make me nervous.		5.9	37.3	45.1	11.8
20. My mind goes blank when I am learning environmental issues.			17.6	64.7	17.6
Attitude toward perception of teacher					
4. My teacher listens to what I have to say.	47.1	45.1	5.9	2.0	
7. Most students in this class really pay attention what the teacher is saying.	45.1	41.2	11.8	2.0	
11. My teacher makes good plan for us.	27.5	66.7		5.9	
18. My teacher expects me to get good information of environmental issues.	49.0	51.0			
Physical environment of the classroom					
15. I consider our chemistry classroom attractive and comfortable.	35.3	54.9	9.8		
17. Our environmental chemistry classroom contains a lot of interesting, valid resources and enough equipment.	3.9	82.4	13.7		
Understanding knowledge					
8. My knowledge has increased about global environmental issues.	25.5	47.1	19.6	5.9	2.0
14. Environmental issues help me understand more basic concept of chemistry and nature of problems in chemistry.	52.9	43.1	3.9		

19. Environmental problems I am studying make me to understand more the relationship between chemistry and daily life.	58.8	41.2

Appendix G

Knowledge for the mid-term examination

Students are asked to answer the multiple choice questions by circling the right question.

1. Burning coal for energy is a problem because it:

a* releases carbon dioxide and other pollutants into the air.

b. decreases needed acid rain.

c. reduces the amount of ozone in the stratosphere.

d. is too expensive.

e. pollutes the water in aquifers.

2. Phosphates are harmful in sea water because they:

a. cause cancer in fish.

b. stop reproduction in fish.

c. make the water cloudy.

d* suffocate fish by increasing algae.

e. make fish nervous.

3. The most pollution of our water sources is caused by:

a. dams on rivers.

b* chemical runoff from farms.

c. methane gas.

d. emissions from in the sewers.

e. human and animal wastes.

4. Which is most responsible for creating acid rain?

a* sulfur dioxide.

b. carbon dioxide.

c. ozone.

d. nitrogen.

e. ultraviolet radiation.

5. Which of the following is the most dangerous to the Earth's environment?

a. damming rivers.

b* overpopulation.

c. household activities.

d. nuclear power plant.

6. Most of the lead in our air is caused by:

a* cars.

b. industrial plants.

c. airplanes.

d. incomplete burning.

e. cigarettes.

7. Environmental problems are a threat to:

a. mostly people in small countries.

b. only people who live in cities.

c. only wild animals and endangered species.

d. mostly tropical plants and animals.

e* all living things in the world.

8. Which of the following does not do much to reduce the pollution by automobiles:

a. properly tuned engine.

b* high octane gas.

c. low lead gas.

d. smog control devices.

e. propane engines.

9. An example of nonrenewable resource is:

a* petroleum.

b. trees.

c. ocean water.

d. sunlight.

e. animals raised for food.

10. Most air pollution in our big cities comes from:

a* cars.

b. jet planes.

c. factories.

d. big cars and trucks.

e. landfills.

11. On a sun day when your car's door and window are closed. It is often hotter inside your car than outside mainly because:

a. the sunlight gets in while the outgoing energy can not pass back through the glass.

b* the sunlight gets in and warms the inside of your car while the cooler outside air can not mix with the warmer inside air.

12. At what pH do certain fish stop breeding

a. pH < 5.6.

b. pH < 6.

c* pH < 4.5.

d. pH < 4.

13. Rainwater is called acid rain when it has pH

a. pH < 4.6.

b* pH < 5.6

c. pH < 6.

d. pH <7

14. The content of Al in acid rain is enough to cause fish die

a. 0.5 ppm.

b. 1.0 ppm.

c* 2.0 ppm.

d. 1.5 ppm.

15. The specific formula of CFC-131 is

a. $C_2H_2Cl_4$

b. $C_2H_2F_2Cl_2$

c. $C_2HF_3Cl_2$

d* $C_2H_2FCl_3$

Appendix H

Guideline for writing essay

This essay can be used to express your feelings about what you learned in the new learning environmental chemistry such as teaching strategies, class activities, and content as well as teacher's behavior, and your suggestion. In order to help you write the essay without bias from the teacher, you can use an alias for expressing your true opinions and feelings.

Appendix I

Framework as guideline for observers

(This framework is used for informal interview)

Feedback on observation of the class and the lab activity:

1. Which topics are you the most interested in or less interested in? Why?
2. Could you please appraise your class observation:
   - Classroom atmosphere.
   - Classroom management.
   - Students' attitude when they participate in the class.
3. How useful do you think the ways of students' learning?
4. How do you evaluate this learning model? Can this kind of learning activities continue and develop in another discipline?
5. Have you had any suggestion in learning activities?
6. How do you evaluate this new teaching method?
   - content for lab and lecture.
   - Teaching strategies
   - Video-tape, transparency papers, and articles.
   - Students-centered model.
7. Through your observation on environmental issues, do you intend to integrate these problems in your teaching?

Appendix K

Lab activity

Lab activity #1 ***Carbon dioxide***

The design of lab activity

Students collect four samples of gases in balloons as sources: ambient air, exhaled air, automobile exhaust, and nearly pure CO_2 from a vinegar and baking soda reaction.

Theses gases have been forced through cold dilute sodium hydroxide solution with phenolphthalein indicator solutions and watch for changing from pink to clear color that indicates the presence of carbon dioxide.

Students are asked to compare the amount of CO_2 in four different sources of CO_2 gas by observing the changes of color indicator.

Collecting samples

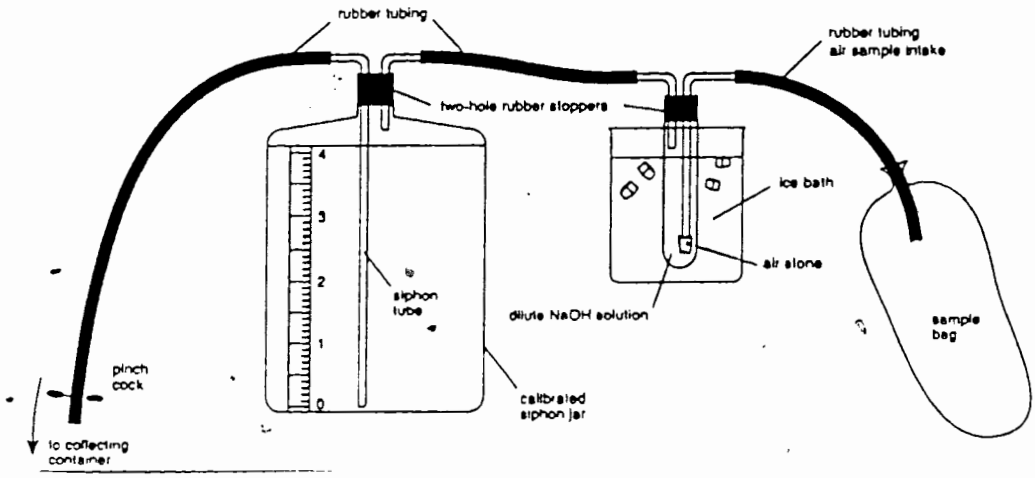
a) Sample A (ambient air): Use a bicycle pump to inflate a balloon to the required diameter. Twist the rubber neck of the balloon and fasten it shut with a twist tie Record the color of the balloon used for this sample.
b) Sample B (human exhalation): One team member should blow up a balloon to the required diameter (the continue step is similar above).
c) Sample C (nearly pure CO_2): Put 100ml of vinegar in the barrow-necked bottle. Using a funnel put 5ml of baking soda into the bottle. Let the mixture bubble for 3 seconds to drive the air out, then slip the balloon over the neck of the bottle.

Inflate the balloon to the proper diameter. Twist, tie, and record the balloon color.

d) Sample D (motor): To fill a balloon with motor vehicle exhaust, place the balloon over the narrow end of a metal funnel and place the wide end of the funnel over the exhaust pipe of a running car. Students should wear thick gloves at all times because exhaust pipes can be hot enough to give severed burn. When inflate the balloon should be about 8cm in diameter the balloon color.

Apparatus

This apparatus is based on Keller's design (1994), p.20.



This apparatus consist of

- A 100ml test tube in an ice water bath to ensure that the dilute NaOH solution is cold
- A two-hole stopper is placed on the test tube
- A tube extending to the bottom of the test tube is placed through one hole of the stopper
- An aquarium air stone is attached to the tube (the air is used so that small bubbles of air will aid the dissolving of the carbon dioxide into the solution
- A short tube is place through the second hole of the stopper
- A gallon jar with two-hole stopper can be used as the calibrated siphon jar. The jar is calibrated by adding 100ml of water at a time and marking the level of the water on the side.
- A siphon tube extending to the bottom of the jar is placed through one hole of the two-hole stopper. A rubber tube is extended from the siphon tube to the bucket.
- A pinch cock is placed on the rubber tube to control the siphon flow.
- A short glass tube is place in the second hole of a two-hole stopper.
- A rubber tube is attached from this tube to the short glass tube in the test tube.

<u>Supplies of requirements for each team of four students</u>

- Four balloons of different colors
- Four twist ties
- A narrow-necked bottle
- 100ml vinegar

- 5ml baking soda
- NaOH 0.01 N
- Distilled water
- Phenolphatalein

The techniques is implemented for measuring CO_2 content in air

The calibrated siphon jar is filled with tap water. The siphon is initiated and allowed to function until the level of water in the siphon jar is at the top reading of the calibration. Two ml. of 0.01 normal NaOH and phenolphtalein are added to cold distilled water to make approximately 10 ml of solution (this solution is used for four samples of human exhalation, ambient air, pure CO_2, and motor vehicle). The test tube is placed in the ice water bath. The rubber tube is placed in the balloon containing the samples.

The process is initiated by opening the pinch cock on the siphon tube. The water removed from the siphon jar is replaced by an equal volume of air that has been forced through the lager test tube containing the NaOH solution. The air sample is permitted to bubble through the air stone into the NaOH solution. The process continues until sufficient CO_2 has been dissolved in the solution to neutralize the NaOH and turn the phenolphtalein clear. When this occurs the pinch cock on the siphon jar marked and the volume of water siphoned is calculated. This should equal the volume of air that bubbled through the apparatus.

Footnotes references

a) The greenhouse effect in a vial by Richard Golden and Cary Sneider Science teacher, vol. (56), p.57-59, May 1989

b) Investigating carbon dioxide by J. David Keller Science teacher, vol. (61), p.18-21, November 1994.

Lab activity #2 **Acid Rain**

Influence of Acid on Different Rocks

Materials: 3 beakers either 400 ml or larger

crushed limestone

crushed granite

acid solution

pH paper

Procedures:

1. Label the beakers 1, 2, and 3.
2. Put 300 ml of acid solution (teacher provides) in beaker 1. Test the pH of the acid solution, record the pH.
3. Put 300 ml of acid solution and 100 g of crushed limestone in beaker 2. Test and record its pH.
4. Put 300 ml of acid solution and 100g of crushed granite in beaker 3. Test and record its pH.
5. Predict what the pH will be in each beaker for consecutive days. Daily, test and record the pH for each beaker.

Footnotes references

1. Teacher's Resource Guide on Acidic Precipitation with laboratory activities by Barrow, L. H. (1983)
2. Combining gases in classes by John C. Hugo (1993). Science teacher, vol 60, 26-29.

Experiment

Report sheet

Determining the CO_2 content of different samples

Name

Date

Group

Data and observation

Sample	Time for changing color	Volume of gas analyzed	Volume of NaOH	Moles of NaOH	Moles of CO_2	Concentration of CO_2
Ambient air						
Human exhalation						
Nearly pure CO_2						
Motor exhaust						

Questions for report

a) Analyze the color change of phenolphtalein indicator in the samples.

b) Compare and explain the amount of CO_2 gas in different samples.

c) Write all of the reactions and calculate concentration of percentage of CO_2 in all of the samples.

Experiment

Report sheet

Influence of acid on different rocks

Name:

Date

Group

Beaker		Test the pH of solution
1	300ml of acid solution	
2	300ml of acid solution and 100g of crushed limestone	
3	300ml of acid solution and 100g crushed granite	

Interpretations

a) Which beaker was the most acidic? Least acidic?

b) Assume that each beaker was a lake basin: Which lake basin was the least affected by acid rain? Why?

Back ground chemistry for lab activity # 1

Reaction of vinegar with baking soda occur below,

$CH_3COOH + NaHCO_3$ --------> $CH_3COONa + CO_2 + H_2O$

For analysis of four different samples such as ambient air, human exhalation, automobile exhaust, and nearly pure CO_2.

These samples are draw through a known concentration of cold sodium hydroxide (NaOH). Phenolphthalein is a acid base indicator that is pink when solution is base and changes to clear when solution neutral or acidic. Carbon dioxide (CO_2) in sample combines with water in cold dilute sodium hydroxide solution making the following reaction

$CO_2 + H_2O$ ------> H_2CO_3 (1)

H_2CO_3 reacts with NaOH below,

$H_2CO_3 + 2NaOH$ -----> $Na_2CO_3 + H_2O$ (2)

When solution containing phenolphtalein indicator changes from pink to clear color. This proved that NaOH is consumed. By measuring the volume of the specific sample draw through water, the percentage of CO_2 can be calculated.

As equation (2) above, one molecule of H_2CO_3 reacts with two molecules of NaOH.

At standard temperature and pressure (O°C and 760mmHg) one mole of gas occupies a volume of 22.4 liters. The concentration of CO_2 in every sample is calculated through the moles of NaOH used. Moles of CO_2 reacting with the known quantity of NaOH can be calculated equation below,

Moles of NaOH = volume of NaOH is multiplied by its normality.

$$\text{Moles of } CO_2 = \frac{\text{Moles of NaOH}}{2}$$

The concentration of the CO_2 in every sample can be calculated below,

CO_2 = Moles CO_2 x 22,4 liters

Volume of gas analyzed

After that the concentration of CO_2 is multiplied by 100 to give percentage CO_2 in the sample.

Back ground chemistry for lab activities # 2

Influence of acid on different rocks

Assume that each beaker was a lake basin. Which lake basin was the least affected by acid? Why?

If the lake basin has a limestone bottom, very little damage occurs because calcium, magnesium carbonates that make up limestone neutralize the acid. The equation occur below,

$$CaCO_3 + H_2SO_4 \text{ ------> } CaSO_4 + H_2CO_3 \rightarrow CO_2 + H_2O$$

$$MgCO_3 + H_2SO_4 \text{ ------> } MgSO_4 + H_2CO_3 \rightarrow CO_2 + H_2O$$

While the lake basin that contain granite or clay is nonlimestone substrates. Granite and clay do not contain carbonates and do not have the capacity to neutralize acid. If the lake basin has low pH (< 5) that cause aluminium-based clay and granite compounds to break down and release aluminium ions. Both the free ions and aluminum hydroxide are harmful to living thing in the water.

Appendix L

Student resource 1

Video-tape: Acid rain

(Length: 28 min., produced year 1984)

Notes: Look at the impact of acid rain precipitation forest, water and wildlife graphs, map and scientific experiments serve to examine what acid rain is, where it originates and how its insidious advance threatens not only the natural life around us but the man-made environmental as well.

Student resource 2 Vietnamese article

A threat to life environment : Environmental acidification

From Thiem, N. (1990), Number 22, p.

Công cuộc công nghiệp hóa mặt mặt cho phép đáp ứng những nhu cầu ngày càng nhiều của nhân loại, như giải quyết vấn đề đói nghèo, việc làm, giảm gia tăng dân số v.v..., mặt khác lại làm nảy sinh những vấn đề mới có hại như làm ô nhiễm môi trường, do nhiều sản phẩm phụ độc hại của công nghiệp gây ra. Ở bài này chỉ nêu vấn đề axit hóa môi trường.

Từ những quan sát ban đầu (đầu những năm 70), người ta đã thấy những cơn mưa axit đã ảnh hưởng đến những miền rộng lớn ở châu Âu và Bắc châu Mỹ. Ở Crecôvi (Ba Lan) những mặt tiền nhiều trạm trổ đẹp của những công trình xây dựng lịch sử bị hủy hoại do tác động của loại « chiến tranh hóa học » này. Những cơn mưa axit, cả những nhân tố độc hại khác trong không khí đang tàn phá quá khứ cổ điển của Hy Lạp, tấn công đá cẩm thạch ở những công trình vô giá như Pactênông ở Aten.

MỐI ĐE DỌA CUỘC SỐNG : SỰ AXÍT HÓA MÔI TRƯỜNG

Thiên nhiên cũng không được tốt lành hơn. Ở Thụy Điển một trong những nước bị tác động nhất, 20.000 hồ (trên 90.000) bị axit hóa, trong đó có 4000 hồ hoàn toàn không còn cá. Ở Na Uy, các chính quyền khẳng định rằng trên 13.000km2 hồ là nước « chết ». Ở phía bên kia Đại Tây Dương, các nhà bác học Mỹ cho biết rằng hàng nghìn hồ trong những núi Adirondac bị axit hóa đến nỗi thực sự trở thành những « nghĩa trang » cá. Ở Tân Écốt có 9 con sông không còn cá hẳn.

Con « mưa axit » là một trong những nhân tố chính gây ra « chết rừng » hiện tại ở 7 triệu hecta rừng (tức 14% tổng số) ở 15 nước châu Âu. Mưa axit đã làm hư hại 52% rừng ở Cộng hòa liên bang Đức. Ở Thụy Sĩ, miền Anpin trung tâm, rừng bị phá hoặc hư hại nặng đến 40%. Các nhà chức trách Thụy Sĩ lo ngại rằng việc làm giảm thảm rừng kéo theo những trận lở núi và thiệt hại nhân mạng. Ở Bắc Mỹ dọc theo suờn dãy Apalasơ từ Giôocgi đến Tân Anh Cát Lợi một sự hủy hoại tương tự đã làm những cây thông đỏ chết. Những trại súc vật ở Đông Canađa cũng bị hại do đất bị axit hóa.

Ở Trung Quốc nhiều miền quan trọng bị ngạt thở dưới cái vòm khí quyển ô nhiễm, do sử dụng quá nhiều than làm chết đất. Ví dụ năm 1982, Trung Quốc đã dùng 450 triệu tấn than làm chất đốt (74% tổng số năng lượng tiêu thụ). Mỗi năm các nhà máy tung vào khí quyển khoảng 17 triệu tấn axit Sunfuric, đồng thời khoảng 23 triệu tấn một khói và bụi. Thành phố bị ô nhiễm nặng nhất ở Trung Quốc—có lẽ cả toàn thế giới—là Benxi, thuộc tỉnh Liaoning. Thành phố này với hơn một triệu dân có khoảng 400 nhà máy thì một nửa số này làm ô nhiễm khí quyển : hàng năm phóng thải thải 210.000 tấn khói và bụi vào không khí, cả 67 tỉ mét khối khí ô nhiễm. Vài năm gần đây, Benxi chìm ngập trong một tấm màn che ô nhiễm khí quyển, đến nỗi dường như Benxi không còn nhìn thấy mặt trời và người ta cũng hoàn toàn không nhìn thấy Benxi trong những tấm ảnh chụp từ vệ tinh.

Phần lớn những chất ô nhiễm khí quyển được sản sinh ở những miền quá đông dân cư và những hành lang công nghiệp, như là bờ biển phía đông Hoa Kỳ, thung lũng Ruhr ở Tây Đức, miền Silêdi ở Tây Nam Ba Lan, Bắc Tiệp Khắc, cả khu vực Luân Đôn. Manchester—Livopun. Không còn nghi ngờ gì nữa, nạn mưa axit tỏa rộng khắp Bắc bán cầu.

Những cơn mưa axit trở thành một vấn đề quốc tế. Công ước về ô nhiễm khí quyển ký tháng 11-1979 tại Giơnevơ tiếp tục tạo nên biện pháp có hiệu lực nhất chống những cơn mưa axit. Công ước có hiệu lực tháng 3-1983, từ nay đến 1993 các nước đã ký phải giảm 30%. Việc làm thoát axit sunfuric. Đến nay có 19 nước thực hiện điều đó từ tháng 9-1987. Cộng đồng quốc tế, dưới sự bảo trợ của Cộng đồng kinh tế châu Âu (EEC), tiếp tục nghiên cứu làm giảm Oxyt nitơ và những nhân tố gây ra mưa axit. Những trung tâm nhiệt ở các nước thành viên EEC, phấn đấu từ nay đến 1995 giảm 60% nồng độ lưu huỳnh thải ra. xăng không chì từ 1989 sẽ được sử dụng trong toàn cộng đồng. Tất cả những xe cộ mới đều được trang bị một lò chuyển xúc tác từ 1965 để làm giảm nồng độ oxyt cacbon, oxytnitơ và hydrôcacbua trong chất khí thải ra.

Những cố gắng đó là đáng hoan nghênh, nhưng không bao giờ đủ để chế ngự sự lan tỏa những chất hóa học ô nhiễm. Đến nay phần lớn các nước đã phát triển chưa thực sự đưa ra những chương trình bảo vệ môi trường, chống lại toàn bộ những chất ô nhiễm. Hội đồng thế giới về môi trường và phát triển trong báo cáo « Tương lai tập thể chúng ta » đã nêu : « Có thể ở châu Âu, hiện tượng axit hóa là không đảo ngược được, phương tiện tài chính sử dụng không có đủ ». Nếu như vậy thì tương lai phát triển công nghiệp ở những miền khác trên thế giới sẽ ra sao ?

NGUYỄN VĂN THIỆM

Student resource 3

Issues in chemical technology: Acid rain

I. what is acid rain?

Acid rain is precipitation that contains sulfuric acid (H_2SO_4) and (HNO_3). In a few areas, hydrochloric acid (HCl) is also a component of rain, snow, drizzle, or fog. All of these compounds are strong acids.

Sources of acid rain

Air pollution caused by burning coal had been recognized long time ago but today acid rain is still associated with heavy industry. Acid rain is formed when sulfur dioxide (SO_2), various oxides of nitrogen, and chlorine are emitted into the air. In areas where vehicle emissions are a main component of pollution, nitrogen oxides are most common, where electric-generating plants burn fossil fuels, sulfur dioxide predominates (Figure 1).

Acidic precipitation is defined as having pH lower than 5.0; pH 4 to 4.5 is not uncommon, the average pH of 2,4 or lower than 2 have been recorded in some where in the north America, whereas the acidity of vinegar and lemon juice have pH 3.0 and 2.2 respectively. The pH scale used to measure acidity (Figure 2).

Sulfur dioxide and nitrogen oxides can remain suspended in the air for as long as four days. During this time, they react with other chemicals in the presence of sunlight, producing sulfate (SO_4^{2-}) and nitrate (NO_3^-) ions. With water or water vapor, these acids form solution of sulfuric and nitric acid. Any chlorine gas that is present reacts with water vapor in the air to form a mixture of hypochlorous and hydrochloric acids. These acids may remain in the air or soil by rain, snow, or fog.

Figure 1 Sources of acid rain

From Miller, T. (1995), p.215

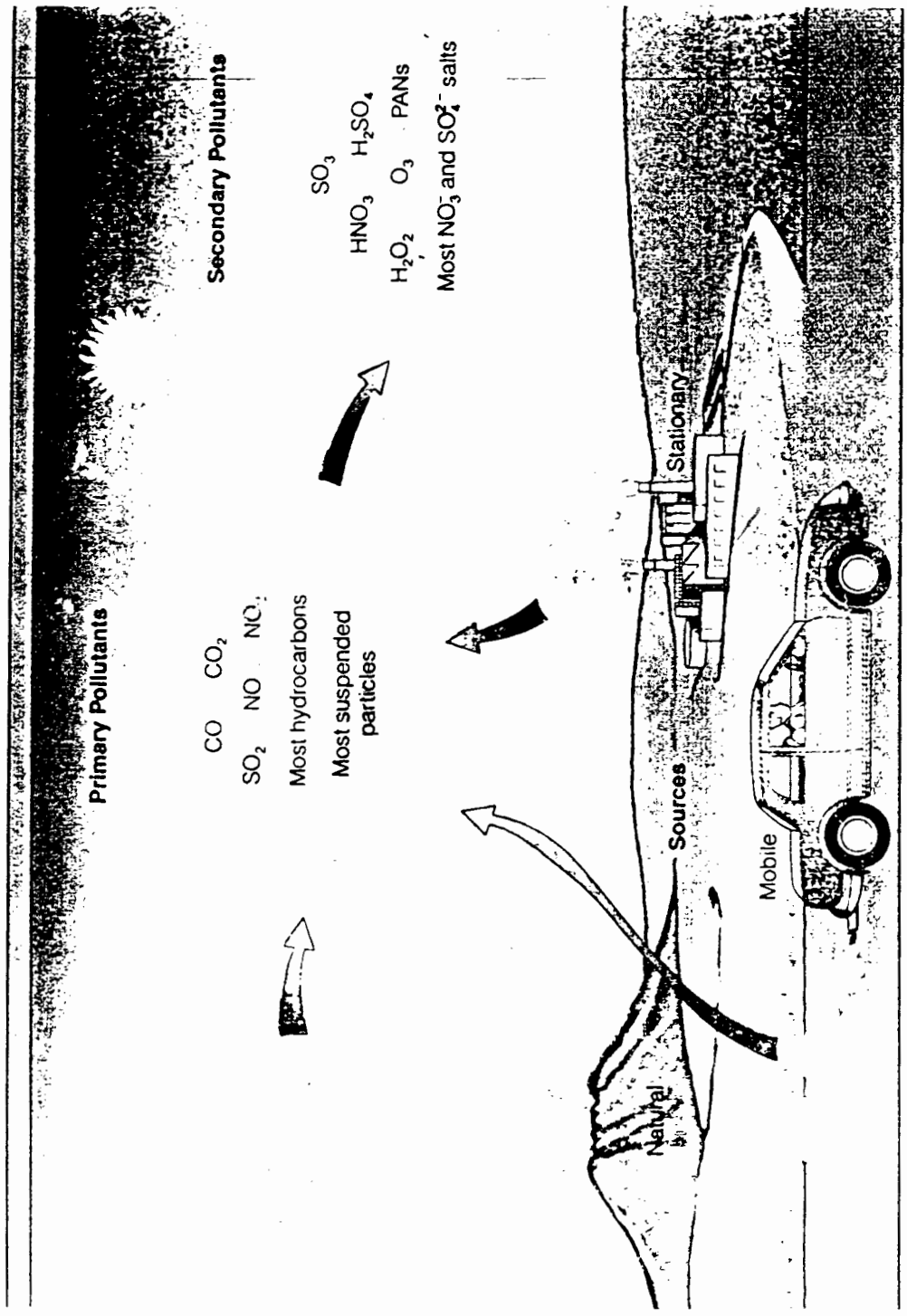
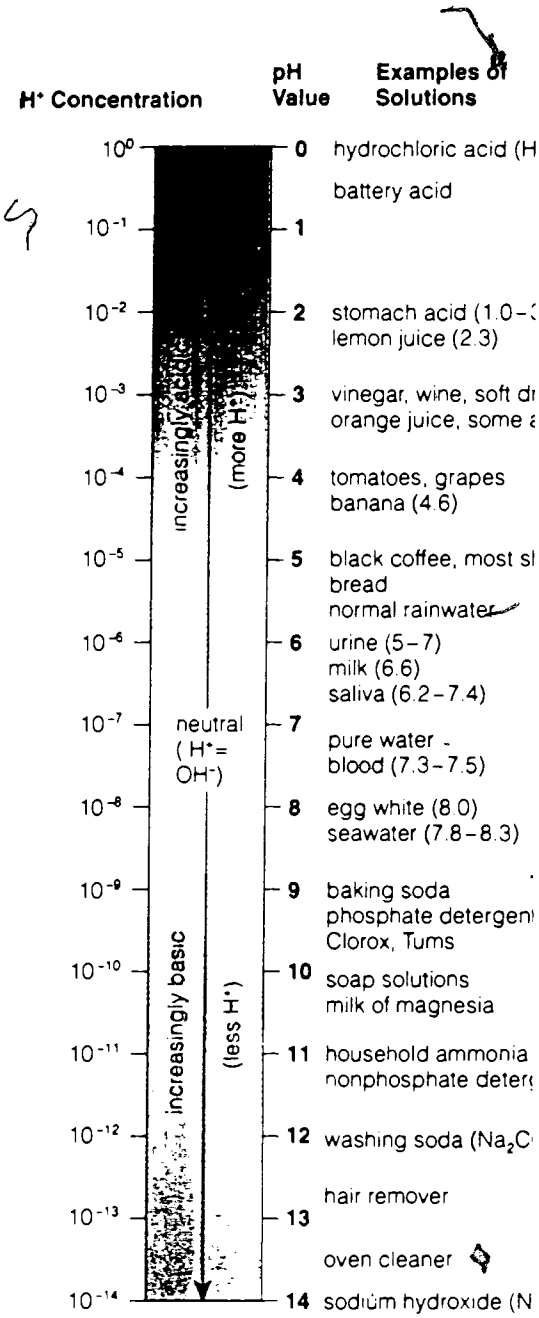


Figure 2 The pH scale used to measure acidity of water solutions.

From Miller, T. (1995), p.219



Sulfur dioxide and nitrogen are transported as much as 1,000 kiloliter (600 miles) by prevailing winds, they form secondary pollutions such as nitric acid vapor, droplets of sulfuric acid, and particles of sulfate and nitrate salts. These chemicals descend to the earth's surface in two forms: wet, as acidic rain, snow, fog, and cloud vapor; and dry, as acidic particles.

The main causes of acid rain are sulfur oxides and nitrogen oxides in the atmosphere. Acid rain become a problem only when they occur in higher than normal amounts as result of human activities. Acid rain result when these gases are oxidized in the atmosphere and return to the ground dissolved in raindrops. SO_2 fall as H_2SO_3 and H_2SO_4, while NO_x falls as HNO_3.

{1} $SO_2 + H_2O$ -------> H_2SO_3

{2} SO_2 $\xrightarrow{\text{oxidize}}$ SO_3 $\xrightarrow{H_2O}$ H_2SO_4

{3} $NO_2 + H_2O$ ------> $1/2\ HNO_2 + 1/2\ HNO_3$

{4} $NO_2 + O_3$ -------> NO_3 ------> H[illegible]

A minor source of SO_2 in the atmosphere is though the oxidation of hydrogen sulfide, which forms by microbial decay of organic matter and which is also released during the processing of "sour" natural gas. The oxidation of H_2S in the atmosphere is believe to occur as follows.

{5} $OH + H_2S$ ------> $H_2O + SH$

{6} $SH + O_2$ -------> $SO + OH$

{7} $SH + OH$ -------> $H_2O + S$ (atomic sulfur)

{8} $S + O_2$ -------> $SO + O$

{9} $SO + O_2$ -------> $SO_2 + O$

In reaction {3}, direct scavenging of NO_2 by atmosphere water is negligibly important, on account of the low solubility of NO_2 in water.

In reaction {4} a night time route to HNO_3 is hydrogen abstraction from some suitable donor X-H by the nitrate free radical NO_3.

The OH. radicals come from photolysis of water as $H_2O + h\nu$ ------> H. + OH.

Notice that the reaction $S + O_2$ ----> SO_2 does not take place directly. The oxidation of atomic sulfur to SO_2 require two steps because removal of an oxygen atom from O_2 has a lower activation energy than insertion of the sulfur atom into the O-O multipled-bond.

II. **Chemistry of acid rain**.

As above introduce, unpolluted rainwater has pH close to 5.6 as a result of equilibration of raindrops with the 350 ppmv CO_2 in the troposphere. This yields the weak acid H_2CO_3 for which $K_a = 4.2 \times 10^{-7}$ mol/lit at 25°C.

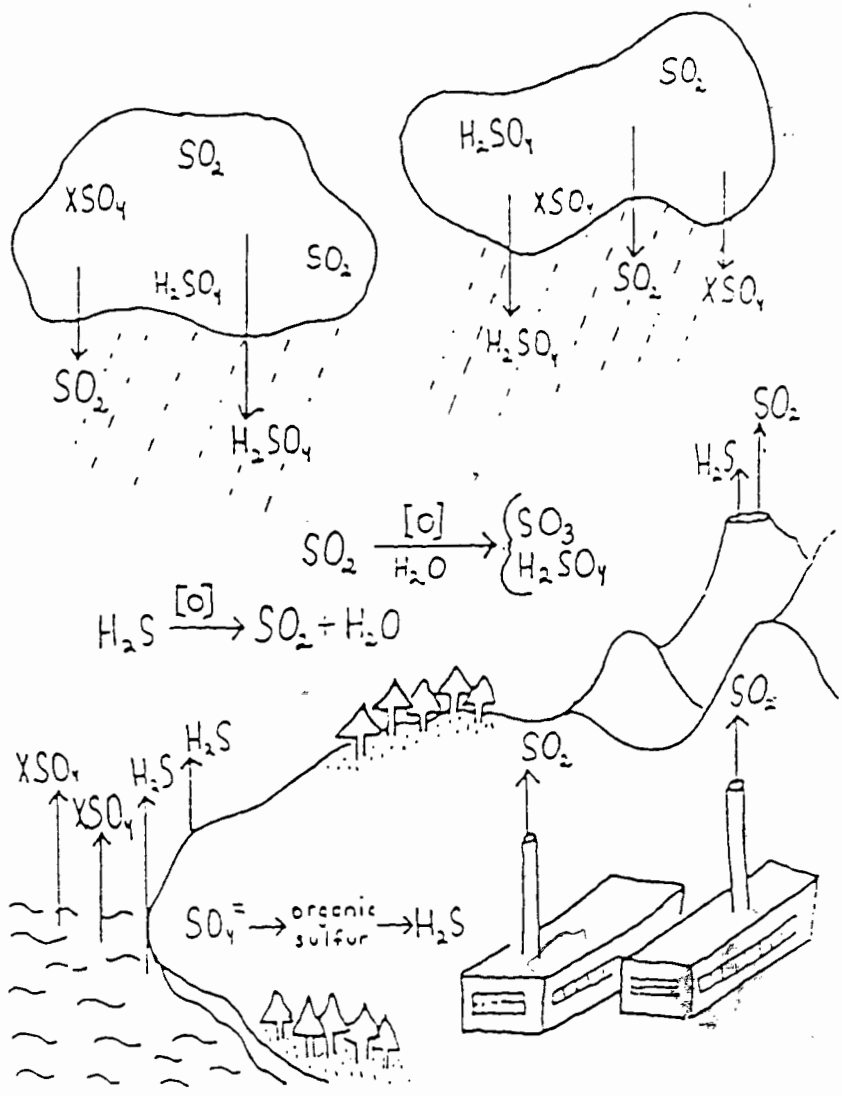
NO_2 and SO_2 are ultimately precipitated in rain as HNO_3, H_2SO_4 and H_2SO_3.

H_2SO_4 and HNO_3 are strong acids, while H_2SO_3 has $K_a = 1.7 \times 10^{-2}$ mol/lit at 25°C.

HNO_3, SO_2, and SO_3 are all more soluble in water than CO_2, low concentrations of these acidic gases have a higher effect on the pH of rainwater than much greater concentrations of CO_2. Carbon dioxide, a component of the at atmosphere, does not contribute to the acid rain problem. Its solubility is limited, and H_2CO_3 is a weak acid. The pH of rain in equilibrium with atmosphere CO_2 is about 5.6, the value that considered is normal.

Figure 3: A simplified diagram of the biogeochemical sulfur cycle: Sulfur enter atmosphere as H_2S, SO_2, and sulfur salts from sea spray. Water droplets transport sulfuric acid and sulfate salts to the Earth's surface.

From Steams, C. (1988), P.232



This is shown below.

For CO_2:

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \quad K_H = 3.4\times10^{-2} \text{ mol/lit atm}$$

$$H_2CO_3(aq) \rightleftharpoons H^+ + HCO_3^-(aq) \quad K_a = 4.2\times10^{-7} \text{ mol/lit}$$

$$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \quad Kc = 1.4\times10^{-8} \text{ mol}^2\text{L}^{-2}\text{ atm}^{-1}$$

For SO_2:

$$SO_2(g) + H_2O(l) \rightleftharpoons H_2SO_3(aq) \quad K_H = 1.2 \text{ mol/lit atm}$$

$$H_2SO_3(aq) \rightleftharpoons H^+(aq) + HSO_3^-(aq) \quad K_a = 1.7\times10^{-2} \text{ mol/lit}$$

$$SO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HSO_3^-(aq) \quad K_c = 2.1\times10^{-2} \text{ mol}^2\text{L}^{-2}\text{ atm}^{-1}$$

Summary: The equilibrium constant for the overall reaction is large in the case of SO_2 than of CO_2 because H_2SO_3 is a stronger acid than H_2CO_3. Consequently, a small concentration of $SO_2(g)$ has a greater influence on the pH of rain than a much large concentration of $CO_2(g)$. For example, 0.12ppmv of SO_2 (g) in equilibrium with rainwater will produce a pH of 4.30 in the water, compared with the pH 5.6 produced 350ppmv of CO_2 (g).

The chemistry of rain acidified by sulfur oxides is complicated because the sulfur may be deposited in different forms. It may either precipitate as H_2SO_3(aq) as shown above, or it may first be oxidized to SO_3(g) and precipitate as H_2SO_4(aq). Deposition may occur either in aqueous from (wet deposition) or in association with particulate mater (dry deposition) in which case much of the sulfur will deposit in the form of sulfide or sulfate ions rather than the free acids.

III. Effects of acidic emissions

1. Effects on vegetation

The effects on plants which must be considered are those of the gaseous pollutants themselves, and that of lowed pH. Sulfur dioxide is very strongly phytoxic (toxic to plants). Plants growth is inhibited at concentrations of SO_2 well below 0.1ppmv. Concentrations between 0.1 and 1ppmv cause observable injury to plants and trees after only a few hour's exposure.

Under condition where coal is burned at the same time that the weather conditions favour photochemical smog, the atmosphere may simultaneously be polluted with sulfur dioxide, a reducing agent, and ozone, an oxidant, and thus further complicating the chemistry. Although nitrogen dioxide also appears to be phytoxic, its effects on plants are not clear-cut as those of SO_2, because the nitrate ion which is ultimately deposited is a plant nutrient. Indeed, in the unpolluted environment, nitrogen fixation as a result of lightning is a significant source of the nitrate available to plants.

Extensive acidity is also harmful to plants. Leaves may be damaged below pH 3.5; soil chemistry will altered well above this pH, and the problem will be most serious for poorly buffered soils, many of which tend to be naturally which are specifically alkaline, or alternatively, acidic. Few plants tolerate acidic soils however, and among other effects, the germination of seeds and the growth of seedlings may be inhibited.

The forests

Unpolluted rain contain carbonic acid. This form when carbon dioxide in the air dissolves in water vapor. This "pure" rain, with a pH of 5.6, is over 10 times more acidic than distiled water, with a pH of 7. Moderately acidic rain has a pH of 4.6 over 10 times more acidic than "pure" rain, and over 100 times more acidic than distiled water. Acid rain

may cause mature trees to become more susceptible to disease and insect damage. It also effects transpiration and photosynthetic processes.

2. Effect on fish and other freshwater species

The forest and fish has occurred in parts of North American, northern and western Europe, the U.S.S.R., and China. The peoples' Republic of China now faces the same predicament as it, too, struggles to industrialize using high-sulfur coal as the energy source for its heavy industries.

In norther Canada and the United States, the spring thaw is also the time when fish breed in river and lakes. As the snow melts, acids incorporates in the water crystals are release into the waterways. The acidity of this melted snow is close to that of vinegar. The sudden, intense addition of acid to lakes and rivers is referenced to as acid shock.

The trout and Atlantic Salmon are extremely sensitive. The trout and Atlantic salmon are extremely sensitive to acid shock. The fish may not be able to reproduce or their offspring may be deformed. The young of frogs and salamanders that breed in pools of melted snow may be deformed or die soon after hatching. A decline in the number of fish and amphibians in turn affects the populations of other living things. Aquatic insects on which the fish and amphibian feed increase while the birds and mammal that use feed and amphibians frog food may decrease in number. In addition, the increasing acidity affects the type and growth of all plant and animal life in a lake and river.

When acid rain falls on the soil surrounding a body of water, the rain trickles through the ground and into the water, carrying with it many metals from the soil, Aluminium leached from the soil damages the gill of fish, killing them. Toxic metal such as mercury, cadmium, and lead can become incorporated into the tissues of the fish, posing a health threat to consumers. The presence of the heavy metals in the water may also cause chemical imbalances in the lakes or stream which threaten other organism

3. Effects on health

Sulfur dioxide and nitrogen dioxide are both irritant to respiratory tract. Atmospheric levels of no more than 1 to 2 ppmv SO_2 are absorbed high in the respiratory tract, and do not reach the far more sensitive alveoli. Penetration to the alveoli occurs when the concentration reaches ~ 25ppmv, which may be encountered in industries such as smelting, tanning, paper-making, and sulfuric acid manufacture. However, actual injury is rare because of the irritant effects of SO_2 at these concentrations (wheezing, coughing, tearing).

The effects of SO_2 exposure on the long-term health of workers are uncertain: some studies show long-term respiratory effects, but others do not. There appears to be a definite synergism between SO_2 and arsenic in the predisposition of arsenic smelter workers towards respiratory cancer. Experimental studies in animals also implicate SO_2 as a promote of carcinogenesis.

Since acidic emissions are accompanied by particulate mater, especially when coal is burned, it is difficult to separate their effects.

Both sulfur dioxide and nitrogen oxide have been linked to the increased occurrence of heart disease, lung cancer, asthma, pneumonia, and bronchitis, primarily among children and the elderly. Acid rain is thought to contribute to at least 100,000 deaths a year in the U.S.A.

4. Effects on structures

Limestone ($CaCO_3$) has been a commonly used building material for millennia. Even under conditions of very clean air it is subject to show attack by the same chemical processes which carve out caves and gorges.

$$CaCO_3(s) + H_2CO_3(aq) \text{ ------> } Ca^{2+}aq) + HCO_3^-(aq).$$

This process has small equilibrium constant and occurs exceedingly slowly. Acidic precipitation greatly increases both the equilibrium constant and the rate of dissolution.

$CaCO_3(s) + H^+(aq) \text{-----} > Ca^{2+}(aq) + HCO_3^-(aq)$

The damage of influence of acidic precipitation loss the detail of outer layers. Fine stone carving is particularly at risk, as the outer layers of the store flake off. This process, called " sulfation", involves the replacement of $CaCO_3$ by $CaSO_4$, which is both more water soluble and has less structural strength.

$CaSO_3(S) + SO_2(g) + 1/2\ O_2(g) \text{------} > CaSO_4(s) + CO_2(g).$

Iron and steel structures are highly susceptible to corrosion, the chemistry of corrosion under atmospheric conditions is extremely complex.

IV. **What can be done**?

In the United States, legislation calls for reductions in the levels of SO_2 emissions from plants that burn fossil fuels. These reductions can be achieved in several ways "Scrubbers" can be installed in smokestacks to remove sulfur from gas emissions. New combustion methods can be used that burn fuel more completely and produce fewer pollutants. Also, fuels low in sulfur can be used in place of high sulfur fuels.

In order to keep air in local communities clean enough to meet air quality standards, industries and power plants have built ever-taller smokestacks that discharge sulfur dioxide and pollutants in.

The clean Air Act regulates emission level of nitrogen oxides from cars, trucks, buses, and motorcycles. At present, the act provides for a steady reduction in the nitrogen oxide emissions over the next decade. This action will help to reduce nitric acid precipitation.

Another method to help reduce acid levels in lakes involves the buffering action of lime. Many problems exist with this method, however, first, it is nearly impossible that

may be affected by acid rain. Second, adding lime can not counteract spring acid shock., nor can it undo the damage already done to a lake. Third, it can not rid a lake of heavy metal.

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Student resource 4

1. How can acid rain threaten our food supply and drinking water?
2. Is the problems of acid rain to be long any country which polluted with it? Do you think that this problem occur between national boundaries? Have you ever though Vietnam in the near year future has this phenomenon?
3. What is meant by lake acidification? How could lake acidification cause a lake to " die"?

Student resource 5

Environmental issues about the depletion of ozone layer

Ozone plays a important role in the atmosphere as the principal absorber of ultraviolet (UV) radiation in the range 240-320nm. Unit focuss on the series of reactions which ozone is formed and destroyed in the atmosphere. The possible depletion of ozone layer through atmospheric pollution is a matter of great current concern.

I. The atmosphere

1. The troposphere

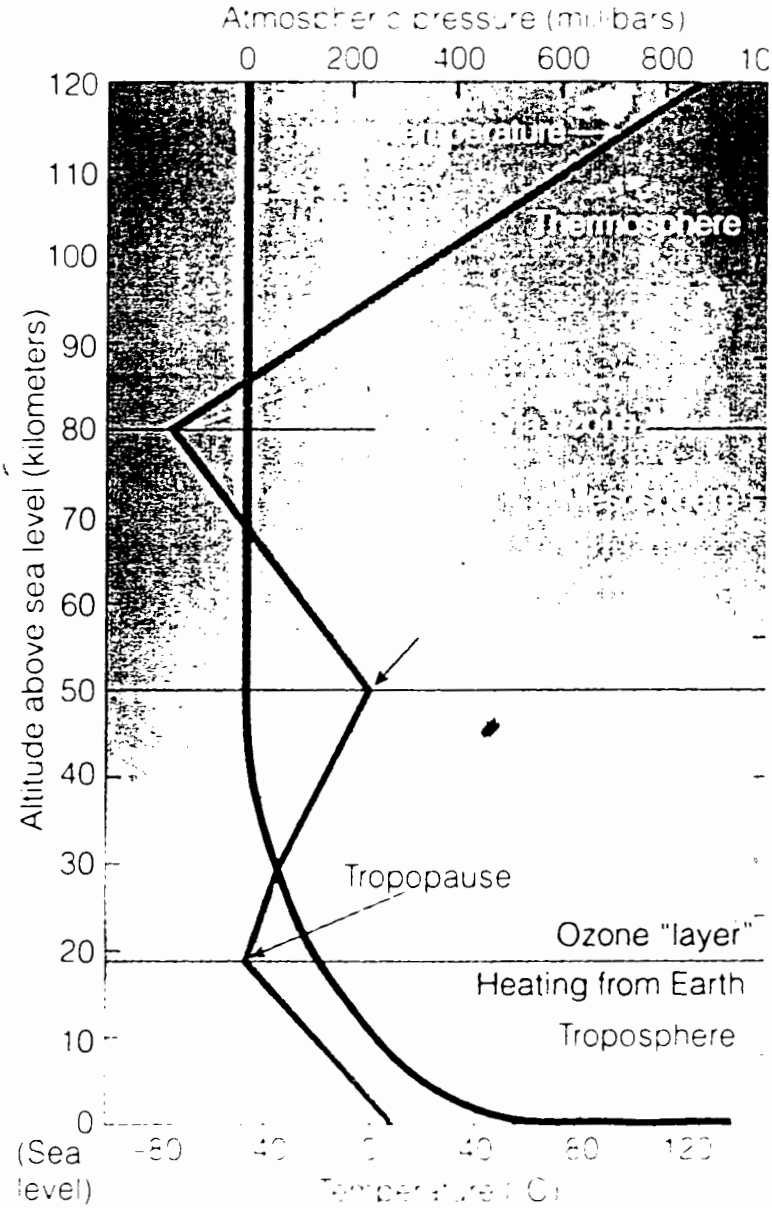
We are living in the atmosphere of the troposphere layer. This thin envelope of life-sustaining gases surrounding the earth is divided into several spherical layers characterized by abrupt changes in temperature due to differences in the absorption of incoming solar energy (Figure 4).

About 75% of the mass of Earth's air is found in the atmosphere's innermost layer, the troposphere, which extends only about 17km (11 miles) above sea level at the equator and about 8km (5 miles) over the poles. If the earth were an apple, this lower layer, containing the air we breathe, would be not thicker than the apple's skin. This thin and turbulent layer of rising and falling air currents and winds is the planet's weather breeder.

The composition of the atmosphere has varied considerably throughout Earth's long history. Today about 99% of the volume of clean, dry air in the troposphere consists of two gases: nitrogen (78%) and oxygen (21%). The remainder has slightly less than 1% argon(ar), 0.036% carbon dioxide (CO_2), and trace amounts of neon (Ne), helium (He), methane (CH_4), Krypton (Kr), hydrogen (H_2), Xenon (Xe), and chlorofluorocarbons (CFCs, put there by human activities). Air in the troposphere also holds water vapor in amounts varying from 0.01% by volume at the frigid poles to 5% in the humid tropics.

Figure 4: Earth's present atmosphere consists of several layers. Most ultraviolet radiation from the sun is absorbed by ozone (O_3) in the stratosphere, most of which is found in the so-called ozone layer, between 17 and 26 kilometers (11-16 miles) above sea level.

From Miller, T. (1995), p.213



2. The stratosphere: Earth's global sunscreen

The stratosphere is the atmosphere's second layer, which extends from about 17-48kms (11-30miles) above Earth's surface. Although the stratosphere contains less matter than the troposphere, its composition is similar, with two notable exceptions: Its volume of water vapor is about 1,000 times less, and its volume of ozone is about 1,000 times greater.

Ozone is found in both troposphere and stratosphere; the concentration of ozone is at a maximum in the stratosphere, although the actual value depends on both the latitude and the season.

Stratosphere ozone is produced when some of the oxygen molecules there interact with lightning and solar radiation. Ozone is continually being formed and destroyed, but as long as the rates of these two reversible processes are equal, the average concentration of ozone in the stratosphere remains constant (although the concentration varies at different altitudes and at different places). The presence of ozone in the stratosphere keeps about 99% of the sun's harmful U-V radiation (especially ultraviolet -B) given off by the sun from reaching the earth's surface. This filtering action helps protect the human

II. Ozone chemistry

1. Formation and destruction of ozone

Under the influence of sunlight, oxygen is continually being changed into ozone and ozone is likewise converted back to ordinary oxygen. Each day 350,000 tones ($3.5x10^8$kg) of ozone are made- and destroyed- in the atmosphere.

The ultraviolet photons of the sun have enough energy to split oxygen molecules into oxygen atoms high in the atmosphere.

O_2 ------> O+O {1}

An oxygen atom combining with another oxygen molecule to form the triatomic molecule, ozone. Because the oxygen atom is very energetic, a third molecule labeled M must be

presents at the encounter in order to carry away some of the excess energy. M can be any molecule that happens to be present. In the atmosphere it is most likely to be nitrogen or another molecule of oxygen.

$$O + O_2 \xrightarrow{M} O_3 + M \quad \{2\}$$

(M is a third body, e.g. N_2, O_2).

Reactions {3}and {4} are ozone destruction reactions. As we have seen, ozone can absorb solar rays in the ultraviolet region. When this happens, there is a high probability that the excited ozone molecule will dissociate into an oxygen molecule and an oxygen atom.

$$O_3 \xrightarrow{h\nu\ (230\text{-}320nm)} O + O_2 \quad \{3\}$$

Also, an oxygen atom can combine with an ozone molecule to form two oxygen molecule as.

$$O + O_3 \longrightarrow 2\,O_2 \quad \{4\}$$

Oxygen atoms are very reactive, and have a short life in the stratosphere; this means that all four of these reactions come to a halt at sunset, and so the concentration of ozone at night is essentially the same as at the end of the day.

Sunlight drives both ozone formation and removal, but different wavelength ranges are involved. These absorption and the consequent reactions are responsible for shielding the Earth's surface from two different parts of the spectrum. Both of them highly energetic. Ordinary oxygen is precisely due to its ability to absorb radiation of these wavelengths, which simultaneously converts it back to O_2.

2. Complex chemistry

The complexity of the chemical processes in the atmosphere is great. The consideration of the mechanism's Chapman (1960) was though to be a complete description

of chemistry of the O_2/O_3 system in the stratosphere. These additional mechanisms are catalytic processes, each which is the propagation cycle of a free radical chain reaction.

At the altitude 30km, the relative rates of the possible reaction for decomposing ozone are as follows NO/NO_2 cycle > uncatalyzed reactions ~ Cl/ClO cycle > OH/OH_2 cycle >> H/OH cycle.

They are shown in generalized format is reaction [A] and [B] with "X" as the catalyst.

[A] $X + O_3 \text{ ------> } XO + O_2$

[B] $XO + O \text{ -----> } X + O_2$

Adding[A] and [B] together gives equation [4] above

$O + O_3 \text{ ------> } O_2 + O_2$

Therefore the sequence A, B is another way of carrying out reaction [4], and increase the rate of destruction of ozone.

For separate catalytic cycles have been discovered, all with the catalyst X and odd-electron species. X can be a chlorine atom (Cl), NO, OH, and H.

For example : Consider some of the mechanisms involved to explain ozone depletion by halogens.

$Cl + O_3 \text{ ----> } ClO + O_2$

$OH + O_3 \text{ -----> } HO_2 + O_2$

$ClO + HO_2 \text{ ----> } HOCl + O_2$

$HOCl + \underline{h\nu} \text{ > } OH + Cl$

Adding together above gives equation

$O_3 + O_3 \text{ -----> } 3\ O_2$

3. Additional reaction in stratospheric chemistry

These following reaction is used to account for chemistry the stratosphere

a. Interaction between cycles

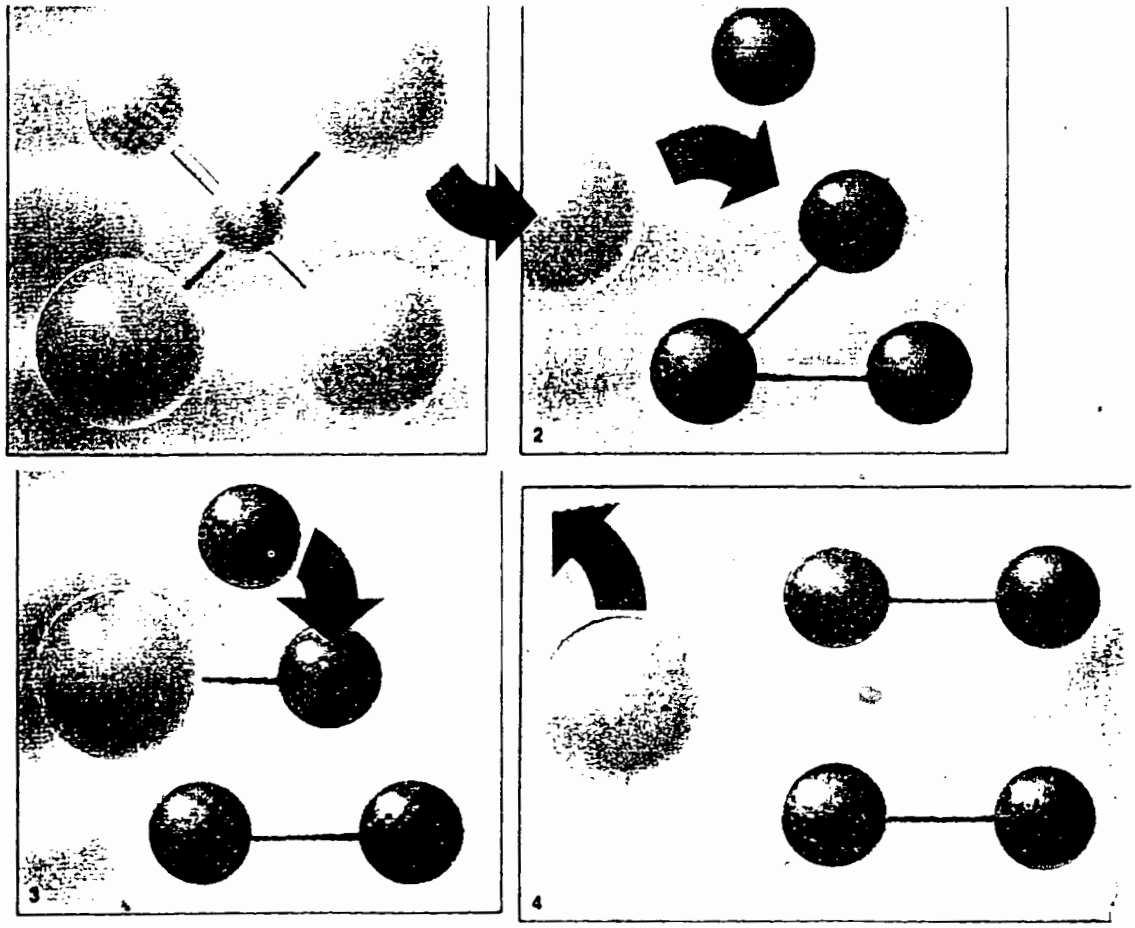
The four separate catalytic cycles represented by reactions [A] and [B], all involve a pair of catalyst X and XO. In principle, X from one cycle can react with XO from another cycle. For example: Following reaction affects the concentrations of reactants in both the NO/NO_2 and the OH/HO_2 cycle.

$$NO + HO_2 \dashrightarrow NO_2 + OH \quad \{10\}$$

b. Initiation and termination reactions

The overall rates of the chain reactions depend on the rates of initiation and termination reactions. This is because the average number of catalytic cycles propagated depends on the balance between the rates at which chains are initiated. Since most initiation reactions are photochemical, their rates depend on the intensity of sunlight, and fall to zero at night.

Figure 5 Chloroflurocarbons (CFCs) attacks to ozone in the atmosphere



Examples are given by Equations {a}-{g}

HNO_3 -------> $NO_2 + OH$ {a}

NO_2 --------> $NO + O$ {b}

O_3 -------> $O_2 + O$ {c}

CH_3Cl -------> $CH_3 + Cl$ {d}

$O + H_2O$ ------> $2OH$ {e}

$N_2O + O$ ------> $2NO$ {g}

Termination reactions remove radicals from the system. Generally, such reactions involve the combination of two radical (i.e. odd electron) species.

Example: $2ClO$ -------> $ClOOCl$

$2HO_2$ ------> $H_2O_2 + O_2$

$NO_2 + Cl$ ------> NO_2Cl

III. Environmental concern of the chemicals in the atmosphere

1. CFCs:

There are two reasons: First, CFCs increase the sink strength for stratospheric ozone with no possibility of compensation by increasing the source strength, which is fixed by the intensity of sunlight. This lowers the state concentration of ozone, which is governed by the balance between sources and sinks. Second, CFCs are extremely long-lived pollutants; their decomposition is very low, even in the stratosphere, because O_2 and O_3 absorb radiation having ~ < 250nm much more efficiently than CFCs, whose lifetimes are estimated to range up to and beyond 100 years. Therefore environmental damage caused by CFCs is a problem that could persist for many generations.

2. Brominated CFCs analogs

Brominated analogs of CFCs are in commercial use as fire extinguishers, under the name Halons. These compounds are very valuable in fighting electrical fires, for example at computer installations. Their mode of action, besides smothering the fire with heavy vapor,

involves cleavage by heat of the weak C-Br bond. The bromide atoms thus formed act as terminators for the radical chain reactions which take place in flames.

Halons immigrate to the stratosphere like CFCs, and are cleaved more easily by light than the corresponding chlorides, because of the lower bond strength C-Br by comparison with C-Cl. The bromine atoms released through photolysis can initiate radical chains for the composition of ozone, analogous to $Cl + O_3$ ----> $ClO + O_2$ and $ClO + O$ ---> $Cl + O_2$. H1211 and H1301 have greater ozone-depletion potential than CFC-11 and CFC-12.

A possible substitute for Halons would be CF_3I, whose fire fighting properties resemble those of Halons. The C-I bond is even weaker than C-B, and is susceptible to photolytic C-I bond cleavage in the troposphere. As a result of troposphere photoreactivity.

Methyl bromide has moderate ozone depleting potential even though most of it is oxidized in the troposphere. Methyl bromide is principally used as a soil fumigant, though it also enters the atmosphere as a result of biological action in the oceans and during forest fires.

3. Nitrogen oxides as ozone depleters

N_2O

Nitrous oxidizes formed by biological denitrification, and is inert in the troposphere, and its concentration is now increasing, most likely due to large increase in the use of nitrogenous fertilizers, except as a greenhouse gas. Nitrous migrates to the stratosphere. In the stratosphere it undergoes photochemical cleavage, and is potentially a source of ozone depletion. N_2O has also been shown to be produced anthropogenically as a combustion of by-product, along with NO_x. Typical NO_x: N_2O ratios in combustion products are about 5:1 and migrates to the stratosphere where it is degraded photochemical.

N_2O -----> $N_2 + O^*$

While this reaction has impact on stratospheric ozone depletion, another sink for stratospheric N_2O is reaction with excited oxygen atoms (which come from photolysis of either O_3 as O_3 h , $\xrightarrow{325nm}$ O_2^* + O^*. This leads either to $N_2 + O_2$ or to nitric oxide by way of reaction as $O^* + N_2O \rightarrow 2NO$.

Nitrogen oxides in the stratosphere decompose ozone catalytically.

$NO + O_3 \rightarrow NO_2 + O_2$

$NO_2 + O \rightarrow NO + O_2$

CFC replacement compounds

The environmental problems to be overcome in finding a CFC replacement are: First CFCs are so stable chemically that they do not break down in the troposphere and hence over time can migrate to the stratosphere; second, they contain chlorine, which catalyzes the destruction of ozone if it is released in the stratosphere. The ideal CFC replacement molecule should therefore be somewhat reactive in the lower atmosphere so that it will be oxidized before it had time to reach the stratosphere, and should also contain few, or ideally no, chlorine atoms. Totally fluorinated compounds (i.e.. fluorocarbons) are unsuitable because they are even more inert than CFCs; this would make them highly persistent greenhouse gases.

The CFC replacement are partly fluorinated hydrocarbons with minimal or zero chlorine content. The presence of hydrogen in the molecule confers reactivity in the troposphere, because it allows the attack of OH upon the molecule. Example, with HFC-134a:

$CF_3CH_2F + OH \rightarrow H_2O + CF_3CHF$ (*)

The radical CF_3CHF formed in above reacts with O_2 and is oxidized to CO_2, HF, and H_2O.

Foams

Replacement of CFC-11 in the soft foams used in upholstery requires a substitute of low flammability, since the industry is under pressure to improve the fire resistance of its products. HCFC-22 (CHF_2Cl) was being used in this application in the early 1990s, but most foams being made with the use of HCFC-141b.

Chloroflurocarbons (CFCs) used as the operating fluid refrigerator, displacing the highly toxic and odorous SO_2 and NH_3. A refrigerant fluid must be gaseous at room temperature, but easily compressible to a liquid requirement met by substances having normal (1atm) boiling points a little below O^0C (e.g., CFC-12, -30°C; SO_2, -10°C; NH_3, -33°C). CFCs in addition are non-toxic and non-flammable, making the refrigerator safe enough to be operated as a domestic appliance in every home, where previously it had been restricted to industrial use.

CFCs is used as propellants for aerosol sprays (chiefly CFCs -11, CFC-13), and as cleaning solvents for microelectronic components (CFCs-113, $CF_2ClCFCl_2$); CFC-11 and CFC-12 are manufactured cheaply from carbon tetrachloride

$$CCl_4 + 2HF \xrightarrow{\text{catalyst}} CF_2Cl_2 + 2HCl$$

In the late 1980s the annual worldwide production of CFCs peaked at over 1.2 million tones, almost all of most of which reached the atmosphere because of the "open" nature of most of theses uses.

CFCs were first discovered in the atmosphere in the early 1970s. The troposphere concentrations of CFC-11 at ground level were 50 parts per trillion by volume (pptv); 1 part in 10^{12}) in 1971, and had risen to ca.150pptv by 1979 and to 270 pptv in 1993.

CFC-11 and CFC-12 are completely unreactive in the troposphere (they are important troposphere greenhouse gases). They migrate upwards to the stratosphere with half-life for migration 3-10 years; they are susceptible to gradual photolysis,

$$CF_2Cl_2 \text{ -------> } CF_2Cl + Cl$$

The chlorine atom thus released can participate in the catalytic mechanism for destroying ozone in the example [1].

Cleaning solvents for electronic components

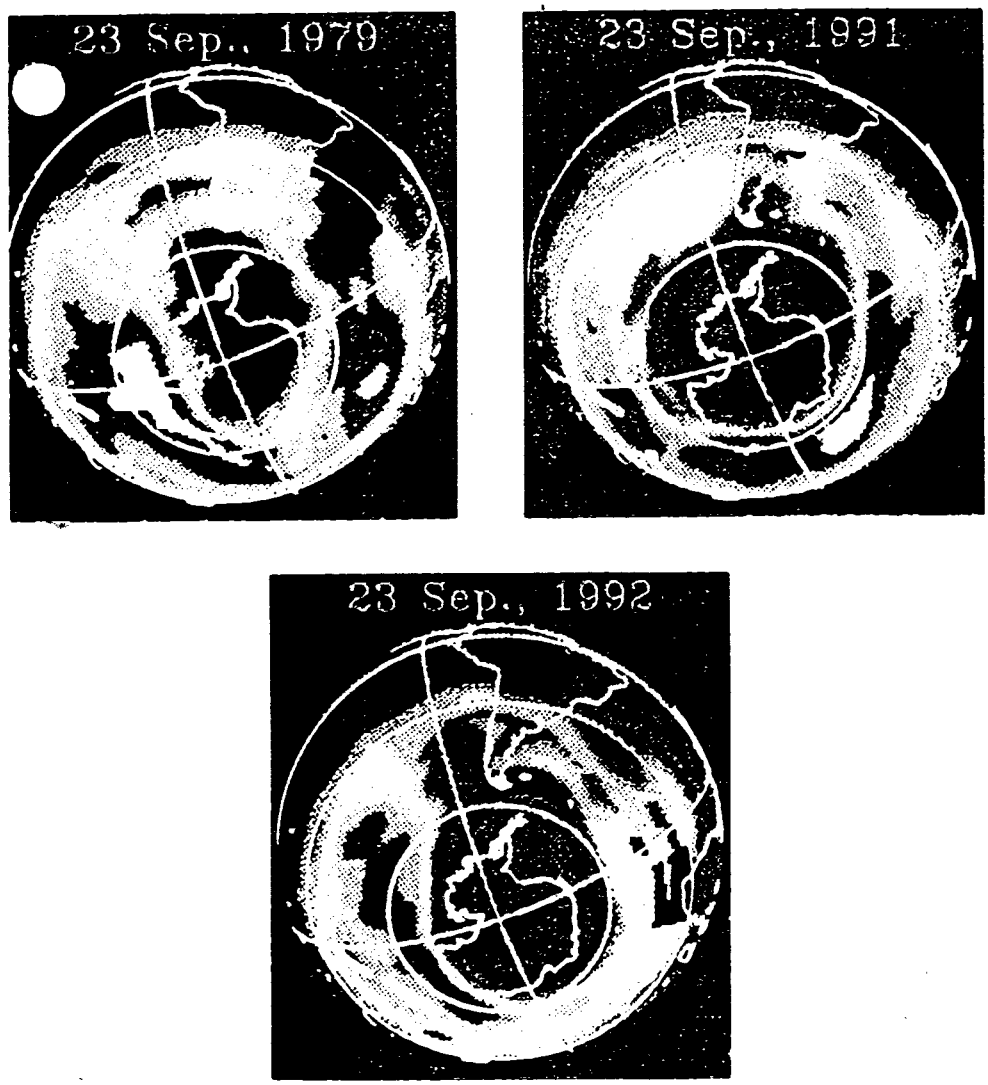
This application requires a solvent of low surface tension and low viscosity which permit the solvent to penetrate tiny crevices, a task for which CFC-113 was formed used. Blends such as HCFC-22 and methanol have been used for this application, thereby reducing the ozone depleting potential by more than 95% compared with CFC-113. However, water-based, CFC- free solvent formulation are now available.

Aerosols

Aerosols that replaced for CFC-11 is hydrocarbons such as isobutane can successfully substitute for CFC-11 and CFC-12, with methylene chloride added as a flame suppressing a gent. Dimethyl ether is also available as a propellant; it can be mixed with up to 50% by weight of water, to lower its flammability.

Figure 6: Seasonal thinning or loss of ozone (shown by shades of pink), called an ozone hole, in the upper stratosphere over the Antarctic region, as measured by the Nimbus-7 satellite on September 23 of 1979, 1991, and 1992.

From Miller, T. (1995), p. 249



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Student resource 6

What you can do to protect the ozone layer

From Miller, T. (1995), p. 254.

What You Can Do to Help Protect the Ozone Layer

If you believe, as do most scientists, that there is a serious threat to the ozone layer, here are some things you can do:

- *Don't buy products containing CFCs, carbon tetrachloride, or methyl chloroform (1,1,1-trichloroethane on most ingredient labels).* Read labels and seek out substitutes for these products.
- *Don't buy CFC-containing polystyrene foam insulation.* Types of insulation that don't contain CFCs are extended polystyrene (commonly called EPS or beadboard), fiberglass, rock wool, cellulose, and perlite.
- *Don't buy halon fire extinguishers for home use.* Instead, buy those that use dry chemicals (CO_2 extinguishers release this greenhouse gas into the troposphere). If you already have a halon extinguisher, store it until a halon-reclaiming program is developed.
- *Stop using aerosol spray products, except in some necessary medical sprays.* Even those that don't use CFCs and HCFCs (such as Dymel) emit hydrocarbons or other propellant chemicals into the air. Use roll-on and hand-pump products instead.
- *Pressure legislators to ban all CFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform by 1996 (with no loopholes)—and HCFCs by 2005 instead of by 2030.*
- *Pressure legislators not to exempt military and space programs from any phaseout of ozone-depleting chemicals.*
- *Buy new refrigerators and freezers that use vacuum insulation (as in Thermos bottles) instead of rigid-foam insulation and that use helium as a coolant.* (Such refrigerators are available from Cryodynamics, 1101 Bristol Road, Mountainside, NJ 07092). China has purchased 9 million of them.
- *If you junk a car, a refrigerator, a freezer, or an air conditioner, make sure the coolant is removed and kept safely for reuse or destruction.*
- *Have car and home air conditioners checked regularly for CFC leaks—and repair them if necessary.*
- *If you buy a car with an air conditioner, look for one that doesn't use CFCs.* These should be available on most new models by 1995.

The pros and cons on CFC substitutes

From Miller, T. (1995), P. 255.

Types	Pros	Cons
HCFCs (hydrochlorofluorocarbons)	Break down faster (2-20 years). Pose about 90% less danger to ozone layer. Can be used in aerosol sprays, refrigeration, air conditioning, foam, and cleaning agents.	Are greenhouse gases. Will still deplete ozone, especially if used in large quantities. Health effects largely unknown. HCFC-123 causes benign tumors in the pancreas and testes of male rats and may be banned for use in aerosol sprays, foam, and cleaning agents. May lower energy efficiency of appliances.
HFCs (hydrofluorocarbons)	Break down faster (2-20 years). Do not contain ozone-destroying chlorine. Can be used in aerosol sprays, refrigeration, air conditioning, and foam.	Are greenhouse gases. Safety questions about flammability and toxicity still unresolved. May lower energy efficiency of appliances. Production of HFC-134a, a refrigerant substitute, yields an equal amount of methyl chloroform, a serious ozone depleter.
Hydrocarbons (such as propane and butane)	Cheap and readily available. Can be used in aerosol sprays, refrigeration, foam, and cleaning agents.	Can be flammable and poisonous. Some increase ground-level pollution.
Ammonia	Simple alternative for refrigerators; widely used before CFCs.	Toxic if inhaled. Must be handled carefully.
Water and Steam	Effective for some cleaning operations and for sterilizing medical instruments.	Creates polluted water that must be treated. Wastes water unless the used water is cleaned up and reused.
Terpenes (from the rinds of lemons and other citrus fruits)	Effective for cleaning electronic parts.	None.
Helium	Effective coolant for refrigerators, freezers, and air conditioners.	This rare gas may become scarce if use is widespread, but very little coolant is needed per appliance.

Vietnamese article

Summit for the Earth

From Tu, N. C. (1992), Number 489, p.14

[illegible] 1992 [illegible] Tên chính thức của hội nghị là «Thượng đỉnh về Trái đất» (Summit for the Earth, Sommet de la Terre): tất cả các nước có chân trong Liên Hiệp Quốc (gần 200) đều được mời ở cấp cao nhất, để tới ký vào hai qui ước mà các phái đoàn thương thảo các nước ở Liên Hiệp Quốc đã thảo từ trước.

Hai qui ước đó là hai qui ước gì?

DƯ ÂM CỦA HỘI NGHỊ THƯỢNG ĐỈNH VỀ TRÁI ĐẤT

● TS. NGUYỄN CHUNG TÚ

Học sinh Tiệp Khắc (vùng Bohême) đeo khẩu trang chống không khí ô nhiễm

Một là qui ước về khí quyển và về độ tăng nóng của khí hậu do hiệu ứng lồng kính gây nên bởi các khí công nghiệp phế thải ra.

Chúng ta biết hiệu ứng lồng kính là hiện tượng trong đó một lồng thủy tinh kín giữ *nhiệt độ ở trong cao hơn nhiệt độ ở ngoài*. Là vì ánh sáng trắng từ Mặt trời tới đi qua được thủy tinh. Vào trong lồng, ánh sáng đó chiếu vào các vật khiến cho các vật này phát ra tia hồng ngoại. Tia này không đi qua được thủy tinh, bị giam trong đó, mà đặc tính của nó là tỏa nhiệt. Mặt tích cực của hiệu ứng là ở miền ôn đới, người ta chế tạo những nhà kính để trồng trọt trong đó những cây cối của vùng nhiệt đới (phytotron). Mặt tiêu cực của hiệu ứng là các khí do công nghiệp phế thải họp thành một lồng kính, khiến cho nhiệt độ khí quyển tăng lên.

Các khí đó là oxyd carbon, khí carbonic, khí sulfurơ, cloroflucro carbon (CFC) không những làm tăng nhiệt độ môi trường, lại còn gây ô nhiễm, nguy hại cho sức khỏe con người. Tích tụ ở cao độ trong mấy chục năm, các khí chặn các tia *hồng ngoại ở dưới lên*, tức là tia nhiệt không được tỏa mạn trong không gian. Sinh thái mất cân bằng, và đá băng ở cực có thể tan khiến cho mực nước biển có nguy cơ tăng lên 6 centimét *mỗi thập niên*. Hậu quả là những nhiễu loạn kinh tế, địa lý trong thế kỷ sắp tới, do sự biến mất của các hải đảo thấp và của một số bờ biển. Hàng chục triệu dân sẽ phải sơ tán, khi mà những cánh đồng phì nhiêu chìm lỉm dưới nước mặn. Có những vùng nước ngọt sẽ thành nước mặn. Bangladesh, Trung Quốc, Ai Cập... là những nước mà lụt lội và bão táp có thể gây nhiều tai sầu và về kinh tế và xã hội.

Trên đây không phải là chuyện khoa học giả tưởng (Đại Hồng Thủy) mà là một phần nội dung của một báo cáo của các chuyên [illegible]

[illegible]

[illegible] công nghệ thế giới trong một năm chứa đựng một khối lượng carbon bằng 5,7 tỉ tấn! Còn về nhiệt độ không khí tăng lên bao nhiêu thì bản báo cáo mới trên của PNUE (chương trình Liên Hiệp Quốc về môi trường) chỉ thuật lại cuộc tranh luận gay go giữa nhiều trường đại học và phòng thí nghiệm nghiên cứu vấn đề ở Hoa Kỳ và Tây Âu, và họ cũng chưa nhất trí về con số nhiệt độ tăng thêm. Ít nhiều chỉ là 2 hay 3 độ Celsius, theo [illegible]

[illegible]

[illegible] có thể chấp nhận được (công nghiệp Mỹ vượt quá cực đại này) mà chỉ nên nói chung chung (flou voulu). Một số nước khác trách dự thảo không thiết lập những tỉ lệ bách phân chính xác về những cắt giảm lượng khí thải ra. Các nước đang mở mang — cụ thể là Mã Lai — lại trách dự thảo không lưu ý tới những vấn đề kinh tế mà sự cứu vãn môi trường sẽ gây nên cho thế giới thứ ba.

[illegible]

[illegible] nhiều chế bức về «bộ hoa đưa vào nhà máy» với chú thích ở dưới: «Thiên nhiên giàu có hơn tất cả các ngân hàng thế giới cộng lại». Môi trường học (écologie, lấy màu xanh lá cây làm biểu hiệu) bỗng nay là một áp phe bằng vàng. Tổ chức Greenpeace (Hòa bình xanh) phổ biến bản cáo tố cáo mười xí nghiệp «đa quốc» hủy hoại môi trường. Các đại diện xí nghiệp lớn đã hội họp để ra thông cáo cho biết các tổ chức «xanh» chưa hề bao giờ đưa ra những đề nghị cụ thể về phát triển, và các xí nghiệp đã thực hiện nhiều điều về môi trường để giảm ô nhiễm từ mười năm nay, đặc biệt là từ nay đến năm 2000, lượng khí phế thải được giữ như ở mức năm 1990.

Rốt cuộc, tất cả các nước — kể cả Anh, Nhật, Mỹ — nhất là Mỹ —, đều đã ký vào qui ước số 1 này. Riêng Nhật hứa đóng góp 7 tỉ đô la vào quỹ Liên Hiệp Quốc dành riêng cho sự cứu vãn môi trường đồng thời giữ vững phát triển (quỹ này hiện nay là 50 tỉ đô la mỗi năm nhưng thiếu hụt 20%).

Qui ước thứ hai về bảo vệ 1500000 giống động vật và thực vật. Hoa Kỳ chống lại một cách triệt để. Washington cho rằng qui ước này chứa đựng những thiếu sót nặng nề liên quan tới phương thức chi tiêu để thực hiện những chương trình bảo vệ các giống sinh vật hay bảo vệ các giấy phép sản xuất và cách thức làm ăn của công nghiệp Mỹ về sinh kỹ thuật học.

Thái độ cứng rắn của Hoa Kỳ làm cả thế giới bàng hoàng vì không hiểu tại sao đến nỗi như vậy. Riêng bà Ségolène Royal, Bộ trưởng môi trường trong phái đoàn [illegible] ngạc nhiên vì nước [illegible] nhất thế giới lại đi tùy thuộc một vấn đề quan trọng cho tương lai hành tinh vào một cuộc tranh cử [illegible] 3 tháng nữa [illegible]

[illegible]

Student resource 7

1. What consumption patterns and other features of your lifestyle is putting chemicals that deplete ozone layer directly or indirectly to the atmosphere? What things you are ready to stop using or don't use in order to slow the loss of ozone layer?
2. All of uses CFCs, hallons, other-depleting chemicals be banned production and consumption in the world or not? Explain. It is air conditioner (especially in car and may be in families it must be banned. Do you agree this ban? Do people have the right to use the atmosphere as a dumping of the ground for pollutants? Explain? If not, how would you restrict activities?
3. How do CFCs attack the ozone layer?
4. Do people have the right to use the atmosphere as a dumping of the ground for pollutants? Explain? If not, how would you restrict activities?

Student resource 8 The video-tape: Greenhouse effect

(Length: 28 min, produced year: 1984)

Notes: The greenhouse effect is the world's gravest environmental concern and one with which the international scientific community is just beginning to come to terms. This program details its causes and inescapable consequences, and explores the inevitability that looming temperature increases will change the allocation of natural resources forever.

Student resource 9

Greenhouse effect

In the troposphere collection of gases of small amount of carbon dioxide, water vapor and trace amounts and other gases is so-called greenhouse gases. By analogy, the glass of a greenhouse limits the dissipation of the warmth from inside the greenhouse, the greenhouse gases act somewhat like the glass panes of a greenhouse or of a car parked in the sun with its window rolled up. These gases let in incoming light, infrared radiation, and some ultraviolet radiation from the sun to pass through the troposphere. The earth's surface absorbs much of this solar energy and retard its reradiation longer, infrared radiation- that is, heat- which then rises into the troposphere. Some of this heat escape into space, some is absorbed by molecules of greenhouse gases, warming the air; and some radiates back toward the earth's surface. This trapping of heat in the troposphere is called the greenhouse effect (Figure 7).

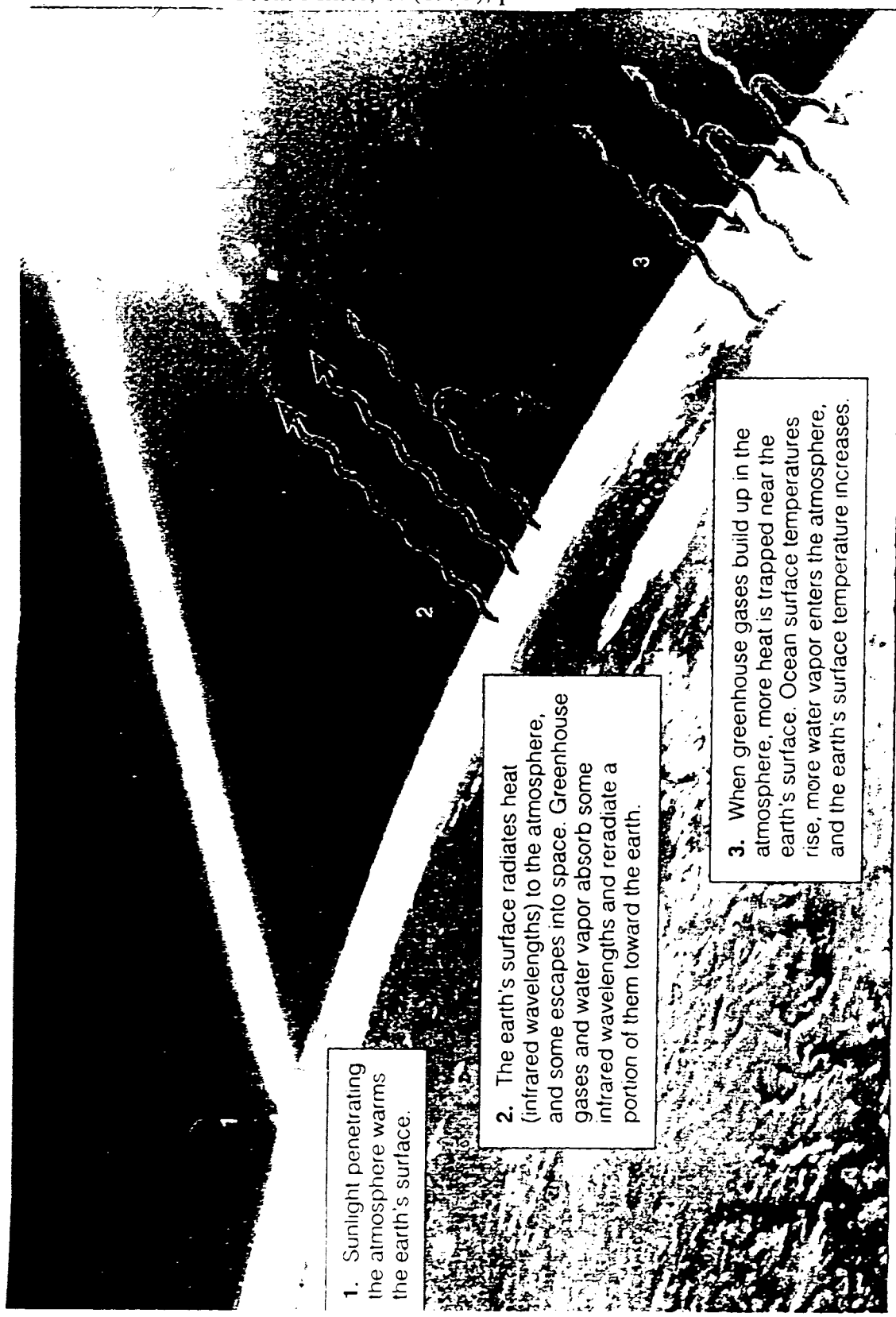
Increased levels greenhouse gases

Greenhouse gases are those which can absorb infrared radiation. Atmosphere nitrogen, oxygen, and argon do not absorb infrared radiation, but some kinds of following substances do.

Carbon dioxide (see " student resource #11")

Figure 7 The greenhouse effect.

From Miller, T. (1995), p.238



Water (H_2O)

Global warming, a predicted consequence of an "enhanced" greenhouse effect, would increase the average amount of water in the atmosphere through evaporation from the oceans because the equilibrium vapor pressure of water rises with temperature. This situation would present positive feedback, i.e., increased temperature leading to a raise in $p(H_2O)$, causing in turn a further increase in the efficiency of trapping infrared radiation.

Trace gases

These include methane, nitrous oxide, ozone, and chloroflurocarbons, all of which have atmospheric concentrations which are hundreds or more times less than those of CO_2 and water vapor. This might lead one to suspect that their infrared absorbing potential would be insignificant compared with water and CO_2. Such is not the case, because each greenhouse gas absorbs radiation in its own characteristic region of the infrared; some of these gases absorb radiation in regions of the spectrum in which CO_2 and H_2O are transparent, and from which the radiation would otherwise escape into space. In addition, most of them are more effective infrared absorbers than CO_2 on a molecule-for-molecule basis. Their concentrations are increasing faster, on a percentage basic, than that of CO_2.

Chloroflurocarbons (CFCs)

They are believed to be responsible for 24% of the human contribution of greenhouse gas. They also deplete ozone in the stratosphere. Like N_2O, they have no tropospheric sinks, but are infrared absorbers. CFCs take 10-20 years to reach the stratosphere and even halons. These greenhouse gases is present in small amounts, some of them trap heat thousands of times more effectively than CO_2 does. Example: Fluorocarbon has 20,000 times the capacity of CO_2 to trap heat, and Fluoro-carbon 11 has 17.5000 times.

Methane (CH_4)

The concentration of tropospheric methane is currently about 1.7 ppmv but is rising at 1-2% annually. Methane is believed to be responsible for 18% of the increase in greenhouse gases. Methane is produced when anaerobic bacteria break down dead organic matter in most places that lack oxygen. These areas consist of natural wetlands; rice paddies. As its common name "marsh gas" implies, wetlands are an important natural source of this gas. Human agricultural activity adds greatly to the natural background. Methane stays in the troposphere for 7-10 years. Each methane molecules traps about 25 times much heat as a CO_2 molecule.

Nitrous oxide (N_2O)

Nitrous oxide, structure N=N=O, has a dipole moment and absorbs infrared radiation effectively. Its present tropospheric concentration of 300 ppbv is increasing at the rate of about 0,2% per year.

It account for 6% of human input of greenhouse gases, it also depletes ozone in the troposphere. It is released from nylon production; from burning of biomass and nitrogen-rich fuels, from the break down of nitrogen fertilizer in soil, livestocks, wastes and nitrate-contaiminated groundwater. It stay in the troposphere is 140-190 years, and it traps heat about 230 times as much heat per molecule as CO_2.

Ozone and carbon monoxide

These substances share the characteristics of very low concentration in the unpolluted troposphere, but much larger concentrations when the atmosphere is polluted. Ozone is one of the more active greenhouse gases.

Footnotereferences

1. Environmental chemistry by Nigel Bunce. Copy right 1994 by Wuers publishing LTD. Winipeg, Canada.
2. Environmental Science working with the Earth. Wadword, Inc., Belmont, California.

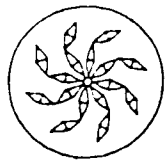
Student resource 10

1. Why human activities can affect global pattern?
2. What you can do to reduce the global warming?
3. Explain why nitrogen and oxygen that are the major air constituents do not absorb infrared radiation in the atmosphere?

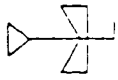
Student resource 11

Challenge: The greenhouse effect

From Getis, J. (1991), p.60



CHALLENGE: THE GREENHOUSE EFFECT



Unless you're a virtual hermit, you have undoubtedly heard about the greenhouse effect. But unless you're a science major or follow the news closely, you are probably uncertain as to what all the fuss is about. So here, to resolve that uncertainty, we present "Everything you ever wanted to know about the greenhouse effect but were afraid to ask."

Q: What is the greenhouse effect?

A: The theory of the greenhouse effect is that certain gases concentrate in the atmosphere, where they function as an insulating barrier, absorbing infrared radiation that would otherwise be reflected back into the upper atmosphere. In other words, like glass in a greenhouse, the gases let in incoming solar radiation but retard its reradiation back into space. The greenhouse effect could cause a gradual warming of the earth's surface and the lower atmosphere. Higher temperatures would have significant impacts on the earth's ecosystems.

Q: What gases are we talking about?

A: Carbon dioxide (CO_2), created mostly by burning fossil fuels, is the most plentiful of the gases and is thought to be responsible for about half of the warming. Each year, we send about 5.6 billion tons of CO_2 into the atmosphere, only half of which is absorbed by the oceans and forests. Burning the tropical rain forests not only adds to the emissions but also means losing trees that naturally absorb CO_2.

Equally important, taken together, is the accumulation of three other types of gases: (1) methane, from natural gas and coal mining, agriculture and livestock, swamps and landfills; (2) nitrous oxides, from motor vehicles, industry and chemical fertilizers; and (3) chlorofluorocarbons (CFCs) and halons, widely used industrial chemicals. Although these gases may be present in small amounts, some of them trap heat thousands of times more effectively than does CO_2. Fluorocarbon 12, for example, has 20,000 times the capacity of CO_2 to trap heat, and fluorocarbon 11 has 17,500 times the capacity of CO_2. Even methane is thirty times more potent than CO_2 in trapping heat close to the earth.

Q: What evidence is there that these gases are accumulating in the atmosphere?

A: We know that during the last 250 years the concentration of CO_2 in the atmosphere has risen from about 274 parts per million (ppm) to over 340 ppm. (Just since 1958, concentrations of CO_2 have increased from 315 ppm. This increase is one of the effects of the Industrial Revolution. The methane concentration in the lower atmosphere has *already* more than doubled from its preindustrial level (from 650 parts per billion to 1,700) and is currently increasing by just over 1% per year. The carbon monoxide concentration also seems to be increasing at a rate of slightly over 1% per year.

Q: Is the world really warming up? If not, why do they say it will?

A: It's too early to tell if the earth is warming up. When CO_2 concentrations reach about 550 ppm (double pre-Industrial Revolution levels), average annual global temperatures are expected to rise by 4° to 9°F (2° to 5°C). Predictions of when this doubling will occur vary. The year 2050 is commonly cited, but because gases other than CO_2 are contributing to the greenhouse effect, the warming may occur as early as 2030.

Proponents of the greenhouse-effect theory believe that human activity has already put enough of the various gases into the atmosphere to cause a significant rise in temperature in the next century. They contend that some warming is inevitable even if all emissions were to stop today, because the greenhouse gases are already in the atmosphere.

Q: What difference does it make if temperatures rise by a few degrees?

A: Researchers have developed various mathematical models to simulate the effect of greenhouse gases on the earth. The warming will not be uniform. It will be greater at higher latitudes than in equatorial regions, and it will produce significant changes in sea level, precipitation, and vegetation. The sea level is expected to rise 1 to 4 feet (0.3 to 1.2 m) as a result of ice-cap and glacial melting and thermal expansion of the water (water expands as its temperature increases). Most coastal marshes and swamps would be inundated by salt water; coastal erosion would increase. Water quality would decline as aquifers became polluted by salt. Such low-lying regions as the North American Gulf Coast, the Netherlands, the Nile Delta, Bangladesh, and much of Southeast Asia could lose substantial amounts of land. Many major ports might be flooded.

Warming of lakes and oceans would speed evaporation, causing more active convection currents in the atmosphere and thus fiercer

storms. Important regional changes in precipitation would occur, with some areas receiving more precipitation, others less. Polar and equatorial regions might get heavier rainfall, and the mid-latitudes become drier.

Changes in temperature and precipitation would affect soils and vegetation. The composition of forests would change as some areas became less favorable for certain species of plants and more hospitable to others. Hotter, drier weather would reduce crop yields in some areas, such as the corn and wheat belts of the Midwest. Conversely, more northerly agricultural regions, such as parts of Canada and the USSR, might become more productive.

Q: Don't some scientists dispute the greenhouse effect?

A: Yes. Some argue that global temperatures might stabilize or even decrease as the concentration of greenhouse gases increases. A hotter atmosphere, they say, would increase evaporation, sending up more water vapor that could condense into clouds. The increased cloud cover might reflect so much sunlight that it would slow the rate at which the earth would be heated. Others contend that the increased evaporation would produce more rainfall. As it fell, the rain would cool the land and subsequently cool the air over the land.

Finally, some researchers believe the geological record shows that large fluctuations in global temperature have always occurred independently of human activity, never as a result of it. These fluctuations are caused by such unpredictable events as variations in solar radiation, shifts in the earth's orbit and in ocean currents, meteoric activity, and volcanic eruptions.

Q: Why don't we just wait twenty or thirty years until we see what's going to happen?

A: If those who believe in global warming and its consequences prove to be correct, the longer we wait, the worse the situation will become. If we continue to spew billions of pounds of CO_2 and other greenhouse gases into the atmosphere each year, we help guarantee that the theory will become reality.

Furthermore, reducing gaseous emissions makes sense *regardless* of concern about the greenhouse effect. Decreasing the amount of coal, oil, and natural gas we burn saves money, saves resources, and will extend the life of precious fossil fuel reserves. It will reduce smog and acid rain. Controlling CFC emissions will help retard depletion of the ozone layer. Growing concern over CO_2 emissions will help prevent the destruction of the tropical rain forests and spur the effort to develop nonpolluting, renewable energy sources like solar and wind power.

Student resource 12

Oil pollution

Oil pollution of the sea attracts great public attention because it is visible and most people encounter it, either at first hand on bathing beaches, or from pictures on television and in the press whenever there is a spectacular oil spill.

Petroleum hydrocarbons reach the sea by many routes, however, and tanker accidents are by no means the only source of oil pollution.

I. what is oil?

Crude oil is a complex mixture of hydrocarbons with C_4-C_{26} or more carbon atoms in the molecules. Arrangements include straight chains, branched chains, or cyclic chains including aromatic compounds (with benzene rings). Some polyclinic aromatic hydrocarbons (PAH) are known to be potent carcinogen. Sulfur and Vanadium compounds are also included in crude oil and non-hydrocarbons may represent up to 25% of the oil. The exact composition of crude oil varies from one oil fuel to another.

Crude oil must be refined before it can be used. Refinding is essentially a distillation process with different fractions or cuts taken at different boiling ranges.

Refinery cuts of crude oil

Crude oil	Boiling range (^{0}C)	Molecular size (Numbers of carbon atoms)
Petroleum	30	3-4
Light gasoline, Benzene	30-140	4-6
Naphtha	125-175	7-10
Kerosene	165-200	7-15
Gas oil (diesel)	175-365	15-20
Fuel oil and residues	350	20

Light gasoline is the basis for petrol used in motor vehicles; naphtha provides feedstocks for petrochemical industry, the residue is used as bunker fuel in ships and power stations and the higher fractions are used as tars, and so on. Many of commercial products are further refined, made into particular formulations, and receive additives of other materials to suit them for their various purposes.

All components of crude oil are degradable by bacteria, though at varying rates, and variety of yeasts, and fungi can also metabolize petroleum hydrocarbons. Small, straight and branched chain compounds degrade most rapidly, cyclic compounds degrade the slowest. High molecular weight compounds, the tars degrade extremely slowly.

II. Sources of oil spill

An oil spill is the leakage of petroleum (usually crude oil) onto the surface of a large body of water. About half of all spilled oil seeps naturally from offshore geological formations. Another 20% is released due to accidents. These involve offshore or coastal drilling operations, the loading and unloading of oil from ships, and collisions or damage to tankers transporting oil. A third source of spilled oil is used organic solvents and lubricants that are dumped in coastal regions and on inland waterways. The amount of oil entering the worlds' ocean from all these sources is estimated at approximately 1,000.000 metric tons per year.

III. Fate of oil

When a spill occurs, the oil spread out on the surface of the water to form a slick. This thin layer impedes the exchange of gases with the water and it poisons surface organisms. If the seas are stormy, a froth is created as the oil is broken up into droplets by wave action. Wind and current may also move the slick from one area to another. In some cases the oil becomes stranded at the shoreline where it damages beaches and estuaries.

Some components of crude oil are volatile. Thus over a three month period about 25% of the oil evaporates. Over the following months, bacteria digest and degrade some of the nonvolatile but lighter components of the oil. Eventually the heavier components clump into tar balls. This 15% of the original oil spill settles to the ocean floor.

IV. Effects of the oil

When oil slicks reach the shoreline, they coat every thing with a sticky, slimy film that can have devesting effects. Water solutes components of crude oils and refined products include a variety of compounds that are toxic to wide spectrum of marine plants and animals. Aromatic compounds are more toxic than aliphatics, and midle-molecular weight constituents are more toxic than high- molecular-weight tars. Low molecular-weight compounds are generally unimportant because they are volatile and rapidly lost to the atmosphere. A spillage of diesel fuel, with a high aromatic content, is therefore much more damaging than bunker fuel and weathered oil, which have a low aromatic content. A spillage of petrol or may present a serious fire hazard, but has little impact on marine organonism in the water. Marine organisms close to shore die as the oil clogs their gills or other respiratory passageways. Large numbers of shell fish such as oyster, scallops, mussels, and clams die.

1. Plankton

Plankton might be supposed to be particularly at risk because it is exposed to the highest concentration of water- soluble constituents leaching from floating oil.

2. Fixed vegetation

Salt marshes, and, in the tropics, mangrove swamps are low energy areas likely to trap oil, and the plants which form the basis for these ecosystems suffer accordingly. Both are important ecosystems at the boundary between land and sea. They control coastal erosion, are a source of organic production which is transferred to the sea, and they provide shelter for the young stages of marine organonisms, some of commercial value.

The effects of oil pollution on annual plants living in a salt marsh depend on the season. If the plants are in bud, flowering is inhibited, if the flowers are oiled they rarely produce seeds, and if the seeds are oiled, germination is impaired.

3. Public health risk from oil pollution

Some petroleum hydrocarbons are toxic to humans and there are a few cases on record of children being made seriously ill or dying after inadvertently swallowing kerosene (paraffin). But humans have an extremely low taste threshold for petroleum hydrocarbon and the taste is particularly repulsive. There is therefore little risk of humans unknowingly receiving measurable does of these toxins from contaminated food or drinking water.

Oil includes polyclinic aromatic hydrocarbons, some of which are known carcinogens. These compounds might concentrate in the tissues of marine organism with the concentrations increasing up the food chain to reach the highest levels in carnivorous fish. Human consumers of theses fish might therefore be exposed to relatively large amounts of these carcinogens even in the absence of over oil pollution.

4. Commercial damage from oil pollution

Fisheries

Fixed installation where fish or shellfish held in intensive maritime culture are particularly vulnerable to damage from accidental oil pollution because the animals can not escape. A slick of oil drifting through such an installation may inflict commercial damage quite incommensurate with the size of the spillage.

Fish eggs and larvae are more sensitive to toxins and are commonly in surface waters where they are likely to encounter high concentrations of petroleum hydrocarbons, they are expected to be particularly vulnerable to damage by oil pollution.

V. Methods of cleaning the spill

Skimming devices can be used to clean up an oil spill. These devices separate the oil from the water and collect the oil in tanks. The effectiveness of these devices depends on

the viscosity (thickness) of the oil, the area of spill, and the weather conditions. Because the oil it was carrying was particularly thick, vacuuming and skimming procedures did not work. Therefore, the spill was allowed to reach shore and then removed by bulldozers and shovels.

Another approach to clean up has been the use of absorbent materials such as straw, volcanic ash, or plastic shavings. These materials are spread on the oil on the surface of the water and then removed, taking the oil with them. However, as yet no satisfactory method for disposing of the oil soaked absorbent has been devised.

Detergents have also been used to try to emulsify the oil and thus to minimize its effects. Examples: In 1967 the tanker Torrey Canyon ran aground off the coast of England, spilling more than 117,000 metric tons of oil. More than 20.000 tons of detergents were deposited on the spill to help disperse it before it could reach the shoreline. The detergent were water soluble and toxic, however. they caused the death of marine plants and animals in the areas of the spill. Unfortunately the detergent treatment did not prevent the oil from reaching the shore. In the end, the detergent caused more problems than oil alone.

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Chemistry issues in chemical Technology by, S. A., Staley, D. D., Jimpson, C. D., and Matta, M. S. Addition Wesley publishing company, New York

Student resource 13 Vietnamese article

How does effect of oil pollution damage on living thing?

From Tuan, H. (1991), p.80. (He translated French into Vietnamese from Evenement du Jeudi 326/1991)

Ô NHIỄM DẦU TRÊN BIỂN TÁC HẠI ĐẾN SINH VẬT NHƯ THẾ NÀO ?

LỚP dầu lan trên biển giết sinh vật qua hai thời kỳ. Trong những giờ đầu tiên, chất hydrocarbure nhẹ, như benzen, tan loãng trong nước gây độc cho các động vật đến 30m chiều sâu. Các lớp giáp xác, lớp nhuyễn thể và các loại cá nhỏ ít hoạt động sẽ chết trong chớp mắt. Chỉ có những loài cá lớn du mục có thể sống sót vì bơi kịp được sang vùng nước lành nhờ cái đập của những vây lớn. Lucien Laubier, giám đốc Viện khai thác ở biển của Pháp, nhớ lại : "Sau tai nạn của chiếc tàu chở dầu Amoco- Cadiz ngày 16-3-1978, người ta tìm được 240.000 tấn thú vật chết đưa bụng lên trời. Những con chạch chết trong hang, chỉ có giống cá mè vàng thoát nạn". Trong thời kỳ thứ hai, chất hydrocarbure nặng lắn vào nước. Trong vòng 48 giờ, nó tạo thành một lớp "rêu màu chocolat" rất độc. Lớp váng nâu đen này nổi hàng tuần trên mặt biển. Chim chóc đáp phải, lông chúng bị dính chất độc này. Dầu ăn mòn chất mỡ, lông chim mất tính không thấm nước. Nước ngấm vào đuổi đi lớp nệm khí giữ thăng bằng cho con vật. Bị dính dầu đến cổ, con vật chết vì đói và lạnh.

Lớp váng hydrocarbure tự phân chia và biến mất, bị tiêu hóa dần dần bởi các vi khuẩn (dầu là chất hoại sinh). Nhưng rủi ro nếu một làn gió cát thổi qua, lớp váng dầu lại biến thành hắc ín, chìm xuống đáy biển, làm chết ngạt tất cả các động vật và thực vật.

Phải cần đến 7 năm để khôi phục lại các động vật và thực vật bị sát hại do tai nạn tàu Amoco- Cadiz. Chiếc tàu dầu này đã làm chảy 220.000 tấn dầu vào biển và vùng duyên hải. Trong vòng 4 tháng, 15.000 người tình nguyện chiến đấu chống lại đám triều đen trên biển. Các phương pháp làm sạch đến nay vẫn không tiến bộ hơn bao nhiêu.

Lớp san hộ ngầm của vùng Vịnh là chỗ trú ẩn các động vật và thảo mộc thuộc nhiều giống khác nhau, một số thuộc loại độc nhất trên thế giới. Có những giống chắc chắn gặp nguy ngập : đại hải âu, hải yến má trắng. Những con vật vô tư này đã chọn vùng đất nóng này của quả đất làm nơi trú ngụ cố định, tưởng rằng sẽ qua những ngày tháng an lành. Nếu ô nhiễm nặng, chúng có nguy cơ biến mất vĩnh viễn. Ngay cả giống hạc trắng cực hiếm của Sibérie và hàng ngàn con chim di trú cũng bị đe dọa.

HOÀI TUẤN

(Theo Evénement du Jeudi 326/91)

Student resource 14

1. Do research on a recent oil spill. Answer the following questions about the spill. Where did the spill occur? What was the cause of the spill? what measures were taken to clean up the spill? What impact did the spill have on living things and the shoreline?
2. Why is an oil spill a threat to the environment?
3. What can be done to clean up oil spill?