UNITED NATIONS ENVIRONMENT PROGRAMME

REGIONAL OFFICE FOR ASIA AND THE PACIFIC

UNEP

RESOURCES VOLUME FOR TERTIARY LEVEL EDUCATION AND TRAINING IN THE MANAGEMENT OF TOXIC CHEMICALS AND HAZARDOUS WASTES

NETWORK FOR ENVIRONMENTAL TRAINING AT TERTIARY LEVEL IN ASIA AND THE PACIFIC (*NETTLAP*)

NETTLAP PUBLICATION No. 12
1995

Note: This document has been edited by John E. Hay, Wimala Ponniah and Mahesh Pradhan as a contribution to the *Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP)*, a project of the United Nations Environment Programme (UNEP). The preparation of this document was carried out under project FP/3101-92-01 (3020).

The designations employed and the presentation of the material in the document do not imply the expression of any opinion whatsoever on the part of UNEP concerning the legal status of any State, city or area, or its authorities, or concerning the delimitation of its frontiers or boundaries. The document contains the views expressed by the authors acting in their individual capacity and may not necessarily reflect the views of UNEP.

For bibliographic purposes this document may be cited as:

Hay, J.E., W. Ponniah and M. Pradhan: Resources Volume for Tertiary Level Education and Training in the Management of Toxic Chemicals and Hazardous Wastes. United Nations Environment Programme (UNEP), Regional Office for Asia and the Pacific (ROAP), Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP). NETTLAP Publication No. 12, UNEP, Bangkok, Thailand, 1995, 212pp.

UNITED NATIONS ENVIRONMENT PROGRAMME

REGIONAL OFFICE FOR ASIA AND THE PACIFIC

UNEP

RESOURCES VOLUME FOR TERTIARY LEVEL EDUCATION AND TRAINING IN THE MANAGEMENT OF TOXIC CHEMICALS AND HAZARDOUS WASTES

John E. Hay,
Wimala Ponniah
and
Mahesh Pradhan
(Editors)

UNEP
LIBRARY AND DOCUMENTATION CENTRE

NETWORK FOR ENVIRONMENTAL TRAINING
AT TERTIARY LEVEL IN ASIA AND THE PACIFIC
(*NETTLAP*)

NETTLAP PUBLICATION No. 12
May, 1995

COMPANION REPORT

A formal report on the workshop at which the present volume was prepared is also available. Details of the report are given below:

Hay, J.E., W. Ponniah and M. Pradhan: Report of the Second NETTLAP Resources Development Workshop for Education and Training at Tertiary Level in the Management of Toxic Chemicals and Hazardous Wastes. United Nations Environment Programme (UNEP) , Regional Office for Asia and the Pacific (ROAP), Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP). NETTLAP Publication No. 9, UNEP, Bangkok, Thailand, 1995, 86pp.

PREFACE

The resource materials related to education and training the management of toxic chemicals and hazardous wastes which appear in this volume were prepared at a workshop convened by UNEP's Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP). The workshop was held in Hyderabad, India from November 22 to 24, 1994.

The materials reflect the fact that sound management of toxic chemicals and hazardous wastes requires, amongst other actions, an investment in training and education. A factor which is hindering the introduction *and* maintenance of appropriate management practices in all developing countries of the Asia-Pacific region is a shortage of trained, experienced and qualified personnel.

Training programmes targeting staff in appropriate universities and technical institutes can do much to address this shortcoming, especially if the training activities are coordinated with the many important initiatives being taken by UNEP's Environmental Education and Training Unit (EETU), the Industry and Environment Office (IE/PAC), IRPTC, the Secretariat for the Basel Convention (SBC) and the International Programme on Chemical Safety (IPCS), and by other organizations including the United Nations Institute for Training and Research (UNITAR), the Economic and Social Commission for Asia and the Pacific (ESCAP), the Asian Development Bank (ADB), the United Nations Industrial Development Organization (UNIDO), the International Labour Organization (ILO) and the World Health Organization (WHO).

Chemicals arise naturally and are a normal part of the environment, having been used by people since the beginning of civilization. Other chemicals are synthesized by humans. Again, many of these are used, to the benefit of modern life. However, some of these chemicals do exhibit toxic and other hazardous properties. Such materials require identification, reduced use, adoption of less hazardous alternatives and a "cradle to grave" approach to the management of the quantities in continuing use.

Based on recent estimates, the Asia-Pacific region produces approximately 50 million tons of hazardous waste each year. This is a significant proportion of the 300 to 400 million tons generated world wide, especially when the region's comparatively limited capacity to manage this waste is taken into account.

According to the International Register of Potentially Toxic Chemicals (IRPTC) there are more than 8 million known chemicals, with about 70,000 in common use. Each year between 1,000 and 2,000 new chemicals are released onto the market (UNEP, 1992).

Consequent priority areas for human resource development that impinge on the teaching and educational activities of tertiary institutions include the following themes, many of which are identified in Agenda 21:

- enhance capacity to contribute to and make use of national and international assessments of chemical risks;

- develop and use mechanisms for the risk management of chemicals;
- increased understanding and use of a new harmonized classification and compatible labelling system for chemicals;
- develop greater understanding and use of databases and other information systems on toxic chemicals;
- develop and use mechanisms for the safe production, management and use of dangerous materials, formulating programmes to substitute them with safer alternatives;
- promote and adopt interdisciplinary approaches to chemical safety problems;
- encourage investigations into and promote the use of cost-effective alternatives for processes and substances that currently result in the generation of hazardous wastes;
- seek and adopt economically attractive mechanisms leading to the ultimate phase out of those substances that present an unmanageable risk and are toxic, persistent and bio-accumulative;
- explore and implement strategies that lead industry to adopt cleaner production methods, to invest in preventative and/or recycling technologies and to pursue hazardous waste minimization and management programmes which are environmentally sound;
- promote the development and implementation of environmentally sound technologies;
- develop methods for tracking the generation, movement, storage and disposal of hazardous wastes and for the identification of contaminated sites;
- assist in the identification and application of methods for the environmentally sound disposal of hazardous wastes and for the rehabilitation of contaminated sites; and
- encourage the development and implementation of procedures and programmes for hazardous waste audits and for regulation of hazardous processes, activities and materials generation.

Through research, tertiary institutions have already contributed extensively to the ability to manage toxic chemicals and hazardous wastes in ways which are environmentally sound and to the development of alternative approaches that avoid the use of toxic chemicals or the generation of hazardous wastes. Technology transfer and training and educational programmes for both students and members of the public and private sectors have lead to these environmentally sound approaches achieving widespread use and acceptance. But the process is far from complete, and tertiary institutions still have a critical role to play.

On behalf of the Executive Director of the United Nations Environment Programme, Ms Elizabeth Dowdeswell, I invite you to use the contents of this volume to enhance the quality and relevance of training programmes in the region.

Dr. Suvit Yodmani
Director and Regional Representative
United Nations Environment Programme
Regional Office for Asia and the Pacific
Bangkok, Thailand

CONTENTS

[cont.]

Contents (cont.)

ACKNOWLEDGEMENTS

This NETTLAP workshop would not have been possible, or as successful, without the cooperation and assistance of the following:

- the Environmental Protection, Research and Training Institute in Hyderabad, India, and its Director, Mr Tishya Chatterjee

- Mr G.V. Subramanyam, NETTLAP National Focal Point for India

- the Government of India

- UNEP's Industry and Environment Office and, in particular, Dr F. Balkau

- International Register of Potentially Toxic Chemicals and, in particular, Mr G. Chkolenok

- UNEP's Regional Office for Asia and the Pacific and, in particular, Dr Suvit Yodmani (Regional Director), Dr Wimila Ponniah (NETTLAP Project Coordinator) and the cooperative and hard-working office staff

- NETTLAP's Thematic Network Coordinator and Thematic Network Nodes for Toxic Chemicals and Hazardous Waste Management

- UNEP's Environmental Education and Training Unit and, in particular, Mr Michael Atchia

- UNEP's International Environmental Technology Centre and, in particular, Mr T. Tamura

- the Economic and Social Commission for Asia and the Pacific

- Lynette Hay for editorial and other assistance

- the numerous other individuals and organizations which made significant contributions

A STRATEGY FOR PREPARATION OF RESOURCES FOR EDUCATION AND TRAINING IN THE MANAGEMENT OF TOXIC CHEMICALS AND HAZARDOUS WASTES

John E. Hay
NETTLAP Coordinator
UNEP/ROAP
Bangkok
Thailand

and

Environmental Science
School of Environmental and Marine Sciences
University of Auckland
Auckland
New Zealand

Introduction

The present paper describes the strategy used in UNEP's Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP) to prepare resource materials for environmental training and education. The key action in the strategy adopted by NETTLAP is to bring together individuals who are acknowledged as being successful in their professional activities in a given theme in the region. In the present case this is management pf toxic chemicals and hazardous wastes (TCHW). The individuals help identify and develop methods, tools and materials applicable for use in education, training and awareness programmes conducted by staff in tertiary institutions and related to the integrated management of hazardous materials.

The intention is to strengthen the ability of staff in tertiary institutions of the Asia-Pacific region, and in the present case in the South and Central Asian sub-region in particular. The ultimate goal is to inform a range of audiences (e.g students, industry decision-makers, government officials, leaders of non-governmental organizations, tertiary level trainers) in the safety, cost effectiveness, local and impact aspects of toxic chemicals and hazardous waste management (TCHWM).

Focus on Tertiary Level Education and Training

Staff from tertiary institutions, including universities, technical institutes, professional training institutes and teacher training colleges, will be the immediate beneficiaries of this workshop. They form a large and influential constituency. In addition to training and educating substantial numbers of students who are the decision-makers and managers of the future, staff of tertiary institutions are often directly involved in advising on, and assisting with, the development and implementation of policies related to the management of toxic chemicals and hazardous substances. These staff will be encouraged and assisted to incorporate the newly acquired information and teaching methods in their regular teaching activities, and also in short courses offered for government and industry. Thus, despite involving only a small but key group of people in the workshop itself, the information and skills will be transferred both widely and rapidly.

A Multiplier Effect

Specifically, the workshop will result in the direct training of workshop participants, but through them it will be possible to train their colleagues in tertiary institutions, students in formal degree and certificate programmes, participants such as government officials, industry managers who attend short courses, as well as the general public through community outreach programmes conducted by the tertiary institutions. Relevant members of NETTLAP will share in the results of the workshop through distribution of a resources volume based on relevant workshop outputs. There is thus there is a large "multiplier effect" arising from this workshop.

The workshop is not a conventional technical workshop related to aspects of the management of hazardous materials. Rather the focus is on the identification, development, evaluation and dissemination of methods, tools, and materials used to support training activities in the management of hazardous substances. Thus the approach of the workshop is to share relevant knowledge, skills and experiences, to demonstrate and evaluate methods and tools, to develop and evaluate materials and to identify and commit to appropriate follow-up activities, individually and collectively.

Integrated Approach

The selection of workshop participants, and the programme itself, recognises that not all the relevant training expertise lies within tertiary institutions. For this reason the workshop brings together a broad range of participants: experienced trainers in hazardous materials management, from government and the private sector as well as from tertiary institutions themselves; individuals who are experienced in the more technical and practical aspects of hazardous materials management; and experienced environmental trainers and educators who can make contributions to training at the more generic level.

Workshop Format

The workshop is conducted as a series of substantive modules focusing on training and communication in:

- the management of toxic chemicals;
- chemical safety and process risk assessment;
- emergency planning and response (both on and off site) and integrated management of

chemicals;
- prevention and minimization of hazardous waste generation;
- treatment and other aspects of hazardous waste management;

and on:

- generic training methods;
- curriculum development; and
- training packages, kits and materials.

All outputs and outcomes of the workshop relate to some aspect of training in the management of hazardous materials:

- curriculum guidelines, training methods tools and materials related to TCHWM, and of principal use by staff in tertiary institutions;

- a published workshop report that also includes case studies demonstrating the application of the above outputs;

- tertiary level trainers aware of the resources and expertise available to them for teaching and training in TCHWM, and familiar with methods being used by experienced and successful trainers; and

- commitments for follow-up activities that build on the methods, tools and materials shared at the workshop.

Participants' Pledges

In order to encourage effective follow-up to the workshop, each participant at the workshop can be asked to make an individual pledge in response to the questions: i) what will you do? and ii) what would you wish to do as a member of a joint activity? The following are the individual pledges.

Workshop Evaluation

In help ensure that the workshop process is effective, each participant should be asked to complete the relevant parts of a formal evaluation questionnaire at the end of each day. The completed questionnaire can be submitted during or immediately after the final session. The questionnaire used in the NETTLAP workshops is designed to assess participants' expectations of, and experiences in, the various aspects of the workshop programme and activities.

For each question the quantitative responses can be aggregated and the resulting data presented graphically (see Figure 1). The left hand diagram in each graph indicates whether participants felt that the session or activity was above or below their expectations of relevance, usefulness and practicality. This information was derived from the individual responses to a request that each participant indicate the extent to which they had expected the session or activity to be relevant and then score their actual experience. Thus the expectation and experience responses are scored directly, while the information on whether the session or activity was above or below expectations is derived from the differences between these two responses. This relative information may therefore be a more correct reflection of the actual opinion of a participant.

For each individual it is also possible to obtain some explanation as to why their expectations are met, exceeded or not achieved. Each participant can be asked to identify the session high point and low point and to offer any other written comment.

Reactions of participants to other aspects of workshop organization and implementation can be determined using conventional questionnaire approaches. Participants may also be given the opportunity in a group session to verbalize their views of the workshop and to discuss these with fellow participants. Finally, at the end of each day the workshop planning and implementation group can meet to assess informally the quality of that day's activities and to adapt the programme for the upcoming day in light of that assessment.

Summary and Conclusions

The strategy outlined above forms the basis of the approach used by NETTLAP in the development, evaluation and dissemination of quality and targeted materials that support education and training in the region. The large multiplier effect means that, despite the limited resources that are available to support such activities, a large number of key individuals and groups are soon benefiting from the activities undertaken by NETTLAP.

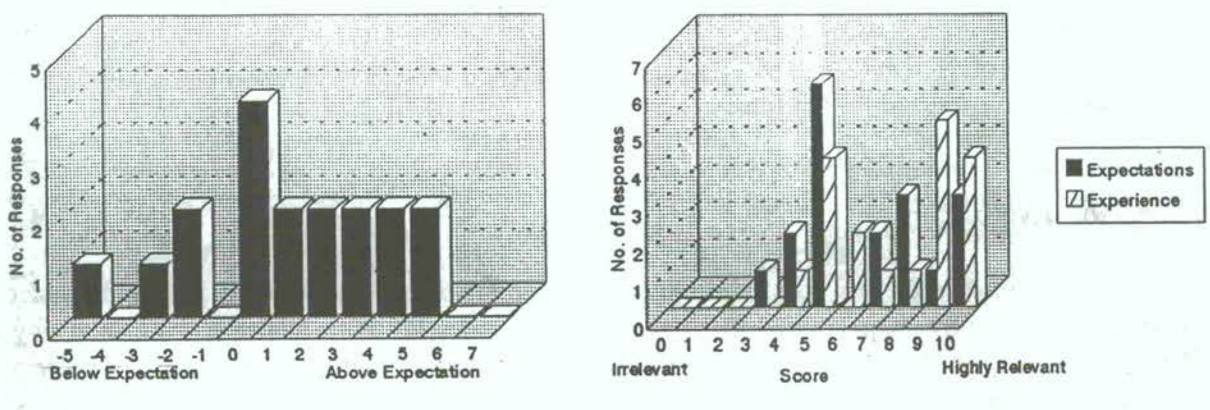


Fig. 1 Example of responses in evaluation of a particular workshop session.

TRAINING APPROACHES FOR ENVIRONMENTAL MANAGEMENT IN INDUSTRY: UNEP'S ACTIVITIES AND ROLES

Fritz Balkau
UNEP Industry and Environment
Paris
France

Introduction to Training in Industrial Environmental Management

There is little doubt that environment has now become an important element in business management in all countries. This is true even if management does not realize it yet, as environment is actively shaping international trade and markets for products. However, many companies lack the personnel who understand the issues and who are familiar with the environmental management tools needed to respond. Ongoing training of industrial personnel is therefore one of the key actions needed to move the industrial sector into a more pro-active phase of environmental action.

Traditionally, environmental action has been the domain of specialists who had extensive expertise in remedial actions. Such environmental specialists continue to be needed, but the approach to environmental responsibility has evolved to now include also other categories of personnel.

In particular, the notion of a preventative environmental approach, ie. avoiding problems instead of resolving them afterwards, means that production personnel will also contribute to environmental performance. Production personnel and management therefore need a clear view of the issues, and how they should respond.

Due to the number of environmental issues that now confront a company, their complexity, and the fact that the issues are themselves evolving rapidly, companies need a systematic and flexible approach to environmental management. The earlier ad-hoc, single-issue approach to environment is costly and often ineffective. In practice this will imply a formal environmental control system, with explicit responsibilities being defined for guiding the system. Company management needs a clear view of how environmental decisions can be integrated into normal commercial considerations.

It is obvious from the above that environmental training for industry needs to take place at several different levels. In particular, training should aim to build:

* environmental literacy for all personnel
* expertise in use of environmental tools by specialists

* environmental decision-making skills for managers

The time at which training takes place will vary greatly. Re-training in environment for existing managers and production personnel is certainly necessary in order to address the urgent environmental problems of today. Experience shows however that re-training has its limits. If possible, the next generation of technicians and managers should already have good awareness and skills in environment. All future employees, whatever their profession or trade should understand the importance of preventative action. This places a major responsibility on all secondary and tertiary educational institutions.

In training it is important to distinguish knowledge from skills. Knowledge can be acquired and updated relatively easily. Traditional environmental education systems have stressed the acquisition of knowledge.

Environmental decision-making is based on more than mere knowledge. It requires skill in assessing environmental information, integrating various environmental factors, and balancing these against other social and commercial considerations. In the real world it is important to be able to make decisions in the absence of sufficient data, based on a feel for the issues. Skill in decision-making has not been a major feature of environmental education in the past, but is now very important for industrialists and administrators.

Future consultants are an important target. Consultants, as advisers to companies, need to ensure not only that they are technically correct in their advice, but that they are using the right approach for the situation. For example, a preventative, waste minimization approach is often more cost-effective for a client than simply building a large effluent treatment plant. Consultants need to appreciate the broader picture as well as possess specialized knowledge and skills.

With such a complex challenge to the industrial training issue, it is necessary to ask if there are enough trainers available, and what methods and curricula they use. As environmental issues evolve so quickly, it is no longer satisfactory to merely copy the training curricula of the past, and to repeat what other course have offered elsewhere. Updating trainers in environmental issues has become an important element in the total equation.

In practice, experience shows that good environmental training programmes are scarce, and that good trainers who understand the issues and use the right training methodologies even more so. There is a great need for industry associations, institutes and international organizations to support an expansion of environmental training in, and for, industry.

Training for Industrial Environmental Issues - UNEP's view

UNEP sees training as part of the capacity building initiative which was so extensively discussed at the Earth Summit in Rio in 1992. Capacity building means creating a local ability to solve problems, including also the infrastructure and services necessary to take action. Local ability to train for environmental skills is an important part of capacity building.

As the unit within UNEP that deals specifically with industry issues, UNEP Industry and Environment is a natural focal point for training activities concerning industry. These training activities take a number of forms:

* awareness-raising and training on important thematic issues such as cleaner production, industrial accidents (APELL), and ozone layer protection. Targets are senior industry and government personnel with responsibility to make decisions on environmental issues. Training will also be a major part of the operation of the UNEP/UNIDO national cleaner production centres now being established in several regions. The cleaner production working group on education promotes training on this issue in institutions around the world.

* awareness-raising and training of business managers on environmental management systems and management tools such as auditing. Through seminars and workshops, managers acquire the information and skills to change the operations in their companies in order to enhance the effectiveness of environmental actions.

* training of technical specialists in the use of environmental management tools such as waste and emission auditing, CFC replacement techniques, environmental impact assessments, chemical risk assessment and priority setting. This training is usually in the context of broader UNEP programmes such as cleaner production, Ozonaction or IRPTC.

* influencing environmental curricula and courses offered by engineering and technical institutes and business schools (training the trainers). Targets are teachers/trainers who will subsequently multiply the effect through their own courses. So far the workshops and seminars in this initiative have had a very good response. At the same time, UNEP has been encouraging other institutes to teach on key environmental issues, and to use UN material that is available. Several UNEP units contribute to this "train the trainers" programme, with collaboration also from other UN agencies and institutions.

* general public awareness, including undergraduate schools and colleges is an ongoing activity throughout UNEP, that is particularly promoted by UNEP's Environmental Education and Training Unit (EETU).

In addition to actual training events in the above areas, UNEP has produced training resource material that can be used by others. This material may include a suggested course or workshop, but more often is a resource package from which trainers can select what they need for their own situation. Packages cover cleaner production, industrial accidents, hazardous waste management, contaminated land and chemicals assessment as well as industry sectors such as tanning, mining, and recycling. A current list of training publications is shown in Appendix I.

These training packages are usually backed up by technical support material, background reading and extensive reference lists to enable trainers who are not specialists to advance their own understanding sufficiently to teach on the subject, and to develop additional material themselves.

A feature of much of the UNEP training material is the extensive use of case studies, simulations and practical work exercises. This allows the trainer to simulate actual situation in a company or a country, and give the trainees practical experience in environmental decision-making.

Gradually UNEP is also building networks of trainers who can share their own material and discuss useful approaches among themselves. The 1994 workshop in Dresden brought together 30 trainers from 24 European countries, and resulted in a great interest among the institutions to continue to cooperate into the future. Network-building has also commenced in Africa and Asia. A special benefit of these networks is that they are able to adapt and further develop the UN-produced training materials to the particular needs of their region, including translation into regional languages.

Through these networks UNEP has been able to compile lists of appropriate training material produced by others. Such lists are available on request.

The environmental training of business leaders is another key issue being addressed by UNEP IE. Through work with management development institutes around the world it is hoped to include more explicit discussion of environmental issues in the senior management courses offered by these institutions. This initiative also has the support of ICC and other business groups. In order to extend the scope of this initiative, UNEP, ICC and FIDIC are preparing a training kit to allow institutes and associations everywhere to understand the importance of environmental management systems, and how they are operated within companies. This kit will be completed in the second half of 1995 (see Appendix II).

The fruits of training will only be realized if companies adopt action plans based on integrated, systematic and preventative approaches. Accordingly UNEP's programmes on cleaner production, industrial accidents and sectorial publications will continue to provide the technical assistance needed to make real changes in industry. The close association of the training programmes with these technical activities ensures that the latter are actually implemented, and conversely, that training programmes remain relevant as environmental issues and tools continue to evolve.

Summary

Environment has now become an important element in business management in all countries. However, many companies lack the personnel who understand the issues, and who are familiar with environmental management tools needed to respond. Environmental training is therefore one of the key actions needed to move many companies into a more pro-active phase of environmental action.

The training needs can be summarized as follows:

* there is a need for specialists who have good environmental skills, but

equally, all professionals in industry must be environmentally literate

* training must build skills (understanding) as well as knowledge (facts)

* skills include the ability to use new environmental tools, and to integrate diverse disciplines into management decisions

* training curricula must continually develop as environmental issues evolve

Skill building requires new teaching approaches, including greater use of case studies, simulation exercises and practical problem-solving.

As well as carrying out direct training on important thematic issues and industry sectors, UNEP has been working to enhance the capacity of institutes and trainers to incorporate new issues into their curricula. Training packages have been developed for worldwide use in cooperation with business groups and UN agencies. UNEP's technical programmes continue to underpin these training initiatives, and ensure that they remain relevant and up-to-date as environmental issues evolve.

Annex I

SELECTED LIST OF RELEVANT TRAINING PACKAGES
AVAILABLE FROM UNITED NATIONS ORGANIZATIONS

United Nations Environment Programme Industry and Environment (UNEP IE)

Cleaner Production. September 1994. Contains background reading, transparencies, bibliography, case studies, and work exercises. 110 pages.

Cleaner Production in Leather Tanning. A set of work exercises. September 1994. Contains work exercises and bibliography. 65 pages.

Environmental and Technological Issues Related to Lead-Acid Battery Recycling. Preliminary version September 1994. Contains background reading, transparencies, bibliography, and work exercises. 130 pages.

Management of Accident Prevention and Preparedness. September 1994. Contains background reading, transparencies, bibliography, case studies, and work exercises. 110 pages.

Hazardous Waste, Policies and Strategies. A Training Manual, December 1991. Contains background reading, case-study, work exercises, reference tables, and bibliography. 250 pages. 350 FF.

Landfill of Hazardous Industrial Wastes. A Training Manual. March 1994. Contains background reading, case-study, work exercises, reference tables, and bibliography. 315 pages. 350 FF.

INVENT. Industrial Waste Prediction Model, 1990. A training package and manual to familiarize users with the INVENT Calculation Programme.

Environmental Management of Mining Sites, UNEP/DDSMS. to be published in 1995. Contains background reading, transparencies, case-studies, work exercises, and bibliography. 200 pages.

Site Identification and Remediation Options for Contaminated Industrial Land. Preliminary version September 1994. Contains background reading, transparencies, bibliography, case studies, and work exercises. 110 pages.

Tools for Action to Prevent Ozone Depletion. Preliminary version May 1994. Contains background reading, transparencies, bibliography, and work exercises. 100 pages.

Environmental Management System Training Kit, UNEP/ICC/FIDIC, to be launched in 1995. Contains a comprehensive trainers guide, an environmental management system lecture section, over 100 supporting transparencies.

While the format of individual packages varies, the contents may include:

* users guide
* introduction to the environmental issues
* technical background papers
* a basic set of transparencies for trainers
* bibliography and other resources available
* case studies and country/company scenarios
* work exercises based on the case studies, plus other exercises
* answers to the exercises
* suggestions for effective training
* outline of a typical training workshop
* technical support documents

In future it is hoped to include also some audio-visual material within the packages.

The packages are not intended to be static. Practising trainers are encouraged to adapt, and develop the material further, adding additional case studies and exercises as they develop these themselves.

The case studies and country scenarios are an important feature of many of the packages. They allow trainees to simulate decision-making in realistic situations, if necessary assisted by experienced trainers and technical resource persons.

In practice the technical information needed to support the simulated decision-making is also useful in real life, and the trainers packages have been extensively used by consultants and government officials in addressing actual situations in their professional lives.

Enquiries: F. Balkau, UNEP IE, 39-43 Quai André Citroën, 75739 Paris, France.
Fax. (33 1) 44 37 14 74.

United Nations Industrial Development Organization (UNIDO)

A Training Course on Ecologically Sustainable Industrial Development, 1994. Contents: 10 learning units, a video cassette containing seven short films, two floppy discs, three booklets, and a learning recall tape (30 min.). Available from UN sales centre, $250.

Enquiries:R. Luken. UNIDO, P.O. Box 300, 1400 Vienna, Austria.
Fax. (43 1) 211 313 352.

International Labour Office (ILO)

Environmental Management Training: ILO/UNEP Programme in Support of Managers and Management Institutions (5 Volumes), 1987. Currently being updated.

Environmental Training, Policy and Practice for Sustainable Development, 1994.

Higher Productivity and a Better Place to Work. Practical ideas for owners and managers of small and medium-sized industrial enterprises, 1988.

Safety and Health in the Use of Chemicals at Work. A training manual, 1993.

Workers Education and Health. Discussion Booklets, 1993. Contains six booklets addressing workers-related environmental problems.

Enquiries:Publications Department, ILO, CH-1211 Geneva 22, Switzerland.
Fax. (41 22) 798 86 85.

World Health Organization (WHO)

Assessment of Sources of Air, Water and Land Pollution (2 Volumes), 1993. Describes the rapid source inventory assessment technique (RSIT), including updated emission factors and guidelines for applying RSIT to environmental management problems.

Problem-Based Training Exercises for Environmental Epidemiology. Instructor's Guide, *Problem-Based Training Exercises for Environmental Epidemiology. Student's Guide*, 1991. A two-part collection of exercises based on real-life situations which reviews the basic concepts in environmental epidemiology. The Instructor's Guide includes recommendations on how to use the exercises and suggested answers to problem sets.

Enquiries:F. Lapensee. WHO, Environmental Technology Division of Environmental Health, 1211 Geneva 27, Switzerland. Fax. (41 22) 791 07 46.

International Programme on Chemical Safety (IPCS)

Chemical Safety (Fundamentals of Applied Toxicology). Training Modules. Out of print, but currently being revised. Contents: material to handout, demonstration and exercises, slides, colour transparencies, and diskettes of text files and databases.

Multilevel Course on the Safe Use of Pesticides and on the Diagnosis and Treatment of Pesticide Poisoning, 1992.

Resource Guide on Training and Technical Assistance Activities of International Organizations in the Area of Chemical Safety.

Enquiries:The Director, IPCS, 20 Avenue Appia, CH-1211 Geneva 27, Switzerland. Fax. (41 22) 791 48 48.

United Nations Educational and Scientific and Cultural Organization (UNESCO)

UNESCO Series of Learning Materials in Engineering Sciences. Postgraduate Course in Environmental Education. Module on selected topics in environmental management, 1993.

Enquiries:Unesco, Engineering and Technology Division, 7, place de Fontenoy, 75700 Paris, France. Fax. (33 1) 40 65 95 35.

International Maritime Organisation (IMO)

The Global Waste Inventory and Database, 1992. Not a training package, but a useful database that can be used as a teaching aid.

MARPOL 73/78 Annex I & II. A model course on marine pollution and environment protection.

Enquiries:A. Ross, IMO, 4 Albert Embankment, London SE1 7SR, UK. Fax. (44 71) 587 32 10.

Annex II

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)
and
INTERNATIONAL CHAMBER OF COMMERCE (ICC)
and
INTERNATIONAL FEDERATION OF CONSULTING ENGINEERS (FIDIC)

ENVIRONMENTAL MANAGEMENT SYSTEM TRAINING KIT AND WORKSHOPS

In May 1995, UNEP, the ICC and International Federation of Consulting Engineers (FIDIC) will release a jointly developed environmental management system (EMS) training kit based on the ICC Business Charter for Sustainable Development, the draft ISO 14001 standard on environmental management systems, and cleaner production. This UNEP/ICC/FIDIC EMS Training Kit will be disseminated internationally through jointly organized information seminars and EMS workshops.

This project was endorsed in April 1994 at the occasion of the UNEP/ICC Advisory Panel meeting. This Advisory Panel, compromised of high level government ministers, industry representatives, and non-governmental organizations, meets bi-annually to review progress on the implementation of the ICC Business Charter. At the conclusion of the meeting, it was announced that "UNEP and the ICC have agreed to cooperate in a world-wide campaign to encourage business enterprises of every size, and particularly small and medium-sized companies, to implement the ICC Business Charter".

The objective of the UNEP/ICC/FIDIC EMS Training Kit, developed under the guidance of an international Steering Committee, is to provide the basic building blocks of environmental management systems to business and industry manager's in developing countries and that environmental management systems are an important tool to integrate environmental issues into business operations and that adopting such systems in an enterprise can often increase it's competitive advantage.

The UNEP/ICC/FIDIC EMS Training Kit includes:

* a comprehensive trainers guide designed to build the environmental management capacity of trainers;
* and environmental management system lecture section tailored to SMEs, based on the draft ISO 14001 standard, and cleaner production;
* over 100 supporting transparencies;

The UNEP/ICC/FIDIC EMS Training Kit will be launched at introductory seminars to be held in Sophia, Bulgaria and China in 1995. These seminars will be followed by 2-3 day workshops based on the UNEP/ICC/FIDIC EMS Training Kits to be run by locally identified focal points. Possible seminar locations for 1996 include Colombia and India.

For further information, please contact:

UNEP Industry and Environment
39-43 quai Andre Citroen
75739 Paris Cedex 15,
tel: (33.1) 44.37.14.50
fax: (33.1) 44.37.14.74

International Chamber of Commerce
38 Cours Albert 1er
75008 Paris, France
tel: (33.1) 49.53.28.08
fax: (33.1) 49.53.28.59

COMMUNICATING AND TRAINING: TOXIC CHEMICALS MANAGEMENT

Tishya Chatterjee
Environmental Protection, Training and Research Institute
Hyderabad
India

Introduction

In the South Asian context, a bottom - up information network can be an effective tool to supplement established communication and training methods in environmental areas. This is very true for the toxic chemical management sector, where risks and consequences have a shorter time span than in general environmental impacts. In toxic chemicals management, education and training must reach potential victims and users faster. The more the focus of information content on local conditions, the more effective will be the communication / training.

Comparative Analysis

Global databases should be used as references and guidance at distributed network nodes. But national, tertiary level and regional databases on toxic chemicals should ideally be built up from ground level monitoring, analysis and after stakeholder interaction. Toxic chemicals management encompasses important policy , enforcement, educational, training, information, health, geographic spread and waste reduction/cleaner production implications that should first of all be interpreted, simplified and communicated at the local level and to those directly affected. This is of greater importance for South Asian countries.
A comparative analysis is summarised in Table 1.

In the developed countries the level of industrial standardisation and awareness is such that toxic chemicals used in industrial processes can now be followed through life-cycles of clearly identifiable processes and products. Populations are mobile and highly aware of environmental implications to the extent that people, in partnership with industries, supervise toxic chemicals management. In fact, environmental management for eco-friendly production has become a new business thrust in the developed world.

In South Asia, on the other hand, populations are more static and traditionally attuned to local issues. Industries are mostly just a step ahead of trade and into low-tech manufacturing. Investments are low with low economies of scale and with very short term returns in view. The importation, manufacture, storage, use, transport and disposal methods

Table 1

Contrasts in Toxic Chemicals Management Between Developed and Developing Countries

Developed	Developing/South Asia
1. High industrial standardisation	1. Low industrial standardisation.
2. High Environment Awareness	2. Low environment Awareness and weak implementation of environment laws.
3. Industry-people led environment standards. Business Orientation in Environmental management.	3. Government led standards and enforcement.
4. Toxic chemicals - L.C.A. through raw material - process - product disposal/purchase - destruction/recycle	4. Toxic chemicals use is a "trade secret".
5. Chemical processes and product - well identified and linked.	5. Batch processing technology - trade oriented and order dependant production Adhoc.
6. Local information already incorporated into regional/national databases.	6. Local information not available or is in a highly dis-aggregated form.
7. Mobile population.	7. Less mobile population - local issues more relevant than national.
8. Modular training useful - environmental status similar everywhere.	8. Modular training to be supported with local interactive platforms. Supplying local information up and down.
9. Impersonal Communication Systems - electronic etc.	9. Very personal communication effective. Need for permanent, established interaction.

of toxic materials are generally in the category of "trade secrets". Users do not often have a long term stake in the raw material, process or the product. Technologies using or producing these toxic chemicals are of the batch process design, not allowing steady predictions of toxic concentrations in throughput and outputs. Typically, with massive information gaps at the local level, effects of mishandling toxic chemicals can have, and has had, disastrous local effects, as in India.

Therefore, it is submitted that in the toxic chemicals management area, communication and interaction of both knowledge and skills should ideally commence bottom-up, with information generation and dissemination starting at the impact-points, leading up to more formal, segregated and modular approaches at tertiary and higher levels.

What to Communicate?

In the 'developing' context, tertiary and lower institutional networks must prioritise 'local' information gathering, analysis, storage and dissemination. University curricula, professional courses and other tertiary level training programmes must keep this important characteristic in view, before planning or upgrading training contents. Here 'local' would mean a watershed, airshed or micro-watershed where there is more than 500 per sq km population concentration and an area with identifiable institutional support. Unlike at the national level, the content of communication at this level cannot adopt a modular form. All stakeholder groups must know everything related to toxic chemicals management, impacting this local area. More than adopting particular communication / training methods, the institutions with influence in the affected areas should try to become local repositories of all environmental information , especially relating to toxic chemicals management, so that in time, these can develop into permanent interaction platforms for the local and non-local information seekers and trainees. Communication methods would depend on their effectiveness on the audience.

At the local level, information to be gathered, analysed and communicated should include:

1. Environmental status of land, surface water, groundwater and air.

2. Location and concentrations of toxic substances in the area.

3. The importation, transport, storage, use and disposal patterns of these substances.

4. The health risks of these, both on-site and off-site.

5. Inventory of sources following or not following guidelines.

6. Access to cleaner production / recycling methods along with cost-benefits for the user-groups in the area.

7. Incorporation and updating of this information in individual environmental impact

assessments in the region.

8. Assessing and publicising the toxicities of locally known and used receiving waterways and land.

Why to Communicate?

Communication is necessary in order to:

prevent accidents;
prevent neighbourhood health hazards; and
prevent waste and increase long-term profitability of local industries.

This rather cryptic series of reasons should hold good as objectives for all toxic chemicals management training and communication programmes at tertiary level in the South Asian region. The urgency of the message is clear. Curricula, course content and teaching methods in toxic chemicals management should be fashioned and re-fashioned keeping these priorities in view.

To Whom Should Toxic Chemicals Management be Communicated?

Tertiary level training, education and communicating in a subject such as toxic chemicals management should aim mainly at trainers and information carriers at the impact levels. While the urgency of training the affected people in this subject area cannot be denied, it would be impractical to expect tertiary level institutes to directly train at the community level. This has to be done by intermediary - trainer groups. The primary target for tertiary level training in toxic chemicals management should therefore be individuals and groups who can further train, communicate and demonstrate appropriate aspects of the subject to achieve the stated objectives among the affected people. These groups would include :

- enforcement agencies;
- NGOs with local influence;
- policy makers;
- financiers and industry decision makers;
- workers handling toxic substances;
- researchers and educators;
- information carriers; and
- neighbourhood organisers.

How to Communicate?

Communication methods, for trainer groups at tertiary level, are by themselves a subject matter of training, to suit different audience retention levels. While case studies, case-study based exercises, classroom interaction, training manuals for follow-up, site visits and in-plant surveys would form a strong methodological pattern in the teaching process at the tertiary level, vernacular translations and use of visual aids would be of paramount importance at lower and impact levels of communication. To make tertiary and lower methods of teaching effective, preparatory measures at the tertiary/institutional levels should include:

- gathering locally relevant information;
- analysing locally relevant information;
- predicting accident, health hazards and waste losses in impact areas;
- preparing preventive steps for stakeholders in the impact areas;
- preparing communicable steps for local carriers to identify toxic chemical use and sources;
- prioritising sub-local impact areas;
- de-emphasizing non-impact areas;
- identifying local catalyst/s at local and sub-local areas; and
- engaging catalysts to adopt impact areas and prepare knowledge base and share it in an appropriate manner.

Expected Outputs

Given the peculiarities of the South Asian countries including the importance of the 'local' element, tertiary level education takes on a new dimension. Training, education and information transfer have to take place in stages. This will be at the regional, national and tertiary levels but ultimately for a large, heterogeneous and mainly uneducated audience through intermediary student, professional and non-professional carriers. At the tertiary level, and levels below, this knowledge transfer cannot possibly be modular or packaged as teaching contents and methods vary from place to place depending on local conditions. It will be more in the nature of interactive training, feedback and information exchange at the local level. It will require a permanence of the catalyst training institution at the local/nodal point. The catalyst will be an information gatherer, analyzer, storer and disseminator, primarily for intermediate trainers but with a view to reach all stakeholder groups in the impact zone. The catalyst/tertiary institution will have to facilitate a two-way information flow among the parties involved. By bringing up local information continuously to policy levels, it will contribute to local level policy changes. Its training and communication efforts should throw up the following changes and outputs at various levels, over a period of time :

1. Policy level:

Costs of handling toxic substances to be made higher through pollution fees/toxic substances consumption taxes. Tax enforcement may be easier at the local level due to information base developed as describes earlier. Tax income can be used to fund information gathering and dissemination within the local area. Information gathered can help disperse toxic chemical users in future zoning patterns. Tax incentives and locational advantage can be provided to non-users and clean-users of toxic chemicals.

2. Enforcement at local level:

Enforcers of laws can be supported through provision of local information on toxic chemical importation, transport, storage and use. Enforcers can be involved as trainers and trainees and in publically recognised decision making bodies.

3. Industry financing:

Higher awareness in regard to toxic chemicals and their effects should be created among bankers/shareholders. Stricter locally relevant appraisal norms can be created in terms of environmental impact assessment and the management and audit of toxic chemicals in use. There is a need for enhanced awareness in financing health and accident insurance schemes.

4. Industry management:

Effort should focus on enhancing awareness of alternative technologies. Greater awareness of increasing costs of handling toxic chemicals can be brought about by better enforcement and higher grassroots pressure. Better use of scientific cost-benefit and life cycle analysis skills can be made in order to work out long term investment and environmental management norms. There is a need for greater awareness of laws, compliance and safety norms for on-site accident management. Waste minimisation groups can be developed among toxic chemicals users with similar unit processes.

5. Industry workers:

Industry workers need enhanced awareness of the types and permissible levels of toxic chemicals they can handle. There needs to be a greater use of on-site preventive and protective measures along with more awareness of management's (and individual) responsibilities. Social awareness also needs to be strengthened.

6. Researchers, Academics and Students:

Improved knowledge of local environmental status and assimilative capacity is a priority. There is a need to develop skills to relate theory of chemical processes to actual impact reduction on ground. Applied research in existing processes need to be encouraged in order to make them less harmful upstream and downstream. Effort must be put into creating the capacity to assist in local level reassessment of environmental standards, an into encouraging epidemiological studies with local base.

7. Information carriers:

There is a priority to organise catalytic individuals or organisations with permanent local presence to transfer knowledge about identification, use and health risks of toxic chemicals to local levels. Every effort must be made to encourage learning and, in turn, training among local catalysts, covering such themes as simple skills in life, health protection from toxic chemicals and off-site measures such as (Awareness and Preparedness for Emergencies at Local Level) in vernacular and using related media. Information needs so be shared between toxic chemical users in regard to mitigative measures undertaken.

8. Neighbourhood organisers:

Effort should focus on enhancing knowledge of environment quality status at the local and sub-local levels. There is a need to improve the skills of prevention and protection, and to increase knowledge about the identification, use and health effects of toxic chemicals.

Conclusions

Training, education and information bases at the local level need strengthening. While this is true of almost all environmental and development initiatives, perhaps in the area of toxic chemicals management, with its related accident and health implications, there is an urgency to find and train sub-regional and local catalysts to carry out the downward and upward information exchange. This will involve forming a network of communication within identified geographic areas. The task is not as huge as it sounds. From available information, even in a country as large as India, the special strengthening of approximately 20 tertiary level institutions would provide the required knowledge base and dissemination for eight distinctly degraded areas that can be targeted for coverage in the phase of, say, a five year period.

CLASSIFICATION AND LABELLING OF CHEMICALS AND WASTES

Nilay Chaudhuri
Environmental Engineering
Jadavpur University
Calcutta
India

Abstract

Hazardous chemicals and wastes need to be identified based on certain principles. The principle of branding a chemical or waste as "hazardous" gained significance as the associated risk of handling such chemical or waste was more and more appreciated. There is a quantum of associated risk arising from handling a chemicals or a waste in the hazardous list. Toxicity, reactivity, explosiveness and inflammability are the key characteristics in deciding if a chemical or waste is hazardous. According to the International Register of Potentially Toxic Chemicals (IRPTC) there are more than 8 million known chemicals, with about 77,000 in common use. Each year between 1,000 and 2,000 new chemicals are released on to the market (UNEP, 1992). To know the extent and nature of the hazard associated with a chemical one may refer to IRPTC in Geneva (a unit of UNEP, Nairobi) and obtain detailed information regarding the properties of the chemical.

Although the data sheet of a chemical provided by IRPTC contains all relevant properties, it would still be difficult to identify from the data sheet if the chemical is declared hazardous based on reactivity, explosiveness, inflammability or corrosiveness. Knowledge about how to ascertain reactivity, explosiveness, inflammability and corrosiveness therefore becomes important, as does the nature and extent of toxicity.

In this paper the properties of a chemical that are listed in an IRPTC data sheet are explained. The paper also elaborates the methodology for measuring reactivity, explosiveness, inflammability and corrosiveness and also the nature and extent of toxicity.

Introduction

Metals have played a major role in the advancement of civilization. With the advancement of material science, chemicals started playing a dominant role in the advancement of civilization. Several million chemicals are already known and synthesized. With advancements in polymer chemistry many complex, long-chain chemicals were introduced. However, many of these chemicals, their intermediates, and their metabolites are observed to be toxic. Some have been found to be difficult to handle because of their reactivity, explosiveness, flammability and corrosiveness. These chemicals acquired the title of toxic and hazardous chemicals.

During the sixties, the chemical, petrochemical and petroleum industries brought about tremendous change in manufacturing processes. A number of factors were involved in these changes. Process operating conditions such as pressure and temperature have become more severe. The energy stored in the process has increased and represents a great hazard problem in areas such as materials of construction. Process control is more taxing.

At the same time, plants have grown in size, typically by a factor of about 10, but are often single-stream. As a result, they contain huge items of equipment such as compressors and distillation columns. Storage of raw materials and products and of intermediates has been drastically reduced. There is a high degree of interlinking with other plants through exchange of byproducts.

Operation of such plants is relatively difficult. Whereas in the past chemical plants were small and could be shut down, stopping production in a large, single-stream plant in an integrated site is a much more complex and expensive matter.

These factors have resulted in an increased potential for loss - both human and economic. Such loss may occur in various ways. The most obvious is the major accident, usually arising from loss of containment and taking the form of a serious fire, explosion or toxic release. It is for this reason that industries handling reactive explosive, inflammable and corrosive chemicals are branded as hazardous. Built in safety measures in manufacturing those chemicals have improved further and further. If, in addition, these chemicals are toxic the extent of precaution must be more.

The chemical industries in developed countries have been operating the manufacturing process under extreme conditions and close to the limits of safety. This is usually only possible through the provision of relatively sophisticated protective instrumentation. Around the mid-1960s several such systems were developed in Europe and USA. One of the most sophisticated, influential and well documented is the High Integrity Protective System developed by Stewart (1971) for the ethylene oxide process.

Objective of the Presentation

The associated hazards in handling, storing, manufacturing and transporting many chemicals are progressively recognized. Besides being hazardous, some are toxic too. Both hazardous chemicals and wastes need to be identified based on certain principles. Such branding has gained significance since the sixties as the associated risk in handling such chemicals or waste was more and more appreciated. The quantum of associated risk of handling a chemical or disposal of a waste determines the ranking of the chemical or the waste in the hazardous list. Reactivity, explosiveness, inflammability and corrosiveness are the key characteristics in deciding if a chemical or waste is hazardous. If the substance is also rated to be toxic the chemical gains an additional title and will be branded as toxic and hazardous. Many materials may be hazardous but not toxic. As an example, in developing countries houses are often made of bamboo walls with roofing of rice straw or wheat straw.

This thatching material may be highly inflammable and fire may spread in no time, The end product of burning is carbon dioxide and water, not toxic chemicals. Thus, these building materials are not branded as hazardous chemicals. This means toxicity is implicitly associated with chemicals to be branded as hazardous.

According to the International Register of Potentially Toxic Chemicals (IRPTC), there are more than 8 million known chemicals with about 70,000 in common use. Each year between 1,000 and 2,000 new chemicals are released on to the market (UNEP, 1992). To know the extent and nature of hazard associated with a chemical one may refer to IRPTC at Geneva (a unit of UNEP, Nairobi) and obtain detailed information regarding the properties of the chemical.

Although the data sheet of a chemical as obtained through IRPTC contains all relevant properties, it would still be difficult to identify from the data sheet if the chemical is declared hazardous based on reactivity, explosiveness, inflammability or corrosiveness. Knowledge about ascertaining reactivity, explosiveness, inflammability and corrosiveness therefore becomes important, as does the nature and extent of toxicity. The paper explains the properties of a chemical that are listed in an IRPTC data sheet and also elaborates the methodology for measuring the reactivity, explosiveness, inflammability and corrosiveness as well as the nature and extent of toxicity.

Physical and Chemical Properties

In any chemical production system it is obviously essential to have comprehensive information on all the chemicals in the process: raw materials, intermediates and final products.

A list of some important physical and chemical properties of any chemical is given in Table 1. The significance of most of the items in the list is self evident.

Reactivity, Instability and Explosibility

Reactivity

The NFC 49 Hazardous Chemicals Data (1975) give materials a Chemical Reactivity Rating (CRR), as shown in Table 2. The code lists the rating for a large number of chemicals.

Stull (1973) introduced kinetic as well as equilibrium considerations and has derived an empirical Reaction Hazard Index (RHI):

$$RHI = 10\ T_d\ /\ T_d\ +\ 30\ E_a$$

where

E_a = Activation energy, kcal/mol

Table 1

Some Important Physical and Chemical Properties of a Chemical

General molecular structure, Freezing point, Vapour pressure, Boiling point, Critical pressure, Temperature, Volume vapour density, Specific heat, Viscosity, Thermal conductivity, Liquid density, Specific heat, Viscosity, Thermal conductivity, Latent heats of vaporization and fusion, Dielectric constant, Electrical conductivity .

Flammability: Flammability limits, Flash point, Autoignition temperature, Minimum ignition energy, Maximum experimental safe gap, Self-heating.

Corrosion: Corrosiveness to materials of construction, Incompatibility with particular materials.

Polymerization: Polymerization characteristics, decomposition, decomposition hydrolysis characteristics.

Impurities: Impurities in raw material and plant material Mutual solubilities with water.

Reaction: Heats of formation combustion, Decomposition Energy hazard potential, Thermal stability, Impact sensitivity.

Toxicity: Threshold limit values, Emergency exposure limits, Lethal concentration (LC), lethal dose (LD), Exposure effects (inhalation, ingestion, 50 skin and eye contact), Long-term low exposure effects, Warning levels (smell)

Radioactivity: Radiation survey particle, Ray exposures

Table 2

Chemical Reactivity Rating of the US National Fire Code
(National Fire Protection Association NFC 49, 1975)

Rating	Description
0	Materials which are normally stable even under fire exposure conditions and which are not reactive with water. Normal fire fighting procedures may be used.
1	Materials which in themselves are normally stable but which may become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently. Caution must be used in approaching the fire and applying water
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Includes materials which can undergo chemical change with rapid release of energy at normal temperatures and pressures or which can undergo violent chemical change at elevated temperatures and pressures. Also includes those materials which may react violently with water or which may form potentially explosive mixtures with water. In advanced or massive fires, fire fighting should be done from a protected location.
3	Materials which in themselves are capable of detonation or of explosive decomposition or of explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. Includes materials which are sensitive to thermal or mechanical shock at a elevated temperature and pressures or which react explosively with water without requiring heat or confinement. Fire fighting should be done from an explosion-resistant location.
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. Includes materials which are sensitive to mechanical or localized thermal shock. If a chemical with this hazard rating is in an advanced or massive fire, the area should be evacuated.

T_a = adiabatic decomposition temperature (°K)

The RHI correlates broadly with the CRR.

There are a number of computer programmes which have been developed to calculate the equilibrium products and heat release of decomposition and/or combustion reactions. One such programme calculates four quantities which may be taken as criteria of energy hazard potential (Treweek, Claydon and Seaton, 1973).

These are:

(1) heat of decomposition, H_d

(2) heat of combustion, H_o

(3) oxygen balance

(4) y criterion

A substance may release energy by decomposition or by combustion, the main hazard being decomposition. Rapid energy release can occur when the material reacts with the stoichiometric amount of oxygen to give zero oxygen balance (carbon reacting to carbon dioxide, hydrogen to water etc.) (Lathrop and Hendrick, 1949). The more reactive substances, such as explosives, typically contain enough of their own oxygen to give nearly zero oxygen balance on decomposition. With these materials there is relatively little difference between the heat of decomposition H_d and the heat of combustion H_o under stoichiometric conditions and the adiabatic decomposition and combustion temperatures. Thus Stull gives an empirical correlation between the difference between these two heats H_o - H_d or between the temperatures, and the NEFA CRR.

The oxygen balance (OB) is defined by Lathrop and Hendrick (see above). The Y criterion is given by

$$y = 10 (H_d)^2M$$

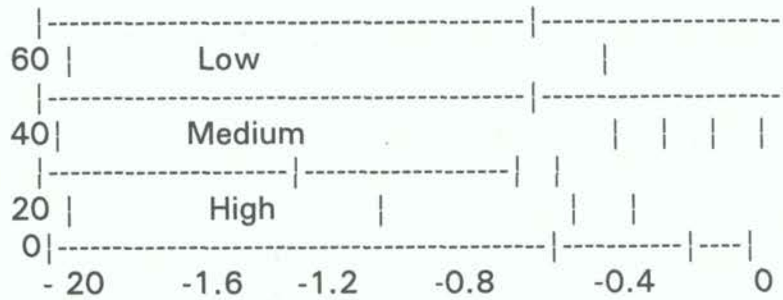
where

M = molecular weight of the chemical.

The energy hazard potentials are related to the four parameters (criteria) as shown in Figure 1.

Criterion	Energy Hazard Potential		
	Low	Medium	High
1	$H_d > -0.3$	$-0.7 < H_d < -0.3$	$H_d < -0.7$

2



3	{OB>240 {OB<-160	120<OB<240 -160<OB<-80	-80<OB<120
4	y<30	30<y<110	y>110

Fig. 1 Criteria for energy hazard potentials.

Instability

The methods for estimating instability need to be supplemented by experimental tests. Some of the main tests for individual chemicals are: (1) thermal stability tests; and (2) impact sensitivity tests. The use of these tests is described by Snyder (1965), Silver (1967) and Coffee (1969).

A reasonably accurate test is to hold a sample in a Dewar flask in a constant temperature environment. A series of experiments is done in which the temperature is increased in steps --- a typical increment being 10^0C. The sample is held for a period in each experiment. If at a given environmental temperature the sample temperature rises, there is an exotherm.

There are many methods; the most widely used of these is differential thermal analysis (DTA). Another is differential scanning calorimetry (DSC). Yet another technique of detecting exotherms is accelerating rate calorimetry (ARC).

The information content of the different types of test varies. Some merely indicate that an exotherm exists; others give a quantitative measure of the heat released by the exotherm.

Explosiveness

Testing for explosivity is not a simple matter. The tests are empirical ones. The mechanisms of explosion are sometimes unclear. This makes it difficult to extrapolate the results of small-scale tests to the full scale.

The tests seek to investigate the various aspects of explosive decomposition: initiation, nature, propagation and influencing factors. Some details of the tests are indicated below.

Initiation may be by mechanical stress, thermal means or electrostatic discharge, Mechanical initiation may be by impact or friction. The principle test of impact sensitivity is the Drop Weight test in which a steel ball is dropped on the sample and the latter is observed to determine whether firing occurs. Results are presented either as the proportion of samples fired when the ball is dropped from a fixed height or as the height required to give firing in 50% of tests.

Friction may be impacted or pure friction. The impacted friction test involves striking the sample on an anvil with a mallet. Results are recorded in terms of whether firing occurs with different types of anvil mallet and blow. The Koenen Friction Test involves passing the sample on a porcelain plate under a porcelain rod and tests pure friction. Results are expressed in terms of the rod loading which gives firing in a specified proportion of cases.

Thermal initiation is tested in a number of ways, as listed in Table 4.2. A brief description is given in this paper. For further details consult Connor (1974).

(i) The Abel Closed Cup test is used to determine flash point. The flash point is defined as the lowest temperature at which vapours above a volatile combustible substance will sustain combustion in air when exposed to a flame. Two methods are generally used, a Tag closed cup with ASTM Method D 56 or a Cleveland open cup with ASTM Method D 93. Often the method used for measurement of flash points is not indicated in literature references, but when it is, "c.c." refers to the closed cup method and "o.c" refers to the open cup method. A general observation is that the closed cup appears to be the more commonly referenced method when it is listed. The closed cup method is also the one utilised by the NTP Chemical Repository programme. Another general observation is that the open cup value is often about ten to fifteen degrees higher than the closed cup value.

(ii) In the Koenen Steel Tube test the sample is heated in a steel tube fitted in turn with different sized orifices. The largest diameter orifice with which the tube explodes in a specified proportion of cases is recorded.

(iii) The Dutch Pressure Vessel test is rather similar. The sample is heated in a vessel which has a bursting disc and is fitted in turn with different sized orifices. The results are given in terms of the largest diameter orifice with which the bursting disc is ruptured in a specified proportion of cases.

(iv) In the RARDE Time/Pressure Test a sample is ignited inside a vessel and the pressure rise with time is recorded. In the Time/Temperature/Pressure test the vessel is heated externally and the temperature rise when ignition occurs and the pressure rise thereafter are determined.

(v) A self-heating test similar to the tests for reaction exotherms already described is also used by RARDE. Both measurable self-healing and self-accelerating decomposition are investigated.

(vi) A trough test for self-sustained burning is used both with and without the addition of other substances as fuel.

Detonation is investigated by various tests. These give information on the energy released by explosion or on the process of propagation. There are several Ballistic Mortar tests in which the sample is fired by a detonator in the mortar and the energy released is calculated from the displacement of the latter.

(a) The Card Gap test gives information on both sensitivity and detonability. The sample is held in a tube with a detonator below but separated by a stack of spacer cards and with a target plate above. It is subjected to a shock which depends on the thickness of cards used. The effect of the explosion on the target plate in relation to the gap between the sample and the plate indicates whether there has been a detonation. This test is described by Snyder (1965) and by van Dolah (1965).

(b) A Steel Tube test is used to investigate the conditions under which detonation may be propagated and to measure the velocity of detonation. The sample is placed in a tube and detonated with detonator and a booster. The detonation velocity is measured by a resistance probe down the length of the tube. Results are presented in terms of the amount of booster required for the detonation to propagate and of the detonation velocity.

(c) There are various other steel tube tests some, developed on an adhoc basis to investigate particular problems.

(d) Information on whether an explosion is a detonation or a deflagration is not obtain from Ballistic Mortar tests, but is given by the Cartridge Case test. The sample is placed in a Cartridge and detonated and the type of explosion is indicated by visual inspection of the cartridge. Deflagrating and detonating explosive give characteristic deformations of the cartridge case. The weight of the cartridge case recoverable is another indication of the explosive performance of the sample.

(e) The behaviour of the bulk material in a fire is investigated in a Bonfire test. The evaluation is by observation supplemented sometimes by monitoring of pressures and temperatures.

(f) The need for tests for packaged materials is considered by Clancey. So far these appear to be confined to Bonfire tests and to tests involving dropping packages or heating them in an oven.

In many of the tests described care is needed in preparing the sample. In particular, moisture in the materials tends to affect results. For tests involving the use of tubes, tube diameter may be an important parameter since for any given substance there is a minimum diameter below which propagation of the explosion will not occur. Quite small admixtures of other substances can give dramatic alterations in the explosibility of a material. This aspect is illustrated by Snyder (1965). In carrying out reactivity or explosibility tests the object should be to obtain a positive result i.e., explosion, whenever possible. If necessary, fairly extreme conditions should be used. It may then be possible to arrange for the material to be handled safely under less extreme conditions. A detailed description of the testing of an unstable material hydrazinium diperchlorate HP_2 is given by Platt and Ford (1966). This account describes various tests, illustrates typical sets of test results and emphasizes the effect of sample condition on these results.

Flammability Characteristics

Combustion of a flammable gas-air mixture occurs if the composition of the mixture lies in the flammable range and if the conditions exist for ignition. Ignition of a flammable mixture may be caused either (1) by bulk gas temperature or (2) by local ignition. The combustion of the mixture occurs if the bulk gas is heated up to its autoignition temperature. Alternatively combustion occurs if there is applied to part of the mixture a source of ignition which has sufficient energy to ignite it.

Flammability Limits

A flammable gas burns in air only over a limited range of composition. Below a certain concentration of the flammable gas, the lower flammability limits, the mixture is too 'learn', while above a certain concentration, the upper flammability limit, the mixture is too 'rich'. The concentration between these limits constitute the flammable range.

The lower and upper flammability limits (LFL, UFL) are also called, respectively, the lower and upper explosive limits (LEL, UEL). In general the most flammable mixture corresponds approximately, but not necessarily exactly, to the stoichiometric mixture for combustion. It is frequently found that the concentrations at the lower and upper flammability limits are roughly one-half and twice that of the stoichiometric mixture, respectively.

Flammability limits are affected by pressure, temperature, direction of flame propagation, gravitational field and surroundings. The limits are determined experimentally and the precise values obtained depend, therefore, on the particular test method. Although there is no universally used equipment, one which has been utilized for the measurement of many flammability limit data is the Bureau of Mines apparatus, which is described by Coward and Jones (1952) and which consists of a cylindrical tube 5 cm diameter and 1.5 m high. The tube is closed at the top but open at the bottom. Gas-air mixtures of different compositions are placed in the tube and a small ignition source is applied at the bottom. The lower and upper limit concentrations at which the flame initiated by the source of ignition just travels the full length of the tube are then determined.

The test is normally carried out with the mixture at atmospheric pressure and temperature and with upward flame propagation but other conditions can be investigated such as different pressures and temperatures, downward flame propagation and or addition of inert gases.

Flammability limits are affected by pressure. Normal variations of atmospheric pressure do not have any appreciable effect on flammability limits. The effect of larger pressure changes is not simple or uniform, but is specific to each mixture.

A decrease in pressure to below atmospheric can narrow the flammable range by raising the lower flammability limit and reducing the upper flammability limit until the two limits coincide and the mixture becomes nonflammable.

Conversely, an increase in pressure to above atmospheric can widen the flammable range. It may be noted that the effect is more marked on the upper than on the lower flammability limit. In the case of higher hydrocarbons, increase in pressure causes an abnormal increase in the upper flammability limit with the creation of a region of cool flames (Hsieh and Townsend, 1939). However, an increase in pressure does not always widen the flammability range; in some cases it can narrow it.

Flammability limits are also affected by temperature. An increase in temperature tends to widen the flammable range.

Toxicity

Comprehensive accounts of occupational health risks involving toxic hazards are given in Industrial Hygiene and Toxicology by Patty (1962) and in Diseases of Occupations by Hunter (1975). Many toxic chemicals are solvents and these are treated in Toxicity and Metabolism of Industrial Solvents by Browining (1965).

Toxic chemicals enter the body in 3 ways : (1) inhalation (2) ingestion and (3) external contact. Generally, gases, vapours, fumes and dusts are inhaled and liquids and solids are ingested. Entry may also occur through the intact skin or the mucous linings of the eyes, mouth, throat and urinary tract.

The effects of exposure to toxic chemicals include:

(1) Irritation
 (a) respiratory
 (b) skin
 (c) eyes

(2) Narcosis

(3) Asphyxiation
 (a) simple
 (b) chemical

(4) Systemic damage

Inhalation of some substance (e.g. chlorine) causes respiratory irritation. The irritation can serve as a warning. There are some chemicals which reach a toxic level they cause appreciable irritation and thus give no warning.

Some substances (e.g hydrocarbon vapours) have narcotic effects so that the person's responses are affected and he or she may become exposed to an accident. With certain chemicals (e.g. toluene diisocyanate) the effect is that the person becomes euphoric and oblivious at danger and he is liable to perform hazardous acts.

Gases which act as simple asphyxiants (e.g. nitrogen and helium) merely displace oxygen in the atmosphere so that concentration falls below that needed to maintain consciousness. But there are also chemical asphyxiants (e.g. carbon monoxide and hydrogen cyanide) which have a specific blocking action and prevent a sufficient supply of oxygen from reaching the issues.

Exposure to some chemicals results in temporary or permanent damage to the system of the body, i.e. poisoning. There is a wide variety of damage effects caused by toxic substances.

Information on toxicity is often incomplete or nonexistent. This is not surprising, since the number of chemicals used in industry is so large. Methods which are used to asses toxicity includes (1) epidemiological studies, (2) animal experiments and (3) microorganism tests.

There are two main types of toxic limit. Limits for brief exposure to potentially lethal concentrations are the Lethal Concentration are the Lethal Dose and those for prolonged exposure to low concentrations over a working lifetime are the Threshold Limit Values (TLVs). Lethal Concentration (LC) and Lethal Dose are determined by tests on animals. Lethal concentration LC refers to the quantity of material administered which results in death of 50% of the test group. Material may be given orally or by skin absorption. There is 14-day observation period.

Limits for prolonged exposure are expressed as TLVs. These have replaced earlier systems such as that based on Maximum Allowable Concentrations (MACs). It is important that the nature and limitations of TLVs be appreciated so that misuse is avoided. Some principal features are:

(a) a TLV is not a sharp dividing line between 'safe'and 'hazardous' concentration;
(b) the absence of a substance from the list does not mean that it is necessarily safe;
(c) the best practice is to keep the concentration of substance in the atmosphere to a minimum regardless of whether it is known to present a hazard and whatever the value of the TLV; and
(d) the application of TLV to a particular case is a specialist matter.

HAZARDOUS WASTE DISPOSAL: A CASE STUDY

Soli J. Arceivala
AIC Watson Consultants Pvt Ltd
Narman Point
Bombay
Maharashtra
India

Introduction

The paper presents a case study based around an inventory of industries and their hazardous waste disposal in Medak District (near Hyderabad), in India. The study involved estimation of volume and characteristics of hazardous wastes, identification of the present disposal methods and their shortcomings and identification of suitable disposal methods and secure landfill sites.

Hazardous Waste Generation

Of the 3284 industrial units investigated, 282 (8.5%) were categorised as polluting and 111 (3.4%) as potential toxic and hazardous waste generators. The majority of the latter were involved in the manufacture of drugs and pharmaceuticals. In all, some 17,000 MT of hazardous wastes were generated each year. The largest categories were: i) waste containing water soluble chemical compounds of lead, copper, zinc, chromium, nickel, selenium, barium and antinomy; ii) sludges arising from treatment of wastewaters containing heavy metals, toxic organics, oils, emulsions, and spent chemicals and incineration ash; iii) phenols; iv) off specification and discarded products; and iii) wastes from paints, pigments, glue, varnish and printing ink.

Table 1 provides details of waste generation per tonne of product for selected units in the drug and pharmaceuticals industry.

Other data presented included waste storage methods, wastewater treatment methods, and treatment and disposal methods adopted. For the latter, burning was most common.

Table 1

Waste Generation per Tonne of Product for Selected Units in the Drug and Pharmaceuticals Industry

Product	Industrial Units	Product Capacity MT y^{-1}	Quantity in kg/Tonne of Product				
			Solids	Semi Solids	Solvents	Boiler Ash	ETP Sludge
Paracetamol	a) Unit 1	100	985	-	-	-	-
	b) Unit 2	250	930	-	-	730	-
	c) Unit 3)	720	550	-	-	507	-
	d) Unit 4	144	1000	-	-	-	-
	e) Unit 5	300	1000	-	-	-	-
Average Quantity of Waste			893	-	-	618	-
Sulphamethaxazole	a) Unit 1	300	146	-	-	365	-
	b) Unit 2	48	60	-	-	3800	-
	c) Unit 3	12	500	-	-	2500	-
Average Quantity of Waste			235	-	-	2222	-
Ibuprofen	a) Unit 1	120	-	-	-	1520	-
	b) Unit 2	120	-	-	-	3040	-
	c) Unit 3	90	-	-	-	1338	-
Average Quantity of Waste			-	-	-	1966	-
Trimethoprim	a) Unit 1	9	243	-	-	-	2230
	b) Unit 2	48	76	-	-	1140	152
	c) Unit 3	36	96	101	-	-	1013
Average Quantity of Waste			138	101	-	1140	1131
Analgin	a) Unit 1	180	32	-	-	-	152
	b) Unit 2	240	21	-	20 lit	1375	138
Average Quantity of Waste			26.5	-	-	-	145
Medendazole	a) Unit 1	24	-	-	-	7562	-
Acetyl Sulphanyl Chloride	a) Unit 1	360	-	-	-	110	640
	b) Unit 2	150	-	-	-	140	-
Average Quantity of Waste			-	-	-	125	-
Theophyline	Unit 1	21	471	189	314	-	47
Frussenide	Unit 1	18	367	37	-	-	27500
Norflaxacin	Unit 1	24	0.5	277	-	27500	1128
Ciproflaxacin	Unit 1	-	-	-	-	66000	5280
Sodium azide	Unit 1	132	530	-	-	-	-
Trimethoxy Benzine Acid	Unit 1	36	458	183	-	-	37
Chromium Diphosphate	Unit 1	18	278	-	-	-	-
Methyl isothiocyanate	Unit 1	36	18	-	-	-	-

Disposal Methods

The study then went on to identify suitable disposal methods and the quantities involved and to identify secure landfill sites. Table 2 categorises wastes for incineration and landfill.

Features of new landfill sites that were considered included: population within 500 m, distance to nearest drinking water well, distance to nearest surface water or tank, depth to ground water, soil permeability, depth to bedrock, susceptibility to seismic activity air pollution potential, intensity of use of site by nearby residents, distance to nearest buildings, presence of roads and railways for access, land use zoning, ownership, approximate area of land available for a secure landfill, growth potential and any other critical environmental feature.

The results of this investigation was considered by participants to make an excellent case study.

Table 2

Categorisation of Wastes for Incineration and Landfill
Units: MT y^{-1}

	Incineration	Landfill
Solid	3,743	6,726
Semi-solid	1,158	474
Solvents	821	Nil
Electroplating Sludges	Nil	4,082

ENVIRONMENTAL CHEMISTRY WITH REFERENCE TO AIR POLLUTION

Devendra Prasad Wagley
Central Department of Chemistry
Tribhuvan University
Kirtipur
Kathmandu
Nepal

Abstract

An introduction to various important aspects of air pollution is given with a view to develop awareness, of the ill effects of various chemical air pollutants and to create a feeling for the need for systematic monitoring of toxic air pollutants. Tertiary level trainers who have been presumed to be the target audience can benefit from such background material. Some aspects of vehicular and industrial emissions and recommendation for the remedial measures are cited, together with case studies in the context of Nepal in general, and Kathmandu in particular.

Introduction

In contrast to the wealth of data on air pollution available in developed countries, no systematic monitoring has been undertaken to examine the situation in Nepal. Though Nepal is just beginning to industrialize, the limited quantitative measurements in urban air that have been carried out, show a level of potential pollutants comparable to urban air of industrialized countries. Lack of systematic data on quantitative aspects of pollutants in Nepal's atmosphere is concealing a significant public health problem and is hampering development of control measures in Nepal. Many people in Kathmandu have started wearing masks in the traffic area. Though there are some legal provisions on the permissible level of vehicular and industrial emissions in the country, their enforcement is weak. The preliminary step to mitigate health and ecological hazards arising from air pollution is to educate people and develop in them an awareness of the risks involved therein. The Institute of Science and Technology of Tribhuvan University is planning to open a Environmental Science Department in near future, in order to pursue work in this field.

Objective of the Presentation

The presentation described here is to orient tertiary level trainers on the impacts of air pollution so that they can develop a feeling for the importance of systematic surveillance of potential pollutants. Tertiary level trainers, who may come with different backgrounds from government offices, NGO's, universities and industries, can benefit from this instruction by arranging workshops/seminars in their respective groups after completion of this workshop. The material presented here does not cover either microbial pollution or radioactive pollutants.

Methodology

We start with the structure of the atmosphere, define air pollutants, classify them and discuss the health and ecological hazards due to them. As most of the pollutants come from anthropogenic sources they can be controlled, for which we cite possible remedial measures.

Orientation

The loading of pollutants in the air of Kathmandu has grown to such an extent that people have started to wear masks while on the street. As most of the air borne pollutants come from anthropogenic sources, there are methods to attenuate such harmful pollutants before releasing them into the clean air. In addition, systematic monitoring of the air we breathe in is an important aspect.

Effective Communication Medium

The most effective medium of communication, in view of the meagre facilities at ones disposal, is class-room lectures. Provision of slide projector and overhead projector would be an added advantage. In order to motivate the audience about the topic photographs of the city before and after smog formation is recommended for presentation.

References for Further Study

Miller, G.T., 1990: Living in the Environment, An Introduction to Environmental Science, Sixth Edition Wadsworth Publishing Company.

APHA, 1972: Methods for Air Sampling and Analysis American Public Health Association,

Content of the Presentation

The presentation starts with the prerequisite basics as follows:

Structure of the Atmosphere

We begin with the structure of the atmosphere which is a thin envelope of gases surrounding the earth. It can be radially divided into successive layers. The innermost layer (called the troposphere) extends to about 17 km above the earth's surface and holds 95% of the mass of the air. The composition of the clean and pure air in the troposphere is about 78% nitrogen, and 21% oxygen by volume. The remaining volume of the troposphere is slightly less than 1% argon, and 0.035% carbon dioxide together with some water vapour. As some parts of the troposphere are heated they become lighter, ascent occurs and this air is replaced by cooler air. Thus air is always in dynamic motion undergoing vertical as well as horizontal movements which help dilute the potential pollutants present in that area. But long lived pollutants are transported to greater distances before they return back to the earth's surface as solid particles, liquid droplets or chemicals dissolved in precipitation.

A second layer of the atmosphere extends from 17km to 48km from the earth's surface and is called stratosphere. There is a thin layer of ozone in the stratosphere extending from 17-26km and peaking at 24km from the earth's surface. This ozone layer has the capability to absorb most of the harmful ultraviolet radiation from the sun and thus protects us from increased sun burn, cataracts of the eyes and skin cancer. By filtering out ultraviolet radiation it also prevents the conversion of oxygen in the troposphere into ozone. The trace amount of ozone in the troposphere present as a component of urban smog damages plants, respiratory systems of humans and other animals and materials like rubber. Thus our good health depends on higher amounts of 'good ozone' in the stratosphere and as low as possible amounts of 'bad ozone' in the troposphere. Unfortunately our activities are decreasing ozone in the stratosphere and increasing it in the troposphere.

It may be mentioned here that troposphere is heated from the earth below whereas the stratosphere is heated via ozone. The adiabatic lapse rate, which is the rate of change of temperature with altitude, is negative in the troposphere, zero at the boundary and positive in the stratosphere. Negative lapse rate denotes unstable air and so the troposphere has a self cleansing ability by vertical transport of the pollutant load in the atmosphere. If the lapse rate is zero or positive it is considered to be a stable atmosphere with a restricted vertical transport. Zero lapse rate prevents Stratospheric ozone from coming down to the troposphere. Thus under normal conditions in the troposphere as the adiabatic lapse rate is negative, pollutants are diluted by vertical transport phenomena. But sometimes it so happens that even in the troposphere the lapse rate becomes positive for some time in some local area. It is called a temperature inversion. In that period, as warm air acts as a lid to the cool air beneath it, pollutants can not be diluted because of the reduced vertical transport. The atmosphere during a temperature inversion period is very much polluted as more and more pollutants are accumulated without being diluted.

Air Pollutants

Let us define air pollutants now. Studies detected 2800 compounds in urban air. Many of these chemicals are classified as air pollutants. When the concentration of a normal component of air, or a new component added to it or formed in it, builds up to the point of causing harm to humans, other animals, vegetation, metals, stones or other materials, that chemical is classified as air pollutant.

A primary air pollutant, for example sulphur dioxide directly enters the air as a result of natural events or human activities. A secondary air pollutant such as sulphuric acid is formed in the air through a chemical reaction between a primary pollutant and one or more normal air components.

Air pollutants may be solids, such as dust or soot particles, liquid droplets, such as sulphuric acid mist, or gases, like sulphur oxides, hydrogen sulphide or oxides of nitrogen. They include fumes or particulates from lead, vanadium, arsenic, beryllium and their compounds, fluorine and phosphorous compounds. In addition, they may be formed by the interaction of these and other substances in the presence of sunlight. These substances may travel through air, disperse and react among themselves and with other substances both chemically and physically. Eventually, whether or not in their original form, they can leave the atmosphere. Some substances, such as carbondioxide, enter the atmosphere faster than they leave it and gradually accumulate in the air. Apart from natural disasters like volcanic eruptions, most of the out door pollutants come from car, trucks, power stations, factories, industries and other human activities.

Suspended Particulate Matter (spm)

The retention time of suspended particulate matter varies with size. Particles with size greater than 10 micrometers remain in the troposphere for a day or two before being brought back to earth by gravity or precipitation. Medium sized particles ranging from 1-10 micrometers are lighter and tend to remain suspended for several days. Fine particles, with size less than one micrometer, may remain in the troposphere for 1-2 weeks and in the stratosphere for 1-5 years, long enough to be transported all over the world. This is the reason why the radioactive fallout from a nuclear explosions has evenly been distributed all over the world, increasing the background count level. Fine particulate matter can also carry with it droplets or other particles of a toxic and carcinogenic nature. Thus fine particulates with sizes less than one micrometer are most harmful to us as they can easily penetrate our lung's defense mechanism against foreign particles.

Photochemical Smog

Peroxyacylnitrates (PAN) and ozone are components of photochemical smog and are formed by the interaction of ultraviolet radiation with a mixture of nitrogen dioxide, hydrocarbons with 1-17 carbon chains and oxygen. They are called oxidizing pollutants and even at 0.1 ppm they irritate our eyes. While ozone injures the upper part of leaves, PAN affects the lower side making it silvery, bronze like and shining. Ozone also promotes throat irritation, choking, cough and fatigue. Typically, as the level of ozone and PAN increase, the level of nitrogen dioxide decreases. Nitrogen dioxide in the polluted area is typically 1-3 ppm and is suspected to cause persisting change of lung pathology.

Acid Rain

As emissions of sulphur dioxide and nitric oxide are transported long distances they form secondary pollutants: nitrogen dioxide, nitric acid vapours, sulphuric acid mist and sulphate and nitrate salts. As they descend to the earth in wet form, like rain, dew, fog, or snow, or in dry form as gases, fog and dew they can be directly absorbed by leaves or roots of the plant. The combination of dry and wet deposits and absorption of acid and acid-forming compounds at or near earth's surface is called acid deposition. It may be mentioned here that even at a pH value of 5.5 salmon fishes are killed. Declining pH is a threat to aquatic life since most organisms cannot live below pH 4.

Sulphur content in available coal is 1-5%. An increase in the level of sulphur dioxide has been found to be directly proportional to the annual incidence of respiratory illness.

Carbon Monoxide

Carbon monoxide, due to its affinity for haemoglobin binding sites being 210 times as great as oxygen, causes dizziness, headache and lassitude. It has a global level of 0.1 ppm by volume. It kills under high concentration and retards mental and physical activity at low level. Concentration of carbon monoxide has been found to increase with traffic volume.

Effect of Air Pollution on Materials

Each year air pollution causes millions of dollars of damage to various materials. Many valuable marble monuments in the world are being damaged by acidic air pollutants.

Exposure to Indoor Pollutants

By comparing the source of selected pollutants by emission and exposure we find that air deodorisers emit p-dichloro-benzene; while carbontetrachloride, a known carcinogen is exposed via dry cleaned clothes. In our homes unvented gas stoves and kerosine heaters give off carbon monoxide and nitrogen dioxide.

Emission Sources for Outdoor Pollutants

The five most common air pollutants in tons annually emitted in the US are carbon monoxide, sulphur dioxide, hydrocarbon, nitrogenoxides and particulates. 60% of the total pollutants come from automobiles, 17% from industries, 14% from electric power plants, 6% from space heating and 3% from refuse disposal. The highest amounts of carbon monoxide, nitrogen oxides and hydrocarbon are emitted from automobiles, highest sulphur oxides from electric plants and highest particulates from industries.

Case Study

Vehicular Emissions in Kathmandu

Let us turn our attention to the pollution load due to mobile sources in Kathmandu. Kathmandu valley has approximately 410 sq km. area surrounded by high mountains of up to 1000 metres high. From the sky it looks like a big bowl. Sixty percent of the vehicles registered in Nepal operate in the valley. The 72,853 vehicles have only 820 km of roads on which to run. It has been estimated that on an average 0.012 km/ vehicles is available.

A report made public in 1983 when automobiles were very few states that 22000 tons of carbon monoxide, 2000 tons of nitrogen oxides, 400 tonnes of hydrocarbon, 333 tons of sulphur dioxide and particulates together with 554 ppm lead are emitted by vehicles in one year. Similarly, Pradhananga and his co-workers collected SPM data for 16 different places in Kathmandu and found an average of 304 micrograms per cubic metre SPM which reached as high as 775 micrograms per cubic metre (Table 1). The average value exceeds WHO

Table 1

Concentration of SPM in Selected Areas of Kathmandu
(October 1992)

SAMPLING SITE	PARTICULATE MATTER ($\mu g/m^3$)
HEAVY TRAFFIC	
Maitidevi	775
Putalisadak	707
New Road	524
Chhetrapati	461
Teku	443
Ratna Park	410
Tripureshore	310
Jamal	290
LESS DENSE AREA	
Lazimpat	331
Swyambhu Ring Road	280
New Baneshore	278
Naxal	274
Durbar Marg	247
Nayabazar & Gausala	236
Bhatbhateni	197
OUTSKIRTS	
Pulchowk	244
Bansbari Ring Road	396

standard set at 120 microgram per cubic metre (Table 2). Similarly it has been reported that based on study of SPM, sulphur dioxide and nitrogen oxides in various areas of the Kathmandu valley, SPM was above the WHO limit (Table 3). Devkota has reported that peak hour exhaust emissions in business areas, residential areas and the hospital area in the valley resulted in high amounts of carbon monoxide. The parameters studied were carbon monoxide, volatile organic compounds (VOC), hydrocarbons(HC),nitrogen oxides, sulphur dioxide, SPM and benzene.

Nepal is importing diesel that contains 2% by weight of residual carbon. Gasoline imported in Nepal a high(2.93) octane value but the locally available gasoline has the value of 1.87 only. A high octane value promotes thorough combustion with little carbon dust. To improve the octane quality tetraethyl lead is added. To clear engines of lead, ethylene dibromide and dichloride are added as lead scavengers. Both have potential carcinogens. Lead is emitted in the form of inorganic aerosol. Bhattarai and Shrestha have reported that lead levels in the traffic area of Kathmandu vary with traffic volume, ranging from 10ppm (for <100 vehicles/ day) to 574 ppm (for 2200 vehicles/day) (Table 6). It may be mentioned here that there is no defence mechanism in the human body to prevent lead going to the brain once it reaches the blood stream.

To improve through burning, the ideal fuel/air ratio should be set at 1:13. In order to remove deposits of soot particles catalysts such as AK33X have been used in the United States.

Standards

Let us look at the current standards. The Kathmandu Valley Vehicular Emission Control Project (KVVECP) collected emission data from 743 diesel run vehicles. After analysis they found 90% vehicles emitted 75 HSU (Hartridge Smoke Unit) and they suggested 75 HSU as standard for Nepal (Table 4). The situation in neighbouring countries are as shown in (Table 4). Similarly, after a study of 987 petrol run vehicles the project has set a standard of 3% carbon monoxide for such vehicles (Table 5). Data for other countries are as shown in Table 5.

In the United States primary standards are set to protect human health with a margin for children, old people and vulnerable people. They also have a secondary standard set to maintain visibility and to protect crops, buildings and water supplies. They use a pollution standard index (PSI) to define how many times a year a location exceeds the primary health standard. Time series of PSI values versus the annual pollution pattern. Citizens are informed to encourage proper measures to be taken.

Industrial Emissions

In 1989 the number of industrial establishments in Nepal was 2334. The main sources of industrial pollutants from the industrial sector are the combustion of fossil fuels for heating and power. As fuels contain 0.5-4% sulphur, burning of fossil fuels for heating and power emit sulphur oxides. A high combustion temperature facilitates the formation of nitrogen oxides. Thus sulphur oxides, nitrogen oxides, carbon monoxide and SPM are the important pollutants in the industrial sector.

Few studies have been undertaken to examine the industrial emissions in Nepal. In 1987 Miyoshi studied sulphur dioxide and nitrogen oxide emissions in steel mills, several chemical industries inside and outside the valley, textile mills, sugar mills and distilleries, paper and pulp industries and cement industries. He found that the levels of sulphur dioxide and nitrogen oxides were not significant. The leather and tannery industries have reported that the amount of sulphur dioxide emitted by the operation of two boilers was 55-100 ppm.

Table 2

Standards Set by the World Health Organization

POLLUTANT	AMBIENT AIR PERMISSIBLE LEVEL
Dust Particles	120 $\mu g/m^3$
Sulphur dioxide	125 $\mu g/m^3$
Nitrogen oxides	150 $\mu g/m^3$

Table 3

Air Quality in Kathmandu

Place	**SPM**	**SO_2**	**NO_2**
	($\mu g/m^3$)		
Post Office (GPO)	300-1572	13-162	12-41
Ranipokhari	182-500	13-102	17-35
Balaju	53-162	13-26	11-71
Maharajganj (Residential area)	115-350	13-34	13-19

Table 4

Emission Standards for Diesel Fuelled Vehicles

COUNTRY	STANDARD (HSU)	INFERENCE
Nepal	75	On the basis of 90% of the 749 vehicles studied emitted less than 75 HSU
India	65 70	City area Non city area
Singapore	50	
China/Thailand	68	
Hongkong	90	
Indonesia	68	
Malaysia	50	

Table 5

Emission Standards for Petrol Fuelled Vehicles

COUNTRY	%CO	INFERENCE
Nepal	3	Set after a study of 987 vehicles
India	5 4.5 4	50 cc 2-3 wheelers >50 cc 2-3 wheelers Four wheelers
China	6 4.5	At present From 1995
Indonesia	4.5	
Malaysia	4.5	
The Philippines	6.0	

Table 6

Road Traffic and Lead in Kathmandu

LOCATION	VEHICLES/DAY	LEAD (PPM)
HEAVY TRAFFIC		
Maitighar	2,200	574
Kathmandu GPO	2,000	374
Narayanhity	1,600	323
LIGHT TRAFFIC		
Balaju	< 100	34
Dharmasthali	< 100	51
Budanilakantha	< 100	10

The Economic Services Centre(ESEC) conducted a survey also in 1987 and covered industries in various parts of the country. The industries selected included cement, leather tanning, paper and pulp, sugar and textiles. The ESEC findings were as follows:

1. Textile mills emit cotton dusts in their premises.

2. The Birganj Sugar and Distillery has not installed any equipment for controlling air pollution.

3. Bhrikuti Paper Mill has adopted appropriate measures for controlling air pollution with a dust collector and a 30 metre tall chimney.

4. The flue gas emitted by Hetauda Cement Factory composed of 18% carbon dioxide, 0.1% carbon monoxide, 150 ppm nitrogen oxides abd 50 ppm sulphur oxides. The composition of the flue gas was within standard.

5. In Himal Cement Factory they observed Nitric oxide(200 ppm), nitrogen dioxide(30 ppm), sulphur dioxide(5 ppm), carbondioxide (16% of the flue gas) and carbon monoxide(2.6% of the flue gas).

6. While Himal Cement emits 5-6 tonnes dust /day out of which 1.25 tonnes are of < 10 mm size, the Hetauda Cement Factory emitted 6 tonnes/day dust.

Remedial Measures

Let us turn our attention to the remedial measures. On the basis of technological feasibility and economic viability the measure to control pollutant falls into one of the four alternatives:

1. The first alternative applies to the use of unleaded gasoline fuels. Engines have been developed that run without tetraethyl-lead.

2. The second alternative is to use fuel with reduced sulphur content i.e., 4% to 1% say. This would increase the cost to 30% more. Technologies are available (Fluidized Bed Combustion of Coal and Limestone Injection Multiple Burning, LIMB).

3. By controlling the temperature ie, not allowing the combustion peak to reach the value that produce nitrogen dioxide and by recycling part of the waste gas, evolution of nitrogen dioxide can be minimized.

4. Use of Bag Filters, Wet Scrubbers, Electrostatic Precipitators etc, to control SPM.

Training Recommendations and Conclusion

1. Simple laboratory knowledge with the affiliation of university teachers is recommended for trainees so that they could sample the air and do simple experiments like determination of SPM using matched weight technique.

2. The trainees should gather information about the state of air pollution in their local areas. They are recommended to prepare a report on it.

Evaluation

For evaluation, it is recommended an examination be set containing 20% objective, 40% structured and 40% long answer type questions covering almost all the important parts. It is also recommended that the trainees should gather data on the permissible level of autoexhaust emissions and industrial emissions. They should then be advised to collect data on the load of various pollutants in the atmosphere and see if they are within the permissible levels or not.

TRAINING AND COMMUNICATION IN CHEMICAL SAFETY/EMERGENCY RESPONSE AND INTEGRATED MANAGEMENT

Paul Clarey
Faculty of Science and Technology
Deakin University
Clayton
Australia

Abstract

This paper illustrates some of the curriculum and methods for training undergraduates in the Bachelor of Applied Science (Environmental Management of Hazardous Materials) at Deakin University, Victoria, Australia. This degree, the first of its type in Australia, attempts to integrate a variety of practical scientific and managerial skills into the framework of a science degree. The course was designed by representatives from government, industry, the unions and academia to fill a perceived niche in undergraduate training. The methods and curriculum presented should be adaptable to most tertiary educational environments. They represent the experiences of the author in producing and presenting material for this type of training. Deakin University is keen to assist other universities in the Asia and the Pacific in the development of such materials and training aids at a local level in conjunction with government and industry.

Introduction

It is important that the training of scientists and engineers include studies and some practical experience in the areas of chemical safety, emergency response and the concept of integrated management as applied to toxic chemicals and hazardous wastes.

The integrated management of hazardous materials involves a holistic approach through consideration of all relevant areas in undertaking a scientific assessment or making a management decision. Hence, in addition to the common considerations applied to toxic chemicals and hazardous wastes (where/how to store and dispose of them), there needs to be awareness of industrial processes, appropriate land use planning, risk assessment techniques for process industry, chemical hazard and risk analysis, occupational health and safety, emergency response planning, waste minimisation, etc.

Instruction in integrated management therefore occurs over the range of subjects studied. They all need to be examined with this overview in mind. It requires a forum where the subjects can all be brought together in a practical sense. This is the area where innovative training techniques need to be incorporated into a syllabus.

Some General Training Principles

1. Set down the rules first

When training undergraduates or postgraduates it is important to set down the rules first i.e. the definitions and interpretations of key terms, principles or concepts. It is apparent across a wide range of disciplines that different groups can have different interpretations of certain words (for example, risk, hazard and safety). If part of the class think you mean one thing and others think you mean something else then we have problems before we have even begun. In many instances international bodies or associations have published dictionaries or glossaries that define key terms in the commonly accepted manner.

2. Communicate clearly

Technical jargon is extremely useful when communicating with colleagues and students, but only if they know it. When the range of studies cover a number of disciplines this can be very confusing if jargon (and acronyms) are used without an appreciation as to whether the audience understands. It also creates a situation where no one wants to ask what something means in case it is a stupid question, i.e. by using such terms you are implying that they should already know them. Should they? Refer to (1), above.

3. Avoid confusion, conflict and complexity initially

Try and avoid confusion, conflict and complexity at the initial level of training. Then through work-related assignments, readings and tutorials the participants discover conflicts, confusion and complexity in the issues being examined. This assists the learning process and allows trainees to appreciate the need for consistency in terminology and approach.

4. Good training can sometimes be theatrical

Sometimes in order to make an impact, or to make a change from the conventional approaches to teaching (e.g. chalk and talk, overheads), or to assist the student to recall of some facts/concepts/principles that you wish them to remember, or simply just to ensure that you can keep their attention (and attendance) for an hour or two it may be desirable to change the style of presentation. This includes using a more theatrical approach to how material can be delivered and comprehended, i.e. entertain and educate.

5. Importance of examination of case studies

Real life examples or case studies or even well planned hypothetical examples should be utilised to give insight into events and processes and experience in scientific investigation and decision making. Breaking a class into groups will often reveal that different interpretations of data and therefore how decisions are made between different groups. This provides a useful point of discussion as the groups debate their various points of view and discover conflicts and the inherent complexity of the issues involved. Refer to general principles 3 and 7

6. Importance of developing good communication skills

This obviously applies as much to the trainer as it does to the student, so hopefully it is a case of leading by example. It is important to stress the need for students to become competent communicators of scientific ideas and principles to a range of audiences. Often the scientist or engineer will be called upon to present submissions or make explanations to non-scientific personnel both within or outside their organisation - for example, to local or State government officials, local interest groups, politicians, managing directors, lawyers, judges, accountants, insurance agents and the media. Interactive forums involving role playing can be useful in developing communication skills.

7. Make relevant contacts with industry and government

It is important for the trainer to have regular contact with relevant personnel within government and industry. By participating in consultancy to industry and government or by making submissions to government when draft policies are released or by simply offering occasional advice or assistance to these groups a useful network can be established. This can also assist in the employment of graduates. Such participation provides the opportunity to practice what is advocated and to build up a library of potentially useful case studies and anecdotes in which one has been personally involved.

Examples of Training Methods in Chemical Safety and Emergency Management

In order for students to fully appreciate the range of skills required to be competent in the area of chemical safety and emergency management a number of inter-related yet different exercises will need to be undertaken by the students. From first hand experience the following types of exercises are put forward as one way in which part of this can be achieved. Reference will also be made to the general training principles discussed above, where relevant.

The Emergency Response Plan

Let us assume that we want our students to be able to research and produce an Emergency Response (and Management) Plan (ERP) for an industry (these may be hypothetical or real cases).

To produce the ERP the student will need to have an appreciation of the nature, type and quantity of chemicals involved at the site, how they are stored, their location on-site, an appreciation of the plant's general locality with respect to housing and other sensitive land uses, and the basic production process. The student will need to use their knowledge of chemistry, but more importantly have an appreciation of chemical incompatibilities. The student must also be able to quickly determine the nature and types of accidents or events which are probable within the plant as well as a possible worst case scenario, and then develop appropriate plans and responses for dealing with each type of emergency.

In addition, the student also requires knowledge and awareness of the potential and limitations of local emergency services and other organisations that may be involved in, or assist with, an emergency response situation. In writing the plan the student must be made aware of the pressures applied to individuals in its use in an emergency situation, i.e. it must be clear, concise, succinct and easy to read in a situation of considerable pressure and responsibility.

Task 1 - To start with, all students should have an appreciation of the fact that all chemicals are inherently hazardous, i.e. the nature and properties of a chemical will mean that under certain conditions it will present a hazard to the environment or to humans. For example, we cannot make petrol non-flammable and we cannot make cyanide non-toxic! Therefore, if we cannot control the hazard, what can we control? We can control the risk i.e. the probability of the hazard being realised. In many instances the risk can be managed so as to make us safe from a potential hazard, e.g toxicity. Ensure that all students appreciate the meanings of the following words *hazard, risk, safety, toxicity,* and that there is no confusion. Have them study various risk criteria and risk factors. A tutorial can be run based on their own lifestyle. They can calculate their theoretical risk of dying in the next twelve months and compare this to the average (e.g. 333×10^{-6} in Victoria). See items 1 and 5 in Section 2.

Task 2 - Demonstrate chemical hazards and appropriate safety gear. Demonstrate a number of chemical incompatibilities (preferably outside) i.e produce some small fires and explosions by mixing incompatible chemicals. Before doing so ask the students what they might expect to happen given their knowledge of the properties of the materials. Also ask them to predict what the products of the combustion or explosion might be. Be sure to overdress in terms of safety gear so that students anticipate some real hazards. If asked after the demonstration as to why all the gear was necessary explain that one can never predict with any certainty what will happen when incompatible chemicals are mixed together - one day it might explode, another day it may just fizz and let off some smoke. Therefore it is always best to err on the side of safety. Sometimes, in fact, the demonstration will not work and you need to explain that the previous demonstration was successful. This helps emphasise the unpredictability of the exercise.

Another demonstration may involve entering a lecture fully dressed in protective clothing and equipment whilst a video at the front plays footage from a recent industrial accident or chemical warehouse fire (or equivalent). Remember to explain the cause of the incident. You may have to contact the government agency responsible for the investigation or the company. Later you may make part of the class don some of this gear (or multiple sets of such gear, i.e gloves, respirators, etc), so that they gain an appreciation of the difficulty in working and communicating in the equipment.

Humorous anecdotes about the perception of risk relating to chemical hazards can also drive the point home (e.g. a hydrogen peroxide leak from a storage tank under pressure discharged water vapour and oxygen which was headline news in the local paper the following day as "Toxic Gas Leak" complete with pictures of the white plume of water vapour taken at night under lights). See item 4, 5 and 7 in Section 2.

Task 3 - Investigate some accident case studies and discuss them. After a range of examples have been examined (i.e. both cause and effect), describe only what happened and what equipment/chemicals were involved and ask the students to postulate what the cause may have been. A good reference for this is the book by Trevor A. Kletz, "What Went Wrong? - Case Histories of Process Plant Disasters", second edition, 1989, Gulf Publishing Company. See item 5 in Section 2.

Task 4 - Visit the local fire brigade's headquarters and organise demonstrations and training with their equipment. Once the local station realises your graduates will one day be giving their members advice at incidents involving hazardous materials they should be happy to cooperate and demonstrate how they can assist, as well as their limitations. It is important for students to fully appreciate the roles and responsibilities of emergency services. Most students will find this an exciting and worthwhile field trip. In addition, the trainer should endeavour to undertake some training with emergency services, if this is possible, so that it is possible to relate first hand some of these relevant experiences in class. See items 4, 5 and 7 in Section 2.

Task 5 - Conduct a number of different "table-top exercises". These "table-top exercises" are hypothetical emergency response and management exercises conducted by a group of three or four on a table which has a map of the area in which the emergency occurs. A number of books which can be used to source chemical information. Books that allow searches by UN number are useful (e.g. the UN's "orange book" on dangerous goods).

Each person at a table plays a different role. Typically these are emergency services (e.g. fire brigade, police, ambulance service), technical services (e.g. company chemist or engineer, Environmental Protection Agency or Pollution Control Board, Department of Labour and Industry - Dangerous Goods Branch (or equivalent), and support services (e.g. local government, water and sewerage authority). It is best to have only three to four tables functioning at once. It is difficult for the trainer to remember what is going on from table to table as the trainer travels from table to table providing information about the nature and type of incident (e.g. transport accident resulting in a spill of toxic chemicals or hazardous wastes) and other conditions relating to the incident (e.g. weather conditions, UN numbers of chemicals in drums/cylinders/tanks).

By changing conditions and not allowing everything to go as planned students can gain an appreciation of what a real incident might be like. If properly run the "table-tops" should put students under considerable pressure, create some confusion, give them an appreciation of the types of resources that may or may not be available, help them to better understand the roles and responsibilities of different services, be prepared for unplanned events and make decisions when not all the information that would normally be required is available. At a debriefing students can be given some clue as to other ways in which the incident could have been handled. See items 3, 5 and 6 in Section 2.

Task 6 - To minimise the risk associated with chemicals to an acceptable level, (i.e. chemical safety,) information on the hazard is required. This works in conjunction with the movement towards the philosophy of "right to know", i.e. workers and the public have a "right to know" what chemicals are in products or in the workplace and what are the potential hazards and risks associated with these chemicals. Consequently students should be able to draft and interpret information on chemicals and use it to estimate the potential hazards and risks associated with the chemical. Material Safety Data Sheets (MSDSs) are required on all chemicals used in the workplace in Australia. Students therefore are required to research and prepare them for different chemicals and then present their MSDS to the class. This is a very useful exercise. By assigning different types of chemicals to different students (e.g. solvents, drugs, production intermediates,) it becomes apparent during their presentations that some chemicals have significantly more information available than do others.

This exercise is also designed to have students source information from a variety of texts and data bases using their campus library (the IRPTC data base would be useful here). Knowing where and how to obtain such information is a desirable skill as is the practice of presenting technical information to an audience and answering questions relating to the substances studied. The presentations let participants realise that not all the answers are available. See items 2, 3 and 6 of Section 2.

Task 7 - Students are now ready to research, write and present an Emergency Response Plan (ERP) on a hypothetical industry. Firstly, a discussion of what constitutes the essential elements of an ERP is undertaken in such a way so that the students work it out for themselves. Nevertheless, each group invariably ends up with variations on a common theme.

Typically the reports are structured as follows : Contacts (roles and responsibilities) and Communications (on-site/off-site); Site Plans/Description of Inventory, Production and Storage; Accident Scenario Flowcharts (for Spills and Fires, Explosions and Toxic Impact - SAFETI); and Evacuation Plans (On-site/Offsite); Material Safety Data Sheets (for chemicals and wastes used, produced and stored on-site). Challenges the students face include determining the nature and type of accidents/incidents possible (this is linked with other studies they undertake involving quantitative risk assessment of chemical process industries) and producing a report that is concise and easy to use. Students usually work in groups of two or three. See items 2, 3 and 6 of Section 2.

Contaminated Site Remediation

. In this exercise students are asked to make management decisions about eight different hypothetical contaminated sites. Students are given information including the nature and type of contamination, location, adjacent land uses and zoning, details on soils and ground water, area and depth of contamination. They are asked to construct a decision making matrix which allows them to classify and rank the sites in order of priority for cleanup. This is an individual exercise which requires some research and thought as to what criteria are important.

All results are summarised by the trainer and a tutorial discussion conducted on the different criteria developed and rankings obtained for the sites. Invariably most students rank the same group of sites as 1 or 2. Similarly, sites ranked 7 and 8 (lowest priority) are picked up by most students. The greatest variation in the order of the sites occurs with those ranked 3, 4, 5 and 6. Hence the subjective nature of what tries to be an objective exercise is illustrated. Those students who obtain totally different results have usually used different criteria in ranking their sites (perhaps costs?) and thus it can be seen that, depending upon the criteria selected for evaluation, any result can be produced and justified to some extent. This realisation shocks some students who appreciate the political ramifications of such a process. All of this is useful material to discuss in class. See items 3, 5 and 6 in Section 2.

Qualitative and Quantitative Risk Assessment

Students undertake simple exercises in quantitative risk assessment of chemical process industries by long-hand techniques rather than using computer models as. The latter are expensive and also operate as a "black box". As such they do not give the same appreciation of the process, the nature of the calculations, and the complexity of what is actually taking place in the computer. The students, in groups of three to four, are given a simple chemical plant to study. They conduct a preliminary hazard analysis (HAZAN), a hazard and operability study (HAZOP), produce a number of "Fault Trees" on determined events to estimate probability and determine the significance of various plant improvements and safety devices, undertake a consequence analysis on the most probable and significant events, and draft recommendations on plant improvements and the appropriate safety separation distance for this plant from residential or sensitive land uses. This is a time consuming and onerous task for the students who often do not appreciate what they have achieved until they finish their group report.

Because of the time consuming and complex nature of quantitative risk assessment it is important for students to also gain an appreciation of the often useful qualitative nature of risk assessment. To this end students are encouraged to study Kletz's book "What Went Wrong?" (see 3.1, Task 3 above). An exam question may be set using some of the examples from Kletz's book to create a hypothetical chemical plant in which the students must determine what can go wrong, how that occurs, and what to do to prevent it from occurring. This is undertaken in a qualitative manner.

Similarly, if there is an industrial accident in the news (e.g. welder dies in chemical plant explosion) where the cause can be ascertained is useful to run a tutorial and have students determine what went wrong. The implication here is that if appropriate safety devices had been installed or appropriate procedures (e.g. hot work permit) or training followed (e.g use of gas detectors) the accident could have been avoided - and a life saved. The point can be emphasised by pointing out that in their future jobs participants will save lives as a consequence of their work but in most instances they will never know it. See items 3, 5 and 7 in Section 2.

Conclusion

The tasks discussed above are just some of the sequences of training given to students in the area of chemical safety and emergency response. The outline serves as an example of the integrated style of training in the *Environmental Management of Hazardous Materials* course run at Deakin University. This is also reflected in the integrated approach to the management of hazardous materials in general, i.e. one cannot just look at chemical storage, or production, or risk assessment, or occupational health and safety, or waste management in isolation from the other, as all aspects need to be integrated if proper management is to take place.

Training programs need to be innovative, hands on, practical in nature, require the students to "work it out for themselves", entertaining, and have variety in the nature of tasks set. Yet they must also be coordinated so that each task builds upon the previous ones. Case studies, whether real or hypothetical, need to be included to provide both awareness and experience. The trainer therefore has an enormous challenge in designing, producing and delivering such materials. Hence the resources of the Network for Environmental Training at Tertiary Level in Asia-Pacific (NETTLAP) and (the United Nations Environment Programme) need to be fully exploited by all trainers in this area of toxic chemicals and hazardous waste management.

Some Useful References

International Labour Office (ILO), Major Hazard Control - A Practical Manual, ILO, 1990.

Kletz T.A., What Went Wrong? - Case Histories of Process Plant Disasters, Second Edition, Gulf Publishing Co., 1989.

Verschueren K., Handbook of Environmental Data on Organic Chemicals, Second Edition, Van Nostrand Reinhold Co., 1983.

Federal Office of Road Safety, Transport and Communications, Australian Code for the Transport of Dangerous Goods by Road and Rail, Fifth Edition, Australian Government Publishing Service, 1992.

DISPOSAL OF HAZARDOUS SOLID WASTE

Ajantha Perera
Department of Zoology
University of Colombo
Colombo
Sri Lanka

Introduction

The total amount of waste collected within the city of Colombo each year exceeds 200,000 tons. The annual collection at present is increasing at a rate of 10,000 tons per year. The waste include material collected from households, solid waste generated by industries as by products, (including sludge from the liquid waste treatment plants, clinical waste from medical care in hospitals, medical centres and clinics) as well as containers of agrochemicals from the agricultural sector. The Colombo Municipal Council and other municipal councils are identified as the agencies responsible for the collection and disposal of waste in urban areas. No specific legal requirements have yet been identified with regard to waste disposal. Therefore all waste is accepted at solid waste dumping sites of the municipal councils.

The current cost attached to waste collecting approximates Rs. 550/- per ton. The capital requirement to meet fleet improvement programmes generally requires the individual municipal councils to spend approximately 20 - 25% of their annual budget on solid waste management. The fleet consist of 65 compactor trucks and over 35 other vehicles.

Sri Lanka, as a developing nation, strives to reach the status of a newly industrialized nation by the year 2001. Hence several industrial sites have been opened and proposed. These sites are scattered throughout the country. At the stage of proposal for an industrial complex the industrial complex as a whole as well as each individual industry is required to undergo an environmental impact assessment (EIA). During this study the type of waste generated by each industry is considered and their disposal methodology is studied and appropriate guidelines and recommendations are made, with sanitary landfill, incineration, recycling as options. Unfortunately, due to the deficiency in the post monitoring system, these waste products nevertheless ends up in open dumps. Similarly, due to the lack of proper legal enforcement, medical waste, waste from laboratories and containers of toxic chemicals such as pesticides also reach open dumps.

The content of the current presentation would be of interest and value to undergraduate as well as graduate students. They will be informed of the situation in the country, on the deficiencies in hazardous solid waste management, its consequences, and the need for improvement and possible remedial measures. Through the knowledge gained they will be stimulated to become involved in further research work to find remedial measures either to eradicate/or drastically reduce this problem to a manageable level. The trainers of the undergraduate and postgraduate students can communicate this material through lectures supported by field visits, laboratory experiments, slides, and videos. The case study and the examples utilized in the presentation can be replaced by others according to the country concerned.

Objective

A critical problem faced in Sri Lanka is the lack of adequate capacity for final disposition of solid waste. All types of solid waste are either brought to a specified landfill site allocated for that municipal council area or the waste is simply dumped by the road side. Though the city of Colombo has not recorded a steep rise in the population, its suburbs are very rapidly undergoing a process of urbanization. The increasing population as well as the increasing number of industries will result in generation of large quantities of waste which will lead to serious environmental problems unless the handling of this waste is given serious attention.

In the Colombo metropolitan area, which is the capital city of Sri Lanka, approximately 800 tons of municipal solid waste are disposed of each day. Of this waste, 550 tons are disposed in its landfill site at Wellampitiya. This is to reach its full capacity by the end of 1994. The remainder of the waste is disposed in numerous small open dumps. Since there are no legal requirements regarding the disposal of solid waste, household waste and industrial waste, medical waste are all found in open dumps. Sri Lanka does not yet possess a sanitary landfill. Wellampitiya the landfill within the Colombo metropolitan area, was planned to be a sanitary landfill. Due to financial constraints as well as the urgency for a landfill site the engineering designs required for a sanitary landfill were totally ignored. Hence today it is a large open dump.

Sanitary landfill

A sanitary landfill is an engineered structure designed to dispose of the residual solid waste in a controlled and an environmentally sound manner. In such a landfill the solid waste is disposed of by spreading in thin layers, compacting to the smallest practical volume and then covering each day or periodically with earth so as to minimize environmental problems.

The five major aspects of a sanitary landfill design are leachate control, liners, covers, gas control and the after use of the site.

Leachate control

Leachate is the liquid produced as water from precipitation and/or ground water moves through the deposited solid waste. In dry climates the control of the leachate is not significant as evapotranspiration exceeds precipitation. In wet climates, such as in Sri Lanka, the leachate control is a critical design issue. Leachate control involves the minimization of leachate generation, collection, treatment and disposal. Once the leachate has been treated, if it complies with the standards set for discharge of wastewater to natural waterbodies, it can be released into a flowing waterbody.

Liners

Liners are single or composite engineered systems which are designed to control the leachate movement, thereby preventing groundwater pollution. Native clay soils as well as synthetic materials, such as PVC or polyethylene, can be used as the barrier layer. The barrier layer is place on a prepared sublayer of granular material. A second layer of granular material is placed on top of the barrier layer to allow the landfill equipment to operate without puncturing the liner.

Cover

There are two types of covers; intermediate and final. Intermediate covers are placed at the end of each day of operation to control litter, odour and prevent precipitation from entering the fill. Intermediate layers can be soil. Final cover is placed once the fill has reached the designed height. The cover has many purposes: it minimizes the precipitation infiltration into the fill, controls the movement of landfill gases and provides a layer upon which vegetation can grow.

Gas control

Gas control can be accomplished through either a passive or active system. Passive systems simply allow gas to vent and be flared off at selected points through the cover. Active systems use air compressors to draw the gas from the fill.

End use of the site

This has to be decided at the initial design stage. Possible end uses include natural parks, golf courses and other recreational areas. Unless the adjacent land value is high the construction of buildings on former landfill sites is not suitable due to the high cost to deal with foundation and landfill gas issues.

Difficulties in Selection of a Landfill Site

There are several factors which influence the selection of a site for a sanitary landfill. However most selection factors fall into two main categories: public attitude and technical possibilities.

Even the most technically suitable site will never be established if the general public strongly oppose it. Similarly, even the strongest public favour will not guarantee acceptance if the technical factors are strongly weighted against it. Therefore a balance of technical and public relation factors is necessary in order to ensure success.

The basic criteria which should be included in proper site selection are availability of land, drainage characteristics, soil characteristics, location, the highest flood level, and access to major transportation routes. Some of these criteria can be conflicting, while others can be overcome by good design.

In a densely populated urban area such as in Colombo metropolitan area where the population density approximates 2152 person/sq.km., it is extremely difficult to locate a large area of land for a sanitary landfill. Even when land area is available, competing land use demands such as for the purpose of industries, commercial or residential development can hinder the obtaining of land.

If the land area chosen is zoned for use other than for industrial purposes there will be conflicts with the local community. If the land is privately owned then agreement to purchase the land is required. This is complex if there are a multitude of owners.

When the suitability of the site is considered the actual study area should extend beyond the landfill site. The site must be designed to be free draining during the operation phase as well as upon completion. Major problematic sites are the areas of perched runoff collection, groundwater recharge areas and direct surface flows to waterbodies.

Another important factor to be considered is the soil type. Soil is important as cover, as well as permeability barrier. The soil type between the waste and the groundwater system is of tremendous importance and it should be of low permeability. In addition, the seasonally high watertable must be as deep as possible. The site should be near reliable transportation zones.

Mitigatory Measures

In a developing country such as Sri Lanka, which has experienced only open dumps in the past, gaining public and political approval for a selected site is a tremendous task. Generally the only option for a landfill site in a crowded urban area of a developing country is a low lying marsh, normally inundated with water, characterised by a low topography, with a high groundwater table and on a floodplain. The development of such a site into a sanitary landfill with minimal chance of ground and surface water pollution is technically feasible, yet very difficult.

The pollution of ground water has to be well protected by providing low permeability sealing layers for the base, sidewalls and a good cover for the top of the landfill. However the final success of the landfill depends on the collection of leachate, its treatment and final disposal pattern into the surrounding environment.

If the site is situated on a flood plain measures must be taken to accommodate the anticipated volume of runoff during the heaviest rainfalls that occur, particularly during the monsoon period. Entrance of flood water could be prevented either by construction of flood protection barriers/bunds around the landfill site or by constructing the base of the landfill and the landfill foundations to be at an elevation above the maximum flood level.

A site of this nature has to be developed in phases. The first phase would consist of the basic site engineering and the site will be developed in cellular fashion, so that at any one given time no more than 15 - 20 ha. will be developed. Site restoration too will follow in a progressive basis, allowing the first phases of the landfill to be completed and restored and made available for useful purposes while the landfill operations continue elsewhere on the site.

Development of landfills often requires the resettlement of families. In such an event an acceptable resettlement plan has to be worked out with a reasonable compensation package. Generally a project such as a landfill, which is likely to have a high public protest, should incorporate some form of a community development plan as part of the project development. As the public perceive that the community may receive tangible benefits from the project, it will lessen the protest and will move towards acceptance to siting a landfill in their community.

The Case Study

The landfill site at Wellampitiya in the Urban Council of Kolonnawa is 12 hectares in extent. This landfill site was established in 1987. Originally the site was abandoned paddylands.

The site is divided into 6 cells. At first a bunt was constructed on the periphery of the site. The idea of constructing an earth bunt was abandoned due to financial constraints.

Offices, washing places for the workers, vehicles and equipment are located at the site. Some of the marginal land area has been used to construct shanty dwelling units. Shanty dwellers have lived in that area for the past 7 - 8 years.

Two drains have been constructed along the bund. These ultimately connect to a waterway which leads to Kelani ganga. No treatment is applied to the leachate prior to disposal. Also there is no systematic pumping of leachate into the drainage canals. There is stagnation of drainage water in canals which are blocked with spilled waste material. During the heavy rains part of the water which accumulates in the cells find its way to the Kelani river. The canal that take the leachate into Kelani river finds its way through a marshy land. Yet in recent years this area too has been filled for the construction of houses. The Biological Oxygen Demand (BOD) of the leachate ranges from 300mg/l to 350mg/l. This is beyond the specified gazetted tolerance level. The tolerance level of BOD for effluents to be discharged into inland surface waters is 30mg/l.

Water collecting in solid waste which remains uncovered enhances the breeding of mosquitoes and other insects. In order to combat this problem a pesticide such as malathion is sprayed over the site on a regular basis. The drainage water carrying this pesticide eventually reaches the Kelani river also.

There is a school and at least 30 houses adjoining the site, As a consequence there are constant complaints regarding the bad odour, mosquitoes and deteriorated health among the residents. Nevertheless, there is a large population of scavengers who make a living by collecting reusable material from the waste. Neither the municipal workers nor the scavengers wear any protective clothing such as gloves or boots.

Training Recommendations

Many of the scientists in a developing country who either write an environmental impact assessment report for a sanitary landfill or those in authority who decide regarding acceptance or disapproval of a sanitary landfill generally have never seen an actual sanitary landfill in operation. Therefore it is important that a few such people be trained at a well operating landfill site. They should be informed of the costs and the benefits of such a site.

Conclusions

Among the disposal options, the most appropriate option is the reuse or recycling of the waste. But there are certain wastes which can neither be reused or recycled.

Incineration reduces the volume of the waste but has other consequences such as cleaning of flue gas, treatment of wastewater and sludges. The ash generated generally has a high concentration of heavy metals which require special action. The financial cost of the above requirements is beyond the financial capability of most state sector organizations in Sri Lanka. In fact an estimation has recently been made that the installation of an incinerator with a capacity of 100 tons of municipal waste per day would need a capital cost of Rs. 2000 million and an annual recurrent cost of Rs.30 million. Despite its high cost the disposal of hazardous clinical waste has to be carried out by incineration.

The most effective option which is affordable for developing nations is the sanitary landfill. Yet a clear distinction has to be made between a sanitary landfill and an ordinary open dump.

The Wellampitiya site was selected without an Environmental Impact Assessment (EIA). Such a study would have foreseen the impacts on the physical, biological and social environment and identified the possible mitigatory measures. However, the experience of the Wellampitiya site, along with the analytical data collected from the site, enables scientific designing of the future landfills.

Evaluation

A. If the time available is only during the class hour:

1. An EIA (environmental impact assessment) carried out for a proposed sanitary landfill can be evaluated by groups of students.

2. The physical, biological and social characteristics of a site chosen for a sanitary landfill can be described to the students and they can be requested to discuss the likely impacts on the given environment and suggest possible mitigatory measures.

B. If time outside of the classroom is available:

1. Visit a garbage dumping site. Request the students to evaluate how far this site deviates from a sanitary landfill.

2. Collect water samples from the drainage canals. The students can be asked to analyze these samples for the basic water quality parameters and discuss whether the drainage water is suitable to be discharged into a natural water body.

3. A group of students can be given Terms of Reference and requested to carry out a mini EIA.

A NEW APPROACH TO HAZARDOUS WASTE MANAGEMENT TRAINING

Joo-Hwa Tay
Division of Water Resources and Transportation
School of Civil & Structural Engineering
Nanyang Technological University
Singapore

Introduction

Different instructional methods have been developed by educationist to enhance the learning ability of students and trainees. These methods have their merits and limitations to achieve specific objectives. Education and training for the same topic may require different instructional methods for different target groups. As the educationalists always say - Adults learn best when they are actively engaged. When they 'learn by doing', the adults will remember:

20% of what they hear;
40% of what they see; and
80% of what they discover for themselves.

To train or educate adults on new topics, an 'active' learning process is far better than a 'passive' learning process, particularly in the environmental management area.

Environmental problems are highly complex and complicated. Their cross-sectoral nature involve various academic disciplines, professional bodies, governmental agencies and industrial sectors. Effective solutions will call for practical inter- and multi-disciplinary problem solving approaches. Any training programme on environmental management should include the technical, legislations, social and economic aspects.

The Carl Duisberg Gesellschaft - South East Asia Programme Office (CDG-SEAPO) launched a Hazardous Waste Management (HWM) training programme in 1986 in order to address the issue of training for the region. CDG-SEAPO commissioned several consultants from the region to prepare training manuals for HWM in metal finishing industries by using an innovative approach - the Project Casework (PCW) method. The PCW was initiated by Mr Guenter Tharun, the Head of CDG-SEAPO. CDG-SEAPO has been using the training manual and PCW methodology to provide numerous HWM training courses in nine East and Southeast Asian countries. This paper briefly describes this innovative PCW method for HWM training.

The Project Casework (PCW) Approach

Project casework (PCW) is mainly a blend of three types of active learning methods: (a) the "prospective" project method; (b) the "retrospective" case method; and (c) "interactive" group work. The PCW approach with its prestructured tasks for group work, such as a case study, is intended to generate sufficient motivation and pressure to build feasible solutions under pressure of time. The approach is flexible and open to additional inputs such as role playing, simulation games, and/or actual project work. These definitely enrich the learning experience.

The main objective of the PCW-based training programme is to produce environmental professionals from different institutions who are able to make appropriate decisions on environmental issues taking account of unique local conditions, constraints and resources. While working through the different stages of the PCW, the participants can realize that at many turning points numerous decisions have to be taken by them in order to proceed. This experience, together with the varied results of the different working groups, demonstrate to participants the fact that numerous, even small, decisions can lead to many different outcomes. These are simulated real-world planning and decision-making processes which might prepare them better for undertaking actual environmental projects.

The PCW approach stresses on problem analysis and assessment, development of strategies, selection of options and reasoning. These components facilitate decision-making processes. The participants, playing realistic roles, will be put in situations of decision-making and acting. Thereby, they experience simulated consequences of their decisions and the inter-relationship between decisions and resulting outcomes.

Instead of merely providing technical information, PCW seeks to develop and strengthen participants' decision-making capacities in complex environmental issues. To meet these objectives, PCW proceeds in three major steps. The first step is the assessment of a problem by taking into account available resources and existing constraints, risks, and opportunities. The second step is to devise strategies for action, analysing, costing, and comparing various feasible options. The final step is to select a most viable alternative based on the available resources and constraints.

These steps are mainly performed by the trainees themselves. PCW offers real world scenarios that demand solutions designed by the participants. Real world situations are further simulated by group work and role games. The participants will act as factory owners, technical consultants, and representatives of government regulatory bodies. Both group work and role games are designed to stimulate interaction and communication among the participants in a way that resembles the experience of their daily work.

The PCW Training Programme

The main components of the training programme using the Project Casework (PCW) approach include the following:

1. Target group

2. Training manual

3. Interactive group work

4. Project presentation

Target Group

The target group should be defined clearly for any training programme. For the PCW training programme on HWM, the target group should include professionals, academicians, governmental officials and industrialists. The training programme is intended for engineers with a few years background or experience in pollution control. The programme will also be helpful for government regulatory agency personnel and academic/research professionals to understand the problems encountered by the industrial establishments. Upon intensive examination of the technical and financial capabilities and constraints, balanced by a sense of social responsibility to society, the training material paves the way for a more effective approach to environmental problem-solving.

Participants from various backgrounds will be able to interact and mutually understand each others problems, constraints, limitations and responsibilities. The optimum number of participants would be 25 to 30. The group can be divided into 3 small sub-groups of 8 to 10 each. Each sub-group should consist of participants from different backgrounds and organisations. The participants will learn from the group members on various issues of environmental management.

Training Manual

The training manual for HWM by the PCW approach should present a typical pollution problem scenario faced by the industries in the developing countries in the Asia-Pacific region. It centres around pollution and waste production caused by an industry.

To enable the participants to develop feasible solutions to the case presented, sufficient background information and data are provided. These include mainly technical and financial data as well as institutional/legislative information on government regulations. An additional dimension of social, political and economic constraints is also included.

The PCW training manual should be packaged in the framework of a simulation exercise and role play, in which the participants will act as members of a pollution control project team in an industry and/or members of a consulting group, while the trainers will guide and work along with participants, and serve as external consultants, if needed.

The training manual should include relevant information and resource materials. It is best to divide the information into different sections. Part A of the manual presents the general conditions, location, area development plan and pollution control ordinances of the project. Information in part B includes treatment options, resources recovery, waste recycling and reuse. Part C provides the cost data for the chemicals, utilities, facilities and equipment.

Interactive Group Work

The three groups of participants will play the role of consulting firms. Each member of the group will have different responsibilities. The groups are asked to provide a solution to a specific problem outlined in the training manual. Each group will work out the exercises according to a prestructured sessional work programme. The sessional work programme could be divided into 4 parts as follows:

Session 1: Assessment of Pollution Problems and Development of Control Objectives

Session 2: Development of Pollution Control Options and Resource Recovery Alternatives

Session 3: Cost Evaluation of Options

Session 4: Overall Analysis and Selection of Solution.

Each session programme contains the following:

- Objectives
- Activities and Discussion Guidelines
- Time Allocation
- Information Input
- Measurable Outputs

Some information can be deliberately withheld and will be supplied by the trainers and resource persons only upon request. Trainers and resource persons are not acting as all-competent teachers. They are the advisors, facilitators and consultants. They cautiously guide participants in their analytical, problem-solving, and planning efforts, especially when they are in a deadlock situation. Further explanations and other relevant inputs are given by the resource persons in the form of technical presentations and lectures. The presentations are integrated into the programme at times when information is needed.

Time constraints should be incorporated into each session to simulate the real work situation. Participants should complete the assigned task by the allocated hours. In case the assignment is not completed in a set time, the group may have to burn the midnight oil to work out the solution.

Project Presentation

Interim and final presentations should be required for the training programme. Each group will present their solutions to the audience, and be challenged by the other groups. A game play could be incorporated into the presentation. For example each group might be assigned a role of consulting firm to compete for a job, and they are presenting the best solutions to the selection panel members to win the contract.

As the training manual is developed with open-ended solutions, the solutions presented by each group may be different. Based on the experience and background of each group, the solution adopted for a specific problem could be varied.

The project presentations not only consolidate the learning of the participants, they also enhance the understanding of problem solving. The group has to work as a team to crystallise their knowledge on the understanding of the existing problems and provide the best solution. They have to face the challenges of other groups and resource persons who act as members of the board of selection. Thorough understanding of the problems and alternative solutions would be enhanced through the presentations.

A healthy divergence among the working groups in their conclusions and arguments, although some consensus might merge, is not only unavoidable, but even an intended outcome. This learning experience itself is an excellent result as it demonstrates and stresses, firstly, how different views, values, and priorities can lead to different results. Secondly, that the results are influenced by the value judgments, attitudes and expertise of people carrying out assessments of environmental problems, constraints and opportunities for action. Thirdly, that the dynamics and procedures of such assessment processes themselves are also important to the results. It shows that such assessment is not just a question of carrying out a technical exercise, but foremost a decision-making process itself.

Summary

An innovative Project Casework (PCW) approach was initiated by Mr Guenter Tharun, Head of Carl Duisberg Gasellschaft - South East Asia Programme Office (CDG-SEAPO) as an effective training programme for hazardous waste management. Training manuals were prepared by several consultants from the region for the training programmes. The PCW is mainly blended with three types of active learning methods: a) the "prospective" project method; b) the "retrospective" case method: and c) "interactive" group work.

The PCW approach is different from other existing environmental training programmes. The PCW approach stresses problem analysis and assessment, development of strategies, selection of options and reasoning. The participants acquire knowledge of hazardous waste management by working on a real world problem and develop in a viable solution based on the available resources and constraints.

PCW can be simply an additional input to any seminar or training course, or alternatively, it can comprise the dominant feature of the whole course. The course material could be expanded or modified to reflect the current requirements, local conditions and resource constraints.

The PCW approach for hazardous waste management for the metal finishing industries has been used for numerous training courses in 9 Asian countries by the CDG-SEAPO. The responses from the participants are overwhelmingly favourable for the PCW approach. The training material has been translated into Chinese and Thai for the benefit of Chinese and Thai speaking participants.

Acknowledgements

The author wishes to thank Mr Guenter Tharun, Head of CDG-SEAPO, for granting permission to present the PCW approach, and for his invitation to develop the HWM training manual and participate in various training programmes organized by CDG-SEAPO in Asian countries. The concept of PCW presented in this manuscript were extracted from the following publications:

Guenter Tharun, "Approaches and Methods of Training in Environmental Planning and Management for Local and Regional Development", in: Regional Development Dialogue, Vol.8, No.3, pp 196-228, 1987.

Guenter Tharun, "Future Trends in Environmental Education and Training", Mimeographed Paper, Asian Institute of Technology, Bangkok, Thailand, 1989.

PREVENTION AND MINIMISATION OF HAZARDOUS WASTES

M. Anwarul Islam
Department of Environment
Dhaka
Bangladesh

Abstract

With the development and increase of various chemical uses and the growing generation of hazardous wastes, hazardous waste management is becoming more and more important. In most South Asian countries the best option to start with in terms of hazardous wastes management is prevention and minimization of hazardous wastes. Only in that way is the situation manageable with limited resources and management capabilities. Most countries do not have adequate understanding, or legal and institutional capabilities to manage the problem and to achieve the goal to prevent and minimise hazardous wasters. Adequate measures need to be taken to improve the situation, among which dissemination of knowledge and training in the relevant field is very important.

Introduction

Not all waste are hazardous, but there is a fast growing trend of generating more and more hazardous wastes. This has given rise to the need for hazardous waste management. In reality this particular management field has grown so rapidly that technology transfer has had difficulty in keeping pace with ambitious regulatory programs.

Obviously management of hazardous wastes is a much more difficult task than to just defining it. Defining 'hazardous waste' itself is a complex process, since many factors are potential contributors to the hazardous nature of a substance, particularly waste.

Hazardous waste management is an all encompassing term. It can be used to describe several distinct phases - the elimination or reduction, the recycling or reuse, the treatment or destruction of these materials and the minimal use and handling of hazardous and toxic chemicals (leading to generation of hazardous wastes) i.e physically destroying, chemically detoxifying or otherwise rendering these materials permanently harmless.

Effective control of the generation, storage, treatment, recycling, reuse, transport, recovery and disposal of hazardous wastes is of paramount importance for proper health, environmental protection, natural resource management and sustainable development. This requires proper understanding of the problems and their management aspects, dissemination of knowledge, expertise and experience and execution of subsequent actions. This also requires the active cooperation and participation of the international community, governments and industry.

Prevention of the generation and minimisation of hazardous wastes are key elements and both require knowledge, experienced people, training and other facilities, financial resources and technical and scientific capacities.

In countries like Bangladesh, it is extremely difficult to manage hazardous waste, once they are generated and reach the environment, as these countries are densely populated, the environment is fragile and the countries do not have the requisite technical and financial capabilities for proper clean up actions. Therefore, it is of the highest importance to prevent the generation of, and minimize, hazardous wastes.

Objective of the Present Paper

The objective of the present paper is to describe the needs for prevention and minimization of hazardous wastes and the required means to do that particularly in the Asia-Pacific countries like Bangladesh. This paper may be used for acquiring ideas and ways to prevent and minimize hazardous wastes, by the concerned people from the industry and all generators and managers of hazardous wastes.

It is expected that the target group of users of the present material may adapt it directly or with modification.

The Methodology of Presentation

Taking into account the fact that only very basic facilities are available for communicating/training in the South and Central Asian region, the presentation of the present material can be made as a classroom lecture with the help of minimal audio visual facilities such as overhead projector (with transparencies), flip charts, and cards.

Major Contents

Targets

Within the framework of the integrated and pragmatic management of hazardous wastes, the overall objective is to prevent, to the extent possible, and minimize the generation of hazardous wastes as well as to manage those wastes in such a way that they do not cause harm to health and the environment.

The overall targets are:

- Preventing or minimizing the generation of hazardous wastes as part of an overall integrated cleaner production approach;

- Eliminating, or reducing to a minimum, transboundary movements of hazardous wastes, consistent with the environmentally sound and efficient management of those wastes and ensuring that environmentally sound hazardous wastes management options are pursued to the maximum extent possible within the country of origin (the self-sufficiency principle). The transboundary movements that take place should be on environmental and economic grounds and based upon agreements between the states concerned.

- Ratification of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and the expeditious elaboration of related protocols, such as the protocol on liability and compensation, mechanism and guidelines to facilitate the implementation of the Basel Convention.

- Elimination of the export of hazardous wastes to countries that individually or through international agreements prohibit the import of such wastes, such as the contracting parties to the Bamako Convention (for Africa), the Fourth Lome Convention or other relevant conventions, where such prohibition is provided for.

Objectives

Among the most important factors in hazardous waste management is the recovery of hazardous wastes and their transformation into useful material. Technology application, modification and development of new low-waste technologies are therefore currently a central focus of hazardous waste minimization.

The objectives for promoting the prevention and minimisation of hazardous wastes are:

- To reduce the generation of hazardous wastes, to the extent feasible, as part of an integrated cleaner production approach;

- To optimize the use of materials by utilizing, where practicable and environmentally sound, the residues from production processes;

- To enhance knowledge and information on the economics of prevention and management of hazardous wastes.

Bangladesh Scenario

A detailed inventory of both the quantity and characteristics of hazardous wastes in Bangladesh has not yet been made. Some preliminary summarises have been made in this regard. Based on these it has been observed that certain types of industrial, hospital and agrochemical inputs are the major contributors in terms of significant hazardous wastes. The available information on hazardous wastes is limited to only recognised industries and very little information is available on small scale or cottage industries.

Bangladesh does not have a large industrial sector (total number of industries according to some estimates is about 30000, of which most are small or cottage), but industrialization is being given high priority in recent times and is gaining momentum.

The Resources

a) Industries

According to a World Health Organisation assessment, 626 registered industries units (the actual number may be far higher) produce a variety of wastes containing 62 hazardous substances of both categories of high-risk toxic chemicals (cyanide, pesticides, chromium, toxic sludge) and low risk categories (such as phosphogypsum, fly ash and metalliferous slugs).

The most dominant sources include tanneries, textiles, pharmaceuticals and chloralkali plants. About 160 tanneries as a cluster within the Dhaka city generate about 15800 cubic metres of waste water per day and discharge it to the environment untreated. All these use chrome tanning (at least about 300 million tons of basic chromium sulphate (Chromosol) is used annually) and loss of chromium is significant. The chloralkali units using graphite electrode, consume 900 g of mercury per ton of alkali, as against 55-56 elsewhere. About 75 percent of the mercury consumption of about 4 tons per year for a particular chloralkali unit has been flowing into an adjacent river Karnaphuli for the last 26 years, totalling about 78 tons.

Textile dye finishing industries are discharging untreated effluent in various parts of the country. These discharges include heavy metals. In the textile dyeing and printing industry about 3000 million tons per year of dyeing chemicals are used.

During a 1993 survey of the use of ozone depleting substances (ODS) in Bangladesh it was revealed that as much as 30% of the chlorine produced by the Chittagong Chemical Complex was lost of the atmosphere in an area which is densely populated.

Mercuric chloride is used in the relatively large torch cell industry. This and other highly toxic chemicals are handled by workers, in most cases without safety precautions..

Electroplating industries use chlorinated hydrocarbons, chromium, nickel, copper, zinc and silver salts, along with other chemicals like cyanide. Effluents contain these metal ions, acids, alkalis, cyanide, oil and grease. These are discharged to the environment without treatment.

Wastes from paint industries contain heavy metals such as chromium, lead, copper, cadmium, organic solvents, and cyanide. Nothing is being done at present to treat the waste before it reaches the ecosystem.

b) Pesticides

More than 5000 million tons of different types of pesticides are used annually in Bangladesh. All these chemicals have different degrees of toxicity. It is known that numerous pesticide products are formulated by local, unauthorised companies. These chemicals pose a hazard during storage and use. The residues of these chemicals are washed into the water bodies, causing pollution and damage to ecosystems.

c) Hospital Wastes

Hazardous hospital wastes are all infectious wastes, dangerous drug wastes and any waste that has been or may have been exposed to contagious or infectious disease.

In Bangladesh there are about 731 small and large hospitals. Among these hospitals the number of beds is about 32,969. In terms the waste generated in these hospitals, no study particularly of characteristic and volume of waste has been reported. The hospital waste generation in the country can be estimated from the number of patients staying in the hospital. If hospitals are fully occupied by patients, the daily waste generation will range between 3 lakh lbs. to 7 lakh lbs. It is therefore a great concern in respect of environmental pollution as well as human health. A study in 1992 conducted by NIPSOM (National Institute for Preventive and Social Medicine) in the Thana Health Complex near Dhaka, reported that most of the time (64%) the wastes generated in the two hospitals were not disposed of properly. In a comparative study, also undertaken by NIPSOM in a Medical College Hospital and in a Thana Health Complex in same year it was reported that in Medical College Hospital appropriate waste are disposed more frequently than at the Thana Health Complex.

Present Management Practices

With a very few exceptions, none of the industries has treatment facilities for their discharges. Thus hazardous wastes reach the environment untreated. The present legislation does not require provision to take measures against those who discharge hazardous wastes, and the regulator agency - the Department of Environment is still very weak in this regard. Storage, handling and transportation of hazardous wastes are in most cases not environmentally friendly or acceptable. Moreover, workers are not generally aware or made aware of the potential risks associated with hazardous wastes. Hazardous wastes are even transported through densely populated areas. Also, often the management people (or even industries) are not fully aware of the safety and environmental requirements of their plants. There is no legal framework for compensation of persons affected by hazardous wastes.

Measures to be Taken

Initially each country is to have a detailed inventory of its hazardous wastes - both in terms of quantity and its characteristics. Also inventoried are the source of generation and modes of disposal. To achieve this assessing the waste generation rates is very important as is development of a systematic data base on hazardous waste management.

Waste generation rates vary greatly as a result of many factors. The major influence is the production activity at the facility generating the wastes. Because of the variations that exist among types of wastes and in the gross properties of a particular type, it is often difficult to develop or use a consistent set of criteria to be used when evaluating waste generation rates. Hazardous waste generation rates can also be affected by other environmental developments. Another contributor to overall waste quantities is remedial activity stemming from clean-up of existing, improperly controlled storage and disposal sites.

In countries like Bangladesh, which has very few resources and a huge population in a very limited area, the best method to manage hazardous wastes is to prevent its generation and minimize the quantity and further reduce the strength of the hazardous characteristics of the effluent. In this way very little waste with low hazards potential will be generated and it will be manageable.

An important element in reducing generation of wastes including hazardous wastes, is waste minimization. It looks at the industrial processes and aims to use the natural resources more efficiently, resulting in lower water and energy consumption, reduced wastage of process chemicals and reuse and recycling of valuable by-products.

Available hazardous waste minimization techniques are related to, and can be a combination of:

- Use of cleaner raw materials - for example, vegetable dyes instead of heavy metal based dyes or vegetable tanning instead of chrome tanning; even removal of salt from hides in tanneries by shaking, in which the salt can be reused, is a positive step towards reducing wastes.

- Improved process control

- Minimization of spillage of process water and chemicals by optimization of process control

- Improved process

- Separation/segregation of process effluents

- Recovery of process chemicals.

With the current state of industrial development in Bangladesh one of the most significant benefits can be achieved at this stage from the implementation of recovery of waste products and/or process chemicals. The recovery of chromium used in the tanning process needs early attention. Through the recovery process 95 percent of the chromium in the effluent can be recycled, at a considerable cost saving to the industry. It will reduce the demand for chromium by about 30 percent of the quantity currently being used.

Recommendation

To achieve the objectives of hazardous waste management, including prevention and minimization of hazardous wastes, countries should establish and subsequently implement policies and action programmes that include:

- Integration of cleaner production approaches and hazardous waste minimization in planning and the adoption of specific goals;

- Promotion of the use of regulatory and market mechanisms;

- Establishing an intermediate goal for the stabilization of the quantity of hazardous waste generated;

- Establishment of long-term programmes and policies including targets, where appropriate, for reducing the amount of hazardous waste produced per unit of manufacture;

- Encourage industry to treat, recycle, reuse and dispose of wastes at the source of generation, or close as possible thereto, wherever hazardous wastes generation is unavoidable and when it is both economically and environmentally efficient for industry to do so;

- Encourage industry to develop schemes to integrate the cleaner production approach into design of products and management practices;

- Encourage industry to exercise environmentally responsible care through hazardous waste reduction and by ensuring the environmentally sound re-use, re-cycling and recovery of hazardous wastes, as well as their final disposal;

- Develop inventories of hazardous waste production, in order to identify their needs with respect to technology transfer and implementation of measures for the sound management of hazardous wastes and their disposal;

- Include in national planning and legislation an integrated approach to environmental protection, driven by prevention and source reduction criteria and adopt programmes for hazardous waste reduction, including targets and adequate environmental control;

- Achievement of a qualitative improvement of waste streams, through activities aimed at reducing their hazardous characteristics; and

- Facilitation of the establishment of cost-effective policies and approaches to hazardous waste prevention and management, taking into consideration the state of development of each country.

Conclusion

Most countries of the region, including Bangladesh, lack the capacity to handle and manage hazardous wastes. This is primarily due to inadequate infrastructure, deficiencies in regulatory frameworks, inadequate education and training programmes and lack of coordination between the different ministries and institutions involved in various aspects of waste management.

In addition, there is a lack of knowledge about environmental contamination and pollution and the associated health risks from the exposure of populations, especially women and children, and ecosystems to hazardous wastes; assessment of risks; and the characteristics of wastes. Steps need to be taken immediately to identify populations at high risk and to take the necessary remedial measures.

One of the main priorities in ensuring environmentally sound management of hazardous wastes is to provide awareness, education and training programmes covering all levels of society. There is also a need to undertake research programmes, where possible, to understand the nature of hazardous wastes, to identify their potential environmental effects and to develop technologies to safely handle those wastes. Finally, there is a need to strengthen the capacity of institutions that are responsible for management of a hazardous wastes.

References

Dave, J.M., 1993: "Toxic Chemicals and Hazardous Wastes, Bangladesh", WHO, Dhaka, Bangladesh.

Huque, M.M., 1994: "Environmental Impact and Management Problems of Toxic Chemicals and Hazardous Waste - the Bangladesh Scenario". Dhaka, Bangladesh.

Khhabir, B.N., 1994: "Use of toxic chemicals and generation of hazardous wastes in Bangladesh; with particular reference to small and cottage industries". Dhaka, Bangladesh.

Khan, M.A.Q, 1994: "Hospital and Radio Active Wastes - the hazardous source of growing concern". Dhaka, Bangladesh.

Islam, M.A., 1994: "Toxic Chemicals and Hazardous Wastes, June 1994". Department of Environment, Dhaka, Bangladesh.

Abeyesundara, A.N.A., 1993: "Address at workshop on the management toxic chemicals and hazardous wastes, June 1994". Dhaka, Bangladesh.

IPCS/OECD/WHO, 1994: "Health aspects of chemical accidents". OECD Environment Monograph No. 18, OECD, Paris, France.

Khan, M.S.M. and Sobhan, M.A., 1994: "Policy aspects of national and international management practices of toxic chemicals and hazardous wastes". Dhaka, Bangladesh.

MANAGEMENT OF TOXIC CHEMICALS AND HAZARDOUS WASTES

R.M.U. Senarath
Environment Department
Board of Investment of Sri Lanka
Colombo
Sri Lanka

Introduction

Sri lanka is a island located in the Indian Ocean, halfway between Europe and the Far East. It is situated at the intersection of major shipping and air routes as well as traditional trade routes linking east and west. While the main sea port is located in the commercial centre of Colombo, two other ports have been established at Trincomalee and Galle.

Sri Lanka is situated 880 km north of the Equator. With a total land of 65,610 sq. km it spans over 432 km lengthwise, and is 224 km in breath.

The climate is tropical and varies according to the monsoons and the elevation above sea level. Although there are no well marked seasons, the latter half of the year however is considerably cooler than the first half. The temperature ranges from 20^0 C to 31 ^{0}C.

The annual rainfall varies according to the location. In the S.W. region it varies from 2500 mm to over 5000 mm a year.

Sri Lanka liberalized its economic policies in 1977. Export oriented industrial development became the main strategy in economic development. As a result there has been an inflow of technology and there is now a need to address the issues arising from the wide range of raw materials being imported, as well as being produced by industrial processes.

Environmental issues are considered extremely important. The needs identified for mitigation of the adverse environmental impacts are:

1. Environmental Standards

2. Technology

3. The Necessary Infra structure

Sri Lanka being a developing country, initially did not possess the capability to develop on its own either environmental standards or appropriate technologies. Therefore, Sri Lanka made a start by obtaining external assistance to developed them. Good progress is being made now in addressing environmental issues and implementing mitigation measures.

Policy, Legal and Institutional Frame work

The Board of Investment (BOI) of Sri Lanka (former Greater Colombo Economic Commission) was established by a act of Parliament in 1978, for promoting and facilitating export oriented industrial development. Since there was no adequate information locally available at this time, the BOI sought assistance from UNDP to establish environmental norms. As a result the following environmental norms were introduced in Sri Lanka, by the BOI, in 1979.

1. Tolerance limits for Industrial Waste Water Discharged into the Common Waste Water Treatment Plant.

2. General Standards for Industrial Waste Water Discharged into Inland Surface Waters

3. Tolerance Limits for Industrial Waste Water Discharged into Marine Coastal Waters

4. Tolerance Limits for Industrial Waste Water Discharged on Land for Irrigation Purposes.

5. Interim Source Air Emission Norms

6. Interim Noise Level Criteria

7. Drinking Water Standards

The Central Environmental Authority (CEA) of Sri lanka was established by the National Environmental Act No. 47 of 1980. The National Environmental Act was amended in 1988, empowering the CEA to institute legal action in case of a violation of an environmental stipulation. The tolerance limits for discharged of effluent (2,3,4 above) were stipulated by the CEA in a gazette notification, along with three other industry specific standards.

In 1980 the CEA introduced the *Environmental Licensing Scheme*. It is now a legal requirement that industries discharge or emitting waste into the environment obtain a permit/licence from the CEA.

Considering the commitment and capability of the BOI in environmental protection, the CEA has delegated its authority and functions to BOI, empowering the latter in respect of projects/development with in its responsibility.

The requirements pertaining to the need for *Environmental Impact Assessment (EIA)* were framed in Sri Lanka in mid 1993. These regulations stipulate the procedure for carrying out an EIA, as well as describing the types of projects of in which an EIA is mandatory.

Under the Clean Air 2000 Programme the ambient air quality standards were formulated and are to be gazetted. The standards for the source emissions are being formulated in respect of twenty one types of industries initially

A Technical Advisory Committee, comprising representatives from the relevant agencies, has been established to control and monitor chemical imports to Sri Lanka. A database of toxic chemicals was prepared and is being updated. The important fields of the databases are chemical name, physical/chemical properties, acute toxicity, chronic toxicity, environmental effects, health effects, bioaccumulation, disposal method, Source etc. The restriction and guidelines in the import of chemicals are made available to the Customs Department for implementation.

Sri Lanka has also ratified the Basel Convention pertaining to the transboundary movement of hazardous waste.

In accordance with the Montreal Protocol for phasing out the production of ozone depleting substances, Sri lanka has been able to set a time target of:

1. January 1, 2000 for phasing out completely the use of controlled substances in the manufacture or assembly of appliances/systems;

2. Allow the use of controlled substances in the servicing of existing appliances/systems up to January 1,2005; and

3. Permit the import of any controlled substance only on an import license.

The Customs Ordinance, The Import and Exports Control Ordinance, Section 17 of the Control of Pesticides Act No 33 of 1980 and the National Dangerous Drugs Act control the entrance of dangerous chemicals into the country.

Environmental Examination of Projects

A. Within the Zones

Exclusive Industrial (EPZ) zones have been established. Due consideration the potential environmental pollution and hazards that could arise from the manufacturing industries in general, means that environmental management of development projects to be undertaken within the EPZ becomes much simpler. No other activity other than those directly linked with industry are permitted within an EPZ.

Not withstanding the above, each project proposal is subjected to an Initial Environmental Examination (IEE) where the specific nature of the manufacturing processes involved is taken into consideration, the potential environmental impacts are identified and the possibility of satisfactory mitigation of any identified adverse environmental impact is evaluated as an integral part of the project appraisal procedure. For this purpose each entrepreneur completes an application form which gives details of the project, including the raw materials, manufacturing processes, and fuels used etc. have environmental significance.

The project application submitted by an entrepreneur is appraised with the inputs from three departments, namely the Appraisal Department for the investment aspects, Engineering Services Department for the infrastructure requirements and the Environment Department for the environmental aspects. Where necessary, other relevant agencies such as the CEA, Labour Department, National Water Supply and Drainage Board, Coast Conservation Department, National Aquatic Research Agency, Ceylon Institute of Scientific Industrial Research , Atomic Energy Authority, Registrar of Pesticides, Provincial and Local Authorities, are consulted for advice. The BOI takes a decision to approve a project in its original form or in an amended form, or reject the project, only after having considered these appraisal reports. All project approvals are subjected to conditions needed to meet with the parameters laid down by the BOI.

When a project has been approved by the BOI for establishment within a particular EPZ, the project proponent must to enter into a legal agreement with the Commission. The Agreement requires the proponent to fulfil the environmental and other requirements of the Commission that are clearly indicated.

B. Outside the Zones.

The procedure adapted for the zones is also same when a project is located outside a zone. According to the site or suitable sites indicated in the application, a visit is made to the site/s under question to study in detail the existing environment and the information supplied by the developer. At this stage any further information or clarification specific to the site or project that is required to process the application and to evaluate the environmental impacts is also obtained from the developer. On the basis of the observations made, details supplied by the developer and the zoning plan for the area, an Initial Environment Examination (IEE) report is made. On the merits of this report, the project is either recommended subject to conditions needed to mitigate adverse environmental impacts of the project or rejected. The respective local authority where the project is to be located is advised accordingly. If the project is acceptable, such acceptance, together with the conditions under which the project can be approved, is sent to the respective local authority with a copy to the developer.

Environmental Scoping

In the event the Initial Environmental Examination (IEE) report reveals that detailed studies are needed to consider the project, the developer is advised to submit a detailed Environmental Impact Assessment report. Where it is necessary to obtain expert opinion on a given aspect, the details are referred to the expert agency for their observations and comments. In the event of the project having environmental impacts needing the attention of more than one expert agency, representatives from all the connected agencies are summoned for a "Scoping Meeting" where the project is discussed in detail. The developer is also summoned for these meetings along with their consultants, such that first hand information is available to the agencies if the necessity arises during the discussion.

The end result of this exercise is to make the proposed development project environmentally sound and feasible. This is done through the process of stipulating feasible conditions to mitigate the adverse environmental impacts. If it cannot be made environmentally sound and feasible, then it is rejected. If the project is acceptable, as indicated before, a letter containing the conditions under which the project can be approved is sent to the respective local authority with a copy to the developer.

Construction of Factory Buildings

Prior to the construction of the factory buildings pertaining to the project, the building plans are submitted to the Commission for its approval. At this stage the plans are scrutinized to ensure the incorporation of specific requirements for mitigation of environmental pollution. Having satisfied that the requirements have been met adequately, the plans are approved and returned. The projects are very closely monitored during the construction stage in order to ensure conformity to the approved plans. When all the requirements have been met with, a "Certificate of Conformity" is issued to the enterprise.

Trial Operations

When the buildings are completed, the enterprise embarks upon trial production. Monitoring is carried out very closely at this stage to ensure that the mitigation measures adopted are satisfactory for arresting the adverse environmental impacts of the project. If further measures need to be taken, these are intimated to the enterprise and their incorporation ensured.

Having ensured that the enterprise has incorporated all the requirements and is in a position to carry out commercial operations, they are issued with the "Letter of Authority for Commencement of Commercial Production". Tax benefits permitted under the BOI come into effect from the date of its first commercial export.

Regular Environmental Monitoring

Notwithstanding the above procedure, the enterprises are constantly monitored to ensure conformity to the BOI environmental norms. Any shortcoming is brought to the notice of the enterprise concerned and rectified expeditiously.

Environmental Protection Licence Scheme

Under the provision of the National Environmental Amendment Act No.56 of 1988, industries which discharge, deposit or emit waste into the environment should obtain an Environmental Protection Licence from the Central Environmental Authority and abide by the conditions laid down by the Authority under this law. The CEA has delegated its powers and functions to the BOI with regard to the issuing of Environmental Protection Licences to industries Accordingly, the Environmental Protection Licence Scheme is also being implemented by the BOI.

CLEANER TECHNOLOGIES FOR INDUSTRIAL PRODUCTION

G.V. Subrahmanyam
Ministry of Environment and Forests
New Delhi
India

Introduction

All developmental projects utilize natural resources in one form or the other and the efficiency of conversion process depends, amongst other factors, the level of technology utilised. The technical conversion process must be made as efficient as possible so as to provide a much higher output of productive goods and services from the same resource base and, consequently, reduce wastage in the form of pollutants in gaseous, liquid and solid forms.

Cleaner technologies (CT) of production are the practical application of knowledge, methods and means so as to provide the most rational use of natural resources and energy and to protect the environment.

A clean technology is a more efficient technology to achieve the following :

- waste prevention and minimisation by reduced consumption of raw materials;
- modification and upgrading of the process so that optimal utilisation of natural resources is achieved; and
- adoption of a preventive, rather than a corrective approach to pollution abatement.

There are three broad approaches in cleaner technologies of Industrial Production. These are:

- Waste minimisation technologies involving raw material substitution, process changes, improved housekeeping, waste recycle and reuse, equipment redesign and product reformulation;
- end of the pipe treatment technologies involving recovery of raw materials, energy and useful byproducts; and
- waste utilisation technologies involving reclamation and utilisation of wastes as secondary raw materials in other industrial units.

Cleaner technologies are dependent upon innovation and high level of cooperation between different industries, particularly when exchange of certain wastes are involved.

Environment Policy Framework

Legal Framework

India has a large body of laws and regulations governing the environment. These include laws enacted by Parliament, regulations issued by Central and State Governments as well as an increasing body of judicial decisions affecting industrial activity that generates pollution. The major Environmental Acts are :

- The Water (Prevention & Control of Pollution) Act, 1974

- The Water (Prevention & Control of Pollution)Cess Act, 1977.

- The Air (Prevention & Control of Pollution) Act, 1981.

- The Environment (Protection) Act, 1986.

- Public Liability Insurance Act (1991).

- The Hazardous Waste (Management & Handling) Rules, 1989.

- Environment Audit Rules, 1992.

The Government of India identified 17 categories of highly polluting industries for prioritising pollution control. Standards for effluent and emissions from industries have been identified and the industries have been directed to adopt action programmes leading to compliance with these standards on a time bound basis. This has resulted in a record number of companies initiating or continuing pollution abatement schemes. Legal action is taken against the defaulting units. For example, over 200 units have in recent months been closed in Agra and in the Ganga-basin by the order of the Hon'ble Supreme Court.

Policy Framework

Environmental Policy for industry in India, till recently, had focused mainly on pollution control through end-of-the pipe (EOP) treatment which allow the wasteful use of resources and then consume further resources to solve the environmental problems in a particular medium. Also, end-of-the pipe control technologies, more, often than not, transfer pollutants from one environmental medium to another and consume resources out of proportion to the accrued benefits.

With due recognition of the future raw material and energy scenarios, the impact that the industry and its products have on the natural resource base and environmental quality and the necessary thrust being given to the industrial growth in our country, the Ministry of Environment and Forests has formulated comprehensive policies for promoting sustainable development. These are Policy Statement for Abatement of Pollution and the National Conservation Strategy and the Policy Statement for Environment & Development. We have also recently prepared Environment Action Programme identifying the priority areas.

The Policy Statement for Abatement of Pollution emphasises that it is not enough for the Government to notify laws which are to be complied with, and affirms the Government's intention to integrate environmental and economic aspects in development planning with stress on preventive aspects of pollution abatement and promotion of technological inputs to reduce industrial pollutants. The overall policy objective is to integrate environmental considerations into decision making at all levels. The policy aims at:

- Prevention of pollution at source;

- Encourage, develop and apply the best available practicable technical solutions;

- Ensure that the polluter pays for the pollution and control arrangements;

- Focus on the protection of the heavily polluted areas and river stretches; and

- Involving the public in decision making.

The National Conservation Strategy and Policy Statement on Environment & Development sets out the following priorities:

- Conservation of natural resources - land and water;

- Prevention and Control of Atmospheric Pollution, including noise pollution; and

- Industrial development by using a mix of promotional and regulatory steps.

The Environment Action Programme sets out the following priority areas:

- Control of industrial and related pollution with emphasis on the reduction and/or management of wastes particularly hazardous wastes;

- Tackling urban environmental issues; and

- Strengthening scientific understanding of environmental issues as well as structure for training at different levels, orientation and creating environmental awareness, resource assessment, water management problems etc.

In all these policies the emphasis is on prevention of pollution and conservation of natural resources. This becomes all the more necessary in the liberalised environment so that the cleaner technologies and better management practices being adopted are efficient to enable our Indian industry to compete in the international market.

Initiatives for Promoting Cleaner Production

Pursuant to the Policy Statement for Abatement of Pollution several initiatives have been taken for promoting cleaner technologies of industrial production. These are :

(i) Economic Instruments

In an effort to integrate economic and environmental planning, Government of India is promoting a variety of incentives to adopt efficiency enhancing waste minimisation practices. These include :

(a) Water Cess

The Water (Prevention and Control of Pollution) Cess Act, 1977 provides for the levy and collection of cess on water consumed by industries and local authorities. The present water cess rates are being increased by three-fold to motivate the conservation of water which is increasing by becoming a scarce natural resource in our country.

(b) Effluent charges

Effluent charges based on nature and volume of the effluents released are being considered. The scope of the charges will be extended to emission and solid wastes. These charges provide a continuing incentive towards optimal releases and encourage new technology production processes.

A study has been undertaken through National Institute of Public Finance and Policy to analyze the market based instruments such as taxes/charges for pollution abatement.

(c) Financial assistance by way of credit and loans at reduced rate of interest.

World Bank Assisted Industrial Pollution Prevention Project is mainly targeted at introducing cleaner technologies in industrial units. Under the investment component of the project, world bank line of credit is available to industrial units for pollution abatement, with a focus on waste minimisation and adoption of cleaner methodology production. The technical assistance component supports to :

- Establishment of a "clean technology institutional network" designed to promote the development, diffusion and transfer of technologies with environmental benefits for the industrial sector; and

- Extension services for the identification of appropriate waste minimisation and abatement methods for small scale industry, and organisation of waste minimisation circles.

The clean technology cell in the Ministry of Environment & Forests would be the Host Centre and would facilitate the interaction between the network and international agencies besides providing inputs to the policy framework. The Central clearing House for clean technologies would be housed at the NEERI. This in turn would network with

Consortium of CSIR laboratories and other research and academic institutions. The clearing house is expected to collect information on clean technologies from all over the world and make information available to entrepreneurs intending to establish new units or those who plan to improve the existing units.

(ii) Strengthening of Standards:

- In order to promote the conservation of water use by industry,rules relating to standards for consumption of water by polluting industries (chemicals, pulp and paper, fertilisers, tanneries, sugar and distilleries and metallurgical industries) have been notified.

- To promote the shift from pollution control to pollution prevention, rules relating to load-based standards instead of concentration based standards have been notified for a limited number of polluting industries viz. Refineries, smelters, manufacturers of inorganic acids, coke ovens, aluminium plants, glass manufacturers and some synthetic fibres.

(iii) Waste Minimisation Circles:

The Government has initiated to launch a campaign to encourage formation of waste minimisation circles (WMCs) in Indian Industry especially in the small scale sector. These circles would be an assembly of representatives of such industries who would work collectively to provide waste minimisation in their respective units.The group will meet on periodic basis and exchange information on waste reduction efforts. An entrepreneur will act as the nodal person for the circle and will be provided by a resource person either from universities or technical institutions to feed possible solutions to SSIs who are members of WMCs.

A number of practices have been identified for reducing pollution in the small scale sector.The main approaches to waste reduction are :

- improving the process technology and equipment that alter the primary source of waste generation;

- improving plant operation such as better house keeping, improved material handling and equipment maintenance automating process equipment, better monitoring and improved waste tracking and integrating mass balance calculating into process design;

- substituting raw materials that introduce fewer hazardous substances or small quantities of such substances into the product process;

- recycling a potential waste or portion of it on the site where it is generated; and

- Redesigning or reformulating the end products.

The National Productivity Council of India has brought out a manual on Waste Minimisation in small scale industries.with the financial support of the Ministry of

Environment and Forests. NPC is also working on sector-specific manuals for waste reduction.

UNEP and UNIDO with the help of National Productivity Council in India are also establishing National Cleaner Production Centres (NCPC) based on the concept of waste minimisation to encourage cleaner production in small and medium enterprises.

(iv) Environmental Statement

The Policy Statement for abatement of pollution provides, for an environmental statement by all polluting units, which would subsequently evolve into an environmental audit. Pursuant to this policy, Government of India has made submission of environmental statement mandatory through Gazette Notification issued under the Environment (Protection) Act,1986. The statements are to be submitted once in every year. The notification requires that industry provide information on water and raw material consumption, pollution generated, information on hazardous wastes and solid wastes along with disposal practices. The industries are also required to make an assessment of the impact of pollution control measures on the consumption of natural resources.

The Environmental Statement enables units to take a comprehensive look at their industrial operations and facilitates understanding of material flows and focuses on areas where waste reduction and consequently savings in in-put costs is possible. Thus it serves as a management tool to evaluate the performance of various environmental management practices being adopted and would allow the management to look inwards and see as to whether cleaner technologies could be adopted which would avoid generating wastes.

(v) Scheme "Adoption of Clean Technologies in the Small Scale Industries"

The main aim of the scheme is to promote adoption of technologies and best practice techniques for environmental benefits amongst small scale industrial units.The scheme provides financial assistance for development and demonstration projects, creation of data base on the availability of clean technology or present status of clean technology used in the industries, identification and diffusion of clean technology to the industries and training and awareness programmes among the small scale enterprises regarding adoption of pollution abatement measures.

(vi) Eco-labelling

Eco-labelling scheme of Government of India supports cleaner production policies as there is strong emphasis on cleaner manufacturing processes in the criteria for grant of Eco-labels.

The scheme has been initiated for household and other consumer products to meet certain environment criteria along with the quality requirements of Indian standards. The label is known as Ecomark.

The product categorise for which notifications have been issued for the criteria are: Toilet soaps, detergents, Paper, Architectural Paints and Laundry soaps.

(vii) Awards

(a) National Awards for Prevention of Pollution

The Government of India have initiated annual awards to be given every year to the industries and operations which make a significant and measurable contribution towards development of use of clean technologies, products or practices that prevent pollution and finding innovative solutions to the environmental problems.

Awards numbering up to 18 are given every year, one each for the identified categories of highly polluting industries among SMES and awards numbering up to 5 are given every year to the identified categories of small scale industries. The awards are accompanied by a trophy and a citation.

(b) Rajiv Gandhi Environment Award for Clean Technology

Government of India have instituted Rajiv Gandhi Environment Award for clean technology to encourage the industrial units for adoption of clean process technologies in their manufacturing processes.

The award is granted in the form of a trophy to the meritorious unit which makes a significant and measurable contribution towards the development of new, or innovative modification of existing, or remarkable adoption and use of clean technologies and practices that substantially reduce, eliminate or prevent environmental pollution.

Major Issues in Promotion of Cleaner Technologies in Industrial Production

There are certain barriers which prevent industry from adopting the relatively new concept of cleaner technologies of industrial production in existing or new production facilities. These are

(i) Lack of information on latest technological achievements as well as inability to locate sources of such information;

(ii) Lack of information exchange between various interested groups on opportunities for pollution prevention;

(iii) Lack of confidence that techniques for reducing waste will be economically and technically feasible in practice;

(iv) Cleaner technologies of industrial production are country specific based on socio-economic conditions. They cannot be directly imported from successes abroad as in the cases of add-on-units for EOP treatment;

(v) Lack of adequate financial support. In the absence of any specific and preferential funding mechanism, the capital intensive cleaner production projects e.g. black liquor recovery in agro-based small pulp & paper mills, do not take off; and

(vi) Lack of institutional support facilities -inadequate institutional network and limited and non-availability of trained manpower.

Strategies for Promotion of the Adoption of Cleaner Technologies of Industrial Production

(i) Access to technology Information

- Preparation of information packages on development and demonstration of cleaner technologies of industrial production;
- Establishing a viable and responsive region wide interactive network facilitating dissemination of information on clean technologies of industrial production among small and medium scale enterprises;
- Preparation of sector specific manuals on waste minimisation;
- Preparation of training manual for organising national and regional training programmes on cleaner technologies of industrial production for participants at different levels; and
- Organisation of catalogue exhibition-cum-technology promotion workshops.

(ii) Institutional Network

To encourage identification, acquisition, development and promotion of cleaner technologies at all levels, a network of cleaner technology centres need to be set up, with a national centre coordinating their activities. A centre for clean technology should be able to carry out the following:

- identify the areas where introduction of clean technologies is possible;
- identify the sources from where clean technology and data/details thereof can be obtained;
- assess the technology available indigenously as well as those to be imported;
- modify the technology, if necessary and demonstrate it to the satisfaction of the users so that it can be replicated;
- undertake R&D efforts to develop technologies for cleaner production;
- collect, collate and disseminate information on cleaner technology; and
- maintain interaction with industry financial institutions and R&D laboratories for adoption of clean technologies.

(iii) Research and Development

Clean technology of industrial production is dynamic in nature. For constant updating of technological inputs a strong R&D base within industry and outside need to be set up.

(iv) Demonstration Projects

Demonstration of cleaner technologies of industrial production can be very effective in making the SMEs to adopt them. Such projects should illustrate the best practice to be adopted based on proven technologies. If the benefits of cleaner technologies are proved to the prospective users, the adoption can be much easier.

(v) Financial Assistance

Higher International financial support through grant in-aid are soft loans should be made available to the SMES to enable them to adopt cleaner technologies of industrial production.

(vi) Regulatory measures

- Reorient the industrial policy to play pro-active role in cleaner production; and

- Build in resource utilisation norms as part of emission/ effluent standards;

(vii) Economic measures

- Evolve rational resource pricing policy to internalise cost of waste minimisation; and

- Provide incentives viz. corporate tax benefits, preferential procurement of CP products by the Govt. etc. to make CP projects economically attractive.

International Cooperation

The World Bank supported industrial pollution prevention project is presently being implemented. The project support the implementation of the policy framework for industrial pollution prevention. The project will play a role in the development and diffusion of pollution prevention technologies by industry.

The investment component of the project is designed to support sub-projects by individual firms for pollution abatement, with a focus on waste minimisation and adoption of cleaner methods of production.

The technical assistance component of the project is designed to support:

- The establishment of clean technology institutional network, designed to promote the development, diffusion and transfer of technologies with environmental benefits for industry; and

- Extension services for the identification of waste minimisation and abatement methods for small scale industry, and the organisation of waste minimisation circles.

UNIDO with the help of appropriate institutions in India is also establishing National Cleaner Production Centres (NCPCS).

Conclusion

The need for adoption of cleaner technologies of industrial production is well recognised in the context of increasing developmental activities. Cleaner technology plays an important role in development of pollution free production processes, in recycling wastes and in recovering materials from the waste products. Adopting such clean technology can be a source of profits for the enterprise as increased profits can result from reducing costs through improved materials efficiency. However, such technologies will become more attractive only if the conditions of marketability, cost effectiveness and availability of technical know-how are satisfied. This necessitates an integrated and practical approach to promote the development and adoption of cleaner technologies. To achieve this objective national and international organisations, multi-lateral and bilateral financial aid institutions, industry equipment manufacturers, academic and R&D institutions will have to work in full cooperation with each other.

PREVENTION AND MINIMISATION OF HAZARDOUS WASTES

T. Chakrabarti
Scientist and Head
Toxic Waste Management Division
National Environmental Engineering Research Institute
Nehru Marg
Nagpur
India

Abstract

The options for hazardous waste management include, on the one hand, reactive control measures such as pollution prevention and end-of-the-pipe (EOP) treatment and disposal, and on the other, anticipative and preventive strategies such as waste minimization through the adoption of low and non-waste technologies (LNWT) of production. At the core of the subject, however, are a host of technology-related issues. Among the issues being considered are application of life cycle analysis or assessment (LCA),cleaner technology (CT) options and process management. The aim is to avoid an end-of-the-pipe solution cost to meet a command and control requirement as well as application of recycle and reuse technologies which have a favourable payback period.

This paper will introduce the concepts of LCA and CT and address two technical issues, namely:

1. Waste minimization techniques based on source reduction and recycling (on-site and off-site); and

2. Pollution prevention through plant maintenance as tools in process management.

Since prevention and minimization of hazardous waste require an integrated approach involving the regulatory process, executive level management and the application of suitable technology, the target audience includes representatives from industry, regulatory bodies (Pollution Control Boards), academia and the legal profession. The flow charts and tables included in this paper can be used to communicate the central idea of prevention and minimisation of hazardous waste to the subject audience.

The paper also presents case studies on waste minimization in the caustic and chlorine industry, textile industry and dyes and intermediate industry, nickel, copper and chromium recovery from wastes and utilization of fly ash. Further, this paper also introduces the concept of environmentally balanced industrial complex (EBIC), an approach, which makes

it possible to transform pollution problems of one industry into an asset for another industry by using the waste as a raw material, thereby effecting lower production costs and elimination of adverse environmental impacts.

Introduction

Waste minimization means the reduction, to the extent feasible, of hazardous waste that is generated prior to treatment, storage or disposal of the waste. It includes any source reduction or recycling activity (Figure 1). Waste minimization is different from pollution prevention which is defined as the use of materials, processes or practices that reduce or eliminate the creation of pollutants or wastes at the source.

The options for hazardous waste management include, on the one hand, reactive control measures such as pollution prevention and end-of-the-pipe (EOP) treatment and disposal, and on the other, anticipative and preventive strategies such as waste minimization through the adoption of low and non-waste technologies (LNWT) of production.

Considerations of resource conservation, economic efficiency and environmental protection warrant the adoption, as far as possible, of a preventive strategy because EOP treatment and disposal methods, more often than not, transfer pollutants from one environmental medium to another and consume resources out of proportion to the benefits that accrue.

Further, reactive controls deal only with the problem of first-generation pollution which is created by the manufacturing processes and regulated by legislation, while ignoring the problem of second-generation pollution related to product use.

The policy of pollution control also fails to internalize environmental costs and to induce the development of innovative technologies besides being ridden with all the fallacies of a legalistic approach in which the burden of proof lies with the enforcer and not with the polluter. Waste minimization, on the other hand, has several payoffs to offer. It improves financial viability of the industry and reduces the possibility of conflict with public interests; provides direct economic benefits from conservation of resources and avoidance of pollution control costs; and stimulates economic growth by creating new markets for recycling, reclamation and conservation technologies, and by generating new employment potential.

Pollution prevention through LCA is a departure from evaluating waste management (source reduction and recycling) options and can be used as an objective technical tool to identify and evaluate opportunities to reduce environmental impacts associated with a specific product, process or activity. It can also be used to evaluate the effects of various resource management options designed to create sustainable systems.

The policies of pollution prevention and waste minimization is even more relevant in the case of hazardous wastes. These pose an ominous liability, not only in terms of their health and environmental implications, but also in respect of provision and maintenance of an ever increasing number of land disposal sites.

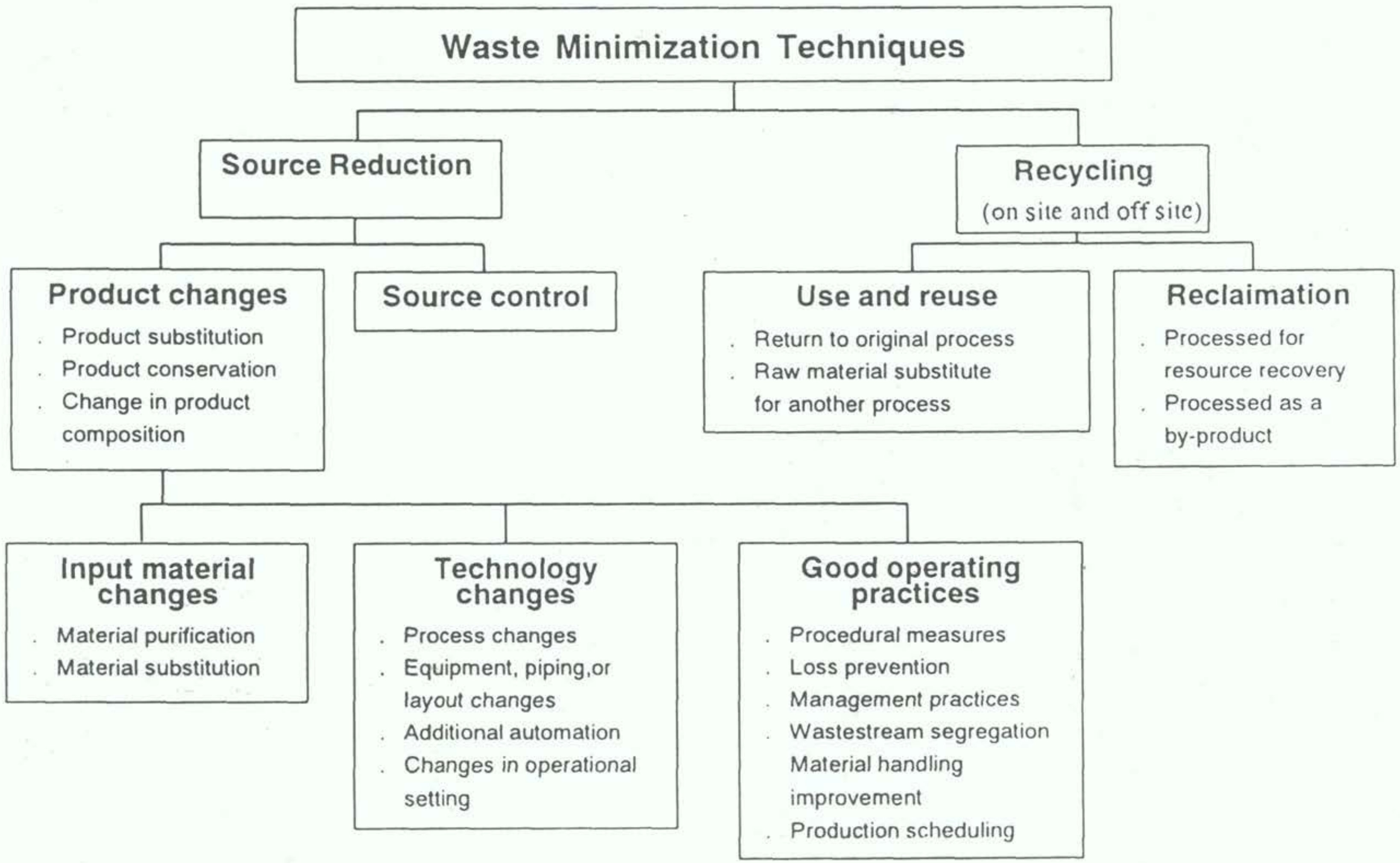


Fig. 1 A waste minimization approach.

Objectives

The scope of the topic encompasses the role LCA, alternative cleaner technologies (CTs) and process management in preventing and minimising hazardous waste generation. Agenda 21, in Chapter 30, calls on governments, industry and business to recognise the importance of proper environmental management in achieving sustainable development. Production processes in developing countries have a relatively high raw material and energy intensity compared with relevant technologies in developed countries.

As a strategy, LCA, cleaner production (CP) and process management are recommended for achieving environmental protection and sustainable development. The target audience includes representatives from industries, regulatory bodies (Pollution Control Boards), academia and legal profession. The challenge of sustainable development demands that all those working on environmental management are sufficiently environmentally literate that they will not undermine the future through present actions that harm the environment. The flow charts and tables included in this paper can be used to communicate the central idea of prevention and minimisation of hazardous waste to the subject audience.

Life Cycle Analysis (LCA)

The concept of LCA is to evaluate the environmental effects associated with any given activity from the initial gathering of raw material from the earth until the point at which all residuals are returned to the earth. In this concept, often referred to as "Cradle to grave" assessment, the product in question is analysed at all production, transportation, use and final disposal stages to assess the cumulative amounts of materials, energy and pollutants. The principal purpose of LCA is to assess the environmental "friendliness" of the product in relation to other products.

Life cycle assessment is defined as a concept and a methodology to evaluate the environmental effects of a product or activity holistically, by analysing the entire life cycle of a particular product, process or activity.

Components

The three separate but interrelated components of a LCA include:

1. The identification and quantification of energy and resource use and environmental releases to air, water and land (**inventory analysis**);

2. The technical qualitative and quantitative characterization and assessment of the consequences on the environment (**impact analysis**); and

3. The evaluation and implementation of opportunities to reduce environmental burdens (**improvement analysis**).

Some LCA practitioners have defined a fourth component, the scoping and goal definition or initiation step which commences an assessment by:

a) defining its purpose, boundaries and procedures; and

b) tailoring the analysis to its intended use.

LCA is not necessarily a linear or step wise process as its components overlap and build on each other in the development of a complete LCA. For example:

- **inventory analysis** alone may be used to identify opportunities for reducing emissions, energy consumption, and material use;

- **impact analysis** addresses ecological and human health consequences and resource depletion, as well as other effects, such as habitat alteration, that cannot be analysed in the inventory; and

- **improvement analysis** helps ensure that any potential reduction strategy are optimised and the improvement programmes do not produce additional, unanticipated adverse impacts to human health and environment.

The inventory analysis component is a technical, data based process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes and other releases for the entire life cycle of a product, package, process, material or activity.

The stages of a life cycle inventory include:

- raw materials acquisition;

- manufacturing;

- material manufacture;

- product fabrication;

- filling/packaging/distribution;

- use/reuse/maintenance; and

- recycle/waste management.

The steps involved in performing a life cycle inventory are to:

- define the purpose and scope of the inventory;

- define the system boundaries;

- devise an inventory checklist;

- institute a peer review process;

- gather data;

- develop stand-alone data i.e. normalized data consistently defining the system by reporting the same product output from each subsystem (e.g. on the bases of 1,000 kg of output);

- construct a computational model;

- present the results; and

- interpret and communicate the results.

Inputs in the product life-cycle inventory analysis include:

- raw/intermediate materials;

- renewable and nonrenewable resources;

- energy;

- coal;

- petroleum;

- natural gas;

- hydropower;

- wood;

- residues and renewable energy sources; and

- water.

Outputs of the product life cycle inventory analysis include:

- atmospheric emissions;

- waterborne wastes;

- solid wastes; and

- products.

A broad based life cycle inventory begins with raw materials and continues through final disposition, accounting for every significant step in a product system. The purposes and boundaries of a life cycle inventory analysis should be clearly defined with a view to ensure that the results will be validly interpreted. In a comparative life cycle inventory, the basis of comparison should be equivalent usage. Each system should be defined so that a functionally equal amount of product or equivalent service is delivered to the consumer. Level of required details to carry such analysis should, however, be evaluated in the light of available funding and the size of the system, while maintaining the technical integrity of the study. Understanding the consequences of narrowing a study boundary is, therefore, important for evaluating trade-offs between the ability of the inventory to address the environmental attributes and cost, time or other factors.

The private and public sector uses of life cycle inventory are:

. Private sector uses
  - evaluation for internal decision making; and
  - evaluation for public disclosure of information.

. Public sector uses
  - evaluation and policy making; and
  - public education.

Other applications of this analysis are directed to:

- support broad environmental assessment;

- establish baseline information;

- rank the relative contribution of individual steps or processes;

- identify data gaps;

- make policy;

- support product certification; and

- provide education for use in decision making.

Impact analysis component is a technical quantitative and/or qualitative process to characterize and assess the effects of the resource requirements and environmental loadings (atmospheric and waterborne emissions and solid wastes) identified in the inventory stage.

An important distinction exists between life-cycle impact analysis and other types of impact analysis. Life-cycle impact analysis does not necessarily attempt to quantify any specific actual impacts associated with a product or process. Instead, it seeks to establish a linkage between the product or process life cycle and potential impacts. The principal methodological issue is management of the increased complexity as the stressor-impact sequence is extended. Methods for analysis of some types of impacts exist, but research is needed for others.

The improvement analysis component of the life-cycle assessment is a systematic evaluation of the needs and opportunities to reduce the environmental burden associated with energy and raw material use and waste emissions throughout the life cycle of a product, process or activity. This analysis may include both quantitative and qualitative measures of improvements.

LCA and Ecolabelling of environmentally friendly consumer products

In a number of industrialized countries growing attention is given to the LCA of products. The full LCA examines the cumulative impact on the environment that a product generates, from the extraction of primary materials needed to produce it until its final disposal. The product thus is analysed "from cradle to grave", i.e. at all production, transportation, use and final disposal stages to assess the cumulative amounts of materials, energy and pollutants. The principal purpose is to assess the environmental "friendliness" of the product in relation to other products.

In some countries, LCA is used to provide a quantitative basis for awarding ecolabels for (relatively) environmentally benign products.

"Environmental labelling" (henceforth called ecolabelling) means the use of labels in order to inform consumers that a labelled product is environmentally more friendly relative to other products in the same category. These labels, granted by a government or privately sponsored agency to (voluntary) applicants from enterprises, are conceived as a market-oriented instrument for environmental policy as they establish no generally binding requirements or bans.

The criteria for the award of such labels, at least in theory, call for an overall assessment of the ecological impact of a good during its life cycle, including production, distribution, use, consumption, as well as disposal. Therefore, ecolabels differ from "single issue labels", which address only one environmental quality of a product, for instance biodegradability. They also differ from "negative labels" containing warnings indicating that the use of the product may be dangerous, such as health warnings on cigarette packs.

The Cleaner Technologies (CTs) of Industrial Production

In 1976 the Economic Commission for Europe (ECE) defined Non-Waste Technology (NWT) as the practical application of knowledge, methods and means so as, within the needs of humanity, to provide the most rational use of natural resources and energy, and to protect the environment. NWT is deemed as the theoretical limit to which low-waste technology can be carried as zero discharge is thermodynamically impossible to achieve. The techno-economic infeasibility of development and implementation of NWT gave rise to the pragmatic concept of Low-and Non-Waste Technologies (LNWT) of production.

The concept was broadened by the ECE in 1979 by coining the term CTs (of production) incorporating aspects of:

- less pollution discharged into natural environment;

- less waste generation; and

- less demand for natural resources.

CP has been defined by UNEP as the conceptual and procedural approach to production which demands that all phases of the life cycle of a product should be addressed with the objective of prevention or minimization of short-and long-term risks to humans and the environment.

The goal of CP is essentially that of sustainable development, production processes, product cycles, and consumption patterns which allow for human development, and the provision of basic needs without degrading or disrupting the ecosystems in which human development must operate. The central tenets of the cleaner production philosophy are that the measures should be preventive and integrative.

CTs are the practical application of knowledge, methods and means, within the needs of humans, that aim to provide the most rational use of natural resources and energy and to protect the environment. They are based on improved manufacturing methods which require less raw materials and energy to obtain equitable levels of output of identical or better quality.

CTs also make greater, if not full, use of wastes and recyclable materials and are dependent upon innovation and a high level of cooperation between different industries, particularly when exchanges of certain wastes are involved.

The concept of CTs is based on the awareness that the environment cannot be considered independent of other development sectors, including consumption of energy and resources, and the economy of the country from the environmental point of view. It means use of minimum resources with maximum efficiency to achieve the twin benefits of resource conservation and environmental protection. From the economic point of view, it means cost effectiveness and increased productivity within the boundaries of available resources.

There are three broad elements of CTs, namely:

- Resource conservation technologies aiming at waste minimization at source through product change (substitution/conservation); production process changes involving raw material changes, technology changes and better housekeeping;

- End-of-pipe (EOP) treatment technologies designed to recover raw materials, energy, water and byproducts; and

- Waste utilization technologies for reclamation and utilization of wastes as secondary raw materials.

The concept of CT is being advocated in different parts of the world under various names, such as low- and no-waste technologies, environmentally sound technologies, waste recycling, residue utilization and resource recovery technologies.

There are therefore three broad categories of CTs, namely:

- LNWT of production aimed at waste minimization at all points in the cycle of production through process changes, good housekeeping, recycle and reuse, equipment redesign and product reformulation;

- Recycle technologies designed to recover raw materials, energy, water and byproducts in the course of EOP waste treatment; and

- Waste utilization technologies for reclamation and utilization of wastes as secondary raw materials, or for processing of wastes to manufacture products with various end uses.

Selection and application of CTs require a comparative analysis and evaluation of various competing technologies based on economic, technological, social and environmental considerations. The results of a cost-benefit analysis depend essentially on the perceived costs and benefits which elude definition for environmental intangibles. Whereas decisions at the industry level may be based on economic analysis of resources conserved, avoidance of pollution control costs, and costs incurred on new technologies; Government at the national level may be guided by benefits to society and impacts on environmental quality as also by the stock and quality of natural resource base.

The ultimate CT will be based on renewable resources as raw material and energy, and on transformation through highly efficient biotechnology to produce environmentally benign products.

CTs of Industrial Production - International Scenario

Emergence of the concept of CTs can be traced back to the UN conference on proclaimed resource conservation as a basic principle for environmental management.

In 1976 Senior Advisers to ECE Governments deliberated on the principles and creation of non-waste technology and production. The seminar identified the term Non-Waste as a kind of technological optimum, which can be used as a norm for measuring the final degree of production efficiency. A joint UNEP-ECE project on Compilation of a Compendium on LNWT in the ECE Region was started in 1977. The objective of the compendium was to provide examples of practical applications in major industrial sectors, reveal gaps in knowledge and thereby identify thrust areas for R&D. Till January 1987, the compendium contained 129 monographs.

Realizing the need for an international network to promote LNWT, UNEP/IEO in 1989 established industrial sector working groups for tanning, textile, halogenated solvents, and electroplating industries, with a view to harmonizing data and government polices.

UNEP/IEO also established the International Cleaner Production Clearing House (ICPIC) which is a computer-based information exchange system. It contains over 400 case studies, a calender of training events and seminars, a directory of experts, bibliography of references and description of international programmes on LNWT. ECE and UNEP/IEO have instituted an award to industry for cleaner technology as a means of encouragement.

ECE, since 1979, is engaged in R & D on CTs. It has taken up programmes through the Council Regulations on Action by the Community relating to Environment (ACE) which include financial support for demonstration projects on cleaner technologies to the tune of 30 percent cost of the full scale plant.

ECE has set up a network for Environmental Technology Transfer (NETT) in 1988. NETT provides for exchange of information and transfer of technologies, cost-effective pollution abatement methods and waste treatment technologies.

The US-EPA has recently changed the focus of its activities from EOP to pollution prevention. It established the Pollution Prevention Office (PPO) and a Pollution Prevention Advisory Committee of senior EPA managers in 1987. The Office of Research and Development of EPA has also commissioned Waste Minimization Research (WMR) programmes comprising:

- Waste Reduction Innovative Technology Evaluation Programme (WRITE);
- Waste Reduction Assessment Programme (WRAP);
- Waste Reduction Evaluation at Federal Facilities (WREAFS);
- Waste Reduction Institute for Scientist and Engineers (WRISE); and
- Pollution Prevention Information Clearinghouse (PPIC).

In October 1990 the U.S. Congress passed the Pollution Prevention Act (PPA) which states the national policy as follows: The Congress hereby declares it to be the national policy of the United States that pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

An important part of the Act is a requirement that all generators who are required to file an annual toxic chemical release form "R" under Section 313 of the Superfund Amendment and Reauthorization Act of 1986 (SARA) must include with that filing a toxic chemical source reduction and recycling report for the preceding calendar year. These reports identify the areas of pollution prevention for future emphasis.

The Clean Air Act Amendments (CAAA) of 1990 also encourage and promote reasonable federal, state and local government actions for pollution prevention. Many states in the US have also passed legislation which focuses on pollution prevention.

Developed countries, including USA, Denmark, France, Germany, Netherlands, UK, Sweden, Norway and Japan, have enacted legislation for recycling of solid wastes. Also, regulations for waste management in households and industries regarding source separation and use of recycled paper in public organizations have been framed. Incentives for use of products manufactured using recycled material are also offered.

Waste utilization policies and programmes have resulted in recovery rates of the order of 40 to 53 percent in Japan and the Netherlands in paper, aluminum, wood, glass and steel sectors. The high rate of success in these countries is attributed to nonavailability of land for waste disposal, together with economic and political costs of importing primary raw materials. Netherlands has also established the world's first waste exchange programme, a free brokerage service, to match buyers and sellers of waste. In addition, it has attempted to stabilize the typical boom-and-bust cycles in recyclables by establishing buffer stocks.

Recovery and recycle of wastes all over the world have registered upward trends in the past three decades, with 5 to 10 percent increase over 1960 recovery rates for paper, aluminum and steel.

Cleaner Technologies (CTs) of Industrial Production - Indian Scenario

In India, the concept of LNWT has been applied in the area of liquid waste management. Examples of waste volume reduction, waste recycle and reuse, and byproduct recovery in several industries, such as textile, tannery, metal finishing, beverages, pulp and paper and distillery, are well documented.

However, by and large, the industry in India has taken recourse to pollution control through EOP treatment. Examples of pollution prevention through adoption of cleaner technologies are meagre.

Also, the approach of Government, so far, has been reactive, repair oriented and media specific. Separate consents for waste and air pollutants overlook the cross-media transfer of pollutants. Fiscal incentives are available mainly for EOP treatment. No such fiscal incentives are yet available for use of cleaner technologies.

Recognizing the potential for resource conservation with concomitant reduction in cost of pollution control, the Indian Ministry of Environment and Forests (MOEF) retained NEERI in 1988 to prepare a draft paper on preventive environmental policy. The paper discussed, among other things, cleaner technologies of production, recycle and reuse technologies for EOP and cross media inter-relationships.

The National Environmental Engineering Research Institute (NEERI), in 1988, prepared a policy paper on waste utilization in India for the MOEF. The paper analysed the informational, economic, technological, managerial and socio-political constraints to waste utilization and delineated appropriate strategies for minimization and reclamation of wastes so as to achieve the twin benefits of conserving material & energy resources and circumventing environmental pollution.

Subsequent to the Waste Utilization Policy paper, a National Waste Management Council (NWMC), with the Minister MOEF as Chairperson, was established in June 1990. NWMC has constituted subgroups to assess status and identify an action plan for waste minimization and utilization in industry, urban human settlements and rural areas. The Federation of Indian Chamber of Commerce and Industry (FICCI) has been compiling and publishing, since April 1991, regular information on the demand and availability of industrial wastes.

On behalf of the Central Pollution Control Board, NEERI has compiled information based on published literature on cleaner technologies case studies,

The National Chemical Laboratory, Pune, with TIFAC (DST) sponsorship, has established a database on Environmental Processes and Technologies which interalia documents cleaner technologies.

The scheme to label environment friendly products, ECOMARK, was notified by MOEF on 21 February, 1991. The scheme, which is operating on a national basis, envisages accreditation and labelling of household and other consumer products which meet certain environmental criteria, along with the quality requirements of Indian Standards. A National Steering Committee for implementation of the ECOMARK scheme has been constituted. A Technical Committee constituted to assist the National Steering Committee identifies the individual products and determines the criteria for awarding the ECOMARK. This is a major step towards promotion of green products.

The Asian and Pacific Center for Transfer of Technology (APCTT) published a compendium of 101 Environment Friendly Technologies in September 1993. APCTT brings out a bi-monthly Asia-Pacific Tech Monitor.

Best Practicable Technology Currently Available - Case Studies

Industrialization in developing countries is causing considerable environmental damage as the conventional response of end-of-pipe pollution controls is inefficient and costly. The social and economic costs of environmental damage caused by current industrial growth in India have been estimated to be much higher than the required expenditure of 0.5-1.0 percent of GNP for pollution control. Cleaner production is the only tool which will aid the industry to move towards sustainability. According to Agenda 21, the Earth Summit's plan for sustainable development, the major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in industrial countries, which, in turn, is aggravating poverty and imbalance. It was also realised by industrialised countries that applying existing cleaner technologies on a world wide scale would not suffice as their efficiency would have to be improved by a factor of ten to twenty to obtain any significant impact.

The two conventional approaches, currently practised by industries to minimize environmental pollution, include (i) an adaptation of the traditional forms of waste control and management, and (ii) an overhauling of the concerned processes and plants so as to cut down or even avoid waste altogether or to make them less detrimental to the environment or to convert them to products which could be reprocessed or stored under controlled conditions, etc. The objective with the second approach needs to be considered by the chemical engineers as it leads to the creation of low waste technologies.

Caustic and Chlorine

Caustic soda and chlorine are commercially produced by the electrolysis of common salt in mercury cells or diaphragm cells. In the United States, around 70% of the total caustic is manufactured by the diaphragm process. In the USSR, preference is given to the mercury process as the product has a higher purity. Indian chlor-alkali plants are primarily based on mercury cells using mercury as the cathode in the process of electrolysis of brine.

The mercury cell is preferred over the diaphragm cell for the following reasons:

- Mercury cell is more economical than the diaphragm cell;

- Diaphragm process cannot yield a pure product as the product retains common salt (a 30% solution of caustic contains 1 g of NaCl per litre). In some applications, such as in the textile industry, use of impure caustic is undesirable and hence preference is given to the caustic produced by the mercury cell process; and

- The asbestos pulp diaphragm has a short service life; it tends to break up owing to swelling and attack by the reacting species.

Chlor-alkali manufacture by the mercury cell process results in mercury pollution which has assumed a problem of national dimension. The national average for the consumption of mercury per tonne of caustic soda produced is 350 g. A survey conducted by the Central Pollution Control Board has revealed that 64.5% of the loss of mercury takes place through brine sludge which is produced to an extent of 0.03 tonne per tonne of caustic soda produced. Mercury content in the sludge has been estimated to be 2.4 mg per g of sludge on dry basis, which amounts to 72 g per tonne of caustic soda produced. Taking into account the country's annual production of 6,00,000 tonnes, around 43 tonnes of mercury is lost into the environment through this route. The loss through the liquid effluent, on the other hand, is only 0.3%, amounting to 33.3 g/MT of caustic.

The higher consumption of mercury in the process in India has been attributed to the higher conversion of metallic mercury to ionic mercury (as Hg^{++}) which is effected by the entrapped chlorine in the cell during power failures and frequent shutdowns. This situation may be avoided by adapting membrane cell technology which eliminates the use of mercury. As of today, membrane cell technology is an established commercially viable process and there is a considerable saving of power if this process is adopted over other processes. The power consumption per tonne of product can be considerably reduced as is evidenced from the following figures :

	Process used	**Power consumption**
1.	Mercury cell	3500 kwh/tonne of NaOH and 3100 kwh/tonne of NaOH for plants commissioned in India after 1975.
2.	Diaphragm	3400 kwh/tonne of NaOH
3.	Membrane cell	2500 kwh/tonne of NaOH

It is estimated that membrane technology will ensure a saving in energy consumption to the tune of 20 crores of rupees a year. In addition, there will be substantial saving of cost of imported mercury and mercury pollution will be totally eliminated. It has also been observed that,on the basis of design conditions, capital cost is much lower for a conversion-cum-expansion project than a new grass roots project. The saving is mainly due to the fact that membrane cells need 1/4th the cell room space and 1/5th brine volume as compared to mercury cells. Thus, for a country like India where conservation of energy assumes utmost priority, conversion of mercury cell plants to membrane technology will derive have the dual advantage of energy saving and pollution control.

Textile Industry

Century Textile and Industries Limited has developed a cleaner production method for sulphur black dyeing which imparts deep colours to the textile products. Traditionally, sulphur dyes are converted into the fabric affinity form by treating it with an aqueous solution of sodium sulphide. This gives rise to a high sulphide content in the mill effluent. The state Pollution Control Board allows 2 mg/l of sulphide in the treated effluent whereas the sulphide concentration in the Century mill's effluent used to be 30 mg/l.

With extensive search for a suitable replacement for sodium sulphide, the mill found hydrol, a by-product of the maizestarch industry. This contains 50 per cent of reducing sugar, and is thus a good substitute. Further research showed that 100 parts of sodium sulphide could be substituted by 65 parts of hydrol plus 25 parts of caustic soda. This substitution was implemented with a re-designed mixing strategy. Dying subsequently obtained showed that the substitution was equivalent to conventional dyeing in terms of fastness, depth of shade, etc. Moreover, there was a qualitative improvement also as sodium sulphide used to produce "bronzing", a reddish dull dying which was eliminated after the substitution.

The substitution involved no capital expenditure and operating costs were, in fact, marginal. Other advantages of this new production process were reduced corrosion in the treatment plant due to reduced sulphide levels, elimination of sulphide odours and better performance of the biological effluent treatment plant. The company saved Rs. 640,000 in capital expenses that it would have borne to install additional effluent treatment facilities and another Rs. 96,000 in running expense per annum.

The BASF Ag (Germany) could recover hexa methylene dlamine from nylon wastes by hydrolysing the waste with concentrated sodium oxide solution to yield starting materials which could be recycled into the poly condensation process. Recovery of sodium sulphate from spin bath, zinc, carbon disulphide and caustic soda has been reported from semi synthetic textiles and viscose rayon manufacturing industries.

Dyes and Intermediate Industry

Manufacture of H-acid (8 amino-1-napthol-3,6-dislphonic acid), a dye intermediate, involves a train of unit processes such as sulphonation, nitration, neutralisation filtration, reduction and isolation of product. The overall yield, on molal basis, is around 50 per cent. M/s. Consafe Science (India) Pvt. Ltd. in Pune observed that during the reduction process, the iron powder used is converted into oxide which traps considerable amounts of organic matter escaping from the process and, therefore, cannot be used in pigments manufacture. The product loss could be reduced by using ample water to wash the iron sludge to make it product free and by employing proper filtration equipment such as membrane process or belt processes. Alternatively, production of iron sludge can be eliminated by adopting a vapour or liquid phase hydrogenation process using solid catalyst. In fact M/s Bayer AG (Germany), could reduce the amount of starting materials by 20%, as well as reduce wastewater sludge and solid waste generation by resigning the H-acid manufacturing process with a different catalyst system in H-acid manufacture. Further, gypsum produced was 38% less than in the conventional process and was of a quality suitable for direct use by the cement industry.

Process Management

The basic concept of pollution prevention is the desirability not to produce waste, rather than implement extensive treatment schemes (end-of the-pipe approach) to eliminate generated waste.

Components of Waste Minimization Programme

- Reaction (mono, multiple, monophase, multiphase)
- Reactor
- Catalyst (optional)

Reaction

- In monophase reaction, the ratio of undesirable products (wastes) to desirable products is determined by reaction stoichiometry;
- rate equations for mass transfer and kinetic reactions (specific for each system);
- relation among the Kinetic rate equations;
- component mole balances (specific for each reactor type);
- total energy balance on reactants (specific for each reactor type);
- energy balance on heat transfer medium (specific for each reactor type);
- equilibrium relations for reversible reactions; and
- temperature effect on reaction and thermodynamic parameters.

Multiple reactions can be classified into three general types:

- series;

- parallel; and
- combination.

In addition to the eight factors mentioned above, the factors which minimize undesirable products in multiple reactions may include:

- mole ratio of the reactants (feed condition);
- distillate feed mole ratio at optimum reflux ratio;
- substitution of air by pure oxygen; and
- flow rate of scrubbing solution when on absorber is used.

Reactor

Type of reactors:

- plug of low;
- continuous; and
- fluidized.

Reactor conditions:

- Isothermal/Adiabatic/Non-adiabatic;
  . Residence time
  . Kinetic model (reaction specific)
  . Temperature conditions at the inlet and outlet and inside the reactor
  . Reactor pressure
  . Reactor mixing conditions
  . catalysts

Reactor conditions which will minimise undesirable products/by-products for series and parallel reactions are given in Tables 1 and 2.

Catalysts

- Reduction in catalyst efficiency process; and
- Process improvement by changing catalyst.

Pollution Prevention and Plant Maintenance

Table 1

Reactor Conditions which will Minimize Undesirable
Products for Series Reactions

REACTION SYSTEM	$aA \xrightarrow{k_D} D \qquad (-r_A)_1 = k_D C_A^m$ $bD \xrightarrow{k_U} U \qquad (-r_D)_2 = k_U C_D^n$	
RATIO OF (UNDESIRABLE / DESIRABLE) RATE	$W = \frac{(-r_D)_2}{(+r_D)_1} = a^{Un} \frac{k_U}{k_D} C_{A0}^{n-m} \frac{(X_1 - X_1 X_2)^n}{(1 - X_1)^m}$ $\frac{k_U}{k_D} = \frac{A_U}{A_D} e^{-\frac{(E_U - E_D)}{RT}}$	
TEMPERATURE LEVEL TO MINIMIZE BY-PRODUCT	$(E_U - E_D) > 0$	LOWER TEMPERATURE
	$(E_U - E_D) = 0$	NO EFFECT
	$(E_U - E_D) < 0$	RAISE TEMPERATURE
CONCENTRATION LEVEL TO MINIMIZE BY-PRODUCT	$(n - m) > 0$	Keep C_{A0} Low • Feed diluted with inerts • Low Pressure (gas phase)
	$(n - m) < 0$	Keep C_{A0} High • No diluents in feed • High Pressure (gas phase)
	$(n - m) = 0$	No effect

Table 2

Reactor Conditions which will Minimize Undesirable By-Products for Parallel Reactions

REACTION SYSTEM	$A \xrightarrow{k_D} D \quad (+r_D) = k_D C_A^{m1}$ $A \xrightarrow{k_U} U \quad (+r_U) = k_U C_A^{m2}$		$A + B \xrightarrow{k_D} D \quad (+r_D) = k_D C_A^{m1} C_B^{n1}$ $A + B \xrightarrow{k_U} U \quad (+r_U) = k_U C_A^{m2} C_B^{n2}$	
RATIO OF $\left(\frac{\text{UNDESIRABLE}}{\text{DESIRABLE}}\right)$ RATE	$W = \frac{A_U}{A_D} e^{-\frac{(E_U - E_D)}{RT}} C_A^{m2 - m1}$		$W = \frac{A_U}{A_D} e^{-\frac{(E_U - E_D)}{RT}} C_A^{(m2 - m1)} C_B^{(n2 - n1)}$	
TEMPERATURE LEVEL TO MINIMIZE BY-PRODUCT	$(E_U - E_D) > 0$		Lower Temperature	
	$(E_U - E_D) = 0$		No Effect	
	$(E_U - E_D) < 0$		Raise Temperature	
CONCENTRATION LEVEL TO MINIMIZE BY-PRODUCT	$(m2 - m1) > 0$	Keep C_A Low - CSTR Gas Phase - Low Pressure - Use Inerts Liquid Phase - Use Diluents	$(n2 - n1) > 0$	Keep C_A and C_B Low Use : - CSTR Fig 3(a) - Feed diluted with inerts - Low Pressure (if gas-phase)
			$(n2 - n1) < 0$	Keep C_A Low and C_B High Use : - Semibatch Reactor, A slowly fed into B Fig 3(e) - Tubular reactor with side streams of A Fig 3(g) - Series of CSTRs with A fed to each reactor Fig 3(i)
	$(m2 - m1) = 0$	No Effect	$(n2 - n1) = 0$	No Effect
	$(m2 - m1) < 0$	Keep C_A High - BATCH - PFR Gas Phase - High Pressure - No Inerts Liquid Phase - No Diluents	$(n2 - n1) < 0$	Keep C_A and C_B High Use : - Tubular reactor Fig 3(b) - Batch reactor - High Pressure (if gas-phase)
			$(n2 - n1) > 0$	Keep C_A high and C_B Low Use : - Semibatch reactor; B fed slowly into A Fig 3(d) - Tubular reactor with side streams of B Fig 3(f) - Series of CSTRs with A fed to the first reactor and B fed to each reactor

a) Preamble

Maintenance is the vital link which assures that operation of the unit is able to achieve a performance level consistent with design and engineering. Maintenance includes activities that are required to keep a facility in an as built condition.

In the UK maintenance is recognised as the largest aspect of a subject known as Terotechnology. Terotechnology represents a combination of management, financial engineering, building and other practices applied to physical assets in pursuit of economic life cycle costs which, in turn, is defined as the total cost of an item throughout its life including initial, maintenance and support costs.

Maintenance practice is concerned with the specification and design for reliability and maintainability of plant machinery, equipment, building and structure.

b) Assumption

All physical equipments are susceptible to:

Failure

- unplanned losses in output of products or services generation of wastes; and
- potential loss of equipment.

Deterioration

- increase in instances of failure;
- unacceptable; and
- waste generation.

Obsolescence, which results from:

- lower unit process cost;
- lower waste disposal cost; and
- better environmental performance.

c) Types

Maintenance (Table 3 and Figure 2) is of two types:

Table 3

Alternative Maintenance Approaches

Reactive Maintenance

Breakdown maintenance

- crisis management
- conditional or indicative maintenance
- problem detection in their early stages

Proactive maintenance

Preventive maintenance

- maintenance conducted on regular schedule
- scheduled inspection
- predictive or reliability maintenance

Prediction based on prior performance records

- developmental maintenance
- reduce fugitive emissions
- improvement in design

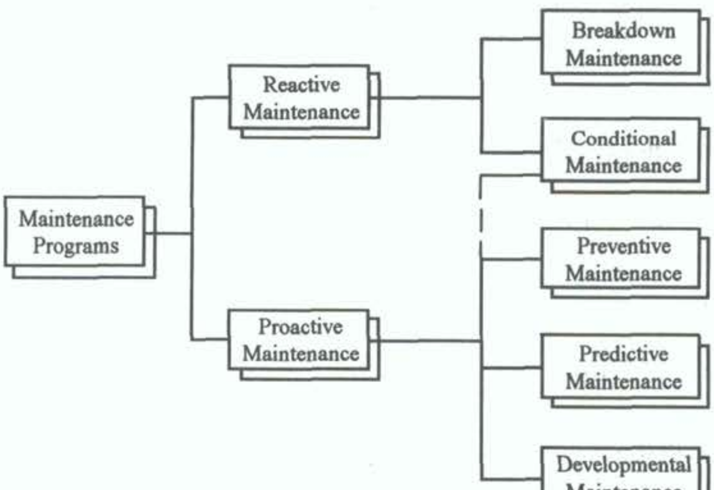


Fig. 2 Alternative maintenance approaches.

Reactive maintenance

- Breakdown maintenance; and
- conditional or indicative maintenance.

Proactive maintenance

- Preventive maintenance;
- Predictive or reliability maintenance; and
- Developmental maintenance.

Maintenance Wastes

Maintenance related wastes can be grouped into three categories:

1) Wastes that can be reduced or eliminated through maintenance (Avoided wastes).

- Unreacted raw materials, impurities or by-product generated due to process inefficiencies;
- Process materials and products purged from the reactors or lines during emergency shutdown and start-up;
- Fugitive emissions from equipment leaks; and
- Wastes generated from adverse events (explosions, fires, equipment breakdown, spills).

Six major loss areas categorized under three group include:

Down time losses

- Losses due to equipment failure;
- Losses during start-up and process adjustment;
- Production losses;
- Losses from idling and minor stoppages; and
- Losses due to reduced speed.

Defect losses

- Losses from process defects; and

- Losses from reduced yield.

These six losses can result in increasing waste generation, while at the same time reducing production.

Process wastes

- unreacted raw materials, impurities or by-products;

- sludge from processes, storage tanks, ETPs;

- process materials purged from vessels and lines during planned shutdowns and start-ups; and

- wastes generated through maintenance.

e) Minimisation Audits

The potential for routine and accidental releases of toxic hazardous chemicals and wastes from industrial facilities into the environment should be known both to regulatory agencies and public. Such releases can be assessed by applying the principles of the minimisation audit.

The 1984 accidental release of more than 25 tons of methyl isocyanate in Bhopal led to the enactment of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986. The release of a toxic chemical is the discharge into the environment of the chemical through such actions as spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment. Release also includes the abandonment or discarding of barrels, containers and other closed receptacles containing wastes. SARA established several federal, state and local programmes of reporting and emergency planning with regard to hazardous and/or toxic substances. One of the programmes in the toxics Release Inventory (TRI), a database, to be compiled and maintained by USEPA is based on reported information on environmental releases from manufacturing facilities handling more than the specified threshold amounts of any of 309 specified chemicals or 20 chemical categories.

The Committee to evaluate mass balance information for facilities handling toxic substances was convened by the National Research Council (NRC of the National Academy of Sciences USA) Board on Environmental Studies and Toxicology in November 1987. Section 313(1) of SARA defines mass balance as "an accumulation of the annual quantities of chemicals transported to a facility, produced at a facility, consumed at a facility, used at a facility, accumulated at a facility, released from a facility, and transported from a facility as a waste or as a commercial product or by-product or component of a commercial product or byproduct. A mass balance analysis provides a rigorous accounting of toxic chemicals flowing through a manufacturing facility. This analysis can be carried out employing:

- an engineering mass balance (EMB)
- materials accounting (MA)

EMB is an application of the principles of mass balance to a production unit or facility. For each unit, and for the whole facility, the mass of inputs, outputs and accumulations are determined by measurement. The masses used may be total mass, mass of nonreacting chemicals, or the masses of individual chemical elements or combination of elements. MA, on the other hand, involves an approach to obtain mass balance data that relies on information likely to be collected routinely at a facility for various purposes. Such information often describes only material flows across facility boundaries. Examples of information used in MA are shipment records of raw materials into a facility and production records indicating the specific amounts of chemicals contained in products shipped from the facility. MA is inherently less accurate and precise than EMB. However, MA is less costly and complex compared to EMB because fewer data and less technical expertise are needed.

The handling of arsenic at a copper smelter is an example of how mass balance components would be entered on the ledger sheet for a smelter facility. The credit column would include arsenic transported into the smelter facility as a contaminant of copper ore. The debit column would include the quantity of arsenic transported from the facility as a product (blister copper) contaminant and released to the environment via the furnace slag, flue dust, and scrubber sludge generated during the smelter operation. If annual average EMB is selected as the approach to determine the release of arsenic from a copper smelter, it requires simultaneous evaluation of the variations in chemical composition and flow rate for the entire year. EMB generally is difficult to conduct because the number of necessary judgements tends to increase with the complexity of the facility and because many manufacturing facilities have multiple unit process components with multiple process streams. EMB requires an evaluation of each stream in terms of total flow rate and the concentration of specific chemicals which vary significantly with the inevitable fluctuations in facility operation. The goal of closure* for EMB requires extensive data and personnel with the technical skills to obtain and evaluate the data. In mass balance applications, closure is achieved when all inputs to a manufacturing facility, output from it and accumulations within have been identified and the masses measured. The mass of inputs should equal the mass of outputs plus accumulations, within the accuracy of the measurements. The masses used may be the total mass, masses of individually nonreacting chemicals, or masses of individual chemical elements or combinations of elements.

The certainty of data acquired through EMB is limited by several factors, namely facility size and complexity, instrument accuracy and application, system variability, errors inherent in sampling and analysis procedures, record keeping errors and waste accountability. Analysis to determine the annual quantities of arsenic and other contaminants in copper fed to a smelter facility is more prone to error as the copper ore composition is heterogeneous and variable. A limited EMB approach involving measurements only at the boundary of the facility could be applied. However, such an exercise would provide little indication of likely sources of error, if closure was not achieved. The MA approach, on the other hand, obtains data through purchase, shipment and production records.

In-plant modifications

i) Preamble

The effective in-plant modifications for waste minimisation include adoption/incorporation in the process of:

. oxygen bleaching, as bleaching with chlorine results in generation of a number of potent mutagenic compounds (Pulp and paper industry);

. countercurrent washing (Paper industry);

. vacuum pumps instead of barometric condensers to reduce loss of hazardous chemicals and reduction in water usage (Pesticide manufacturing formulation by industry);

. ion-exchange to concentrate and recycle mercury and other metals from waste (metal and chlor-alkali industries);

. effective liquid level controls and alarms to check/reduce hazardous chemical spills (Industries handling hazardous chemicals);

. mechanical cleaning to replace acid pickling (iron and steel); and

. substitution of trichloroethylene and tetrachloroethene with biodegradable detergents for degreasing purposes.

ii) Nickel and copper recovery

Nickel can be recovered from electroplating sludge using diaphragm electrolysis. This process was developed in Malaysia. It is also applicable to recovery of other heavy metals such as zinc, copper and chromium.

In India, Swathy Chemical Ltd., Madras developed a process to recover zinc, brass fines and copper from metal bearing waste using hydromotallysgical route. The production capacities for $ZnSo_4$ $7H_2O$ and copper were 2500 TPA and 100 TPA, respectively.

The technology of copper extraction from waste copper residue has been commercialised in China since 1975. The production capacity is 500-600 TPA of copper from 5000-6000 TPA of waste residue. The grades of copper recovered vary from 12 to 15 per cent.

Another process developed in China uses acid luminous copper to replace cyanide used in the traditional copper plating process and prevents pollution due to cyanide. The process was patented and commercialised in China in 1992. China has also commercialized a biotechnological process wherein a strain of Pseudomonas isolated from marine mud is used to convert hexavalent chromium into trivalent chromium.

iii) Chromium recovery

The leather industry is one of the oldest and fastest growing industries in India. There are 2000 tanneries throughout the country, with an annual processing capacity of 5,00,000 metric tons of hides and skins. More than 80% of the tanneries use a chrome tanning process. In chrome tanning, only 60% of the chromium applied - in the form of basic chromium sulfate (BCS) - is taken by the leather, and the balance is discharged as a waste in the effluent. In most countries, including India, pollution control authorities insist that the treated wastewater discharged to sewers or surface water contains less than 2 mg of total chromium per litre. Annually 25,000 metric tons of BCS are used and, out of this amount, 10,000 metric tons of chromium salt are discharged into wastewater streams. These discharges cause environmental pollution, wastage of costly chemicals and result in complications for effluent treatment and in sludge disposal system operation.

It is not difficult to remove chromium from the waste chrome tanning liquor because it is present in a trivalent form which is generally insoluble at a pH of 6 to 12. Mixing the chromium-containing liquor with liming liquor from the operation followed by proper pH control and settling removes the chromium. Also, during biological treatment the residual chromium is precipitated or combined with the protein-containing sludge in the system.

In principle, chrome recovery and reuse can be realized in three different ways : direct reuse, indirect reuse, and separating chromium compounds.

Direct reuse: Spent liquors are reused directly as a tanning liquor for the next batch. Additional chromium is supplied to compensate the deficiency. The main constraint in adopting this method is that the salts and other impurities accumulate because of repeated reuse and have a negative effect on leather quality.

Indirect reuse: Chromium is recovered by precipitation as hydroxide using alkali, which is dissolved subsequently in sulphuric acid. The solution can be used as a tanning liquor. This method uses chromium efficiently and does not affect leather quality.

Separating chromium compounds: Chromium is recovered by separating the chromium compounds from other salts in the spent liquors. The chrome liquor is cleaner than that produced by the direct use method; however, this system requires rather sophisticated techniques such as electrodialysis and membrane separation.

The Central Leather Research Institute (CLRI) has developed a simple indirect chromium recovery and reuse system using alkali. Such a system is technically and economically feasible in Indian tanneries.

Because the leather's quality is not affected, the commercial value of the leather is not lowered or raised. Hence, cost-benefit analysis is restricted to the investment and operating costs and the chemical savings.

For a medium-scale tannery, with a processing capacity of 5 metric ton/d, the capital investment for the chrome recovery system is about 3,00,000 Rupees (US$ 10,000). Using 8% BCS 250 days/yr, the annual use of BCS is about 100 metric tons. If the waste is one-third of the used chromium, then about 30 metric ton/yr of chromium can be recovered and reused. This use represents a savings of 4,80,000 Rupees (US$ 16,000).

The cost-benefit analysis only covers the investment costs and operating costs; the costs of floor space and the buildings for housing the plant are not taken into account because the space required for a chrome recovery system is small and is generally available in most tanneries.

The cost of recovered chromium is about 6,000 Rupees (~US$ 200)/metric ton while the cost of fresh chromium salt is more than 16,000 Rupees (~US$ 530)/metric ton. Profits are relatively higher if production capacity increases. In a tannery with a processing capacity of 1 metric tonn/d of hides, the recovery cost of chromium is about 4000 Rupees (~US$ 130)/metric ton, which is only 25% the cost of fresh chromium salt.

iv) Bricks from fly ash

Coal based thermal power generation results in the generation of around 40 per cent ash. It can be used in brick making. This is usually done by mixing fly ash with lime and sand in the presence of an accelerator with requisite amount of water, followed by preparation of molds in a rotary table process. These brick molds are finally cured by steam at 50 psi in a curing chamber. These bricks are about 11 per cent lighter in weight and have 50 per cent more crushing strength than the traditional burnt bricks from clay and/or soil. From the information available from Cement Research Institute (CRI), out of 19 million tonnes only 3 percent are usable for brick making. According to an estimate of National Research Development Corporation (NRDC), New Delhi, for a production capacity of 25 million bricks of size 250 x 125 x 75 mm per year, equipment and machinery cost is around Rs. 180 million and operational cost per year is around Rs. 48 million. The market price is around Rs. 1700 per 1000 bricks. The technology not only converts waste into marketable good but also spares use of top soil which is traditionally used by brick makers in the country.

An Australian patent on the ash-recycle- activation (ARA) process is available for removing sulphur dioxide from flue gas.

Environmentally Balanced Industrial Complex (EBIC)

The practicality of an EBIC of phosphatic fertilizer and cement manufacturing plant is being explored at NEERI. According to the Cement Research Institute (CRI), the total by-product gypsum amounts to 4-5 TPA per tonne of P_2O_5 can be used by cement manufacturers in India.

In Finland, flash smelting of copper has been practised in conjunction with sulphuric acid manufacture. By combining these two processes, 97.8 per cent of the sulphur could be recovered and over 50 per cent of the energy requirements are met by recovered heat and electric power generated from the steam produced internally. Adding on of a fertiliser plant increased the process efficiency, with lower inputs of energy and raw materials and lesser outputs of pollutants.

Conclusions

Waste prevention and minimization technologies conserve resources, generate less pollution and provide direct economic benefits to the industry. Implementation of these technologies requires informational, economic, legal and other institutional measures that are substantially different from those used within the present environmental policy framework.

The focal areas in implementation of waste minimization technologies include creation of database on LNWT of production and development of indigenous LNWT of production and also of database on waste availability, establishment of waste exchanges and stipulation of resource/product based standards.

References

Environmentally Friendly Technologies, Asian and Pacific Centre for Transfer of Technology, New Delhi (September 1993).

Bazelmans, J., 1992: Regional Activities-Australia. Paper presented in the Steering committee meeting of Commonwealth Science Council on Management Hazardous Waste held in Nairobi on August 24-25, 1992.

Development and demonstration of cleaner technologies of industrial production. Document prepared for Ministry of Environment and Forests sponsored Brainstorming Session held at NEERI in August 1991.

Kulkarni, V.S., Saraswat, N. and Khanna, P., 1991: Development and Implementation of Clean Technologies of Industrial Production. Journal IAEM, 18, 59-69.

Mhaskar, A.S., 1993: Environmental Audit, Media Enviro, Pune.

Environ-News (October-December 1993) ASSOCHAM.

UNEP, 1992: Eduction and Environment. Industry and Environment, 16, pp 1-67.

TRANSBOUNDARY MOVEMENT OF TOXIC CHEMICALS AND HAZARDOUS WASTES AND THEIR DISPOSAL IN MONGOLIA

D. Badgaa
Institute of Chemistry
Academy of Sciences of Mongolia
Ulaanbaatar
Mongolia

Abstract

Due to the lengthy and careful attention of early Mongolians to the protection of nature for the benefit of future generations, Mongolia possesses clear blue sky, clean air, mountains, steppes, Gobi Desert, rural landscapes, pasture and fertile soil, with plentiful flowers and other plant diversity, as well as lakes and rivers with clean water. Ground minerals, wildlife and bird species are also abundant in the country.

In the mean time, industrialization including mining and construction of cities and settlements over the past decades resulted in the contamination of air, soils and water in urban areas. It is essential to reuse resources and introduce waste-free technologies to avoid pollution. An important task is to determine and statistically treat data on the content of solid and liquid wastes, smoke, dust and hazardous chemicals deposited from cities, factories and household and cleaning facilities to avoid contamination of the environment. Such an action would enhance economic effectiveness in general.

Introduction

The Government of Mongolia has recently declared to the world that it would not accommodate the wastes of other countries in the territory of Mongolia. This view will be central in Government policy, even in the future. The Environment Ministry, Ministry of Health and other competent authorities jointly elaborated and are keeping a set of environmental laws. The problems of concern are reflected in these laws. Within this set of laws a special law on hazardous chemicals has been approved. Mongolia adopted the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal, in March 22, 1989. Mongolia, located in the heart of Central Asia and possessing forest steppe, steppe, Gobi Desert combined with four seasons, can be considered an ecological treasure museum. Almost all of the world countries recognize and support this estimation.

However, there is an issue related to pollution of the air, water and soil in the large cities and in the mining industry provinces of Mongolia. Municipal wastes and large scale tannery wastes (chromium) are polluting the Tuul river. Research and project based works are continuously undertaken to develop a waste-free technology for the copper molybdenum mining industry in the city of Ardent, by controlling the content of selenium, copper, molybdenum and other wastes in the air and soil. In this respect there is a joint research project.

Environmental Education

A series of programmes are ongoing in the field of environmental education. These include:

- Incorporation of special courses of study in ecology and natural resources in programmes of all secondary school, colleges and higher educational institutions;
- Plans to establish an environmental institution to be operated jointly by the SCEC and the Ministry of Science and Education and to provide specialized, college level environment training;
- A programme of seminars and courses for environmental inspectors, with duration from two weeks to three months; and
- Using all approaches to increase public awareness (TV, radio and printed/publications)

Present Status

Over the last few decades large cities, settlements, mining industries, electric power supplies and other industrial power units have been constructed, and the agricultural area enlarged. This is a good achievement. However, their wastes, such as municipal waste, sludge, solid and unpurified waste water, ash, dust and smoke, are deposited on the ground surface and not reused. Waste-free technology is not adopted.

These are the reasons why the air, water and soil near the cities are contaminated. The following sections present some results of recent research.

Urban Air Quality

In the city of Ulaanbaatar three large coal driven electric power plants are in operation. The removal of dust, ash and smoke from the plants is done almost only by filtration, and smoke is released to the open air. Therefore, in large cities such as Ulaanbaatar, Ardent, Darkhan and Baganuur the content of SO_2 reaches 0.005-0.01 mg/m^3, while NO_2 equals 0.022-0.040 mg/m^3 and carbon monoxide (CO) content increases in the winter season up to 9 mg/m^3. The annual average content of carbon monoxide is increasing from year to year (Lkhagvasuren, 1990). In 1985 levels were at 0.8 mg/m^3, but increased in 1990 to 2.0 mg/m^3. In addition, some types of coal, for instance in Baganuur, heavy metals such as Cr, As, Sb are present in large amounts and they contaminate the air together with smoke. Thus, the fact that both the content of heavy metals and smoke increase, serves as the main factor for acidifying the precipitation and contaminating soil, plants and water.

Pollution of Soil

Data for the soil near Ulaanbaatar shows the following: Ni=16mg/kg, Pb=2.3 mg/kg, and Cr=4 mg/kg. These metals demonstrate that heavy metal content is several times that in a rural landscape. Especially in areas adjacent to electric power supplies areas, As and Sb content are quite high. Also the concentration of Pb and V along the main roads is significantly higher.

Fresh Water Pollution

In the southern part of Ulaanbaatar the mountains are associated with the pure water of rivers such as the Tuul. But in the river near Ulaanbaatar and 45 km down stream to Songino resort the water mineralisation increases up to 0.27-0.37g/l. Nitrogen compounds like ammoniac nitrogen and nitride nitrogen increase, and other chemicals also increase 4-5 times in comparison with a non contaminated area.

Between 1988 and 1989 in the Songino area the following situation has been observed, namely: NH_4 = 4.4 - 8 mg/l, Pb = 0.23 - 0.57 mg/l, NO_2 = 3 - 15 mg/l, and Mn = 0.8 - 1.0 mg/l. The worst influence is caused by open deposits of solid and liquid wastes including wastes and sludges from the large Industrial Kombnat located on the edge of Tuul River.

Case Studies

Based on the city data it should be concluded that the main sources of pollution of a city's soil, air and water are municipal waste, smoke and dust from electric power supplies and waste water and sludge from factories and municipal facilities.

Decreasing their effect on the environment will depend on the level of effort to determine the chemical composition of the deposits, their controlled storage, transport and reuse. For this reason it is appropriate to present chemical data on some deposits, discuss the possibilities of their rational use and demonstrate an interest in a cooperative work programme to introduce waste-free technologies.

Following are some results of analysis of leather industry sludge from the Industrial Kombinat in Ulaanbaatar after it has dried (Table 1). The sludge volume reaches 30,000 tons per annum. Table 1 shows that the sludge has some beneficial uses, as it contains Ca, Mg, K, N, P and OM useful for increasing soil fertility and feeding plant species. But the sludge contains a high amount of Sodium (Na_2CO_3, K_2CO_3), Cl, Na and Cr and therefore it exhibits a deleterious effect. So it is intended to produce a calcium humate fertilizer by removing Cr and Cl from the sludge.

The Ulaanbaatar municipal waste cleaning station receives 250-270 thousand m^3 of the city's waste water daily. From it 94-98 m^3 of sludge is formed. For the last years the volume increased up to 2,00,000 m^3 per day. The chemical composition of the waste water can be seen from Table 2. The table demonstrates that the sludge contains a lower amount of heavy metals but a higher amount of nutrient elements. Sodium (Na_2CO_3,K_2CO_3), Cl, and Nitrate are present in lower amounts. It is therefore recommended to avoid open disposal of sludge but rather to produce fertilisers through a composting and fermentation process, including saw dust, paper and corn stalks. Such an effort needs to be started, but technical assistance is needed.

Table 1

Content of some Chemical Compounds and Elements in Sludges of a Leather Factory (mg/kg)

Elements	N	P	Na	Cl	Organic matter	carbonate	pH	Cr
Content	3.0	0.2	1.8	0.2	30.0	4.0	7.5	9.0

Table 2

Content of Chemical Elements in Municipal Sludges (mg/kg)

Element	N	P	K	C	Cr	Ni	Cu	Fe	Pb	Ca	Mg	Sol K
Content	1.8	0.2	0.1	no	0.1	0.05	0.02	0.4	0.002	48	98	60

It is also appropriate to present the chemical composition of Erdenet Copper and Molibdenum mining industry process tailings (Table 3). The table shows that this waste contains a relatively high amount of heavy metals and microelements (Gerbish, 1990). Control of the waste is quite satisfactory and its storage well managed environmentally. There is a proposal to use this waste for production of sulphuric acid and rare elements. A collaborative activity is thought to be possible for the preparing works related to technology and technical assistance.

Ulaanbaatar's solid waste is increasing in volume. In 1970 solid waste production was 1.35 million m^3; by 1990 its volume increased to 40.1 million m^3. Unpurified waste water in 1970 was 3.2 million m^3; by 1990 this increased to 20.7 million m^3. The city's solid and liquid waste is deposited in open areas, without control, reuse and processing, thus polluting nature and the environment. From the beginning it is necessary to manage rationally this waste. As a first step for this purpose, it is necessary with the help of the people and administrative and production units to classify the deposits into paper, glass, polyethylene, used tissues, leather, wool etc., to store it in one place and purchase the materials from individuals.

Such methods would be very useful in order to reuse the deposits, produce new products, avoid pollution and, finally, to strength the country's economy. It would be useful to determine just how much of the waste is discarded.

Table 3

Content of some Chemical Elements in Deposits of Erdenet Mining Industry (mg/kg)

Element	Pb	Ab	Sb	Cr	Zn	Ni	W
Content (mg/kg)	79.0	48.0	7.0	18.0	75.0	21.0	9.0

Elements	Sr	Ti	Na	Ca	Mg
Content (mg/kg)	210.0	2600.0	13600.0	4080.0	4100.0

Finally, there is interest in collaborating with foreign partners on technology development or adaptation for a rational use of these resources.

References

Baatar, R. (1981). Report on some results of study of chemical composition of sludges.

Gerbish, Sh. (1990). Content of chemical elements in deposits of Erdenet mining industry.

Lkhagvasuren, B. (1990). Report on some data of study of environmental monitoring of Mongolia.

Tuvaanjav, G. and Sh. Luvsandorj (1982). Hydro-Chemical properties of underground water of the territory of city Ulaanbaatar and their surrounding areas. Scientific work of Institute of Chemistry. No 21.

Tuvaanjav, G. (1983). A change of chemical composition of some river water in territory of the cities and settlements. Scientific Work of Institute of Geography. No 23, 74-79.

Tuvaanjav, G. (1978). General Hydro-Chemical Characteristics of water of the Tuul river and its tributaries. Scientific work of Institute of Geography No 18, 104-107.

INSTITUTIONAL CAPACITIES IN HAZARDOUS WASTE MANAGEMENT: INFORMATION DISSEMINATION AND HUMAN RESOURCE DEVELOPMENT

P.V.R. Subramanyam
Formerly
National Environmental Engineering Research Institute
Nagpur
India

Abstract

Comprehensive information support and creation of a trained manpower base are two important requirements for successful implementation of hazardous waste management programmes in developing countries. Approaches are suggested for networking of information resources within a country and among all the participating countries of the Central and South Asia region. Human resource development can be achieved through training and through the training packages provided for use by trainers to train all the key role players in hazardous waste management. Such initiatives are expected to meet the objectives of UNEP's Network for Environmental Training at the Tertiary Level in Asia and the Pacific (NETTLAP).

Introduction

Phenomenal industrial development and modernisation of agriculture in India and other countries of the Central and South Asia region, as well as the world over, have led to significant growth in the use of chemicals. This rapid increase in the use of hazardous chemicals in industry and trade, besides the large quantum of hazardous wastes generated in their manufacture, has brought a very significant increase in the number of people, both workers and members of the general public, whose lives could be endangered at any one time by an accident involving these substances.

Safeguards in the chemical industry and in the management of hazardous wastes are not limited to the on-site alone. Public concern at multiple injuries and deaths from spectacular events, such as a major explosion, and long term health and environmental hazardous due to inappropriate treatment and disposal of hazardous wastes, call for additional controls at national, regional and international levels.

The rapid pace of progress in modern technology allows less opportunity for learning by trial and error, making it increasingly necessary to ensure that design and operating procedures are right in the beginning, or at the first time. To eliminate technical obsolescence, promotion of continuing education and professional development are unavoidable, as depicted in Figure 1.

In this endeavour, training the concerned personnel assumes greater significance as it provides the needed skills for regulatory decision making, planning and for operation of the facilities, both in hazardous chemical manufacture and hazardous waste management (HWH), in order to ensure minimal impacts.

Objectives

Given the above needs, the objective is to establish a network of personnel drawn from national and regional experts, international counterparts, and personnel from international organisations, bilateral aid agencies and non-government organisations (NGOs) who are involved in technology transfer, regulatory decision making, information dissemination and other such activities. The ensuing training could be tailor-made for network level, sub-regional level, national level and local level once the network is established.

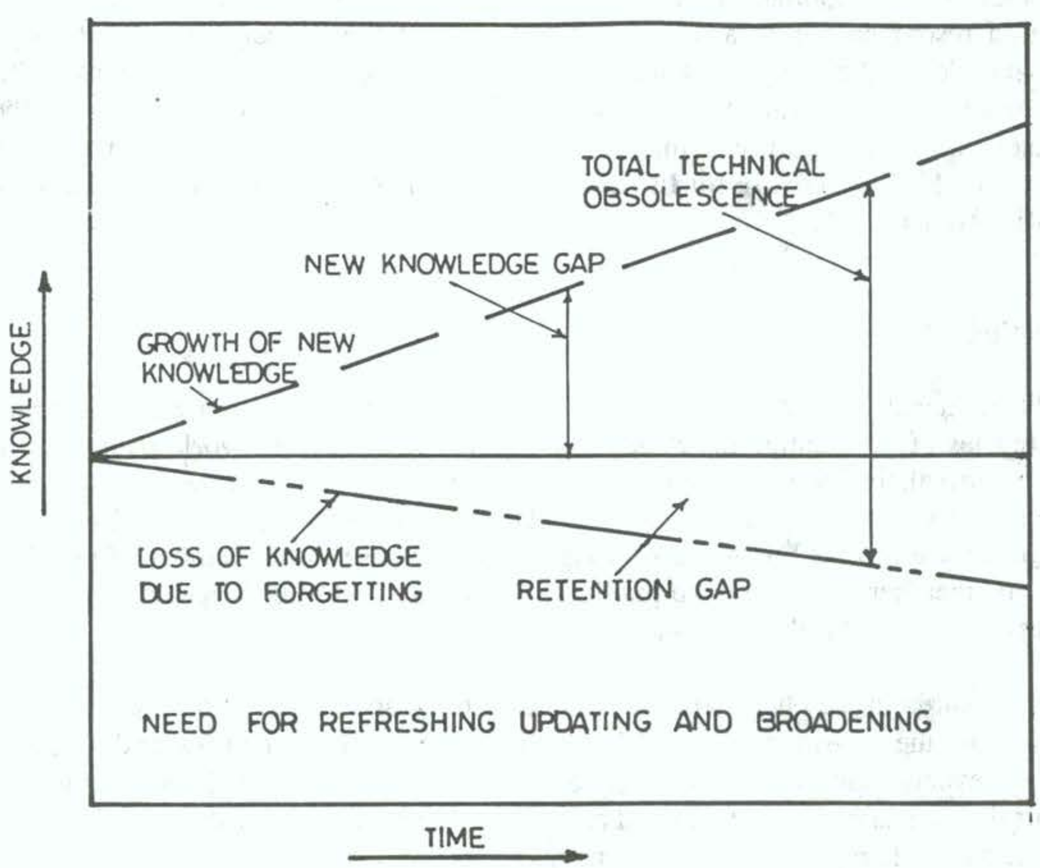


Fig. 1 A diagram for the promotion of continuing education and professional development (author unknown).

Major Issues in Hazardous Waste Management

Some of the major issues requiring consideration for evolving an environmentally sound management of hazardous wastes include:

* Measurement and monitoring of hazardous wastes and their fate, from generation to final disposal (cradle to grave) in the environment;

* Implementation of measures to promote cleaner technologies for production;

* Formulation of guidelines for segregation, collection, storage and transportation of wastes and prevention of accidental spills and leakages, thereby ensuring safety of operators and the public;

* Development of appropriate and cost effective technologies for treatment and disposal of hazardous wastes;

* Identification of potential sites for off-site treatment and disposal, and evaluation of site suitability;

* Provision of adequate treatment and disposal facilities, with measures to encourage their use;

* Development of corrective measures for abandoned and active land fill sites for protection of public health and restoration of environmental quality; and

* Development of emergency preparedness and disaster management strategies with recourse to objective environmental and health risk assessment techniques

Present Status

To address some of the above issues it is necessary to institute a hazardous waste management information system for exchange of experience between government, industry and the research community, within the country and abroad. Further, to oversee and manage the operations of HWM and implementation of regulatory controls, development of human resources through education, training and mass communication strategies forms a crucial element.

Given a developing country's priorities, human resources for HWM will remain extremely hard to find. This situation prompts the necessity for establishing a network at regional level to provide information support, to develop trained personnel at all levels and to provide advice on all aspects of HWM in the participating network countries. This could assist each member in the Network to evolve an environmentally sound management programme for hazardous wastes.

Information Needs and Requirements

The major information needs for HWM can be categorised into the following information databases, both computerised and hard copies, viz.

* Hazardous Waste Monitoring
  - Monitoring techniques
  - Source (stationary & mobile) characteristics and quantities
  - Dispersion/diffusion of wastes, including transboundary movement
  - Abandoned hazardous waste dump sites and remediation
  - New sites for hazardous waste treatment and disposal facilities
  - Treatment and disposal systems
  - Accidental releases of chemicals/wastes

* Toxicological and Epidemiological Studies
  - Direct and indirect effects on human health
  - Effects on flora and fauna and soil quality
  - Toxicological data on chemicals with reference to those found in dump sites

* Hazardous Waste Management Techniques
  - Cleaner technologies of production
  - Waste utilisation through waste exchange
  - Methods of treatment and disposal of wastes including case studies
  - Restoration of environmental quality of affected sites due to past waste disposal activity

* Hazardous Waste Management Programme Summaries
  - Media reports relating to hazardous wastes/gas leaks/oil spills
  - National and international programmes
  - National and international experts
  - Organisations for undertaking HWM Programmes

* Field Study Reports Collection
  - EIA and Risk assessment
  - Emergency response and disaster management

* Legal Aspects
  - Legislation, regulations, guidelines and standards

Information Resources

Well designed infrastructure in communication technology available in a country could be used for establishing an information system for HWM. Available resources exist either in the form of computerised databases or hard copy references. Examples of available computerised databases are presented in Annex I.

Access to databases could be established with the help of computer, telex, modem, communication software, or a telecommunication line with ISD facility. To facilitate faster access, down loading retrieved information to a disc is possible.

Available hard copy databases include:

* Scientific Reviews on Toxicity and Hazardness of chemicals (UNEP/IRPTC)
* Emergency Handling of Hazardous Materials in Surface Transportation (Bureau of Explosives, Washington, DC)
* Management of Hazardous Wastes, Treatment, Storage and Disposal Facilities (Technical Publishing Co.)
* Technical Resource Documents and Technical Handbooks for HWM (USEPA)
* Standard Handbook of Hazardous Waste Treatment and Disposal (McGraw - Hill Book Co.)

Role of International Agencies

International agencies, such as UNEP, UNIDO, WHO, ILO and World Bank, play a catalytic role in HWM through information dissemination activities. Selected information sources are highlighted in Annex II.

Only sporadic efforts have been made in most of the developing countries to provide information support to this emerging area of concern. Major contributions of some institutions in India are presented in Table I.

Information warranted for planning and implementation of Hazardous Waste Management programmes, if made available at a 'single window', could help in achieving the goals with optimal use of available resources.

Hazardous Waste Management Information Network (HAWMIN)

In view of the existing scenario, establishment of an information network on HWM is imperative to fulfil the needs identified earlier.

The major components of the proposed network should comprise:

- Hard data (Textual Information)
- Soft information involving computerised service for storage and retrieval of bibliographical information
- Database on industry situation with respect to generation, storage, transportation, treatment and disposal of wastes
- Database on cleaner technologies of production
- Legal, organisational and management information systems
- Linkage with various national, regional and international organisations
- Information dissemination mechanism
- Access to external databases
- Networking with other information resources

Table 1

Hazardous Waste Information Sources in India

- NEERI, NAGPUR
  . Bibliographic and Textual Information
  . Data on Waste Quantity Generation from Selected Industries
  . Computerised Database
  . UNEP Special Sectoral Source of Information for Environmental Engineering and Science

- ITRC, LUCKNOW
  . ENVIS Centre for Toxicology Information
  . IRPTC Focal Point for Toxic Chemicals

- CESE, IIT, BOMBAY
  . Database on cleaner Technologies of Production

- ICMA (Indian Chemical Manufacturers Association), CALCUTTA
  . Chemical Safety Information Sheets

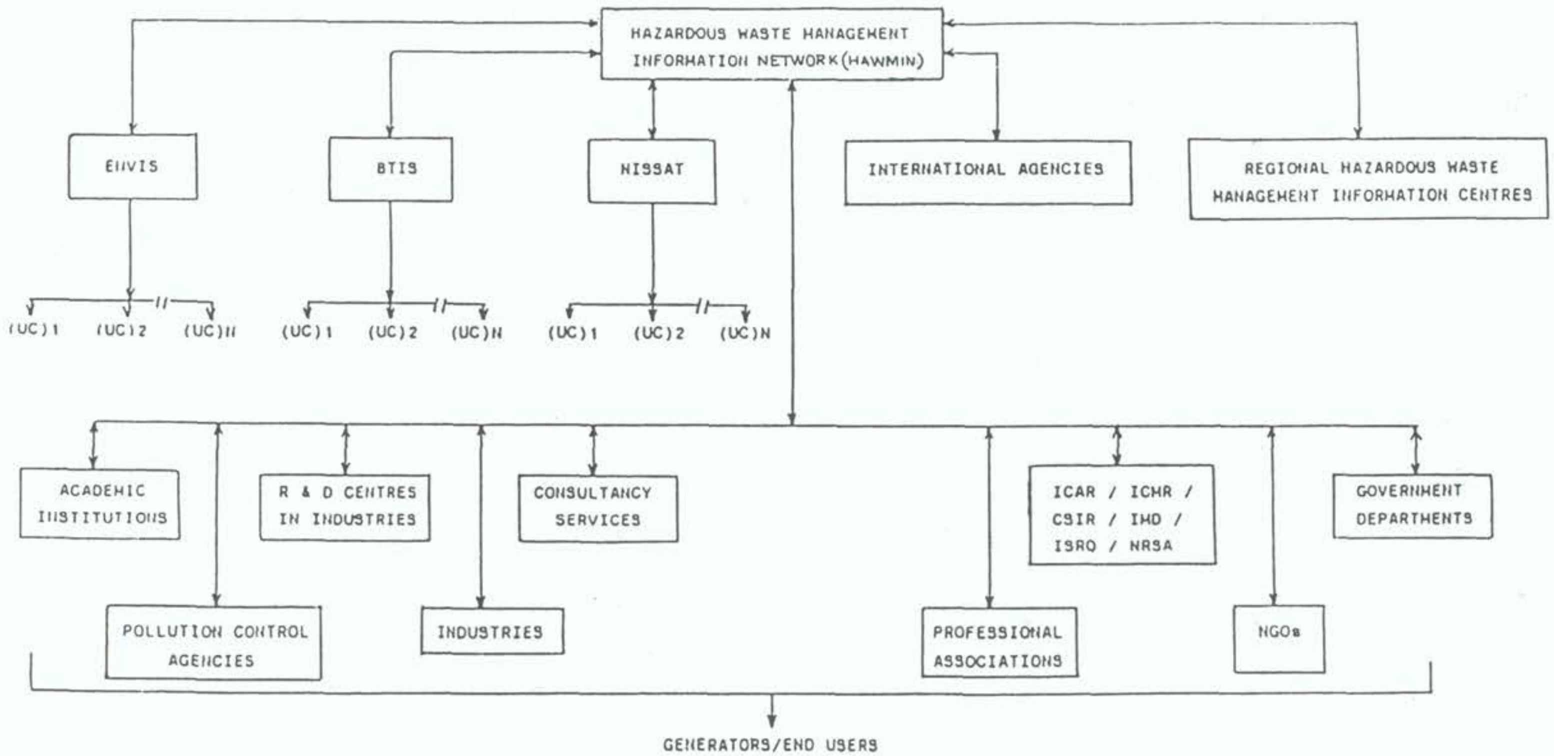
- CCG (Central Crisis Group) ALERT SYSTEM, NEW DELHI.
  . Guidelines for Handling Major Chemical Accidents

- CPCB (Central Pollution Control Board), NEW DELHI
  . COINDS (Comprehensive Industry Document Series)

Storage of the identified information and undertaking proposed activities relating to exchange and dissemination of information within the country and other regions in the Network will be possible with suitable computer facilities. These should include appropriate communication systems which should be and linked to an external database through Mother Earth Station and satellite.

The existing information systems in India (Annex III) include ENVIS (Environmental Information System), BTIS (Biotechnology Information System) and NISSAT (National Information System for Science and Technology). These and similar systems can be integrated with HAWMIN. Arrangements with commercial database vendors such as DIALOG could be established to access database through telex terminal.

A network of organisations and agencies involved in HWM should be major users of the services. Besides providing information to the network members, HAWMIN could also act as a nodal agency for receiving inputs from members for further processing and dissemination. A schematic diagram of the structure of a HWM Information Network (HAWMIN) is depicted in Figure 2.



UC - USER CENTRE
ICAR - INDIAN COUNCIL OF AGRICULTURAL RESEARCH
ICHR - INDIAN COUNCIL OF MEDICAL RESEARCH
CSIR - COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH
IMD - INDIAN METEOROLOGICAL DEPARTMENT
ISRO - INDIAN SPACE RESEARCH ORGANIZATION
NRSA - NATIONAL REMOTE SENSING AGENCY

Fig. 2 Structure of a hazardous waste management information network.

Human Resource Development

The major requirement in most developing countries is to train and employ senior policy personnel who can determine the issues the country faces with respect to HWM, and advise on and implement policies.

Further, the personnel necessary to carry out a HWM programme require generic skills for perceiving change in the environment related to the discharge/disposal of hazardous wastes in an unregulated manner. This requires continual upgrading of skills through needs based training.

The range of topics/issues to be covered include:

* Study of hazardous wastes from 'cradle to grave' encompassing issues such as type, quantity generated and methods of collection, storage, treatment and disposal;

* Study of risk assessment and risk management activities covering regulatory aspects such as rules/guidelines, extent of application and legal framework; and

* Study of formal regulatory mechanisms employed by different national, regional and network level organisations covering both technical and administrative issues.

Training packages should be developed for waste generators, waste treatment and disposal facility operators, regulatory staff, policy makers and non government organisations (NGOs) to enable them to play their role in HWM in an effective manner.

The types of training programmes and their frequency including suggested course/training material are indicated in Annex IV.

Institutions in the region that can form the necessary resource base for multiplication of skills in this inter disciplinary area should be identified.

The training instruments should include advanced training programmes, refresher courses, seminars/workshops, visits to research laboratories and hazardous waste treatment and disposal facilities in the country and exchanging ideas with the specialists.

Educational institutions in the country should be urged to include HWM in the curricula of environmental science/engineering at post-graduate level.

Awareness building for enlightened public participation is one of the key elements in HWM. Towards this objective identification of mass communication techniques and development of communication packages, for successful dissemination of knowledge and information, are to be evolved. These include:

* Publication at regular intervals of handouts/leaflets/bulletins/newsletters, covering information on health hazards of wastes, legislation, standards and public rights and duties etc.;

* Organisation of seminars and exhibitions with participation from community leaders, municipal authorities, environmental groups, waste transporters, educational institutions, local social services, planners and site specific voluntary groups/agencies; and

* Visits to R & D institutions and hazardous waste treatment and disposal facilities.

Technical Advice and Research Support

Each member country in the network could develop expertise to render technical advice and research support within the network countries.

Areas required for technical advice and study support include:

- Codes for safe handling, transportation and disposal of hazardous wastes;

- Guidelines for identification and assessment of abandoned hazardous waste disposal sites;

- Methods for the treatment and disposal of hazardous wastes;

- Methods for restoration of environmental quality of contaminated sites due to past waste disposal activities;

- Methods for conducting environmental impact (EI) and risk assessment (RA) studies for identifying new sites for hazardous waste treatment and disposal facilities; and

- Methods for assessing causes of accidents, hazard prevention and disaster mitigation in the HWM activities.

Conclusions

Information support forms a vital component in the development of trained manpower for HWM activities. Establishing an information system covering all aspects of hazardous waste in each of the participating countries in NETTLAP programme and networking of all these information systems in Central and South Asia region forms the first step.

Specific and target oriented training packages for various levels of personnel involved in HWM are needs to be developed for use by tertiary level trainers.

Expertise to extend technical advice and research support within the participating countries in the area of HWM requires to be developed and support extended.

Acknowledgements

The subject matter used in this article is taken from the following sources:

i) Approach paper on National Hazardous Waste Management Programme, prepared by National Environmental Engineering Research Institute, Nagpur, for Ministry of Environment and Forests, Government of India, New Delhi for the Brainstorming session held in 1990; and

ii) Paper entitled 'Role of Regional Advice Centres in the Management of Hazardous Waste with Reference to Information Dissemination and Human Resource Development' prepared and presented by the author on behalf of NEERI at the workshop on Management of Hazardous Wastes, organised by Commonwealth Science Council, U.K., Trinidad, June 1991.

References

Some Background Information concerning Hazardous waste Management in Non-OECD Countries, Environment Committee, Waste Management Policy Group, OECD, Paris, ENV/WMP/85-17, 1985.

Guidelines for Establishing Policies and Strategies for Hazardous Waste Management in Asia and the Pacific, Proc. of Workshop Organised by ASEAN, UNEP and CDG, and hosted by Ministry of Environment, Singapore, May 1986.

International Perspectives on Hazardous Waste Management, Forester, W.S. and Skinner, J.H.(Eds.), Academic press, 1987

Basel Convention on the Control of Transboundry Movement of Hazardous wastes, UNEP, 1989, Environmental Policy and Law, 19/2, 1989.

The Safe Disposal of Hazardous Wastes - The Special Needs and Problems of Developing Countries, Batstone, R., Smith, J.E (Jr.) and Wilson, D.(Eds), World Bank, WHO, UNEP, Vol I to III, 1989.

Hazardous Waste Policy and Strategies - A Training Manual. UNEP- IE/PAC, EETU, Technical Report Series No.10, 1991.

ANNEX I

Computerised Databases

DATABASE	COVERAGE
- Bibliographic Online Databases	
. Solid Waste Information Retrieval System (SWIRS), USA	Solid Waste
. Toxicology Information Online (Toxline), USA	Toxicological information including effects of chemicals
. Waste Management Information Bureau (WMIB), UK.	Solid Waste
- Full Text Online Database Heilbron (dialog)	Properties, use, hazards for 175,000+ chemicals
- Subject Emphasis Online Database (factual information)	
. Chemical Hazard Response Information System (CHRIS), Chemical Information Service, USA.	Emergency response and Chemical handling information for 1016+ chemical substances.
. CHEMTREC Hazard Information Transmission (HITS), Chemical Manufacturers Association, USA.	Emergency response
. Hazardous Substances Data Bank (HSDB) TOXNET, National Library of Medicine, USA.	Profiles of 4100+ chemicals
. Environmental Chemicals data and information network (ECDIN), Italy	Chemicals data
. HAZARDLINE (Occupational Health Services), USA	Information on 3200+ chemicals, emergency response, safety, health

DATABASE	COVERAGE
. Oil and Hazardous Materials Technical Assistance Data System (OHMTADS), USA	Information on 1200+ substances with clean-up/disposal/hazards
. Major Hazards Incident Data Service (MHIDAS), UK	2500+ incidents, chemicals & equipment involved
- Microcomputer Databases	
. Hazardous Waste collection (EPA), USA	Information sources on hazardous waste
. Waste Management Information Bulletin, Harwell, UK	Abstracts of literature on hazardous waste
- CD-ROM Databases	
. NTIS (Silverplater), USA	Citations on hazardous waste from NTIS database
. OHS - ROM, USA	Occupational health and safety information
. Poise Index, USA	Toxicology

ANNEX II

Information Sources From International Agencies

- UNEP

  . Computerised Database on Industrial Environmental Legislation (CIEL)

  . Database on Low and Non-Waste Technology (LNWT)

  . The Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Waste

- UNEP-IEO (Industry and Environment Office)

  . Industry and Environment Information Database PACT (Pollution Abatement Control, LNWT, Discharge Standards, BIBL (Biblio-graphic Information)

  . Industry and Environment (Papers on Hazardous Waste and LNWT and Technological Accidents)

  . APELL (Awareness of Preparedness for Emergencies at Local Level)

- UNEP-IEO-WHO

  . International Programme on Chemical Safety (Environmental Health Criteria for Chemicals)

  . POISON Information Centre

- UNEP-WHO-WORLD BANK

  . Guidance on Formulating a Policy on Management of Hazardous Waste

  . Technical Manual for the Safe Disposal of Hazardous Waste with Special Emphasis on the problems and Needs of Developing Countries

- UNIDO

  . Programme for Minimizing Environmental Risks Associated with Hazardous Wastes

  . Industrial Environmental Information Network

Information Sources From International Agencies

- UNEP/IRPTC (International Register of Potentially Toxic Chemicals)

  . Information on Policies for Control and Regulation of Hazardous Chemicals

  . IRPTC Register Index

  . IRPTC - Legal File

  . Hazard Alert System (Early Warning System)

  . AWARE (Information on Hazardous Chemicals)

- IMO/UNEP

  . Guidelines on Oil Spill Dispersant Application and Environmental Consideration

- UN

  . Recommendations on Transport of Dangerous Goods

- USEPA

  . Reports on Solid and Hazardous Waste

  . Industrial Waste Information Exchange Centres (Use of Electronic Bulletin Board)

  . Chemical Emergency Preparedness Programme (CEPP) - (Guidance for Hazardous Chemicals Analysis, Emergency Planning)

- US Chemical Manufacturers Association (CMA)

  . Community Awareness and Emergency Response (CEAR)

- International Exploration and Production Forum (UK)

  . SLICFORCAST (Computerised Oil Spill Simulation Programme)

ANNEX III

Information Systems in India

1. Environmental Information System (ENVIS)

The ENVIS has been established by the Ministry of Environment and Forests (MEF), Government of India with a view to build up repository and information centres in various areas under Environmental Science and Technology. The system is being developed in a decentralised manner using the distributed data concept with a National Focal Point at the MEF. Distributed Information Centres (DIC's) have been established in different subjects such as:

* Pollution Control
* Toxic Chemicals
* Environmentally Sound and Appropriate Technology
* Renewable Energy and Environment
* Eco-Toxicology
* Biodegradation of Wastes
* Environmental Impact Assessment
* Waste Management

The information base of ENVIS includes both descriptive as well as numeric data.

2. Biotechnology Information System (BTIS)

The BTIS has been established by the Department of Biotechnology, Government of India in different areas of biotechnology integrating the specialised centres and infrastructural facilities through a nation wide network. Its purpose is to provide a national bio-information network designed to bridge the interdisciplinary gaps on information and to establish link among scientists working in different organisations. It has established database management organisations in six identified areas, viz.

* Genetic Engineering
* Plant Tissue Culture
* Animal Cell Culture
* Nucleic Acid and Protein Sequence
* Bioprocess Engineering
* Immunology

So far 9 Distributed Information Centres (DIC's) have been established which are to function as an information base in each specialty.

3. National Information System for Science & Technology (NISSAT)

The NISSAT programme, which is being looked after by Department of Scientific & Industrial Research, Govt. of India, envisages promotion and support to the development of a compatible set of information systems on science and technology and interlinking of these into a network. The approach adopted is to bring existing centres, systems and services to a higher level of operation.

Sectoral information centres have been established in the sectors such as:

* Leather Technology
* Food Technology
* Machine Tools
* Drugs and Pharmaceuticals
* Textile and Allied Subjects
* Chemicals

These provide bibliographic as well as factual and numeric information on a product, discipline or mission.

Information Analysis and Data Centres are also envisaged to be established for undertaking the task of acquiring, evaluating, integrating, condensing and analysing factual and numeric information.

Some other areas for which NISSAT is providing support are:

* Library Networking
* Computer Based Bibliographic Information
* Computerised Access to Bibliographic Databases.

ANNEX IV

Training Packages Suggested for Human Resource Development for Planning and Implementation of HWM Programmes

Level and Duration

i.	Heads/Senior level personnel from Department of Environment & Industry at centre and state levels, Heads of Pollution Control Agencies and Industry Associations	.. 2 days
ii.	Executives from Pollution Control Boards, Industries and Consultancy Organisations	.. 7 days
iii.	Waste Generators, Waste Collection and Transport Personnel, and Operators of Treatment and Disposal Facilities	.. 7 days
iv.	Community Leaders, Environmental Groups, Voluntary Agencies, Personnel from Municipal Corporations, Educational Institutions, etc.	.. 2 days

Frequency

Twice in a year or as deemed necessary

Training programmes indicated at (i) and (ii) also to be conducted at International Level once a year

Training Package Contents

Training Package I - Hazardous Waste Management - Issues and Approaches

- Overview of hazardous waste management (HWM)
- Appraisal of hazardous waste problems
- Assessment of environmental impacts of waste disposal
- Policy issues concerning HWM
- Treatment and disposal technologies
- Regulatory approaches for Control
- Risk assessment, management and emergency response
- Socio-economic issue and public education
- Legal issues and enforcement

Training Package II - Designing and Execution of Hazardous Waste Management Facilities:

- Identification and assessment of hazardous wastes storage, transportation and disposal of wastes
- Exposure pathways to man and environment; health and ecological effects
- Introduction to measurement, monitoring and modelling for exposure
- Methods for assessment of abandoned hazardous waste disposal sites
- Risk assessment, disaster management and emergency response
- Methods for site selection for establishing hazardous waste treatment and disposal facilities
- Treatment and disposal techniques - land, thermal, physical/chemical and nova approaches
- Waste minimization, recycle and reuse
- Ground water management - leachate collection, analysis and treatment
- Economics of waste treatment/disposal
- Regulations, jurisdiction and enforcement
- Approach to planning for evaluation of treatment and disposal facilities
- Requirements for setting up hazardous waste analysis laboratory, sampling and handling techniques, storage and transportation, disposal of residues and manpower planning
- Visits to treatment and disposal sites

Training Package III - Operations and maintenance of Hazardous Waste Management Facilities

The course contents will be the same as for Training Package II but stress will be more towards problems arising out of hazardous waste handling, transport, storage, treatment and disposal and solutions available in solving the issues.

Training Package - Hazardous Waste Management - Awareness Programme

- Overview of hazardous waste management
- Health impacts
- Environmental impacts in absence of a treatment and disposal facility - case studies
- Available treatment and disposal methods, their limitations
- Social and economic issues
- Public rights and issues
- Legal issues and enforcement
- Visits to treatment facilities
- Awareness of preparedness for Emergencies at Local Level (APELL)

Topics proposed under each training package are to be covered through a series of lectures, group discussions and audio-visual demonstrations.

MANUFACTURE, STORAGE AND IMPORT OF HAZARDOUS CHEMICALS RULES, 1989

Lakshmi Raghupathy
Ministry of Environment and Forests,
Government of India
New Delhi
India

Introduction

A large number of industrial accidents in this decade have involved hazardous and toxic chemicals. To name a few: the Flixborough explosion, the Seveso disaster, the Mississagua accident, the Mexico explosion and, worst of all, the Bhopal Gas Disaster. The consequences of these disasters revealed the inadequacy in the preparedness for such disasters and the incompetence to predict chemical disasters in order to take necessary steps for the prevention of the adverse consequences.

A number of laws prior to the Environment (Protection) Act, 1986, such as the Explosive Substances Act and the Insecticides Act existed for regulating the handling of the explosive and toxic chemicals. The Factories Act, the Motor Vehicles Act, the Workmens' Compensation Act etc., dealt with emergency situations in the event of accidents. The Water Act (1974) and the Air Act (1981) were for the prevention and control of pollution.

In 1986 the Ministry of Environment and Forests undertook an exercise to find out the lacunae (i.e. gaps) in the existing legislation. On examining these laws it was found that the linkages in handling of industrial and environmental safety were inadequate. A control mechanism was thus required to guard against chemical hazards in the environment and to meet the emergency situations threatening public health and the environment. The Environment (Protection) Act, 1986 was enacted to provide a single focus for all environmental issues and to plug the loopholes in earlier enactments. "Hazardous substances" and "handling" have been defined in this Act and section 3(2) (vi) & (vii) gives the responsibility to the Central Government to lay down procedures and safeguards for the handling of hazardous substances. The Ministry of Environment and Forests, which is the nodal agency for implementation of the Act, has been made the nodal agency for prevention, control and management of chemical accidents.

Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989.

Though called a regulation, the notification under the Environment (Protection) Act, 1986, the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989, has not stipulated any approvals or authorizations. In fact, it encourages the righteous occupier to have a fresh look at industrial activities through the eyes of an expert and assess and prepare for any eventuality.

The principal objective of the regulation is the prevention of major accidents arising from industrial activity, the limitation of the effects of such accidents, both on humans and the environment and the harmonisation of the various control measures and the agencies to prevent and limit major accidents. The industrial activities covered by the regulation are defined in terms of process and storages involving specified hazardous chemicals. The process operations are listed in Schedule 4 of the Rules and are typical operations carried out in chemical and petrochemical industries. However, in order to come within the scope of the regulations, the activity must involve a hazardous chemical which is either listed in Schedule I, Part-II or falls within the criteria of Schedule-I, Part-I.

An important feature of the regulation is that the storage of hazardous chemicals not associated with the process is treated differently from process use and a different list of hazardous chemicals applies. Isolated storage cover sites are separate tank farms or warehouses. The Central Pollution Control Board and the State Pollution Control Boards, as the case may be, are the enforcement agency for these storages.

The division of industrial activity into process activity and isolated storages is important for the application of controls within the regulation. Three levels of control are prescribed in these rules:

1. Low Level Requirements

Some 434 chemicals are subject to general or low level requirements. These apply widely and require persons in control of an industrial activity to:

(a) Take necessary precautions to prevent major accidents;

(b) Report those accidents that arise and take steps to limit their consequences;

(c) Prepare Material Safety Data Sheets and label containers; and

(d) Report the importing of chemicals.

Notification of a major accident applies to both process activity and isolated storage involving any hazardous chemical which fulfills the criteria laid down in the Rules. No threshold quantity is prescribed.

2. Medium Level Requirements

Some 179 chemicals and three classes of compounds are subject to medium level controls. These apply to potentially hazardous activities using hazardous chemicals in specified quantities. The requirements are that the person in control of a relevant activity should:

(a) notify the site;

(b) prepare an on-site emergency plan;

(c) inform the public regarding accidents that might occur and the do's and don'ts in case of an accident; and

(d) help in the preparation of an off-site emergency plan.

3. High Level Requirements

In this case 17 chemicals and three classes of compounds are subject to specific or high level requirements. They are potentially more hazardous, and threshold limits are specified. These require:

(a) Preparation of on-site emergency plans;

(b) Preparation of safety reports;

(c) Provision of information to members of the public who may be affected by a major accident; and

(d) help in the preparation of an off-site plan.

Safety Report

A safety report is required to be prepared as per Rule 10. It involves identification of the nature and use of hazardous chemicals at the installation. The report will also give account to arrangements for safe operation of an installation including control of any serious deviation that could lead to major accident and for emergency preparedness at the site. The report will identify the type, and the relative likelihood of consequences for any major accident that might occur. It will also demonstrate that the manufacturer or the occupier has identified the major accident potential of the activity and has provided appropriate controls.

A list of concerned authorities responsible for overseeing the implementation of the Rules is given in Schedule 5. Some of these are as follows:

Central/State Pollution Control Board	Enforcement of direction and procedures in respect of isolated storage of hazardous chemicals.
Chief Inspector of Factories	Enforcement of directions and in respect of industrial installation isolated storages covered under the Factories Act, 1948 and dealing with hazardous chemicals and pipelines including inter state pipelines.

Chief Inspector of Dock Safety	Enforcement of direction and procedures in respect of industrial installation and isolated storages dealing with hazardous chemicals and pipelines inside a port.

Approval and Licensing

The Rules on Manufacture, Storage and Import of Hazardous Chemicals only lay down reporting requirements by the occupier and issue of an improvement notice by the concerned authorities, whether required. Approval and licensing have not been envisaged at present in the rules.

The Guide

A Guide to these rules, entitled "A Guide to the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1991," has been produced by the Ministry of Environment and Forests in March 1992 in order to facilitate the proper and effective implementation of the Rules.

Crises Management Plan

Emergency planning is just one aspect of the total planning for the safety. This planning has to be done by those who are responsible for handling hazardous chemicals, including the local authorities in charge of emergencies, the State Governments and the Central Government.

In order to respond during a chemical emergency, a coordinated effort at the local level, state level and central level is needed. All available resources need to be mobilised to overcome the crisis in the shortest possible time. With this aim in view, a crisis management plan has been evolved. A Central Crisis Group, State Level Crisis Group and District/Local Level Crisis Groups have been constituted. The Central Crisis Group/District Level Committees would be constituted by the State Governments.

Central Crisis Group

The Central Crisis Group (CCG) had been set up by the Ministry of Environment and Forests and is a paramount apex body comprising senior officials of the Government and technical experts to deliberate on problems arising out of a contingency related to a major chemical accident. It will suggest a course of action to be taken to minimise the effect of the accident, to coordinate the activities of various agencies/Departments and to provide expert guidance for handling major chemical accidents in the country. State Governments are provided necessary assistance at the time of crisis.

Control Room

The Ministry of Environment and Forests has set up a Control Room for fast flow of information. This Control Room is Room No.705, 7th floor, B-Block, Paryavaran Bhavan, CGO Complex, Lodi Road, New Delhi-110 003. The Control Room is equipped with facilities such as hand books on hazardous substances, computers, and databases. During a crisis situation other fast communication facilities shall also be provided by other Departments.

Issues to be Addressed

Issues that need to be addressed by the implementing authorities in respect of chemical rules include:

1. The number of hazardous industrial installations/isolated storages identified by the concerned authorities and characterised as:

    (a) Units requiring compliance to rules, 4, 5, 17 and 18.
    (b) Units requiring compliance to rule 10, Safety Report.

2. The compliance status of the various provisions of the rules by the identified units.

3. Plans drawn up for the effective enforcement by the Concerned Authorities/nodal ministries.

4. Drawbacks, if any, noted in the regulation during implementation.

5. Suggestions, if any, for effective implementation.

The Bhopal Disaster

Lessons learnt from bhopal disaster include:

1. No comprehensive legislation to be followed in the event of a major disaster;

2. Lack of preparedness for disaster while handling potentially hazardous chemicals;

3. Lack of industrial safety practices ;

4. Poor maintenance;

5. No emergency preparedness plans;

6. No literature information/data-base on mic or its pyrolytic products in respect

of toxicity information;

7. Absence of environmental monitoring; and

8. Community was not informed - no community awareness

Prevention Control and Mitigation of Chemical Disasters

The prevention, control and mitigation of chemical disasters requires;

1. Registration and inventory of hazardous substances;
2. Hazard classification;
3. Controls on import and use of hazardous substances;
4. Regulated transportation of hazardous substances;
5. Mandatory hazard and risk analysis;
6. Emergency preparedness - on site and off-site emergency plans;
7. Liability and compensation;
8. Post emergency management and rehabilitation

HAZARDOUS WASTES (MANAGEMENT AND HANDLING) RULES,1989 AND GUIDELINES

Lakshmi Raghupathy
Ministry of Environment and Forests
Government of India
New Delhi
India

Introduction

The progress of a nation has been associated with its development, which in turn is based on the industrial growth to produce goods for the benefit of humanity. In this process, chemicals contribute to most of the basic needs and their use is on the increase by thousands every year. Together with the benefits given to the society, a number of chemicals cause potential harm to humans and the environment, either directly or indirectly.

In India, large scale production of a variety of chemicals during the past four decades, has led to the release of huge quantities of wastes into the environment in the form of solids, liquids and gases. A substantial amount of these wastes are potentially hazardous to the environment. Some of these have proved extremely dangerous to living organisms, including human beings. A potential risk to human health is the contamination of surface and groundwater supplies due to leaching at hazardous waste dumping sites. Contaminants are being detected in sewage and water supplies due to the indiscriminate discharge of waste materials on land and into water bodies.

The problem has been aggravated by the non-availability of appropriate technology and by inadequate facilities to treat wastes generated by such industries. An effective control of hazardous wastes is of paramount importance for proper health and environmental protection and natural resource management.

Regulatory Mechanism

India's Environment (Protection) Act, 1986 was enacted to provide a single focus for all environmental issues and to plug loopholes in the earlier enactments. Section 3(2) (vi) and (vii) gives the responsibility to the Central Government to lay down procedures and safeguards for handling hazardous substances, which include hazardous chemicals, hazardous wastes and hazardous micro-organisms. Separate sets of Rules have been made for these categories of hazardous substances.

The Hazardous Wastes (Management and Handling) Rules were notified in 1989, under the Environment (Protection) Act, 1986. These rules aim at providing control for the generation, collection, treatment, transport, import, storage disposal of hazardous wastes. The principal objective of these regulations is to establish a control mechanism for the management of hazardous wastes. Under these regulations, the agencies responsible for inventorying and monitoring the handling of hazardous wastes have been notified.

The Hazardous Wastes Rules

The Hazardous Wastes (Management and Handling) Rules, 1989, provide for an effective inventory and controlled handling and disposal of hazardous wastes. The applicability of these rules have been stated in Rule 2.

1. Categories of Wastes:

Eighteen categories of hazardous wastes have been identified along with regulatory quantities and the Rules shall apply to these categories of wastes.

2. Responsibility of Generator of Hazardous Wastes:

   a) To report the State Agencies about the hazardous wastes being handled (Rule 4);

   b) To apply for authorization for handling hazardous wastes in Form 1 provided in the rules (Rule 5);

   c) Proper packaging, labelling and transportation of hazardous wastes in accordance with the provisions in Motor Vehicles Act, 1988 (Rule 7);

   d) To maintain records of the operator involved in the generation and disposal of hazardous wastes in Form 3 prescribed in the Rules (Rule 9);

   e) To file the annual return in Form 4 (Rule 9); and

   f) To report accidents to State Pollution Control Boards (Rule 10).

3. Responsibility of State Pollution Control Boards:

   a) To examine the authorization applications and grant authorization in Form 2 (Rule 5);

   b) To suspend or cancel the authorization (Rule 6); and

   c) Examine the cases if import of hazardous wastes and grant/refuse permission after examining each case on merit (Rule 11).

4. Responsibility of State Governments:

   a) Identification of sites for the disposal of hazardous wastes in their States after ascertaining the suitability of the sites through the Environment Impact Assessment Studies (Rule 8); and

   b) Prepare and maintain an inventory of such sites (Rule 8).

5. Responsibility of Importer:

   a) Exporting country and the importer have to provide detailed information on the consignment to the respective Pollution Control Boards seeking permission for the imports to take place. This information is to be examined on merits by the concerned agencies (Rule 11);

6. Appeal:

   A provision has also been made for making an appeal in writing in case of suspension or cancellation of refusal of authorization under Rule 12.

Hazardous Wastes Guidelines

The guidelines for the management and handling of hazardous wastes provide the details for the management of the hazardous wastes from the source of generation to the final disposal. In order to facilitate the speedy implementation of the Hazardous Wastes (Management and Handling) Rules, 1989 for the management of hazardous wastes these guidelines were prepared and have been widely circulated.

The guidelines provide for:

a) Occupier/generator: In respect of safe handling and storage, selection of the transport system and disposal of the waste generated;

b) Transporter: Transportation of hazardous wastes with the requisite details pertaining to the safety requirements during transportation of hazardous wastes;

c) Owner of the treatment and disposal facility: For providing the details pertaining to the norms for the operation of a facility;

d) Implementing authority: Identification and assessment of hazardous waste disposal sites for establishment of a hazardous waste treatment and disposal facility needs careful planning and appropriate decisions. This has been provided in the guidelines for the siting of hazardous wastes treatment and disposal facilities;

e) Treatment and Disposal options: The treatment and disposal methodologies applicable to the categories of wastes listed in the rules;

f) Site selection criteria: The requirements for the selection of landfill sites and preparations of the sites for containment of hazardous wastes in an environmentally sound manner; and

g) Abandoned hazardous waste sites: Identification of abandoned hazardous waste disposal sites and their remediation.

Waste Management

The management of hazardous waste that has already been generated is one of the major problems which requires immediate attention. With the assurance of the hazardous waste regulations awareness has been created for the management of hazardous wastes. However, the practice for the management is yet to be enforced. The technical issues pertaining to waste treatment and disposal needs to be strengthened and the technology input requirements have to be worked out.

Waste Minimisation

An approach for waste minimisation is to be envisaged in order to avoid the problems of treatment and disposal. The technologies for hazardous waste treatment are expensive and it may be economically viable to implemented the alternative adopted in industrialised countries. This is to develop the so called "Clean Technologies" that involve a change in the process and raw materials.

In India commercialised hazardous waste treatment and disposal facilities do not exist. Only some major industrial units have self-contained hazardous waste treatment and disposal facilities. The introduction of "Clean Technologies" would require extensive input of such technologies from developed countries, through transfer of technology. The waste minimisation concept could thus be introduced through simple waste reduction systems without involving a major change in the technology or raw material. This requires the introduction of the waste minimisation concept in the administrative, technological and legal systems. A step by step building of this concept is envisaged by dovetailing the activities of these agencies and stream lining the hazardous waste management system.

ESCAP'S ACTIVITIES IN THE FIELD OF TOXIC CHEMICALS AND HAZARDOUS WASTE MANAGEMENT

Choei Konda
Environment Section
Environment and Natural Resources Management Division
Economic and Social Commission for Asia and the Pacific
(ESCAP)
Bangkok
Thailand

Introduction

The Asia and Pacific region is now undergoing transformation, with rapid industrialization in many countries. The economic growth is 6.8 % for the Economic and Social Commission for Asia and the Pacific (ESCAP) region whereas it is 3 % for the world. In particular, the countries with economies in transition, such as Taiwan, Korea and some ASEAN countries like Singapore, Malaysia and Thailand, are enjoying high economic growth.

While this industrialization is essential to enhance the quality of life of the people, the toxic products and wastes generated in the process pose great risks to human health and the environment. Most of the developing countries in the region do not have the capacity for handling and disposal of toxic products and wastes.

This situation is further aggravated by the illegal traffic in these products and wastes. According to "The Waste Invasion of Asia" issued by the Greenpeace International in January 1994, between 1990 and 1993 several developed countries shipped more than 5.4 million tonnes of toxic wastes to Asian countries.

ESCAP is presently dealing with the issues of toxic chemicals and hazardous wastes, particularly to enhance the capacities in the countries, as one of the priority environmental problems in the region. In this paper emphasis is placed laying stress on hazardous wastes rather than toxic chemicals. A summary of the present state of waste management in the region is presented briefly, followed by the introduction to the main activities by ESCAP in the field.

Present State of Waste Management in the Region

Generation of Hazardous Wastes

Exact data on the amount of wastes generated is not available in most of the developing countries in the region. In this case an indirect method is usually applied to estimate the amount of wastes generated. This method provides us an estimate based on population, assuming per capita waste generation as follows:

High-income countries: (Japan, Singapore)	1.5 - 2.0 kg/capita/day
Middle-income countries: (Indonesia, Thailand)	0.75 - 0.90 kg/capita/day
Low-income countries: (India, Pakistan, Philippines)	0.4 - 0.6 kg/capita/day

In Japan the amount of municipal wastes (trash) generated in 1993 was 138,708 t/day (1.118 kg/capita/day) and the amount of industrial wastes generated in the same year was 1,081,468 t/day (8.711 kg/capita/day). In Bangkok, generation of solid wastes was 5,043 t/day (0.88 kg/capita/day) in 1989 and hazardous wastes generated in Thailand was 1,993,602 t (96 g/capita/day) in 1991. Therefore, the method mentioned above does not always give a good estimation, particularly for industrial wastes.

Transboundary movements

No reliable information is available at present in the region. "The Waste Invasion of Asia", produced by Greenpeace International in January 1994, is the only information source available on the matter. According to the publication, a summary is as follows:

(1) Between 1990 and 1993, Australia, Canada, Germany, UK and USA shipped more than 5.4 million tonnes of toxic wastes to the Asian countries. USA ranks the first holding at 93%.

(2) Lead wastes shipped to 11 Asian countries: over 50,000 tonnes Plastic wastes to these 11 countries: over 100,000 tonnes "Scrap metal", mainly to Korea and India: over 5 million tonnes

(3) These shipments have poisoned farms in Bangladesh, streams in Indonesia, and schoolchildren in Taiwan.

Collection, Treatment and Disposal

Generally speaking, collection rates of wastes are low in most of the developing countries in the region. But some of the large cities in such countries show relatively high collection rates. For example, values are 81% for Bangkok (1989) and 70% for Metro Manila (1985).

Incineration and composting are most popular methods for the treatment of municipal wastes in the region. However, the rates are less than 10% in most cases. Only densely populated countries like Japan, Singapore and Hong Kong adopt incineration of waste to a large extent (Japan: 74%, Singapore: 65% and Hong Kong: 30%). Open dumping with no treatment is still the most common practice in the developing countries in the region. As regards industrial wastes, there is little information on how they are disposed.

Definition and classification

Some countries have their own definitions and classifications for hazardous wastes in their domestic laws and regulations. For example, in Thailand hazardous substances are classified into 4 categories depending on the strength of control by the Hazardous Substances Act (1992) as follows:

Type 1:	must comply with the specified criteria and procedures
Type 2:	must be notified and complied with the specific criteria and procedures
Type 3:	must obtain a permit
Type 4:	is prohibited

Under the Notification of Ministry of Industry, substances to be considered as "hazardous waste" are:

- ignitable substances, corrosive substances, reactive substances and toxic substances with being not used or wanted;

- 20 types of expired or unusable solvents;

- waste or unwanted material from 14 industries such as sludge from lead smelting industry, electroplating industry, insecticide industry and paint industry, etc.; and

- 37 types of waste specified in the Basel Convention.

The diversity in definitions and classifications of hazardous wastes often causes problems. Without uniform definitions and classifications, exchange of information among countries and creating of a regional database necessary for regional cooperation cannot be effective. In this respect, the definition and classification prescribed in the Basel Convention is now working as an international standard, though there is some ambiguity regarding how to interpret the provisions technically.

Two kinds of classifications of hazardous wastes are shown in the Basel Convention. One is the so-called "source-oriented classification" where hazardous wastes are classified by waste streams such as industrial processes (Y1-Y18 for waste streams in Annex I). Another is the so-called "effect-oriented classification" where hazardous wastes are classified by hazardous contents such as heavy metals and organic chlorine compounds (Y19-Y45 for wastes having constituents as in Annex I).A simple method for customs officers to identify hazardous wastes should be established, based on the classifications of the Basel Convention.

Institutional Framework

(1) Ratification of the Basel Convention

As of March 1994, 65 countries had become parties to the Basel Convention, of which 12 countries are from the ESCAP region. They are China, Korea, Japan, Indonesia, Philippines, Malaysia, India, Bangladesh, Sri Lanka, Maldives, Iran and Australia.

(2) Domestic law and regulation

Most of the developing countries in the region have laws and regulations regarding the control of toxic chemicals, especially drugs, pesticides and other industrial chemicals for specific purpose. But only a few countries have a specific law and regulation for hazardous wastes.

Examples are as follows:

Fiji:	Pesticides Act (1971), Dangerous Drugs Act (1968)
India:	Hazardous Wastes (Management and handling) Rules (1989)
Indonesia:	Rules on Toxic Substances (1983)
Korea:	Waste Management Act (1986)
Pakistan:	Pesticides Rules (1973), Drugs Law (1976)
Philippines:	Presidential Decree No. 825, 984 and 1152 on waste disposal Toxic Substances and Hazardous and Nuclear Waste Control Act (Republic Act No. 6969)
Sri Lanka:	Control of Pesticides Act (1980)
Thailand:	Hazardous Substances Act (1992)

Main Activities of ESCAP

Hazardous Waste Management

Outline

The first ESCAP project in this field was a project on hazardous waste management funded by the Netherlands ("Development of Methodologies, Guidelines and Human Resources for Hazardous Waste Management in the Developing Countries of the ESCAP Region"). The overall objective of the project is to assist the developing countries of the ESCAP region in establishing environmentally sound policies for industrial growth, through the development of appropriate methodologies and guidelines, compatible laws and regulations and of human resources for hazardous waste management.

The outputs expected to be produced from the project are:

(i) a database on the current status of generation, treatment and disposal as well as of transboundary movement of hazardous wastes in the developing countries; and

(ii) a manual containing guidelines on appropriate technical measures, and on developing suitable legislative and institutional set ups for environmentally sound management of hazardous wastes compatible to conditions in the developing countries.

Activities in Phase I

The Phase I of the project commenced in April 1991, aiming mainly at the development of the database. Given the current industrial base of some countries and the problem faced by certain others on transboundary movement of hazardous wastes, 8 countries from the Asia region and 3 countries from the Pacific region were selected to participate in this project.

Survey questionnaires were developed and were sent out to all the above-mentioned countries, requesting them to provide as much information as possible. Furthermore, field missions were undertaken to the following countries to collect additional information related to hazardous waste management: Bangladesh, China, Fiji, India, Malaysia, Papua New Guinea, The Philippines and Tonga. Missions were also undertaken to the following United Nations agencies and other organizations to brief them on this regional project and collect information on the work done in the field of hazardous waste management in the industrialized countries: UNEP/IEO (Paris), UNIDO (Vienna), OECD (Paris), Ministry of Housing, Physical Planning and Environment (The Netherlands) and Environment Agency (Japan).

As one of the main activities in the Phase I, the Consultative Meeting on Problem Assessment of Hazardous Waste Management in the Asia and Pacific Region was held from 11-15 February 1992 in Bangkok. Based on the identification and assessment of specific problems of hazardous waste management in the Asia and Pacific region, the Meeting formulated the following main recommendations:

(1) The secretariat should compile the data gathered from the questionnaires and circulate it to all countries, and encourage each country to prepare databases depending upon their individual needs; and

(2) The secretariat should prepare a manual containing guidelines on appropriate management of hazardous wastes including their prevention, treatment and disposal.

Activities in Phase II

The activities of the Phase II commenced in April 1992, The first task was to develop a database on hazardous waste generation in the region. The outcome of this work was summarized into a report. But this was insufficient as a database because of a lack of data and the diversity of classification of industries among participating countries.

Based on the results of the Phase I and the Consultative Meeting, and considering the outcome of the work related to the development of a database, the second task in Phase II was designed to establish a manual for hazardous waste management. As regards a database, with a view to obtaining the estimated quantity of hazardous wastes generated from various types of industry instead of attempting to collect unavailable data, the users' manual of the International Marine Organisation (IMO) database (Global Waste Inventory Database) was utilized as an important basis for hazardous waste management. The outcome of this work was summarized into a manual which consists a workbook and a reference text for planners and decision makers at the technical level in developing countries.

As one of the main activities in the Phase II, was a Workshop on Hazardous Waste Management in Asia and the Pacific held on 17-20 August 1993 in Bangkok. Taking into consideration the discussions in the Workshop and other more specific needs and requirements identified on the problems of hazardous waste management in the region, the Workshop made the following main recommendations:

(1) The Governments of the region may initiate and strengthen action on policy planning, legislation and creation of a database on the quality and quantity of wastes being generated and take the necessary steps for the minimization, recycling and proper disposal of these wastes. Necessary steps should also be taken for the training of personnel and public awareness in this direction; and

(2) The ESCAP secretariat, in consultation with other United Nations agencies and the members and associate members of ESCAP, should develop a comprehensive database on hazardous waste management for the region.

The workshop report is available and the Manual for Hazardous Waste Management reviewed at the workshop is now being printed.

Prevention of Illegal Traffic

Outline

The second project in this field was a project on prevention of illegal traffic in toxic chemicals and hazardous wastes, funded by UNEP ("Preliminary Assessment of Illegal Traffic in Toxic and Dangerous Products and Wastes in the ESCAP Region"). The objectives of the project are:

(i) to provide the governments in the ESCAP region with relevant information regarding the present status of international traffic of dangerous products and wastes so as to assist those governments in the implementation of the London Guidelines and the Basel Convention, and

(ii) to assist the governments in the ESCAP region in their efforts to prevent and reduce illegal international traffic in toxic and dangerous products and wastes by providing the governments with relevant information and by preparing a draft regional programme of action for technical assistance.

This project was designed to follow up Resolution 44/226 of 22 December 1989 by the UN General Assembly. It requested each regional commission to contribute to the prevention of the illegal traffic in toxic and dangerous products and wastes by monitoring and making regional assessments of this illegal traffic and its environmental and health implications. The project was also in line with paragraph 20.45 of Agenda 21, which stipulates almost the same contents as the UN General Assembly's resolution mentioned above.

Documentation and Workshop

Fact finding missions to five countries (Fiji, Pakistan, Singapore, Sri Lanka and Thailand) as well as to the South Pacific Regional Environment Programme (SPREP) were undertaken in order to collect information. An assessment report on institutional, legal and manpower capabilities of some countries in the monitoring and management of toxic and dangerous products and wastes was then prepared, based on the fact finding missions. Several documents including guidelines and a regional action programme were also prepared for a subsequent workshop.

Under the project, an expert-level workshop was held from 1-4 March 1994 in Tokyo. The workshop made numerous recommendations in the six areas: (i) national controls; (ii) institutional capabilities; (iii) non-governmental organizations; (iv) promotion of regional cooperation; (v) establishment /strengthening of analytical laboratories; and (vi) promotion of education.

The workshop report and the Guidelines for Development of a Legal and Institutional Framework are available and other documents distributed at the workshop are included in the proceedings which is now printed.

ESCAP has noted the recommendations made at the expert-level workshop at Tokyo and the Decision II/4 by the Second Meeting of the Parties to the Basel Convention held just after the workshop (more generally UN resolution 44/226 and Agenda 21 in paragraph 20.45) which directed the regional commissions to monitor and assess the transboundary movement of hazardous wastes in the region with the support and guidance of UNEP.ESCAP is now considering some concrete activities for the prevention of illegal traffic in hazardous wastes.

Waste Audit

Outline

A new project for 1994-95, industrial audit ("Capacity Building in Industrial Audit for Waste Minimization" funded by Japan) was started in June 1994 as an integral activity of the two preceding projects which are almost completed. Experience in "end-of-pipe" technologies for the control of industrial emissions and effluent during the last few decades has now established that this single and unidirectional approach has not been able to solve all the problems of environmental pollution from industrial emissions and wastes. A different approach has now become necessary to address the problem, that is waste minimization. In order to minimize the generation of wastes, one needs to examine the operating processes in an industry to identify the origins of wastes, the operational problems associated with the process, and those areas where improvements can be made. This is known as waste audit, which is the first step in a programme of waste minimization and improved process performance.

Main Activities Scheduled

Under this new project, a review of existing methodologies and guidelines for waste minimization techniques and waste audit procedures and a fact finding field missions to three countries (India, Papua New Guinea and Japan) will be conducted within this year. Preparation of a regional overview will be also prepared next year, based on country reports from 10 participating countries. Based on these activities, a draft training manual on industrial waste audit, in which the special problems in the developing countries are taken into consideration in relation to their industrial development and operational practices, will be prepared and then be reviewed at a workshop in the latter half of next year. Finally a training manual on industrial waste audit will be published in the future.

Other Related Activities

i) Monitoring guidelines

In most countries of the region, the practice of monitoring water, air, soil, toxic chemicals and hazardous wastes is either seriously lacking or inadequate, especially from scientific and engineering viewpoints. There is a scarcity of reliable data for the preparation of basic documents for national planning of development projects for incorporating environmental considerations in all economic activities for sustainable development.

Keeping in view the urgent need for such monitoring, "Guidelines on Monitoring Methodologies for Water, Air and Toxic Chemicals/Hazardous Wastes" has been prepared to strengthen the monitoring efforts in this region. The guidelines provide a check-list of options that have proved useful elsewhere. The publication also provides a framework for identifying a variety of technologies available for monitoring required parameters, and it presents a series of policies and strategies that need to be addressed before appropriate monitoring options can be selected. Appropriate monitoring options and technologies for the management and control of water and air quality, safe use of toxic chemicals, and reduction and disposal of hazardous wastes can be selected from these guidelines, to suit the needs of each country of this region.

ii) Prevention of Chemical Accidents

With the increasing production, storage, transportation and use of chemicals, especially toxic chemicals, the potential for and the occurrence of chemical accidents have significantly increased. Since 1974, among the twelve major chemical accidents in the world, four such accidents occurred in some of the developing countries in Asia, namely Bhopal in India, Bangkok and Phang Nga in Thailand and Ashuganj in Bangladesh.

In this regard, a document entitled "Planning of Measures for the Prevention of Chemical Accidents" was prepared under the project "Planning and Management of Environmental Technology in Asia and the Pacific". The document is not as yet published, because of budget constraints.

Conclusion

A lack of information necessary for hazardous waste management is one of the most crucial problems in the region. This comes from the lack of human resources, such as manpower and expertise, and financial resources for implementing policies and regulations on waste management, as well as a lack of public awareness and political indifference.

The following features of the waste issues in developing countries, as compared with those in developed countries can be also applied to the ESCAP region:

(1) Difference in quantity and quality of wastes;
(For example, the quantity is less; paper/plastics are less and garbage/earth and sand are more than developed countries.)

(2) Weakness in financial base;
(Cleaning costs pose heavy financial burden in local governments in developing countries.)

(3) Much involvement of informal sectors such as street vendors, day labourers and scavengers; and

(4) Less in collecting service to slum and squatter areas.

Keeping these constraints and features in mind, in addition to the ongoing projects by ESCAP, a practical and workable programme or project at regional level should be planned and implemented to assist developing countries in the region in coping with hazardous waste issues.

TRAINING METHODS AND CURRICULUM DEVELOPMENT IN TOXIC CHEMICALS AND HAZARDOUS WASTES

Paul Clarey
Faculty of Science and Technology
Deakin University
Melbourne
Australia

Abstract

This paper describes part of an evolving curriculum in the environmental management of hazardous materials and the associated training programmes.

The Bachelor of Applied Science (Environmental Management of Hazardous Materials) course started in 1990. The degree requires students to undertake a major in Chemistry, a variety of core and elective "hazmat" subjects and an optional study stream which can comprise another science major (e.g. biology) or a double major in chemistry or any other science or non-science subjects, that the student wishes to take.

In 1992 a Graduate Diploma in Environmental Management started was introduced. This gave postgraduate students the opportunity for some general training in environmental management. However, only a couple of "hazmat" units are available to students in this course.

In response to considerable interest, both at home and abroad, Deakin University is currently developing a Graduate Certificate in the Environmental Management of Hazardous Materials. This covers of the four core "hazmat" subjects, as follows :

- Integrated Management of Hazardous Materials
- Risk Assessment of Hazardous Materials
- Environment Protection, Occupational Health and Safety
- Environmental Impact Assessment and Land Use Planning

These subjects will be prepared in both on-campus and off-campus modes for delivery in Australia and overseas. It should be noted that the arrangements for delivery overseas are negotiable between Deakin University and the overseas institution which wishes to deliver these subjects. Some seeding money has been provided by UNEP-NETTLAP.

The following paper will briefly describe the curriculum and some of the training methods for these subjects.

Introduction

Deakin University is the first university in Australia to offer specialised training at an undergraduate and postgraduate level in the environmental management of hazardous materials. The success that graduates are achieving as a result of their qualification and abilities demonstrates the usefulness and need for such training. But this need exists not just in Australia but elsewhere in the world also. Deakin University wishes to focus its attention to the needs of Asia and the South Pacific. The nations in this region are developing and industrialising at an ever increasing rate. Trained professionals are required to ensure that problems are avoided before they are created.

NETTLAP workshops and other activities provide an opportunity to make valuable contacts with potential trainers in these subjects and demonstrate the nature of the training that we can provide cooperatively with other institutions in the region.

The Proposed Model for Training

In response to considerable interest, both at home and abroad, Deakin University is currently developing a Graduate Certificate in the Environmental Management of Hazardous Materials. This consists of the four core "hazmat" subjects, as follows :

- Integrated Management of Hazardous Materials
- Risk Assessment of Hazardous Materials
- Environment Protection, Occupational Health and Safety
- Environmental Impact Assessment and Land Use Planning

These subjects are an extremely useful adjunct to the training of industrial chemists and chemical engineers at an undergraduate or postgraduate level, providing them with the basic skills for integrated environmental management of toxic chemicals and hazardous wastes.

The first three subjects listed are essentially generic, i.e. are based on international conventions and standards and reflect the current thinking within the defined areas. The subjects would be readily adaptable to another country or region by the addition of suitable local examples and case studies. The overall training framework, course material, reference lists, practical exercises, recommendations for assessment, etc, are being developed by Deakin University. The subjects would be delivered by the collaborating institution as part of the Graduate Certificate in the Environmental Management of Hazardous Materials to be awarded by that institution (or any other award in which it wishes to include these subjects). The details as to how such a collaborative arrangement can be achieved are negotiable.

The last subject listed, "Environmental Impact Assessment and Land Use Planning", is a little different in concept from the first three. For these four subjects to be integrated at a local level it is essential that this subject be developed at a local level and include local issues, planning regulations and guidelines, administrative systems, etc. For this to be done it will require consultation and collaboration between the delivering institution and Deakin University. Deakin University could provide one of its trainers in this discipline to travel to the collaborating institution so that the subject could be written up to suit local requirements and ensure its integration with the other three generic subjects. The trip would also allow the Deakin trainer to review the generic subjects with the institution and tailor them to the local situation, where necessary. The final result would be a relevant and integrated training package for the institution to deliver nationally or locally in on-campus and/or off-campus mode.

Financial costs with respect to the Deakin trainer working with an overseas institution on "Environmental Impact Assessment and Land Use Planning" would need to be met by that institution. The provision of the other three "hazmat" subjects would be negotiable, either as a fee or as a royalty based upon the number of students studying. It may be possible for overseas institutions to seek government funding to implement such a course of training.

Curriculum and Training Methodologies

The following sections present a brief description of the four hazmat "subjects" and some of the tasks that students are required to do.

A. Integrated Management of Hazardous Materials

This module is provided in response to a need to train students (particularly those with a background in chemistry) in the environmental management of hazardous materials.

It will generally be the first unit undertaken as part of the specialisation in Environmental Management of Hazardous Materials.

The objectives of the course are to enable students to:

(a) become familiar with the basic philosophies, principles and strategies involved in the integrated process of industrial waste management;

(b) become familiar with the United Nations Dangerous Goods system used in the identification, labelling, packaging storage and transport of dangerous goods;

(c) identify the physical and chemical properties of a material that would designate it as hazardous and examine ways in which such hazards can be controlled;

(d) identify the factors which contribute to the productions and accumulation of hazardous materials and wastes;

(e) identify the range of waste products produced by industry and study the various methods available for their recycling treatment, and disposal;

(f) introduce the concepts of waste avoidance/waste minimisation and cleaner production;

(g) develop a basic understanding of chemical engineering principles;

(h) develop an understanding of the social, political, and economic factors involved in the management of hazardous materials; and

(i) apply an integrated process approach to the management of hazardous materials.

Topics to be addressed in this unit will include:

Dangerous Goods and Hazardous Waste Classifications, Dangerous Goods and Hazardous Waste Management (i.e. Storage, Handling, Transport, Transfer, Treatment & Disposal), Waste Minimisation & Cleaner Production, Waste Water Treatment Techniques, Landfill, Incineration, Immobilisation and Alternative Technologies.

The assessment might be undertaken as follows:

Mid semester examination	25%
End of semester examination	25%
Essay (500 words)	5%
Seminar presentation	5%
Case study assignment	25%
Excursion report	10%
Attendance and contribution	5%

Helpful references for this module include:

Australian Transport Code for Dangerous Goods by Road & Rail, 5th edition, AGPS.

Chemistry of Hazardous Materials, Meyer, 2nd edition, 1989.

Environmental Management Handbook: Toxic chemicals and wastes, Kokoszka and Flood, 1989.

Journal of Hazardous Materials.

Hazardous Waste Processing Technology, Kiang & Metry, 1982.

Principles of Hazardous Materials Management, Griffin, 1988.

B. Risk Assessment of Hazardous Materials

This course is provided in response to the need to provide environmental scientists with risk assessment and management skills.

The objective of the course is to enable students to :

(a) understand the concepts of hazard and risk management and characteristics and classify hazardous materials and hazards using current concepts and risk assessment data;

(b) understand the basic processes involved in the risk analysis of chemicals;

(c) formulate plans and practices for the safe handling, reclamation, disposal or stabilisation of a hazardous material in a controlled manner and develop safe emergency procedures for handling hazardous materials in the case of an accident or other emergency;

(d) appreciate the implications of incompatibilities and life-time in handling, storage and transport of hazardous materials and wastes;

(e) analyze the causes and consequences of accidents in chemical process industries;

(f) understand the issues relating to land use planning around chemical industry and the concepts of individual and societal risk in relation to such facilities;

(g) appreciate the various methods for fire prevention and protection;

(h) undertake a quantitative risk assessment study using the processes of HAZAN and HAZOP;

(i) prepare material safety data sheets; and

(j) appreciate the potential hazards and risks associated with the treatment and disposal of hazardous wastes.

Topics to be addressed in this unit will include:

Quantitative Risk Assessment for Chemical Process Industries,
Emergency Management and Response, Chemical Hazards and Risks and Risk Analysis of Chemicals and Wastes.

The assessment of the module might be undertaken as follows:

Examination	30%
Case study assignment	35%
Hazard calculations	5%
Table Top exercise	5%
Emergency response plan	10%
Presentation of ERP	5%
MSDS exercise	5%
Attendance and contribution	5%

Useful references for this module include:

Conway, R.A. Environmental. Risk Analysis for Chemicals, 1982.

Dept. of Planning, Industry Emergency Planning Guidelines, 1993.

Green, A.E. High Risk Safety Technology, 1982.

Kletz, T. What Went Wrong, 1987.

Technica, Risk Assessment of the Altona Petrochemical Complex and Environs, 1987.

C. Environment Protection and Occupational Health and Safety

This course is provided in response to the need to provide environmental scientists with skills in environment protection and occupational health and safety.

The objective of the course is to enable students to:

(a) understand the basic principles of toxicology;

(b) understand the principles of international law and law in Australia as it relates to the control and management of Occupational Health and Safety, Environment Protection and Dangerous Goods;

(c) examine a range of air pollution control devices, their applications and principles of operation;

(d) examine a range of techniques and devices used to control and manage oil spills in an aquatic and foreshore environment;

(e) examine a range of techniques and equipment used in the remediation of contaminated land;

(f) understand the process involved in conducting audits on environmental, occupational health and safety and dangerous goods compliance;

(g) appreciate the range of protective personal equipment that is available and its limitations;

(h) examine a range of portable hazardous materials monitors that would be used for health and safety monitoring and hazard indicators in emergency response; and

(i) examine the dynamics of the workplace and critically assess the processes through which occupational health and safety is managed in the workplace and the methods by which it may be improved.

Topics to be addressed in this unit include:

Environmental Law, Environmental Policy (concerning hazardous materials and environment protection of air water, land, and noise), Toxicology, Oil Spill Remediation, Air Pollution Control Equipment, Contaminated Land Remediation, Stack emissions and workplace testing, Personal Protective Equipment, Leachate Testing and Occupational Health and Safety.

Assessment of the module might be undertaken as follows:

Mid semester examination	25%
End of semester exam	25%
O.H. & S. audit	10%
Dangerous goods audit	10%
Leachate practical	15%
Monitoring station report	5%
Protective equipment exercise	5%
Attendance and contribution	5%

Representative references are:

Connell, D.W. and Miller, G.J. Chemistry and Ecotoxicology of Pollution, 1984.

Dangerous Goods (Storage & Handling) Regulations, 1989.

Fingas, Dual and Stevenson - Basics of Oil Spill Cleanup, 1979.

Jones, A.C. Occupational Hygiene, 1981.

Rizer - Roberts, Bioremediation of Petroleum Contaminated Sites, 1992.

Theodore, L. Introduction to Hazardous Waste Incineration, 1987.

D. Environmental Impact Assessment and Land Use Planning

This course is provided in response to the need to provide environmental scientists with skills in environmental impact assessment and land use planning.

The objective of the course is to enable students to :

(a) understand the basic principles and practices of land use planning and their application to different types of land in terms of ownership and use;

(b) identify the factors which should be taken into account in selecting appropriate techniques for gathering and synthesising information in various situations and for differing purposes (including environmental impact assessment);

(c) employ such techniques in a variety of context including: environmental impact assessment; development and assessment of land use options for both public and private land (at a variety of scales);

(d) appreciate the role Environmental Impact Assessment procedures play in the development and implementation of land use policies and their relationship to the broader processes by which land use is controlled;

(e) appreciate the origins and present nature of legislative and administrative principles of land use planning;

(f) describe the operations and structure of local planning authorities and other related agencies; and,

(g) examine the links between environmental protection and industrial land use planning in relation to public safety and amenity, major hazards, risk assessment, and the role of referral authorities.

Topics to be addressed in this unit will include :

Statutory planning; Roles and responsibilities of relevant government agencies; Relevant legislation, policies and guidelines; Environmental planning, Industrial land use planning, Performance based planning, Environmental impact assessment techniques, Waste management planning, Hazard and risk assessment in land use planning, Preparing submissions for land use planning and tribunals.

Assessment of this module might be undertaken as follows:

Planning Tribunal Presentation	5%
Planning Tribunal Group Report	30%
EIA Assignment	15%
EIA Review	10%
Excursion Report	10%
Mid-semester revision test	15%
Final Revision Test	15%

Representative references are:

Thomas I., Environmental Impact Assessment : Australian Perspectives and Practice, Aristoc Press, Melbourne, 1987.

O'Riordan T. and Sewell S. (eds), Environmental Policy Review and Project Appraisal, Wiley, London, 1983.

Australian and New Zealand Environment and conservation council (ANZECC), A national approach to environmental impact assessment in Australia, AGPS, 1991.

Ellis D., Environments at Risk : Case histories of environmental impact assessment, Springer-Verlag, Berlin, 1989.

Various Relevant Local Legislation, Policies and Guidelines.

Conclusion

Considerable effort has gone into designing a group of subjects which integrate the essential disciplines required to manage hazardous materials in an environmentally sound manner.

The need for professionals with this training within industry and government is recognised and the best way to ensure such training takes place is for it to be taken up by various tertiary institutions within Asia and the South Pacific.

Deakin University offers its Graduate Certificate in the Environmental Management of Hazardous Materials as one model which will be developed and explored further with the purpose of ultimately providing and tailoring it for the local needs and situations of developing nations in Asia and the South Pacific.

Deakin University would be pleased to discuss arrangements for training transfer to any interested tertiary institutions in the region.

HAZARDOUS WASTE:
A REVIEW OF TREATMENT AND DISPOSAL OPTIONS

M. Feroze Ahmed
Department of Civil Engineering
Bangladesh University of Engineering and Technology
Dhaka
Bangladesh

Introduction

The expansion of industrial and agricultural activities and introduction of new products and processes to meet human needs have generated a wide range of wastes potentially dangerous to health and environment-called hazardous wastes. A number of definitions, both qualitative and quantitative, have been used by regulation of different countries for identification of hazardous wastes from other wastes. The World Bank technical paper on safe disposal of hazardous wastes (Paper 93) defines hazardous wastes, other than radioactive wastes, "which by reason of their chemical reactivity or toxicity, explosive, corrosive or the other characteristics are likely to cause damage to health or environment whether alone or coming in contact with other substances". According to WHO, hazardous waste is that "which has physical chemical or biological characteristics which require special handling and disposal procedures to avoid risk to health and or other advise environmental effects". Canada defines hazardous wastes as those wastes which, due to their nature or quantity are potentially dangerous to health or the environment and which require special storage, handling or disposal techniques to eliminate or reduce the danger". In general, hazardous wastes have one or more of the characteristics like ignitability, radioactivity, corrosivity, reactivity and toxicity. Hazardous wastes by their nature may directly or indirectly pose a threat to human health and the living environment and require special handling, treatment and disposal techniques to reduce or eliminate the hazard.

There are many compounds, products and product combinations that fit within the bread definition of hazardous wastes. For practical purpose, all hazardous wastes may be grouped into the following five general categories:

- Radioactive substances
- Toxic chemicals
- Biological wastes
- Flammable wastes

- Explosives

The characteristics and hazards associated with each category of waste are significantly different and need individual consideration in safe handling, processing and disposal.

A screening model for identification of hazardous wastes in the form of a flow chart is given in Fig 1. The hazardous waste criteria used in the screening model relate to only the intrinsic hazard of the waste on uncontrolled release to the environment, regardless of quantity or pathways to human and other critical organisms. The threat to public health and to the environment for a given hazardous waste is strongly dependent on the quantity of the waste involved.

The problems associated with hazardous waste management in developing countries depending on local conditions may be listed as follows;

- Poor control in storage, handling, transportation and disposal;
- Scattered in small quantities in units that generate the wastes;
- Producers of the wastes are not aware of the short and long term effects of the hazardous wastes they produce;
- Limited organizational capacity, skills and financial resources available for the management of hazardous wastes;
- Many other problems receive more importance and attention, due to economic reasons, than do hazardous wastes.

The management of hazardous waste is absolutely essential to protect the environment. Waste minimization and recycling or resource recovery are given priority in hazardous waste management and these are top listed activities in the hierarchy of preferred management options. In-house efficiency and proper management will reduce the quantity of waste generated, but wastes cannot be completely avoided. Hence treatment and safe disposal are the most important functional elements in hazardous waste management.

Treatment and Disposal Options

Treatment Processes

Hazardous wastes may also be classified into the following eight types for processing and treatment operations:

(1) Inorganic chemicals of low toxicity

(2) Inorganic chemicals with toxic heavy metals/compounds

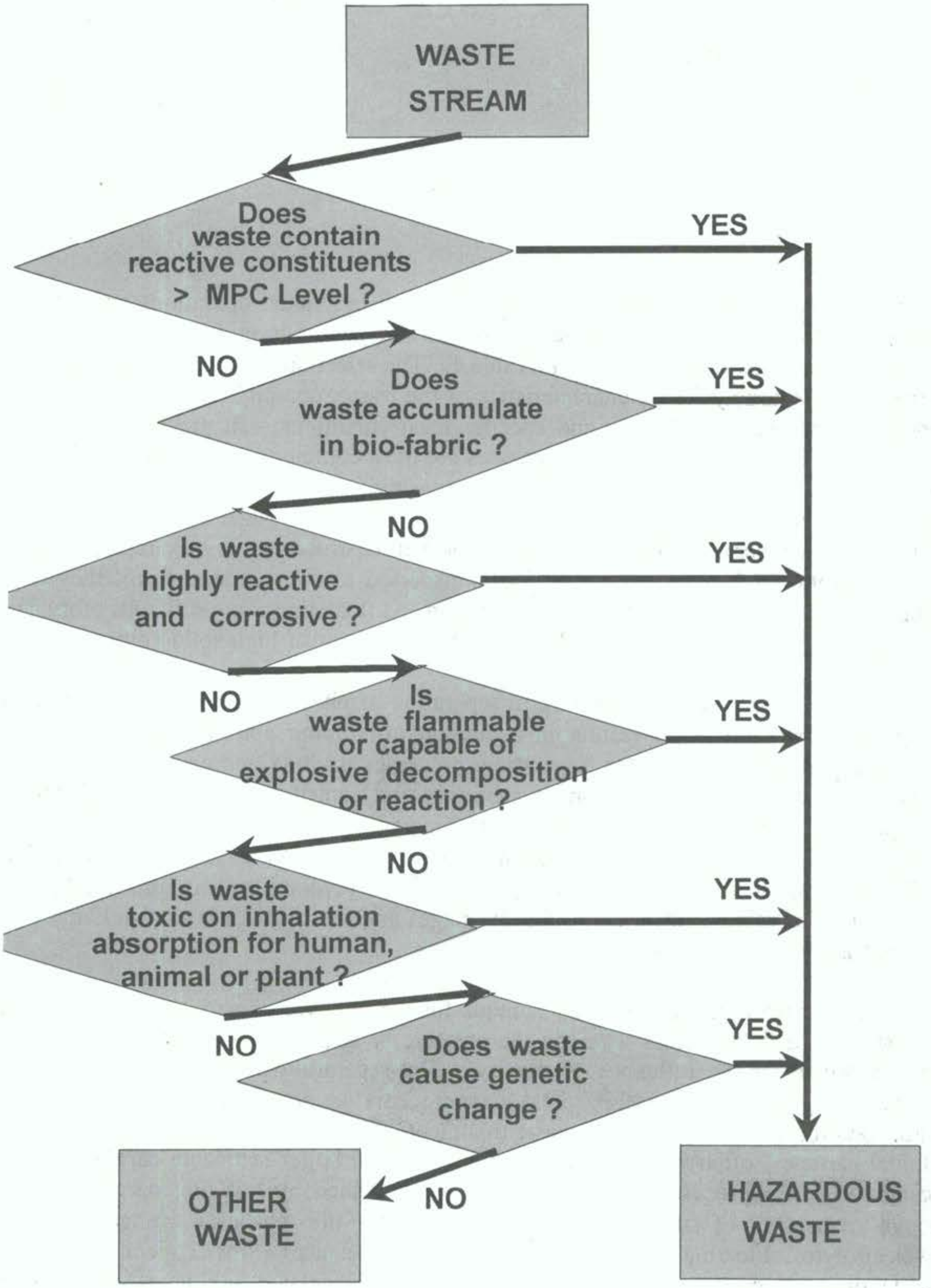


Fig. 1 Flow chart for hazardous waste screening.

(3) Organic chemicals of low toxicity

(4) Organic chemicals with toxic heavy metals/compounds

(5) Radiological wastes

(6) Biological wastes

(7) Flammable wastes

(8) Explosive

and thermal operations and processes. The common individual operations and processes under each category used for treatment of different types of hazardous wastes have been listed by numbers, as labelled above, in Table 1. The selection of the appropriate treatment options depends largely on the characteristics of the waste, quantity of the waste, technical, economic, environmental factors and specific local conditions. In practice the physical, chemical and thermal operations and processes are most commonly used options. Biological processes are used less often because of their sensitivity to operational and environmental conditions. The treatment of hazardous wastes can be accomplished by physical, chemical and biological conversation of the materials, not their destruction. For example, metals are converted from a soluble to insoluble form, dispersed to concentrated form, they do not disappear. Similarly sedimentation, centrifugation and floatation convert liquids of moderate solids content into effluent of low solid content and sludges of high solid content.

Physical processes are effective in separation of phases and components of wastes. The phase separation often results in reduction of volume and makes the subsequent operations simpler. The phase separation processes include sedimentation, floatation, flocculation-sedimentation, filtration, evaporation and centrifugation. The application of these processes can be very effective in the separation of organics and inorganics from aqueous media, removal of heavy metals and recovery of oils and solvents as shown in Table 1. The component separation commonly used include reverse osmosis, ultrafiltration and adsorption. The relative advantages, disadvantages and limitations of the common physical processes are shown in Table 2.

Sedimentation is an effective technique for the removal of settleable solids from the waste stream. It is a process whereby the unstable or destabilized suspended particles are settled down under the influence of gravity. The separation of contaminated suspended particles by gravitational settling in aqueous media is an example of application of sedimentation process in hazardous waste treatment. The agglomeration of stable small and colloidal particles, often with the help of chemicals into larger settleable particles is called flocculation. The process of flocculation is accomplished by bringing particles together through reduction of surface charge or bridging the particles using long chain polyelectrolytes. Floating process is used to separate substances of tower specific gravity and volatile organic components. Plain sedimentation, flocculated sedimentation, floatation processes as shown in Table 1 have wide applications in hazardous waste treatment. The process of filtration is used to separate suspended solids from a liquid by entrapping in granular media or to remove liquid from sludges in sludge dewatering.

Table 1

Treatment Processes Suitable for Different Types of Wastes

Operations/Processes	Functions performed	Type of Wastes	Forms of Wastes
PHYSICAL TREATMENT			
Solidification/Encapsulation	St	1,2,3,4,5,6	L,S.
Floatation	Se	1,2,3,4	L
Carbon Absorption	Vr,Se	1,3	L,G
Stripping	Vr,Se	1,2,3,4	L
Sedimentation/Floatation	Se,Vr	1,2,3,4,5,7	L
Centrifugation	Se,Vr	1,2,3,4,5	L
Floculation/Settling	Se,Vr	1,2,3,4,5	L
Filtration	Se,	1,2,3,4,5	L
Reverse Osmosis	Se,Vr	1,2,3,4,6	L
Evaporation	Se,Vr	1,2,3,4,5,6,7,8	L
CHEMICAL TREATMENT			
Neutralization/Precipitation	De	1,2,3,4	L
Coagulation/Sedimentation	Se,De	1,2,3,4,5	L
Ion exchange	Se,De	1,2,3,4	L
Chlorination/Ozonation	De	1,2,3,4	L
Oxidation	De	1,2	L
BIOLOGICAL TREATMENT			
Waste Stabilization Ponds	De	3	L
Aerated Lagoon	De	3	L
Activated Sludge	De	3	L
Trickling Filter	De	3	L
Anaerobic Digestion	De	3	L
Anaerobic Filtration	De	3	L
THERMAL TREATMENT			
Incineration	Vr,De	3,4,5,6,7	S.L.G.
Pyrolysis	Vr,De	3,4,6	S.L.G.

Functions: *De - Detoxification; Se - Separation; St - Storage; Vr - Volume Reduction*

Waste Type: *1. Inorganic chemicals of low toxicity; 2. Inorganic chemicals with toxic compounds; 3. Organic chemicals of low toxicity; 4. Organic chemicals with toxic compounds; 5. Radiological; 6. Biological; 7. Flammable; 8. Explosive*

Waste Form: *S - Solids; L - Liquids; G - Gaseous*

Table 2

Advantages, Disadvantages and Limitations of Physical Process

Processes	Advantages	Disadvantages	Limitations
Solidification/ Encapsulation	application to many solid, semi-solid and liquid wastes	Not completely immobile and nonreactive	Not effective for all wastes
Carbon Absorption	Very effective application to many organics and inorganics that do not respond to other treatment	Regeneration & disposal of spent carbon required high operation and maintenance costs	Many inorganics and some organics are poorly absorbed
Stripping	Well understood and effective	Air control required	Application only to relatively volatile organic contaminants
Sedimentation/ Centrifugation/ Floatation	Well understood and inexpensive	Generates sludge & scum for disposal	Not applicable for soluble and colloidal solids
Filtration	Low cost	Requires pretreatment	Not effective for many constituents
Reverse Osmosis	High removal potentials	Pretreatment required, produces sludge for removal, expensive	Waste flow and composition affect performance
Flocculation/ Settling	Low cost	Produces sludges for disposal	Not effective for many constituents
Evaporation	Applicable for all waste types	Energy intensive	Solar evaporation is weather dependent

Solidification is a process used to entrap or encapsulate highly toxic and hazardous wastes and render them chemically non-reactive or immobilize before disposal in landfill and deep mines or store them in convenient locations. The additive used in solidification process include cement,lime, bitumen, polyethylene and organic polymers.

The reverse osmosis process makes use of semipermeable membranes to separate components of a solution. The membranes are permeable to the solvent but impermeable to most organic and organic dissolved solutes.

Chemical and Thermal Processes

Many hazardous wastes are chemically treated to effect detoxification, volume reduction and separation. The most common chemical processes are neutralization, precipitation, exchange, hydrolysis, oxidation and reduction. The thermal processes like pyrolysis are used to oxidize or hydrolyze many organic compounds into nontoxic products and incineration to convert all organics into gases and unburnable residues. The relative advantages, disadvantages and limitations of chemical and thermal processes are shown in Table 3.

The high acidic and basic wastes are neutralized before disposal to prevent damage to the environment or to prepare the wastes for subsequent processing and treatment. The term neutralization does not necessarily mean adjustment of pH to 7. It is simply the interaction of an acid with a base or vice versa to adjust the pH to limits specified by a regulation or required for subsequent treatment processes. Neutralization is commonly used for liquid waste but it can also be practiced for gases, solids and powders by dissolving them in suitable liquids. Precipitation is the process of partial or total transformation of substances in solution into solid phase. This is achieved by adding appropriate chemicals to the solution or changing temperature of a saturated or nearly saturated solution in the direction of decreased solubility.

Oxidation, reduction and hydrolysis processes are very effective in detoxification of many hazardous wastes. Oxidation may be achieved by chlorination, zonation or using air at elevated temperatures. Incineration is the most effective process of volume reduction and detoxification applicable to all burnable wastes. Most of the organic toxic and hazardous compounds break down into gases and solid residues. The heavy metals present in the waste stream are unaffected by incineration and remain in the ashes which require safe disposal. The toxic compounds that decompose at high temperatures and vet materials may require additional fuel for burning.

Biological Treatment Processes

Biological treatment of some hazardous wastes are possible provided that the wastes are nutritionally balanced and the toxic elements or compounds present in the wastes are not at inhibitory levels. The limitations of biological treatment of hazardous wastes are as follows:

- The process is effective only in a narrow pH range

Table 3

Advantages, Disadvantages and Limitations of Chemical and Thermal Treatment Processes

Treatment Processes	Advantage	Disadvantages	Limitations
Neutralization/ Precipitation	Wide range of applications, low cost	Produce hazardous sludge for disposal	Complexing agents reduces effectiveness
Coagulation/Floculation/ Sedimentation	Low cost	Generate hazardous sludges for disposal, sometimes pH adjustment needed	Not effective for all constituents
Ion exchange	Can recover metal at high efficiency	Expensive pretreatment required	Not effective for all constituents
Wet air oxidation	Good for wastes too dilute for incineration, too concentrated or toxic for biological treatment	Oxidation not complete may produce new hazardous waste and require pretreatment	Moderate efficiency, poor destruction of many chemicals
Chlorination	Well understood, widely used, cause complete destruction of many chemicals	Produces chlorinated hydrocarbons	Interfering wastes limits application and effectiveness
Ozonization	Can destroy many organics	Oxidation not complete, can produce new hazardous products, high capital cost	Not effective for many wastes
Incineration	Destroy all organics	Generates toxic residues for disposal, causes air pollution, high cost	Requires moisture control, additional fuel for wet wastes or superheating for destruction of some toxic chemicals

- The microbial growth and reproduction is affected by nutrient deficiency of the wastes

- Certain toxic substances at low concentrations have inhibitory or lethal effects on microorganisms engaged in biodegradation.

- The possibility of producing equally or more hazardous intermediate products

- The microbes are unable to detoxify the heavy metals but many can incorporate item extracellular polysaccharides and proteins.

The conventional aerobic processes such as stabilization ponds, aerated lagoon, activated sludge, trickling filter, rotating biological contractors and anaerobic processes like anaerobic digestion and anaerobic filters as shown in Table 1 may be used for the treatment of hazardous wastes. Microorganisms genetically engineered to degrade hazardous and difficult wastes offer a promising area of development. Enzymes, as reported by Polprasert (1993), have good potential for fast degradation of toxic chemicals and hazardous wastes. An enzyme discovered in a stain of *Pseudomonas diminuta* is able to degrade methyparathion, paraxon, dursban, diasinon, cyanophos and other organo-phosphorous compounds. Some algae and higher forms of plants can absorb/adsorb heavy metals and toxic dyes from aqueous solution.

Stabilization ponds and aerated lagoons can be used to treat some dilute hazardous wastes. Some of the advantages of pond and lagoon systems include low operation cost, less sludge production. On the other hand, the systems require long detention time, large land area and have the possibility of release of odour. When stabilization ponds and lagoons are used to treat hazardous wastes, lining would be necessary to prevent pollution of ground water through percolation of hazardous wastes. Activated sludge process has the advantage of short detention periods, but short detention time is applicable only to hazardous compounds easily degradable by the process. Laboratory scale activated sludge units have demonstrated that the process is viable in terms of COD removal from waste containing phthalate esters, 2.4-dimethylphenol and 2.4-dinitrotrophenol (Tokuz 991).

The relative advantages, disadvantages and limitations of some biological processes are shown in Table 4.

The presence of heavy metals and other toxic compounds can have an adverse effect on microbial activity. Table 5 shows the threshold inhibitory concentrations for toxic elements on BOD removal in activated sludge process and anaerobic digestion of sludges.

The mechanism for the removal of dissolved and fine particulate metals in activated sludge process as proposed by Brown and Lester (1979) are:

- physical trapping of precipitated metals in the sludge floc matrix.

- binding of soluble metal to bacterial extracellular polymers.

- accumulation of soluble metal by bacterial cell.

Table 4

Advantage, Disadvantages and Limitations of Biological Treatment Processes

Processes	**Advantages**	**Disadvantages**	**Limitations**
Enzyme treatment	Can degrade many chemicals	Prohibitively high cost	Limited commercial application
Waste stabilization ponds	Low cost	Ground water pollution from unlined ponds	Toxic elements/ compounds limit biodegradation
Aerated Lagoon	Low cost treatment of some hazardous wastes	Produces sludge for disposal	Toxic elements of compounds may inhibit bacterial activity
Activated sludge	Used to detoxicate some hazardous wastes	Gaseous emissions may be hazardous, produces excess biological sludges	As above
Trickling filter	As above	Produces humus sludge for disposal	As above
Anaerobic processes	Low energy requirements	Produce sludges for disposal	Limited to few wastes, toxic wastes inhibit the processes
Absorption/ Adsorption on plants	Effective for heavy metals and toxic dyes removal	Requires safe disposal of plants	Use in experimental stage

Table 5

Inhibitory Concentrations of Toxic Pollutants
in Activated Sludge and an Aerobic Sludge Digestion
(from Anthony and Breimhurst, 1981)

Toxic Pollutants	**Threshold Inhibitory**	**Concentration**
	Activated Sludge	**Anaerobic Sludge Digestion**
Arsenic, mg/l	0.1	1.6(S)
Benzene, mg/l	100-500	--
Benzidine, mg/l	500	5(S)
Cadmium, mg/l	1-10	0.02(S), <20(T)
Carbon Tetrachloride, mg/l	--	10-20(S)
Chloroform, mg/l	--	10-16(S)
Chromium +6%, mg/l	1-10	5-50(S),110(T)
Chromium +3%, mg/l	15-50	50-500(S)
Copper, mg/l	1.0	1-10(S),40(T)
Cyanide, mg/l	0.1-5.0	1-2(S)
Lead, mg/l	1-5	340(T)
Mercury, mg/l	0.1-1.0	13-65(S)
Naphthalene, mg/l	500	--
Nickel, mg/l	1.0-2.5	10(T)
Nitrobenzene	30-500	--
Phenols, mg/l	50-200	--
Silver, mg/l	0.25-5.00	--
Toluene, mg/l	200	--
Zinc, mg/l	0.3-5.0	5-20(S),400T

- volatilization of metal to the atmosphere.

Trickling filers are used to treat wide varieties of toxic hazardous wastes. The industrial wastes successfully treated by activated sludge process include acetaldehyde. acetone, acrolein, benzene, chlorinated hydrocarbons, cyanides, formaldehyde, ketone, phenols, nylon and nylon intermediates.

Anaerobic processes have wide application in the treatment of industrial waste waters. In addition to anaerobic digestion, comparatively new anaerobic processes such as upflow an aerobic filters, anaerobic downflow stationary fixed film reactors, anaerobic attached film expanded bed reactors, anaerobic fluidized bed reactors, upflow anaerobic sludge blanked reactors have wide applications in industrial wastewater treatment. Toxic pollutants inhibitory to anaerobic sludge digestion and their threshold inhibitory concentrations are presented in Table 5. The denitrification process is used to convert nitrate into nitrogen gas biologically under anoxic condition. Denitrifying bacteria obtain energy for growth through decomposition of nitrate into nitrogen gas, but require a source of carbon for cell synthesis. Denitrification process can be carried out in both suspended growth and attached growth reactors. The other compounds that can be broken down by denitrification process include benzene, naphthalene, acenaphthalene and a wide range of related compounds (Cheremisinoff, 1990).

Disposal Options

There are various options for the disposal of hazardous waste but due to the characteristic nature of the waste none of the options can be considered completely safe for the environment. Considering difficulties in safe disposal of hazardous wastes, the unscrupulous producers in industrial countries tempted to sell hazardous wastes, products mixed with toxic wastes or to dump hazardous wastes with financial incentives into ignorant countries with serious consequences. International outcry against such activities has resulted in the "Basle Convention on Control of Transboundary Movement of Hazardous Wastes and their Disposal." It provides strict conditions and protocol on liability and compensation for the affected countries.

The common and conventional methods of storage and disposal of processed treated or untreated hazardous wastes are:

- On land in sewer or inland waters
- Ocean dumping
- Engineering storage
- Deep well injection
- Deep mine storage and disposal
- Land burial on landfill

The effluent from hazardous waste is permitted to be disposed of on land and in inland waters after satisfactory treatment. In such cases the concentration of pollutants must not exceed the effluent quality standard set by the country. The ocean is considered a sink for all forms of wastes and ocean dumping allows some degree of dispersion, but in case of hazardous wastes there exists controversy over the assimilation capacity of the ocean and this practice has come under greater restriction in recent years. Hazardous waste may be disposed off or stored in deep abandoned mines after immobilization but many countries in Asia-Pacific region do not have these facilities. Engineering storage after solidification or encapsulation does not guarantee immobility and nonreactivity over a long period.

There are continuing efforts to develop international criteria and controls on toxic chemicals and hazardous waste discharges into oceans. Therefore, additional demands for land disposal sites can be expected in future. Controlled landfilling methods may be used for disposal of limited amounts of hazardous wastes, but they are not suitable for the disposal of large quantities for:

- percolation of toxic liquid wastes to the ground water;
- dissolution of solid hazardous wastes by acid leachate from solid waste followed by leaching and percolation to the groundwater.
- undesirable reactions in the landfill that may lead to the development off explosive or toxic gases
- volatilization of hazardous wastes leading to the release of toxic or explosive vapour to the atmosphere
- corrosion of containers holding hazardous wastes.

Consequently, the selection of landfill sites, engineering design and operation of landfills for hazardous waste disposal must meet some special criteria.

A flow chart for treatment and disposal of specific hazardous wastes is shown in Figure 2.

References

Anthony, R.M. and Briemhurst. L.H., 1981: Determining maximum influent concentrations of priority pollutants for treatment plants; J. Wat. Poll. Contr. Fed.53 (10), 1457-1468.

Brown, M.J. and Lester, J.N., 1979: Metal removal in activated sludge: the role of bacterial extracellular polymers; Water Research, 13(9), 817-837.

Chremisinoff, P.N., 1990: Biological treatment of hazardous wastes, sludges and wastewater; Poll. Eng.22(6), 87-94.

Polbrasert, C., 1993: Hazardous waste generation, processing and treatment; Proc. of the workshop on Waste Management for Sustainable Development; Prince of Sonkla University, Thailand, 4-7 May.
Tokuz, R.Y., 1991: The response of activated sludge process to hazardous organic wastes; Hazardous Wastes & Hazardous Materials; 8(3), 245-256

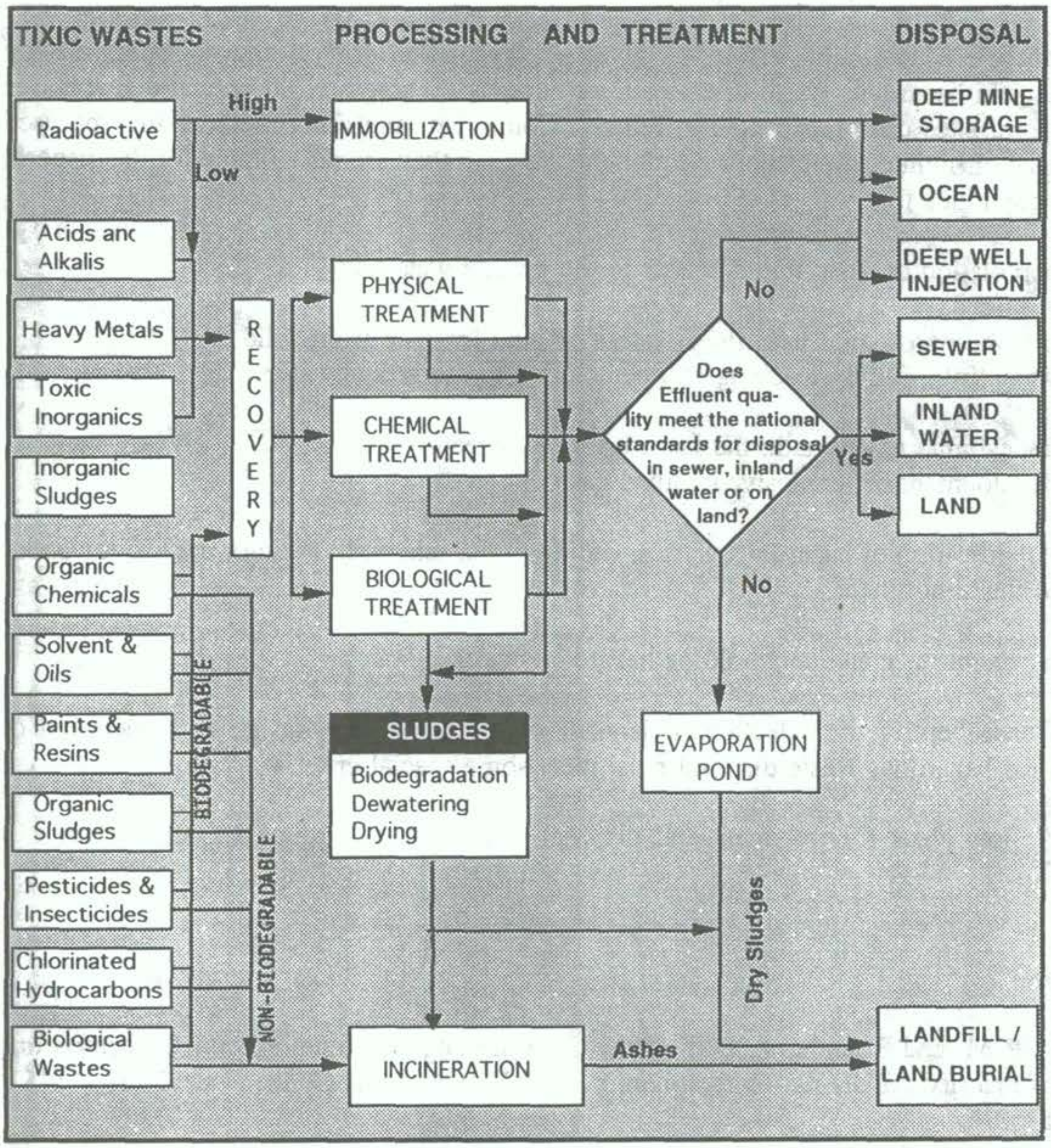


Fig. 2 Flow chart for treament and disposal of specific hazardous wastes.

ENVIRONMENTAL CHEMISTRY WITH REFERENCE TO WATER POLLUTION

Mohan Bickram Gewali
Central Department of Chemistry
Tribhuvan University
Kirtipur
Kathmandu
Nepal

Abstract

This presentation, which introduces fundamentals of water pollution, is addressed to tertiary level educators and trainers. The components covered are types and effects of water pollution, water quality parameters and waste water treatment. A case study of industrial effluents from Kathmandu based industries is also presented. The most effective method to communicate the contents will be classroom lecture. Overhead and slide projectors may be used.

Introduction

Nepal is in the early stage of industrialization. According to the 1988/89 census, the total number of industrial units is 2334. There are 12 industrial districts distributed throughout the Kingdom of Nepal, of which 3 are located in Kathmandu Valley. In spite of the early stage of industrialization, some industrially concentrated areas such as Kathmandu and Birat Nagar have already experienced air and water pollution from industrial effluents and air emissions.

Of all forms of pollution, water pollution seems to be the most serious one in Nepal. The major pollutants are sewage, industrial effluents and agricultural residues and chemicals. Sewage is essentially a domestic waste. Domestic waste and industrial effluents are discharged directly into rivers and streams. Pesticides, fertilizers and livestock also cause ground and surface water pollution.

Treatment plants within industries or industrial districts are virtually non-existent. As already mentioned, industrial effluents are discharged directly into river systems without treatment. Legal provisions seem to be inadequate and diffused. In this regard, it is worth mentioning a recommendation of the International Seminar on Water and Environment organized by the Nepal Chemical Society, Kathmandu, Nepal, March 30 April, 1994.

"We recommend His Majesty's Government to activate water and environment related agencies within the government and implement exiting laws on quality of water and monitoring of industrial effluents, without any compromise."

The Objective

This presentation will introduce types, effects, analysis and possible ways to control water pollutants. Emphasis will be placed on the problem of industrial effluents. This presentation is addressed to tertiary level trainers. It is expected that the materials covered in the presentation will assist the trainers to organize small workshops or seminars in the field of water pollution in their work place. It is noted that in our university system we still do not have formal education on environmental science. The trainers may or may not have adequate science background. In addition to materials of this presentation, the trainers are advised to consult any comprehensive, standard book on water pollution.

Methodology

I. Background in water pollution is provided with the following headings:
- Types and effects of water pollution;
- Water quality parameters;
- Water analysis methods and equipments; and
- Waste water treatment.

II. A case study of industrial effluents from Kathmandu based industries is presented.

III. In order to make the presentation interesting and to orient the subject matter to the participants, the following will be done:

- Old photographs of famous rivers like Bagmati river will be shown and compared with recent photographs;
- Relevant news items from home and abroad will be presented. One such example will be the following:

"Bagmati's Toxic Waters

The water of the Bagmati River which flows across the Kathmandu Valley has been found to highly toxic. According to an analysis of the Bagmati's water and soil, carried out by Mr. Surendra Gautam of the Department of Chemistry of Tribhuvan University at the Research Laboratory for Agriculture Biotechnology and Biochemistry and the Institute for Environmental Science, substances such as cadmium were found to be present in the water. Exposure to or consumption of water contaminated by this highly toxic heavy metal is hazardous to health. It especially affects vital organs such as the lungs, kidneys, liver, and heart."

IV. The most appropriate communication medium in the Nepalese context will be the class room lecture. Overhead and slide projectors may be used.

The Contents

Types and effects of water pollution

The following are the major types of water pollution:

I. Disease-causing wastes: These include bacteria, viruses, protozoa and parasitic worms which usually enter water from domestic sewage and animal waste. These pathogenic micro organisms cause widespread sickness and death in developing countries.

II. Oxygen-demanding wastes: These include domestic sewage, animal wastes, biodegradable organic compounds and industrial wastes. These wastes are degraded by oxygen consuming bacteria resulting in depletion of dissolved oxygen (D.O.). A value of below 4 ppm of D.O. will indicate gravely polluted condition of the water.

III. Water soluble inorganic chemicals: These include acids, salts and compounds of toxic metals such as mercury, cadmium and lead. Their presence in high concentration will make water unfit for drinking. They are harmful to aquatic life. They depress crop yields and corrode equipment.

IV. Inorganic plant nutrients: They include water soluble nitrates and phosphates. They help to sustain algae and other aquatic plants which upon death and decay deplete dissolved oxygen. Depletion of dissolved oxygen is harmful for fish and other aquatic animals.

V. Organic chemicals: They include oil, gasoline, plastics, pesticides, cleaning solvents, detergents, and other water soluble and water insoluble chemicals. These chemicals are harmful to both humans as well as to aquatic animals.

VI. Sediment or suspended matter: They include insoluble particles of soil, silt and other solid inorganic and organic materials that become suspended in water. They are the result of soil erosion by natural processes, agricultural development and mining and construction activities. They have profound effects on aquatic life. For example, the suspended particles hinder photosynthetic activity, make it difficult for aquatic animals to find food and clog the gills of fish. They also carry pesticides, micro-organisms, toxic metals and other harmful materials.

VII. Radioactive substances: They include radio isotopes which may cause DNA mutations, cancer and genetic damage.

Water-quality parameters

In order to know whether a body of water is polluted or not, a wide variety of tests to analyse water is performed. These experiments yield information on water quality parameters. The important water quality attributes are as follows.

Transparency - relates to colour and turbidity.

Turbidity - relates to the presence of suspended and colloidal substances of various origin;

Temperature - relates to the influence of human related factors on the quality of water (thermal pollution);

Electric Conductivity - relates to the presence of substances that dissociate into ions

pH - relates to acidity/alkalinity

Dissolved Oxygen

Biochemical Oxygen Demand (BOD) - relates to the measurement of oxygen required for the biological oxidation of water borne substances under specific test conditions

Chemical Oxygen Demand (COD) - relates to the measurement of oxygen equivalent of most organic materials in water

Nitrogen - relates to the presence of ammonia, nitrate, nitrite and kjeldahl nitrogen (ammonia nitrogen plus organic nitrogen)

Phosphorus

Heavy Metals - Toxic metals such as Iron, Manganese, Copper, Zinc, Nickel, Cadmium, Chromium, Arsenic and Mercury

Pesticides - relates to toxic substances used for the extermination of undesirable plant and animal organisms (weeds, parasites, pests of agricultural crops etc)

Water - analysis methods and equipments

The experimental methods used in water - analysis are given in a standard book called "standard methods for the examination of water and waste" 1985 (16th edition, APHA).

The following is the list of methods and apparatus /instruments for determination of major water quality parameters.

Parameters	Methods	Apparatus/Instruments
Specific conductance	Electrical	Conductivity bridge
Colour	Compared with standards comparator	Standard discs or colour solution
Turbidity	compared with turbidity	Meter requiring a source of electricity

pH	Electrical (or) compared with standards	Meter requiring a source of electric power, standard discs or coloured comparator
Sulphate	Titration	Ion exchanger and volumetric glass ware flasks and burette
Chloride	Titration	Volumetric glass ware flasks and burette
Nitrate	Colour development with absorption measurement	UV-Visible spectro-photometer, volumetric glassware
All forms of phosphate	Colour development with absorption measurement	Autoclave, volumetric glassware and spectrophotometer
Inorganic nitrogen	Colour development with absorption measurement	Volumetric glassware and spectrophotometer
Total kjeldahl nitrogen	Digestion and titration	Kjeldahl apparatus and volumetric glassware flasks and burette
Dissolved Oxygen	Fixation and titration	Sampling bottles and volumetric glassware flasks and burrete or by battery operated DO meter
Biochemical Oxygen Demand (BOD)	Incubation and titration	Electrically operated incubator volumetric glassware flasks and burette

Chemical Oxygen Demand (COD)	Refluxing and titration	Flasks and reflux condensers, volumetric glass ware-flasks and burettes
Total hardness	Titration	Volumetric glassware flasks and burette
Calcium	Titration	Volumetric glassware flasks and burette
Magnesium	By difference between total hardness and calcium	None
Sodium and	Flame emission	Flame emission Potassium requiring electric power
Heavy metals	Chemical complexes are formed and extracted from the aqueous phase by organic solvents to increase sensitivity and enhance atomic selectivity	Atomic absorption spectrophotometer
Pesticides, herbicides and other compounds	Extraction for aqueous media to organic solvent with subsequent organic solvent with subsequent Clean up and drying of solvent phase, then injection into a gas chromatograph	Paper, column and thin layer chromatographic equipment Gas chromatograph

Waste water treatment

a) Primary treatment:

Waste waters are passed through screen to filter waste such as sticks, stones and rags. Suspended solids are allowed to settle down as sludge in sedimentation tank. Sedimentation aids usually mechanical flocculation and chemical coagulation.

b) Secondary treatment:

Micro organisms are used to degrade the dissolved and colloidal organic matter of the waste water. Two commonly used biological treatments involve trickling filters and activated sludge process. Trickling filters consist of a large vat bed containing usually crushed stones and gravels impregnated with micro organisms. As the waste waters are sprinkled through the entire bed, organic materials are absorbed and subsequently degraded by the micro organisms. The second method, namely the activated sludge process, involves mixing waste water with micro-organism rich sludge. After degradation of the organic materials, the waste water is allowed to settle out. Secondary treatment removes BOD up to 90%.

c) Tertiary treatment:

This is the final process of waste water treatment. The left over from the earlier treatments, such as fine suspended solids, micro-organisms, dissolved inorganic solids and traces of organic, are the targets of tertiary treatment. Various specialized physical and chemical processes are involved in tertiary treatment. Some of the methods use involved processes like ion-exchange, adsorption, electrodialysis and electrolytic recovery.

Case Study

We will examine a real life example of problems of industrial effluents. We will describe the results obtained from analysis of industrial effluents from Kathmandu Valley based industries. First, the analysis of industrial waste waters from Balaju Industrial District (BID) is presented. Situated about 3.5 km. north west of Kathmandu City, BID is one of the oldest and busiest industrial districts of Nepal. Next, attention will be directed to effluents from a Brewery industry, a Tannery industry and a Dyeing industry. Brewery and Dyeing industries are located in Godavary and Gwarko of Patan. The Tannery industry is situated in Bansbary of Kathmandu.

For BID waste water studies, six sampling sites were chosen, four (S-1, S-2, S-3 and S-4) from inside the industrial district and the other two, one at industrial water supply (S-0) and the second where waste water enters an irrigation canal (S-6). Samples were collected on August 1, 1991, November 1, 1991 and April 1, 1992.

For the Brewery Tannery and Dying waste waters, samples were collected from exit points. From these points the effluent ultimately enters into the river system. Samples were collected on Jan. 1, 1994 and March 7, 1994.

Table 1 summarizes results of chemical analysis of BID effluents. Our results will be compared with tolerance limits for inland surface waters receiving industrial effluent in Nepal, recommended by Nepal Bureau of Standard and Metrology (NBSM).

Temperatures of the effluent in all three sampling sets were within the tolerance limit set by NBSM.

All samples showed alkaline pH. The pH of samples at sites S-3, S-4 and S-5 in all

Table 1

Results of Chemical Analyses of Effluents from Balaju Industrial District

SN	Parameters	First Sampling 1st August 1991						Second Sampling 1st November 1991						Third Sampling 1st April 1992						Standard Specification			
		S	S1	S2	S3	S4	S5	S	S1	S2	S3	S4	S5	S	S1	S2	S3	S4	S5	Nepal	India	EEC	B'desh
1.	Physical Appearance	Slightly Dirty	Milky	N	Coloured Dirty	Coloured Dirty	Dirty	Clear	Milky	Milky	Coloured & Dirty	Coloured & Dirty	Dirty	Clear	Milky	Milky	Dirty	Coloured & Dirty	Dirty	-	-	-	-
2.	Temperature °C	26	28	O	28	28	28	16	21	21	21	21	20	24	27	25	28	27	26	< 40	< 40	< 38	ΔT + 3
3.	Conductivity µs/cm	435.0	463.0	T	792.0	827.0	789.0	234.0	596.0	386.0	424.0	559.0	626.0	200.0	356.0	510.0	1140	1157	685	-	-	-	-
4	pH	7.70	7.90		9.80	9.90	9.20	9.0	9.50	8.4	11.0	12.0	11.80	7.90	7.80	7.90	9.20	10.0	9.50	5.5-9.0	5.5-9.0	6-9.0	5.5-9.5
5.	D.O mg/l	5.81	1.01	E	3.12	2.17	1.60	5.25	1.21	1.00	2.72	2.56	2.85	5.15	1.12	1.20	3.42	2.36	3.00	-	-	-	-
6	COD mg/l	76.03	874.0	N	294.7	304.1	262.0	32.19	814.0	812.0	480.0	504.0	476.0	24.08	928.0	924.0	284.0	288.0	268.0	250.0	250.0	160.0	20.0
7.	BOD mg/l	36.25	364.2	O	123.3	142.1	128.1	14.09	397.1	387.2	232.9	266.0	221.0	10.78	451.0	439.3	416.0	239.16	127.4	30.00	30.00	40.00	20-100
8.	Nitrogen-Ammonia mg/l	0.58	1.74	U	6.39	5.23	10.56	0.75	2.28	7.28	7.18	11.20	11.91	0.67	2.54	7.15	6.61	9.51	12.78	50.00	50.00	15.00	-
9.	Nitrogen-Nitrate, Nitrite mg/l	0.97	1.15	G	3.87	1.91	2.96	1.12	2.36	2.56	2.80	2.14	2.18	1.29	1.16	2.15	1.45	2.89	2.50	-	-	-	-
10	Phosphorus as Orthophosphate mg/l	0.16	2.08	H	0.84	0.56	0.81	0.24	2.25	1.76	0.54	0.62	0.69	0.26	3.01	2.89	0.76	0.59	0.86	-	-	0.50	-
11	Alkalinity mg/l	101.1	187.3		345.4	319.2	272.7	60.62	45.46	85.65	212.1	363.0	191.9	80.82	52.52	113.1	614.1	533.46	250.4	-	-	-	Slight
12	Cd** mg/l	<0.02	<0.02	E	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	-	<0.02	-	-	-	-	-	-	2.00	2.00	-	-
13	Cu ** mg/l	<0.1	<0.1	F	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	3.00	3.00	0.10	0.10
14	Pb **mg/l	<0.2	<0.2	F	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.10	0.10	0.20	0.20
15	Zn ** mg/l	0.05	0.30	L	0.10	0.15	0.10	<0.2	1.00	1.20	1.00	-	<0.2	<0.2	<0.2	0.40	0.40	<0.2	<0.2	5.00	5.00	0.50	0.10
16.	Ni ** mg/l	<0.1	<0.1	U	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	3.00	3.00	-	-
17.	Ca mg/l	52.88	57.87	E	32.84	44.05	38.84	13.53	64.64	67.64	83.67	-	22.55	-	-	-	-	-	-	-	-	-	-
18.	Mg mg/l	4.13	2.87	N	4.13	4.61	4.13	2.43	6.83	13.68	17.94	-	2.94	-	-	-	-	-	-	-	-	-	-
19.	Fe mg/l	1.80	1.60	T	1.40	3.20	2.20	0.40	6.40	11.80	21.80	-	1.60	3.60	3.20	2.60	1.40	0.40	<0.2	-	-	2.00	-
20	Cr ** mg/l	<0.1	<01		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0 1	<1.0	0.1	2	-	-

** Upto reported limit, the concentration of metal not detected.

three sets exceeded the tolerance limit (ph 5.5 - 9.0) proposed by NBSM. Except for the source samples, all other samples had low DO value, the lowest being 1.0 mg/1 in site S - 2 (Nov. 1, 1991).

The tolerance limits for Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) for industrial effluent discharged into inland surface water, as proposed by NBSM, are 250 mg/l and 30 mg/1, respectively. With the exception of source water samples, COD and BOD of all other effluent samples exceeded the tolerance limits set by NBSM.

All effluent samples for the three sets showed nitrogen ammonia less than the tolerance value set by NBSM.

Metal concentrations (Cd, CU, Zn, Ni, Cr) were found to be within the tolerance limit set by NBSM. In case of Pb, however, the detection limit of the available AAS is higher than the safety standard of NBSM. Therefore, we are not in position to tell anything this metal.

In conclusion, the present study reveals that BID effluents are alkaline and rich in organic waste. Trace metals offer no problem.

Table 2 contains results of chemical analysis of the effluents from Brewery, Tannery and Dyeing industries.

The temperature of Dyeing waste water needs special mention. The temperatures of Dyeing waste were 87 C (Jan. 1, 1994) and 78 C (March 7, 1994). Both these temperatures far exceeded the tolerance limit set by NBSM.

The pH of the effluents from the Tannery in both sets at Brewery (March 7, 1994) exceeded the tolerance limit set by NBSM.

Nitrogen-ammonia of Tannery waste waters in both sampling sets exceeded the tolerance limit recommended by NBSM.

Metal concentrations (Cu, Ni, Zn. Pb, Cd) in these three effluent samples were within the tolerance limits set by NBSM. Chromium concentration of Tannery and Brewery effluents, however, exceeded the tolerance limit of NBSM.

In conclusion, Brewery, Tannery and Dyeing waste waters are found to be rich in organic waste. The Dyeing industry discharges its waste water at elevated temperatures. Chromium concentrations in Brewery and Tannery waste waters were found to be higher than the permissible level set by NBSM.

Training Recommendations

I. If the trainers have some first hand experience of simple laboratory techniques their practical understanding makes them better trainers and educators. It is, therefore, recommended that some arrangement be made were a prospective trainer will spend

Table 2

Results of Chemical Analyses of Effluencts from Brewery, Tannery and Dyeing Industries

		FIRST SAMPLING SET JAN 1, 1994			SECOND SAMPLING SET MARCH 7, 1994		
SN	PARAMETERS	BREWERY	TANNERY	DYEING	BREWERY	TANNERY	DYEING
1	Physical Appearance	Turbid White	Reddish green	Turbid red	Turbid White	Blueish	Brownish black
2	Temperature 0^0C	15	14	87	24	16	78
3	pH	6.4	11.2	5.4	11	11.4	6.9
4	Conductivity µs/Cm	220	5150	1390	769	9800	1617
5	DO mg/l	5	-	0	4.7	-	0
6	COD mg/l	>980	>980	>980	368	>980	>980
7	Total Solid mg/l	560	5146	1484	1080	8760	1630
8	Dissolved Solid mg/l	540	3922	1310	360	8550	1010
9	Suspended Solid mg/l	20	1224	174	720	210	620
10	$N-NH_3$ mg/l	4.5	99.6	14.6	4.5	82.8	8.9
11	Nitrogen nitrite mg/l	5.6	414.4	10	50.4	7.8	8.9
12	Phosphorous mg/l	<0.25	1.25	6.25	0.50	0.25	0
13	Cu mg/l	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1
14	Ni mg/l	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1
15	Cr mg/l	*<0.1	0.4	0.4			
16	Fe mg/l	*<0.1	*<0.1	1.2	0.8	4.8	0.7
17	Zn mg/l	0.1	*<0.1	0.15			
18	Pb mg/l	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1	*<0.1
19	Cd mg/l	*<.02	*<.02	*<.02			

*** Up to reported limit, concentration of metal not detected**

a short time (2 weeks - 4 weeks) in a university laboratory or government laboratory doing or observing simple analytical techniques.

II. The trainers should be well acquainted with local environmental problems. Suppose a trainer is from Birat Nagar and if he/she first presents water pollution problems from Birat Nagar, his/her presentation will be more meaningful. It is therefore, recommended that the prospective trainer should first study or research local environmental problems and have an adequate local environmental background.

Evaluation

The following methods of examination will be used: short answer questions and multiple choice questions.

LIST OF PARTICIPANTS

1. **M. Anwarul Islam (Mr)**
Deputy Director
Dhaka Division
Department of Environment
7/8 C Lalmatia
Dhaka 1207
Bangladesh
Tel: 880-2-312490, 310603
Fax: 880-2-813186

2. **M. Feroze Ahmed (Prof)**
Department of Civil Engineering
Bangladesh University of Engineering & Technology (BUET)
Dhaka 1000
Bangladesh
Tel: 880-2-502196(O) 860366(R);
Fax: 880-2-863026

3. **Tishya Chatterjee (Mr)**
Director
The Environment Protection, Training & Research Institute (EPTRI)
HUDA Complex
S.R. Nagar
Hyderabad
India
Tel/Fax: (91 40) 291 366, 290 399 (O) 247 244 (R)

4. **P.V.R. Subramanyam (Dr)**
205, "Aishwarya"
Apsara Apartments
Sreenagar Colony Post
Hyderabad 500 873
India
Tel: 91-40-228020
Fax: 91-40-291366

5. **Nilay Chaudhuri (Prof)**
Professor
Jadavpur University
Avenue House
#10E, 107 Southern Avenue
Calcutta 700 029, India
Tel: 91-33-765908
Fax: 91-33-2448139

6. **Soli J. Arceivala (Prof)**
Chairman
AIC Watson Consultants Pvt Ltd
Raheeja Centre
13th floor
Nariman Point
Bombay 400 021
Maharashtra
India
Tel: 91-22-2834052, 2843220, 2842076
Fax: 91-22-2040398

7. **T. Chakrabarti**
Scientist & Head
Toxic Waste Management Division
National Environmental Engineering Research Institute (NEERI)
Nehru Marg
Nagpur 440 020
India
Tel: 91-712-226026 (O), 522378 (R)
Fax: 91-712-222725, 229531

8. **K.V. Raghavan (Dr)**
Director
Central Leather Research Institute (CLRI)
Adyar
Madras 600020
India
Tel: 91-44-4912150 (O); 4914465 (R)
Fax: 91-44-4911589
Internet: clri@sirnetm.ernet.in

9. **D. Badgaa (Dr)**
Director
Institute of Chemistry
Academy of Sciences of Mongolia
Mir 54-26
Ulaanbaatar-51
Mongolia
Tel: 976-1-53133
Fax: 976-1-321401 (c/o Dr Ts Adyasuren)

10. **Devendra Wagley (Dr)**
Central Department of Chemistry
Tribhuvan University
Kirtipur
Kathmandu
Nepal
Fax: 977-1-226820 (c/o R.P. Shrestha, CEDA)

11. **Mohan Bickram Gewali (Dr)**
Central Department of Chemistry
Tribhuvan University
Kirtipur
Kathmandu
Nepal
Tel: 977-1-472862 (R)
Fax: 977-1-418551

12. **Ajantha Perera (Dr)**
Department of Zoology
University of Colombo
Colombo
Sri Lanka
Tel: 94-1-586868
Fax: 94-1-432641 (c/o Mr Aruna Perera)

13. **R.M.U. Senarath (Mr)**
Asst. Manager
Environment Department
Board of Investment of Sri Lanka
No. 14 Sri Baron Jayathilaka Mawatha
Colombo 1
Sri Lanka
Tel: 94-1-320080
Fax: 94-1-430512

14. **John Hay (Prof.)**
NETTLAP Network Coordinator
Environmental Science
University of Auckland
Private Bag 92019
Auckland
New Zealand
Tel: 64-9-3737599 Extn 8437
Fax: 64-9-3737470
Email: je.hay@auckland.ac.nz

15. **Jan Sveen (Mr)**
Senior Consultant
NORAD
2834 Hunndazen
Norway
Fax: 61170341

16. **Mahesh Pradhan (Mr)**
NETTLAP Project Officer
UNEP ROAP
UN Building
Rajdamnern Avenue
Bangkok
Thailand
Tel: 66-2-2881801
Fax: 66-2-2803829
Email: pradhan.unescap@un.org

17. **Joo-Hwa Tay (Prof)**
Head
Division of Water Resources & Transportation
School of Civil & Structural Engineering
Nanyang Technological University
Singapore 2263
Tel: 65-7995308
Fax: 65-7910676

18. **Fritz Balkau (Dr)**
Senior Programme Officer
UNEP Industry & Environment
Tour Mirabeau
39-43, quai Andre Citroen
75739 Paris Cedex 15
France
Tel: 33-1-44371450
Fax: 33-1-44371474

19. **Paul Clarey (Mr)**
Deakin University
662 Blackburn Road
Clayton
Victoria
Australia 3168
Tel: 61-3-2447381
Fax: 61-3-2447301

20. **G.V. Subrahmanyam (Dr)**
Additional Director
Ministry of Environment & Forests
Parayavaran Bhavan
New Delhi
India
Tel: 91-11-4364594
Fax: 91-11-4360678

21. **Lakshmi Raghupathy (Dr)**
Joint Director
Ministry of Environment & Forests
Parayavaran Bhavan
CGO Complex
New Delhi
India
Tel: 91-11-4361669
Fax: 91-11-4360678

22. **Toru Tamura (Mr)**
UNEP-IETC/GEC Cooperation Staff
UNEP International Environmental Technology Centre
2-110 Ryokuchi koen
Tsuramiku
Osaka
Japan
Tel: 81-6-9154592
Fax: 81-6-9150304

23. **G. Shkolenok (Dr)**
Scientific Affairs Officer
UNEP/IRPTC
Case Postale 356
CH -1219 Chatelaine
Geneva
Switzerland
Tel: 41-22-9799189
Fax: 41-22-7973460