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United Nations Industrial Development Organization
Department of Industrial Operations
Industrial Operations Technology Division

# CHEMICAL INDUSTRIES

## The technical assistance programmes in the sector of chemical industries

MARCH 1992

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The following selected papers are also available

Who's Who
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## INTRODUCTION

The Chemical Industries Branch has substantial resources for projects, a staff of highly qualified technical officers, together with competent administrative supporting staff, prepared to recommend technical assistance to developing countries in each of the areas described below in this paper. The Branch is involved in all phases of the technical cooperation projects, i.e.

- ♦ project identification
- ♦ techno-economic cost benefit analysis
- ♦ project design
- ♦ project document formulation
- ♦ project execution.

Depending upon the complexity of the technical cooperation project, costs may vary from US$10,000 or less to several million dollars.

### *ACTIVITIES*

The main activities of the programme include:

- ◘ Fielding industrially experienced senior staff members to diagnose the cause of problems occurring in various parts of the chemical industry and make unbiased recommendations. These staff missions can be either undertaken by a staff member alone or with the assistance of outside specialist consultants;
- ◘ Fielding teams of experienced experts to diagnose the cause of problems in industry and to advise Governments on process and technology selection and the conditions for the transfer of technology and industrial project implementation;
- ◘ Holding Seminars with participation of internationally reputed experts to advise the local chemical industry on how to overcome their existing problems, and inform them of useful and potentially profitable ways of expanding the local industry;
- ◘ Technical assistance projects to existing companies and institutions to assist them in developing new capabilities, new technologies, new products and applications for such products;
- ◘ Establishing new training and development institutions.

### *PROJECTS AIM AT*

The technical assistance projects to existing institutions and companies aim at the establishment of new institutions and involve:

- o Fielding of international experts to provide assistance in realizing the project objectives;
- o Training abroad through fellowships and study tours as well as on-the-job training under the guidance of international experts;
- o Provision of equipment including eventually benchscale or pilot plants where necessary;
- o Provision of technical literature and where required establishment of databases and information services, quality control and safety;
- o Economic Cooperation mong Developing Countries/Technical Cooperation among Developing Countries.

*FUNDS*

The main sources of financing UNIDO's technical assistance activities are the *funds allocated by the United Nations Development Programme* (UNDP), for which UNIDO acts as an executing agency. These funds are allocated to each developing country and region and normally programmed in cycles of five years.

The *Industrial Development Fund (IDF)* consists of voluntary contributions from governments and non-governmental organizations (including private enterprises), in local non-convertible and convertible currencies directly pledged to UNIDO. It was created to finance innovative, non-traditional industry-related projects of a pilot character with relevance to a large number of countries and with priority given to projects which will have a multiplier effect. Activities are restricted by the low general purpose convertible contributions, which is the only segment of the IDF that can be freely programmed.

UNIDO has taken a new initiative to include *Special Trust Fund schemes* as part of the special programmes and activities of the organization. The funds required for each project come either from the beneficiary of the UNIDO assistance in the developing country (in which case it is called *self-financed trust fund* project) or from a *third- party donor*, which may be a development finance institution, a governmental or non-governmental donor agency, an individual or a group of companies, or industrial associations. **The three major thrusts of the special trust fund programme are:**

- **direct support of manufacturing plants** in the developing countries for performance improvement, training, manpower development, maintenance and self-help programmes;
- **service to development finance institutions** in designing, formulating and implementing selected industrial projects, particularly in rehabilitation of plants, small- and medium-industry development, indigenous entrepreneurial development, training and technical cooperation among developing countries;
- **programme or project management service to donor agencies** in the design, formulation and implementation of programmes on selected priority objectives, e.g. integration of women in industrial development, enterprise-to-enterprise co-operation, procurement of goods and services, agro-industries and human resources development.

*THE CHEMICAL INDUSTRY*

Chemicals are essential to virtually all industries and to agriculture even though the chemical industry is often mistakenly associated with capital-intensive petrochemical complexes and the use of potentially dangerous and environmentally hostile processes and thus considerably unsuited for developing countries.

However, chemicals are needed for pharmaceuticals and medicines, housing and shelter, textiles and clothing, food production and food conservation, printing and communications. They are just as essential for developing as well as industrialized countries. Chemical products, such as soaps and disinfectants also play a role in improving public hygiene and thus in increasing life expectancy.

Not having a chemical industry can severely handicap a country's industrial development. It will have to pay a much higher price for the chemicals it needs than does a country with an efficient chemical industry. The cost of imported basic chemicals such as acids, alkalis, chlorine for water purification, fertilizers, solvents for paint manufacture, formaldehyde for resin manufacture, lubricating oils and insulating materials is often far higher than the cost of making the product in its country of origin and may be twice as high as in industrialized countries. This can put an insurmountable hurdle in the way of the development of quite simple industries which, with low labour costs, could be otherwise quite profitable.

For those countries fortunate enough to have a chemical industry it is essential that it does have a positive impact on the country's development. This means:

(1) Promoting the growth of industries which use the products of the chemical industry by encouraging and assisting their appropriate and efficient use;
(2) Ensuring the competitive operation of the chemical industry itself, i.e. making available the training of operators, engineers and managers and establishing well run libraries with databases. Also carrying out trouble shooting, and revamping or modernizing simple plants to maintain efficient operation.
(3) Ensuring that the chemical industry, and those industries using its products have a positive environmental impact and are operated safely.

The severe negative impact on the development of many developing countries, without an adequate chemical industry could be reduced in many ways. One way would be to investigate the possibility of setting up of chemical industry operations which are economical even if carried out on a small-scale. Among these are:

(1) the formulation and packaging of pharmaceuticals and pesticides, and production of some of the ingredients;
(2) the manufacture of drugs and medicines;
(3) the chemical related industries, such as soap, cleaning preparations and cosmetics, and
(4) the plastics products industry.

Developing countries can also be helped to improve the efficiency of chemical use by encouraging recycling, efficient product design and efficient plant operation. If it is profitable to use a labour-intensive process for cleaning and recycling plastic waste in an industrialized country, it is far more worthwhile in a developing country.

Careful thought by those individuals, responsible in part for economic growth in their countries, should be given to the development of the chemical industry. As a means of achieving this end the Chemical Industries Branch gives assistance on all aspects of planning and provides advice on a country's economic growth. These objectives are sought through working in partnership with those countries requiring to set up a chemical industry or to modernize the existing industry.

A. Tcheknavorian-Asenbauer
Head of Branch

## CHEMICAL INDUSTRIES BRANCH
**Head: Ms. A. Tcheknavorian-Asenbauer**

| | | |
|---|---|---|
| Mr. A.Atger | Industrial Development Officer | Assisting in the implementation of technical assistance projects |
| **PETROLEUM REFINERIES AND PETROCHEMICAL INDUSTRIES UNIT** | | |
| Mr.M.A.Youssef | Unit Chief | Petrochemical, polymers, plastic processing, additives to plastics, synthethic/carbon fibres and composites, rubbers, dyestuffs. |
| Mr. V. Bysyuk | Industrial Development Officer | Petrochemicals, plastics, paints and pigments and rubbers. |
| Mr. M. Derrough | Industrial Development Officer | Petroleum technology/refining operations, storage and distribution. |
| Mr. E. Puerto Ferre | Industrial Development Officer | Petrochemicals, plastics, lubricating oils, antioxidants, detergents. |
| **PHARMACEUTICAL INDUSTRIES UNIT** | | |
| vacant | Unit Chief | Biotechnology, formulation and packaging, quality control. |
| Mr. T.de Silva | Special Technical Adviser | Chemical technology of medicinal plants, essential oils. |
| Ms. M.Sanchez | Industrial Development Officer | Synthetic pharmaceuticals and fermentation products. |
| under recruitment | Industrial Development Officer | Biological products (enzymes, hormones bioactive substances, blood products) vaccines. |

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**AGROCHEMICAL INDUSTRIES UNIT**

| | | |
|---|---|---|
| Mr. B.Sugavanam | Unit Chief | Pesticides (insecticides, fungicides, herbicides, rodenticides,etc.) |
| Ms. R.Assumpcao | Industrial Development Officer | Pulp and paper, related chemicals, agricultural waste utilization. |
| Mr. I.Volodin | Industrial Development Officer | Inorganic chemicals, fertilizers (nitrogen, phosphorus, potash). |

**ENERGY AND BIOTECHNOLOGY UNIT**

| | | |
|---|---|---|
| under recruitment | Unit Chief | Energy and environment, biofuels, coal processing technology. |
| Mr. G.Ramsay | Industrial Development Officer | Microbiological industry operation, fermentation and enzymatic processes, water pollution control. |

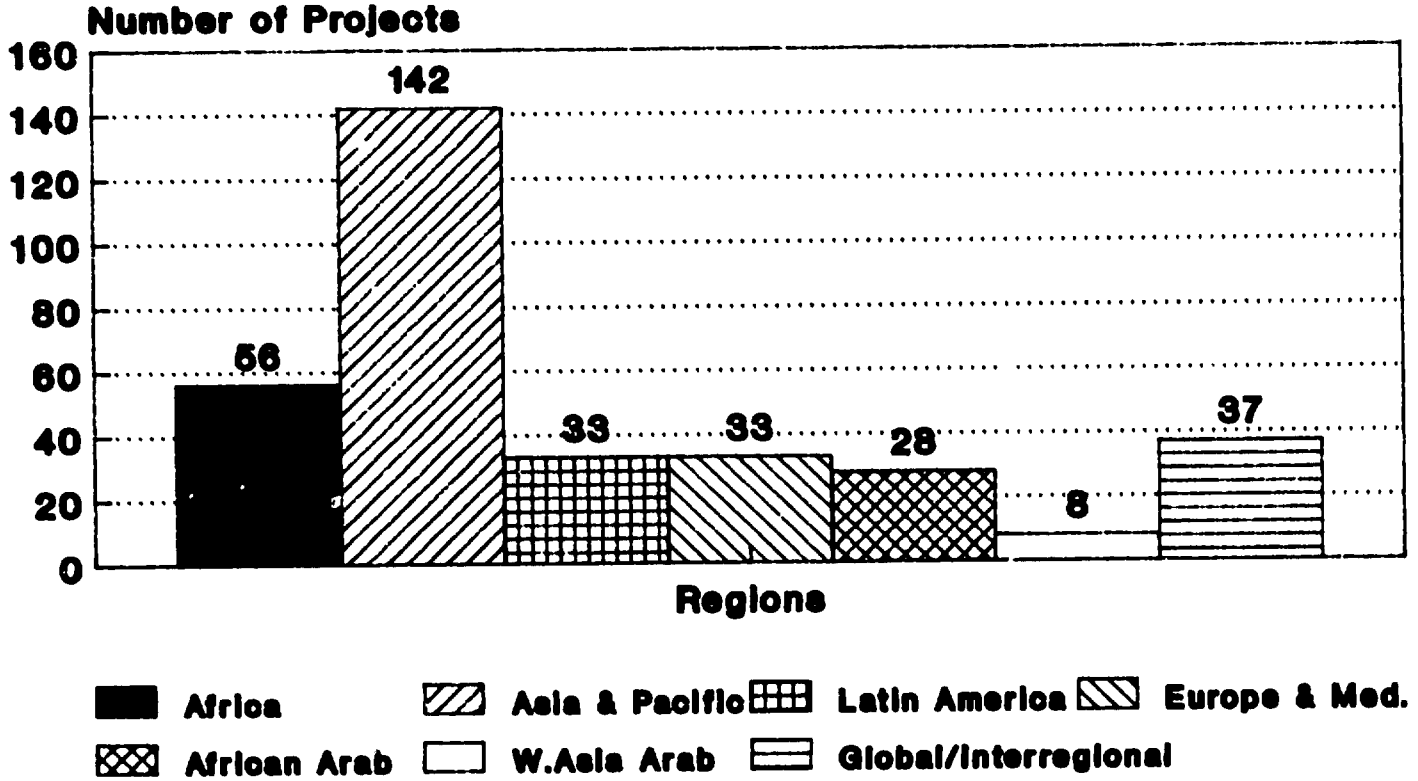
**CEMENT LIME AND CONCRETE BUILDING MATERIALS UNIT**

| | | |
|---|---|---|
| Mr C.Rydeng | Unit Chief | Cement and lime. |
| Mr. K.O. Hagan | Industrial Development Officer | Cement and lime. |

**NON-METALLIC MINERALS, CERAMICS, GLASS AND BUILDING MATERIALS UNIT**

| | | |
|---|---|---|
| Mr. N.Biering | Unit Chief | Non-metallic minerals, ceramics, glass, building materials, low-cost housing, construction industry. |
| Ms. S.Yalcindag | Industrial Development Officer | Non-metallic minerals, ceramics, glass, advanced ceramics, building materials and techniques, dimension stones, gemstones. |
| under recruitment | Assoc.Industrial Development Officer | Glass, ceramics and non-metallic minerals, raw material utilization,low cost building materials. |

# Projects within CHEM
## 1991




By Region

# BIOTECHNOLOGY

Biotechnology may be defined as the integrated use of biochemistry, microbiology and engineering sciences in order to achieve technological (industrial) application of the capabilities of microorganisms, cultured tissue cells, and parts thereof. This covers a vast area of very diverse industrial applications.

**PROGRAMME ACTIVITIES CAN ONLY COVER A LIMITED NUMBER:**

- Production of chemicals and biochemicals
- Production of microbial pesticides
- Energy - the production of fuels from renewable biomass sources using microorganisms
- Composting of the organic fraction of municipal waste
- Biochemical engineering
- Industrial waste water treatment. The core processes used for waste water treatment are usually biotechnology processes, though non-biotechnology operations are also included. The activities of the programme are broader then just the biotechnology operations, and include complete waste water treatment systems and studies of wastes from industrial zones. Furthermore, in line with UNIDO's environmental policy it is far more beneficial to consider waste production at the source through in-factory modifications rather than just considering end-of-pipe waste treatment. The activities of the programme also encompass this broader approach to industrial pollution control, particularly for fermentation and related industries.

**PROJECTS AIM AT:**

- The application of biotechnology processes to enhance the efficient use of the natural and agricultural resources of a country
- The application of biotechnology processes to reduce the environmental impact of industrial activities
- Selection of the most appropriate biotechnology process for a specific set of circumstances
- Development of processes on the laboratory and pilot plant scale
- Reduction of waste generation in factories through the promotion of efficient process technology and the use of in-factory optimization procedures
- Environmental monitoring and control

**PROJECT AREAS**

Examples of the areas covered by the programmes's activities are:

o ***Production of chemicals and biochemicals***

* Citric acid production;
* Enzyme production;
* Production of plastics from sugar cane via ethanol fermentation;
* Production of high value fragrance ingredients from natural compounds by biotransformation using plant cell culture;
* Production of industrial chemicals from indigenous carbohydrate raw materials;

o ***Production of microbial pesticides***

* Process development for microbial pesticide production;

o ***Energy***

* Construction of demonstration biogas plants treating various industrial wastes for evaluation of technical and economic viability and dissemination of the results;
* Enhancing institutional capability in the development and promotion of biogas technology;
* Ethanol production from renewable biomass sources;

o ***Composting of municipal solid wastes***

* Assessment of the viability of composting selection and adaptation of appropriate composting processes;
* Assistance with the design and construction of composting plants;
* Training in the operation, repair and maintenance of composting plants;
* Marketing of compost;

o ***Biochemical engineering***

* Development of novel bioreactors for specific processes;
* Membrane technology for water purification and down-stream processing;

o ***Industrial waste water treatment***

* In-factory waste audits to reduce waste production at source;
* Industrial discharge and ambient monitoring;
* Analysis of effluents;
* Planning of industrial development with regard to environmental aspects;
* Regulation and control of factory discharges;
* Appropriate waste treatment processes.

**TECHNOLOGY SELECTION**

In each of the above project areas there are a range of technology

complexity. In the field of biotechnology the options fall into two main groups, "traditional" biotechnology and "modern" biotechnology, the latter involving genetically manipulated organisms. Waste treatment processes, energy production systems and composting use traditional processes, though even here there is a range of options to be considered. For instance, in biogas production possible technologies range from the contact process to anaerobic fluidised beds. While the latter involves a far greater degree of complexity in design, construction and operation, it can have a volumetric efficiency (kg COD treated/m3 reactor/day) many times greater than that of the simpler systems. With chemical production the range of possible technologies is even greater. For instance, enzyme production can involve a simple extraction from material of plant or animal origin to the development and use of transgenic animals for this purpose. The technology chosen in any case will be the most appropriate for that particular situation, taking into account factors such as local capability in all aspects of process development and operation, local availability and costs of equipment, labour and materials, and the size and nature of the intended market for the product.

**PROJECT EXAMPLES**

Some of the projects being handled by the sub-unit are listed below:

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**Production of chemicals and biochemicals**

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Many developing countries have abundant biological resources, either indigenous or from agricultural activities, containing substances of potential value either through direct use or as raw materials for further processing. However, these are often not effectively utilized because local capability in recognizing and evaluating opportunities to utilize such resources is inadequate.

### 1) *Production of Citric Acid*

**Problem:** Many developing countries rely upon importation of important chemicals even though indigenous raw materials for their local manufacture are readily available. An example of this is the importation of citric acid into countries with resources of raw materials such as molasses, sucrose and sugarcane juice, from which citric acid can be made. However before local manufacture can be considered it is necessary to know accurately local production costs, and to have adequate local expertise in all aspects of the production process. Often these are not available.

**Project:** Assistance with the design, construction, installation, operation and evaluation of a pilot plant for the production of citric acid. The project inputs include training, the supply of specialized equipment and the fielding of experts in both citric acid technology and in feasibility studies. These activities will enable local skills in citric acid production, and in fermentation technology in general, to be enhanced, and the performance data generated from the operation of the pilot plant will allow the technical and economic feasibility of producing citric acid on the industrial scale to be evaluated.

2) *Production of Enzymes*

**Problem:** In many developing countries the by-products from industries processing biological materials contain valuable substances which are not effectively utilized because of lack of local knowledge and expertise. An example of this is the slaughterhouse industry, where discarded animal organs may contain valuable bio-active substances. One developing country, with assistance from UNIDO, has recognized such an opportunity and is exporting chemicals extracted from slaughterhouse by-products. The demand for these is so great that they are now considering ways of increasing the available quantity of these materials.
**Project:** Assistance with the establishment of a national research and development capacity in biotechnology to support the livestock by-product industry, and in particular to support an industry producing commercial quantities of enzymes and other products from the organs of slaughtered cattle. Recombinant DNA technology will be used to construct appropriate expression vectors as a first step to the mass production of enzymes in transgenic animals at a later stage, thus greatly increasing the quantities of enzymes available for purification and sale.

3) *Production of high-value fragrance compounds*

**Problem:** Even where developing countries are exporting products of biological origin, they often do not maximize the potential economic gain from this activity because their processing technology is inadequate or because they only partly process to a relatively low-value intermediate product, which is then further processed after export. More effective processing would maximize the economic gain to the country. A specific example of this is in a developing country where fragrance substances are being extracted from plant material. However because the extraction process is not efficient, many potentially valuable products are lost. Furthermore the extracted products are sold in a crude form, whereas further processing could greatly enhance their value.
**Project:** To optimize the extraction process currently being used, and to assist in the development of a plant cell culture process for transforming the current products into materials of much greater value.

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**Production of microbial pesticides**

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In order to ensure an adequate food supply in developing countries with their evergrowing population the use of pesticides is essential. However man-made pesticides have associated environmental concerns, and because of this reason there is increasing pressure for the use of alternatives such as bio-pesticides. Developing countries often lack expertise in development, production and use of bio-pesticides.
**Problem:** A scientific centre in a developing country has isolated and tested on the laboratory scale a promising bacterial strain for use as a microbial pesticide. However further development, and thorough testing of this strain requires expertise and resources not currently available in the country.
**Project:** To enhance the capability of the centre, through training, experts' services and supply of specialized equipment, to undertake strain assessment and the

products and production processes from the lab-scale to commercial production. The centre will act as a source of expertise for assessing, developing and promoting the development and use of microbial pesticides in the region.

## Energy

Biogas technology utilizes micro-organisms under anaerobic conditions to convert organic waste materials to methane which can be used as a fuel. Application of the technology can thus achieve two objectives: reduction of the pollution potential of the waste and production of a useful fuel.

**Problem:** While biogas technology has been widely implemented on the village scale in many developing countries, application for the treatment of industrial wastes, involving generally much larger and more complicated bioreactors, has been far more limited. This is owing to lack of technical expertise in large-scale biogas production in many developing countries and insufficient data on the economic aspects of it, both of which act as disincentives to wider-scale application. The UNIDO projects aim to address these aspects.

**Project:** The UNIDO projects in biogas production aim to assist selected factories (through training, experts's services and the provision of some specialized equipment) to build biogas plants to treat organic waste streams. These plants are then to be used for demonstration purposes to promote the technology. The properly-operating plants will allow an accurate assessment of their economic performance under local conditions to be made. This information can then be disseminated within the region to allow other factories to make a decision on the appropriateness of using biogas technology. The demonstration plants will also act as centres for training in all aspects of the technology. The UNIDO projects in biogas also include institutional building to increase awareness and capability in biogas technology at the national level.

## Composting of the organic fraction of municipal solid waste

In most large municipalities in developing countries the disposal of municipal solid wastes (MSW's) is a major problem. One partial solution to this problem is composting, whereby the organic fraction of MSW's is degraded by micro-organisms to produce a relatively stable humus-like material with value as a soil conditioner and fertilizer. This can be an attractive alternative to processes such as dumping, landfilling or incineration.

**Problem:** In order to properly assess the feasibility of operating a composting plant at any particular site considerable expertise in composting technology and in economic assessment of disposal alternatives is required. This expertise is often not available in developing countries.

**Project:** Assistance with the establishment of a composting pilot plant (through the provision of experts' services and on-site training), including process selection, plant design, plant construction and marketing of the product. The successful operation of the pilot plant will serve as a basis for broader-scale application of the technology.

## Biochemical Engineering

In order for any industrial biotechnology process to operate effectively it is essential that the design of the process equipment be made based on a thorough understanding of the specific system involved and the application of sound biochemical engineering principles and practices.

**Problem:** Many developing countries do not have sufficient expertise in biochemical engineering, and this may hinder the effective application of biotechnology processes.

**Project:** To raise the level of expertise in biochemical engineering within a national scientific institute. This institute will then serve as a centre of expertise for service to many areas of biotechnology including waste water treatment, the chemical industry and the pharmaceutical industry.

## Industrial Waste Water Treatment

In many developing countries the treatment of industrial waste water is inadequate, causing serious pollution problems. In many cases attempts to reduce this problem have focused on end-of-pipe waste treatment systems, rather than on firstly improving the efficiency of the factory processes so that waste production is reduced. The latter approach is generally less costly because it results in the more efficient use of raw materials and a reduction in the size of the waste treatment plant.

**Problem:** In many developing countries end-of-pipe waste treatment systems have been designed without adequate consideration of waste reduction at source as a preliminary step. Similarly, inadequate expertise in the design and construction of waste treatment plants has meant that those which have been built do not perform properly. Both of these situations have acted as disincentives to other factories to adopt pollution reduction measures.

**Project:** To conduct a series of intensive workshops in process optimization within demonstration factories for selected industrial sectors. Personnel from the region will be invited, and they will be trained in process optimization techniques aimed at reducing the volume of waste discharges from the factories. They will also be trained in appropriate waste treatment technology. They will then be expected to apply these techniques in factories in their own country, and to train other people. The project will also assist in defining appropriate discharge standards and will strengthen the capabilities of the institutions responsible for monitoring and control of industrial waste water production in the country.

# BIOMASS AND ENERGY

The biomass energy field is vast. Activities of the programme can therefore cover only a limited number of areas. These are: energy supply from biomass, production of alternative household and industrial fuels, and coal conversion processes.

**PROJECTS AIM AT:**

- Introduction and development of biomass energy systems for local heat and power supply;
- Development of alternative sources for charcoal production to release the current pressure on the environment;
- Development of environmentally sound coal conversion processes;

**PROJECT AREAS**

Examples of the biomass areas covered by the programme's projects are:

- ***Alternative power supply***
  - Gasification systems for power and heat using forestry or agricultural residues;
  - Steam systems for similar purposes
- ***Alternative household fuels***
  - Industrial charcoal production on basis of improved conventional systems;
  - Charcoal briquette production using newly developed technologies utilizing agricultural and agroindustrial residues.
- ***Coal conversion processes***
  - Processes for heat and power supply including gasification and combustion
  - Coal preparation processes
  - Conversion to chemical products

**TECHNOLOGY SELECTION**

In designing, formulating and executing these projects, suitable technologies are selected from a wide range of options.
It should be noted that in the field of biomass energy, systems tend to be very specific to input (biomass supply) and output (energy demand) characteristics. Careful design is required to match supply and demand and to produce energy or alternative fuel efficiently. Normally existing systems are

modified to suit local conditions, but sometimes it is necessary to develop completely new systems. The latter happened, for example, for the production of charcoal briquettes from cotton stalks, for which UNIDO experts developed a completely new technology that is now in successful operation in an African country.

**PROJECT EXAMPLES**

Some of the projects being handled by the programme are listed below:

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**Introduction and development of biomass energy systems for local heat and power supply**

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Apart from those who are fortunate to be able to utilize hydropower, most developing countries are very dependent on fossil fuel imports for their industrial and domestic energy supply. A situation which imposes a high burden on their fragile economies and which makes them very vulnerable to price increases. This has been the reason for a large number of countries to explore and develop renewable energy resources. While hydro-power remains a viable option for large scale energy supply, biomass energy systems offer a good option for small scale energy supply, in particular in cases where

(a) A combination of heat and power is required and
(b) Biomass resources (e.g. agricultural residues) are abundantly available.

In addition, biomass energy systems contribute positively to the reduction of carbon dioxide emissions and its impact on global warming, if re-planting is carried out

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**Use of Rice Hulls For Energy**

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**Problem:** Lack of expertise in a country to design, built, operate and maintain energy systems using rice hulls.

**Project:** Transfer of proven foreign technology for the gasification/combustion of rice hulls to interested entrepreneurs. This will be achieved through a semi-commercial demonstration of a selected process at a rice mill and subsequent dissemination of the major technical, economical and social results.

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**Development of alternative sources for charcoal production to release the current pressure on the environment**

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In most developing countries charcoal forms the main fuel for cooking in urban and sub-urban areas. The increasing demand for this product is one of the main causes for the continuing deforestation in these countries. This situation has created the need for developing alternative sources for charcoal production and one of the options is the use of agricultural residues. Mostly residues are burned directly after harvesting to prevent uncontrolled fires and diseases.

UNIDO has recently successfully developed a process for the production of briquettes from cotton stalks. The process, which uses equipment which can be constructed and maintained locally, involves carbonization, grinding and subsequent agglomeration of the produced charcoal fines with a suitable binder which is also from a local agro-processing waste. A plant using this technology is presently in operation and produces

briquettes with a marketable quality. There is a clear demand for the briquettes produced.

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**Production of Charcoal Briquettes**

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**Problem:** Lack of expertise and experience in a number of African countries in designing, manufacturing, operation and maintenance of charcoal production plants using cotton stalks.

**Project:** Assistance to local development centres and entrepreneurs to develop suitable systems, set up pilot schemes, provide training to users and manufacturers, undertake market studies and develop activities for the further development and dissemination of the technology.

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**Development of environmentally sound coal conversion processes.**

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The use of coal as fuel for energy production is likely to grow in importance. This anticipated expansion in coal must be achieved in a means which is compatible with the increased concern about the environment.
Various gaseous and particulate emissions from coal fired plants have an environmental impact:

- oxides of sulphur and nitrogen: acid rain
- carbon dioxide: global warming
- particulates: air quality

In developed countries, pollution has been greatly reduced through the application of sophisticated measuring systems, modern and efficient combustion chambers and effective flue gas clean-up technologies. Yet, this has not been the case in most developing countries. Here, old inefficient combustion technology, inadequate maintenance and little or no pollution abatement still contribute to a host of respiratory problems.
A range of activities, including technical assistance, training of staff and management of power plants, and transfer of clean technologies, are urgently needed.

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**Reduction of Sulphur Compounds Emissions**

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**Problem:** The limited capability of a power corporation to control emissions of sulphur compounds from power generation stations using lignite fuel.

**Project:** Provision of specialist training and modern monitoring equipment, which enables the corporation to develop new operational procedures, thus considerably reducing the emissions of sulphur compounds.

# CEMENT INDUSTRY

The technical assistance programme in the cement industry focuses on developing local skills and capabilities in order to eliminate the need for continuing assistance to routine maintenance and operation of equipment. The cement programme provides technical advice and gives development support to the cement industry in the developing countries, either directly or in co-operation with other UNIDO programmes. The technical assistance programme in the cement industry is involved in all phases of technical co-operation.

**PROJECTS AIM AT**

- Trouble shooting
- Training of personnel
- Improved capacity utilization
- Use of fillers and extenders (pozzolanic materials)
- Energy saving
- Pollution abatement
- Application of waste fuels
- Market surveys
- Feasibility studies
- Modernization and improvement of installations.

**USING TECHNOLOGIES**

- Quarrying
- Crushing
- Blending
- Grinding
- Homogenization
- Preheating and calcination
- Clinkerization
- Cooling
- Milling
- Packing

**PROJECT AREAS**

Support activities aim at making full use of the available cement plant installations, with the help of trouble shooting activities designed to identify and solve technical problems in order to promote full capacity utilization. Such activities have been promoted since 1978 and help local teams to make maximum use of their installations.
Where cement demand is on the increase, participation in market surveys and development forecasts are used in the elaboration of pre-investment studies for new production lines.

***Environment and energy saving***

Cement kilns are recognized as safe and effective digesters of various

types of combustible industrial waste. Many cement factories in the developing countries are, however, not qualified for burning waste because their present operation is not well controlled and the excessive emmission, long travelling dust and fumes practically prevent their taking part in recycling.
Therefore, the technical assistance programme in the cement industry is engaged in promoting clean and environment friendly operation of cement plants as well as promoting the use of waste fuels which eventually would help to conserve virgin fuel.

**TECHNOLOGY SELECTION**

To improve technology in the cement industry, the programme is engaged in:

- Rehabilitation of factories, and
- Conversion of factories:
  - from one process technology to another (from wet to dry or semi-dry process),
  - the conversion of firing systems involving change of fuel (the change from oil to gas, or coal firing systems to systems involving a combination of fuels e.g. mixed firing systems and the use of waste fuels).

# LIME INDUSTRY

The technical assistance programme in the lime industry focuses on promoting a first breed of energy efficient small scale industrial lime plants.

**PROJECTS AIM AT**

- Raw material and market studies
- Design of plant installations
- Feasibility studies
- Construction of small plants
- Training of personnel
- Improvement of existing installations.

**PROJECT AREAS**

We are still only at the initial stage of promoting small industrial lime installations, as an alternative to traditional technology. Modern industrial installations, in small scale save energy, reduce pollution and produce lime of the same quality as state-of-the-art large scale industrial plants.

The application of pozzolanic materials or the promotion of lime-pozzolanic binders is seen as an important contribution to protect the environment, and the development is being promoted with the technical assistance and dissemination of information whenever possible.

## TECHNOLOGY SELECTION

Attention is also given to improve traditional technology in order to avoid pollution and excessive consumption of fuel. The traditional artisan technology with high fuel consumption and variable product quality has not yet been abandoned owing to its lower investment requirements as compared to modern technology.
Therefore, UNIDO disseminates information on modern (small scale) technology and explains the need for product quality and low fuel consumption.

## PROJECT EXAMPLES

### Fact finding and trouble shooting missions

**Problem:** Somey cement factories experience technical problems for various reasons, ranging from an over-regulated price setting and very limited resources for the procurement of spare parts, to technical and financial shortcomings in the management

**Project:** In order to assist such factories in overcoming their problems at the lowest possible cost, UNIDO has, on several occasions, sent fact-finding and trouble-shooting missions to advise on urgent repairs and help in strengthening the technical management.

### In-plant training

**Problem:** Cement factories in many developing countries are over-staffed, have no incentive payments and local experts are not sufficiently engaged in the efficient operation of their installations.

**Project:** Nearly all technical assistance to the cement industry has a spin-off in training. Several of UNIDO management assistance projects are designed as on-the-job-training activities to reduce and in the long-term to eliminate the need for continuing UNIDO assistance for routine operation and maintenance.

### Expert support to factory operation and maintenance

**Problem:** In many developing countries cement factories frequently experience that operational and maintenance experts leave for cleaner and better paid jobs. This is one reason for accummulating losses. A good capacity utilization with turn-overs above the break even point is the key to improvements with sufficient reserves for spare parts, services and new investments.

**Project:** The solution is to intensify technical management and training with the help of a UNIDO team of experts, which depending on the requirements can vary from five to hundred specialists. This type of assistance, financed by the clients under trust fund assistance, is rendered to cement factories in different developing countries and has proven its value since 1978. After technical

programme is completed, local experts are usually ready to take over all the duties.

## LINKAGES

The projects of the programme in the cement industry are implemented in co-operation with other operational units of UNIDO in order to help in increasing the efficiency of cement plants and in reducing the need for foreign assistance.

In co-operation with the Feasibility Study Branch, the cement programme is engaged in national and regional market surveys and diagnostic studies to identify the need for rehabilitation of existing cement factories and/or to identify the need for new factories. The positive opportunities identified on the basis of this cooperation are further promoted through preinvestment studies and promotional contacts with potential investors and suppliers.

# FERTILIZERS AND PESTICIDES

The technical assistance programme focuses on the safe and effective development of fertilizers and pesticides in developing countries taking into account the closed and confidential nature of the technology know-how especially in pesticides. Every effort is made to meet the challenge of making these chemicals safer, user and environment-friendly and to take steps for an overall reduction in their use through an integrated approach and without any reduction in efficiency. Today both fertilizer and pesticide industries are faced with stringent controls safety control. There is an urgent demand to control and reduce environmental risks especially effluents/emissions, groundwater contamination, residues in soil and food crops and the excessive use of toxic chemicals. The recent developments in fertilizer and pesticide technology in production, formulation and application have not yet reached many developing countries where still obsolete technology is applied. Also the use of hazardous chemicals and products that are banned or restricted in developed countries create health risks both for workers and end users. UNIDO projects on fertilizers and pesticides aim to maintain public health standards for the fast growing population and take into account the stringent requirements for human and environment safety.

**PROJECTS AIM AT:**

- Policy issues and market analysis
- Import substitution
- Technology transfer
- Pilot scale operation
- Good manufacturing practice
- Quality and safety
- Research and development
- Institution building for establishing demonstration plants and centres of excellence in specialized fields.

**IN THE AREAS OF**

- Mineral fertilizer production (macro-nutrients)
- Nitrogen
- Phosphate
- Potassium
- Organic fertilizers
- Organic/mineral fertilizer mixtures
- Micro-nutrients
- Pesticides
  insecticides, fungicides, herbicides, rodenticides, bio/botanical pesticides, plant growth regulators
- Safety in chemical production
- Effluent control/waste management

# FERTILIZERS

## PROJECT AREAS

The programme holds the primary responsibility for the following areas:

### Environmentally sustainable industrial development

- Issues related to production e.g. emission control, effluents, wastewater treatment;
- Issues related to the fertilizer application but yet to be tackled at the production stage, e.g., cadmium, heavy metals;
- Issues related to by-products disposal - phosphogypsum etc;
- Issues related to raw materials e.g. mining and beneficiation.

### Technology transfer

- Raw materials handling;
- Production of compound and liquid fertilizers according to the demand of agriculture including controlled release of fertilizers etc.

### Maintenance issues

- Corrosion handling
- Preventive and condition based maintenance
- Issues related to the proper performance of the chemical equipment working under pressure and vacuum
- Safety and risk assessment.

### Alternative sources of fertilization

- Organic matter as a fertilizer
- Organic mineral fertilizer mixtures
- Plant growth promoting substances.

### Policy issues and market analysis

- Economic policies, taxation, subsidies, market analysis, supply-demand and balances
- Calculation of production costs, issues of optimization and development of the fertilizer industry
- Role of the fertilizer industry vis-a-vis agriculture.

### Infrastructural development

- Transportation, distribution, logistics
- Industry support

### Human resource development

- Training programmes
  Individual fellowships
- Study tours

### Rehabilitation and restructuring

- The most significant accomplishments are achieved in the

exchange of statistics among UNIDO, The Food and Agriculture Organization (FAO), the World Bank and other institutions.

- Institution building and creation of National Fertilizer Centres; human resource development programmes; R&D in the fertilizer area; technical workshops, committees and seminars; pilot plant establishment and tests.

## LINKAGES

To meet the need of food supplies through the world there are linkages with the FAO and other International Organizations especially the World Bank, the Economic and Social Commission for Asia and the Pacific Fertilizer Advisory Network and the Pacific (ESCAP/FADINAP), the International Fertilizer Development Center (IFDC), International Fertilizer Industry Association (IFA), European Fertilizer Manufacturers Association (EFMA).

## PROJECT EXAMPLES

It is essential that the increasing of supply/demand of fertilizers and the coordination of activities are efficiently and promptly dealt with.

**Problem**: Sustainability of fertilizer industrial development as a major input to sustainable agriculture.
**Project**: Fertilizer strategies for Sustainable Agriculture and Environmental Protection - Steering Committee with UNIDO participation deals with environmental issues and sustainability of industrial and agricultural development.

**Problem**: Lack of environmental compliance in the fertilizer industry.

**Project A**: Activities aim at identifying the barriers towards achieving the sustainability of phosphate fertilizer production and establishing the minimum environmental compliance standards in the phosphate fertilizer industry resulting from recommendations of the fertilizer panel at the Ecologically sustainable Industrial Development Conference in Copenhagen, October 1991.
**Project B**: Activities aim at finding the ways and means of phosphogypsum disposal and minimizing the detrimental effects by proposing the ways for emission control and waste water treatment. Particular attention is given to the availability of heavy metals, iron and cadmium in the final product.
**Project C**: UNIDO has under the auspices of the Industrial Development Decade for Africa (IDDA) developed the Industrial Development Strategies for Fertilizer Industrial Systems in Africa on the basis of which countries were divided into a number of groups according to the identical patterns of the development of their fertilizer industries. At a later stage the programmes for the development of the fertilizer industry were elaborated for a number of countries.
**Project D**: A new strategy for changing the production pattern of the fertilizer industry is currently being worked out in a country in North Africa. At a later date that strategy should be used on a regional basis. It envisages the major shift from the production of straight to compound fertilizers.

**Problem**: Lack of experience for elaboration of proper policies for the development of the fertilizer industry (taxation, subsidies etc) and the identification of the proper role of the fertilizer industry as a major input towards sustainability of agriculture.
**Project**: Investigation and analysis of the sector in order to propose the optimum plan of the industry development including investment plans.

**Problem**: Growing demand from developing countries for alternative sources of fertilization.
**Project**: R and D and transfer of technologies for organic fertilizers, organo/mineral fertilizer mixtures, production and biological plant growth promoting substances is being carried out.

**Problem**: Lack of appropriate maintenance and spare parts resulting in inadequate safety and increased risk of accidents.
**Project**: Development of programmes for preventive maintenance, arrest of corrosion, safety and risk assessment.

**Problem**: Lack of proper technology for raw materials handling and fertilizer production.
**Project**: Transfer of technology for raw materials up-grading, production of certain types of fertilizers and alternative sources of fertilization.

## PESTICIDES

**PROJECT AREAS**

**Market Research**

- Market survey of supply and demand of pesticides and analysis of future trends
- Opportunity and techno-economic feasibility studies for establishing production and formulation plants

**Production**

- Site selection, civil/engineering design of plants
- Preparation of terms of reference for sub-contract arrangements and evaluation of bids
- Establishing pilot/demonstration plants
- Assessment of technologies and obtaining proven and well tested technologies.

**Operation and maintenance**

- Assistance in start-up and commissioning of plants
- Regular operational and preventive maintenance
- Safety checks and audits
- Raw materials purchase and production programme

**Quality control**

- Establishment and strengthening of quality control laboratories
- Analysis of raw materials, intermediate and final products
- Training in chemical analysis, good laboratory practice
- Quality of packaging and accelerated storage testing
- Participation in international collaborative analytical tests

**Safety**

- Industrial safety, hygiene, occupational health and safety
- Control of substances hazardous to health (COSHH)

**Research and development**

- Survey of locally available raw materials (solvents, packaging materials) and testing their suitability for pesticide formulations
- Carrying out laboratory experiments to develop organic solvent free pesticide formulations, dustless granules, wettable powders, environment friendly and user-friendly formulation and application technologies
- Development of non-toxic insecticides (growth regulators, pheremones)
- Development of bio-botanical pesticides (neem based insecticides, bacillus thuringiensis, viral insecticides etc).
- Bio-assay of pesticide formulations
- Toxicological evaluation of pesticides and other chemicals

**Environment safety**

- Waste minimization
- Effluent control/waste treatment/disposal
- Study of fate of pesticides in the eco-system
- Product diversification to safer pesticides
- Supporting Integrated Pest Management (IPM) to reduce pesticide use and preventing onset of resistance to pesticides by formulations of mixtures.

**Dissemination of information**

- Regional/global workshops, expert group meetings on various topics
- Data collection and dissemination
- Publication of special issues, journals, proceedings of meetings and books

## Regional networking

A regional network for the safe development of pesticides has been very successfully capitalized using facilities available in advanced developing countries. In Asia the Regional Network on Pesticides for Asia and the Pacific (RENPAP) has established technical co-ordinator units in selected areas to promote technical cooperation among developing countries (TCDC) and regular workshops are carried out on different topics, and close links are maintained with WHO/ FAO/World Bank/ESCAP which are the associated agencies.
The following technical coordinating units have been set up making use of the existing facilities:

**India** - formulation technology and quality control,
- data collection/dissemination of information;
**Thailand** - residue analysis,
- bio-botanical pesticide development;
**Indonesia** - industrial safety, effluent control, waste management;
**Philippines** - industrial hygiene, occupational health and safety;
**Pakistan** - eco-toxicology;
**Republic of Korea** - impurities in technical material.

## PROJECT EXAMPLES

**Problem:** No knowledge about market demand and supply, availability of raw materials, their use in formulation of pesticides and quality requirements for bio-efficacy and registration.
**Project:** Complete techno-economic feasibility studies carried out, survey of raw materials made and tests carried out for their suitability in pesticide formulation.

**Problem:** No facilities and inexperience in the production of active ingredients and the preparation of intermediates and formulation of pesticides.
**Project:** Provides know-how for well tested technologies and prepares basic design, lay-out, site location, procures equipment for establishment of pilot plants and carries out test runs and product test trials. Assists in product quality and waste management techniques.

**Problem:** Lack of experience in developing new pesticide formulation and commercializing those formulations.
**Project:** Establishes R&D laboratories for developing formulation technology, establishes bio-assay laboratories and toxicology laboratories, and carries out toxicological evaluation.

**Problem:** Development of environment friendly pesticides and their formulation.
**Project:** Assists R&D laboratories in preparing novel compounds as insect growth regulators, develops bio/botanical pesticides and develops formulations that are user friendly, conducting seminar and workshops.

# NON-METALLIC MINERAL BASED INDUSTRIES

The programme focuses on promoting and optimizing the use of domestic non-metallic minerals for ceramics, glass and building material industries. Non-metallic minerals account for the major part of the value of global non-fuel mineral production use in manufactured goods as well as in construction, agriculture and environmental protection. They are non-renewable resources including essential minerals which are threatened by depletion, if not appropriately managed. A programmatic approach to the overall planning of non-metallic minerals exploitation integrates development of a wide range of production technologies and makes optimum use of locally available raw materials. This basic principle implies that close linkages between the various programmes of the sector such as ceramics, glass, building materials, handicrafts, etc. are specifically encouraged and that efforts are made at all stages of project development to ensure full use of all grades of material coming out of the same deposit. This policy has also strong environmental implications in terms of proper resource management, including low waste mining and manufacturing technologies as well as promotion of environmentally-sound mining techniques and plans up to the final phase of mine reclamation and landscape recovery.

**PROJECTS AIM AT:**

- Sectoral development planning with specific focus on government strategies on privatization, environment and energy conservation
- Non-metallic raw material surveys and inventories
- Mineral beneficiation and application
- Technology acquisition, development, adaptation and transfer
- Production rationalization, product design and plant rehabilitation
- Establishment of new plants (small- and medium-scale industries
- Improving energy and water resource management and conservation
- Environmental control including use of industrial and agricultural wastes
- Promotion of construction technologies
- Introduction of structural systems with emphasis on low cost housing and disaster resistant construction

**IN THE PROGRAMME AREAS OF:**

- Ceramics and clay based technologies
- Glass technology
- Building materials and construction industry
- Stone and stone products
- Handicrafts and decorative items
- Industrial minerals and their application

**Non-metallic minerals can be sub-divided into three categories:**

- Low-value commodities - **construction materials**, including sand and gravel, crushed stone, clays, limestone and cement which are produced and consumed in very large annual quantities,
- Medium-value, medium-volume which includes the principal **fertilizer and chemical minerals** such as salt, phosphate, sulphur, potash and soda ash,
- Hig-velue, low-volume category of **industrial minerals** which includes a large variety of commodities with different end-uses. This multiple-use industrial minerals category includes commodities such as talc, barrite, fluorspar, asbestos, feldspar, graphite, mica and many others. In terms of unit value and quantities consumed, this category is comparable to the major metals.

The radius of economically viable trade grows with increasing unit value. Building materials are therefore normally produced for local consumption while, higher value minerals even in their crude state can be exported.

UNIDO's strategy is to promote efforts which will assure a maximization of the local value added component. Increasing the local processing activities, which especially in the framework of a broad range of manufacturing industries, will also reduce import dependence and promote an integrated mineral use that eliminates of inefficiency and wastage in mineral exploitation.

## PROJECT AREAS

The main areas are:

### Structural ceramics

Adobe
Stabilized soil blocks
Fired bricks and hollow blocks
Roofing and flooring tiles
Drainage and water pipes.

### Fine ceramics

Wall and floor tiles
Sanitary ware
Tableware and procelain
Glazes and frits
Pottery.

### Technical ceramics

Stoneware pipes and vessels
Electro ceramics
High alumina products
Special oxide and nitride ceramics.

### Refractories

Fire clay bricks
High alumina bricks
Basic bricks
Silica bricks
Castables and mouldables
Ceramic fibres.

### Advanced ceramics

Wear resistence mechanical parts
Electronic ceramics
Bio ceramics
Sensors
Sialons
Cutting tools.

### Glass products

Sheet and plate glass
Hollow glass ware (bottles and jars)
Table and utility ware
Laboratory glass ware

CHEMICAL INDUSTRIES

Glass fibres and glass wool
Optical and opthalmic glass
Glass jewellery
Reflecting glass beads
Automotive glass
Glass tubing.

**Stone and stone products**

Dimension stone
Crushed aggregates
Decorative stone
Gem stones
High purity quartz
Rock wool
Slate.

**Insulation materials**

Porous or expanded minerals
Organic materials
Composites and synthetics

**Cement based building materials**

Concrete blocks and pipes
Fibro-cement roofing tiles
Prestressed concrete elements
Terrazzo tiles
Wall sandwich elements.

**Hydraulic binders**

Plaster of Paris
Quicklime
Hydraulic lime
Pozzolanic cements.

**Pigments and paints**

Mineral pigments
Ultramarine
Oil and emulsion paints
Renderings.

NON-METALLIC MINERAL BASED INDUSTRIES

**Mineral sorbents**

Activated bentonites
Expanded perlite
Zeolite
Tuffites
Diatomite
Soil upgrading
Filtration
Waste water treatment.

**Fillers and extenders**

Kaolin
Limestone
Talc
Feldspar.

**Abrasives**

Corundum (artificial)
Garnet
Quartz sand
Abrasive wheels and paper.

**Marine based resources**

Sea salt
Magnesia
Mother-of-pearl products.

**Waste recycling**

Flyash products
Rice husk ash utilization
Phosphoypsum products.

**Industrial minerals**

Asbestos
Graphite
Vermiculite
Kyanite

Dolomite
Kaolin
etc.

**Construction systems and techniques**

Low cost housing
Earthy architecture
Roof design and erectrion
Prefabrication
Modular coordination
Earthquake engineering
Fire prevention techniques
Disaster mitigation
Building repair and maintenance.

**LINKAGES**

The non-metallic minerals programme is related to a wide range of other programmes within and outside the chemical industries sector.
Examples of this relationship include:

- Kaolin for paper filling and coating
- Mineral fillers for rubber and plastics
- Lime for sugar, steel, tanneries and other industries
- Sorbents such as bentonite, perlite and diatomite for a variety of filtering applications in food and chemical industry etc.

The non-metallic minerals also offer important linkages to other non-industrial sectors including

- Sorbents in agriculture especially for arid soil upgrading
- Sorbents for waste water treatment
- Plaster of Paris for medical applications etc.
- Specialized glass and ceramics used in basic R&D and quality control work.

**PROJECT EXAMPLES**

**Sectoral development planning**

Given the diversity of the industrial subsectors and of the raw materials and processing technologies on which they are based, the planning of the development of this sector is of major importance for the effective utilization of the available resources and for the successful establishment and growth of its mining and manufacturing enterprises.
This is further emphasized by the potential for multiple uses of many of the major minerals in question as well as by the sector's strong dependence on well functioning linkages up-stream to the mining sector and down-stream to the end users in industry, construction, agriculture and environmental protection.
A characteristic of the sector is the prominence of small and medium-scale mining and manufacturing enterprises using relatively simple technologies and resulting from a variety of factors using distribution of raw material deposits and the comparatively high influence of transportation of cost to the area of end users. This as well as environmental concerns, especially protection of non-renewable resources, and energy conservation measures must be seriously considered in the planning process.
The importance of the building materials sector within the non-

metallic mineral based industries and its close linkages to the housing and construction sector are other important considerations.

It is essential to identify the potential for replacing imported raw materials or products with local ones:

- Elaboration of a resource based long term national strategy for industrial development in the non-metallic minerals sector;
- Investigation of materials requirements in the construction sector;
- Promotion of privatization in the small to medium scale enterprises producing or consuming non-metallic raw materials;
- Organization of a Sectoral Investment Promotion Meeting.

### ◘ *Non-metallic raw material surveys and inventories*

An essential feature of projects in this field is that they are resource based and generally rely on the availability of local raw material resources for their ultimate success.
Any systematic development of a country's or a region's non-metallic mineral based industry must, therefore be based on a well documented information on the local raw materials and in particular most widely used non-metallic minerals consumed by the industry such as bentonite, perlite, feldspar, sand, clay, kaolin, limestone and natural stone.
Since many non-metallic minerals are used for the manufacture of both building materials and other types of products it is essential for each raw material to consider the full range of possible applications when assessing its industrial potential.

- Geological Exploration of a Raw Material Deposit;
- Desk-type Inventory of Non-metallic Minerals.

### ◘ *Mineral beneficiation and application*

Most non-metallic minerals need a certain upgrading or beneficiation before they can be used as raw material inputs to industrial manufactures. Beneficiation can range from a simple separation of two or more different minerals or grades of the same mineral (important in order to achieve optimum utilization) which practically always occur together in the same deposit or removal of impurities or inert materials using technologies such as washing, drying, crushing and/or screening of the mineral to complicated chemical or high temperature processes aimed at modifying the characteristics of the material according to need.
The beneficiation process can be traded lead to a commodity which either as a finished product or as an input to a further industrial manufacturing process. The technology or technologies selected for a specific raw mineral depends both on its own characteristics and on the requirements of the end user. Close linkages to the down-stream application sectors and knowledge the range of possible uses is thus a condition for effective non-metallic mineral development.
If the minerals are being used locally beneficiation is of course a must but also minerals intended for export should to the largest possible extent undergo preliminary processing in the country of origin

to let it reap the benefits of this value adding operation.

- Laboratory and Semi-industrial Beneficiation Trials;
- Establishment of a multi-purpose Non-Metallic Minerals Pilot Processing Plant;
- Preparation of Industrial Profiles for the various Applications of one or more Minerals;
- Elaboration of a Plant for the integrated Utilization of a Non-Metallic Mineral Deposit;
- Survey of the Export Market for a Mineral or Group of Minerals.

### ◘ *Technology acquisition, development, adaptation and transfer*

Not only does the sector cover a very wide range of materials requiring an even wider range of technologies for their manufacture and application, but even a single product type can often be produced in a variety of ways. The specifications of the raw materials, different from case to case, will dictate their selection and pre-treatment as well as the proportion in which they are mixed and will have to be respected when selecting the processing parameters. No two ceramic wall tile bodies, for instance, will have exactly the same characteristics if based on different raw materials and their production technologies will have to be developed through a series of technological trials.
The final choice of technology will, however, depend on several other factors including market size, capital availability, local codes and standards, export potential, level of labour skills, energy supply and environmental concerns. There is a considerable range of options to choose from in terms of labour intensiveness, production capacity, product mix and so forth.
Technology development and adaptation is, therefore, both a requirement and a welcome opportunity offering the prospective entrepreneur the possibility to make optimum use of local resources and market demand.

- Laboratory Testing of Raw Materials and Semi-Industrial Trials;
- Experimental Product Development Work at Production Plant Level;
- Establishment of a Non-Metallic Minerals Development Centre;
- Establishment and Operation of a Pilot Plant;
- Promotion of Enterprise-to-Enterprise Co-operation;
- Preparation of Technology Monographs;
- Regional Co-operation within a Network Structure.

### ◘ *Production rationalization, product design and plant rehabilitation*

Plant rehabilitation has become one of the major strategies of industrial development. Most developing countries have over the years been endowed with a number of building materials plants now failed to meet the requirements of the market or to meet their operational costs or both.

Nevertheless these plants often represent a very considerable asset in terms of both capital investment and accumulated skills in its work force. Thus efforts made to solve the technological problems are justified. They contribute to increased efficiency and endure economic viability.

Technology selection is an important step in the product development process but only provides one set of parameters of the production. In many non-metallic mineral based industries product design is equally important and often determines the market acceptability of the products.

Design is, obviously, essential in most areas of ceramics, glass and building materials production and involves both the esthetic features of the products such as basic shape colour and decorations as well as the technical details which determine that the products are durable, satisfy the codes and standards and are in harmony with other product types.

- Technical Inventory and Trouble Shooting at Plant Level;
- Energy Auditing Using a Portable Energy Auditing Kit;
- Feasibility Study for new or Modified Production Lines;
- Introduction of more efficient preventive Maintenance and Sparepart Management Systems;
- Promotion of increased Utilization of Domestic Raw Material Resources;
- Development of a Design Package for a Specific Product Range;
- Plaster Mould Design and Production for the Ceramic Industry;
- Market Promotion based and Prototype Products.

### ◘ *Establishment of new plants including small- and medium-scale industries*

Increased awareness of the potential of locally available raw materials and expanding domestic or export market possibilities favours the establishment of new non-metallic mineral based industries. Significant advantages can be gained by ensuring that such new industries are in keeping with the actual local needs and resources, and are established with strong backward and forward linkages.

The overriding objective from the point of view of the national economy must be the achievement of maximum value added content in the production output and the maximum creation of local jobs for instance through decentralized establishment of small and medium scale industries.

- Techno-Economic Feasibility Study;
- Investment Promotion and Assistance in Contract Negotiation;
- Technical Support in Plant Erection, Commissioning and Running In;
- Fellowship Training of Key Plant Personnel;
- Promotion of Enterprise to Enterprise Co-operation.

### ◘ *Improving energy and water resource management and conservation*

An important part of the non-metallic mineral based industries

including ceramics, heavy clay products, glass, lime and cement belong to the industries with high energy consumption. There are therefore considerable benefits to be derived from a more effective management of the energy inputs. Saving energy also means less environmental damage. A well regulated combustion process is also a cleaner process resulting in reduced smoke emissions, and less energy consumed often means less firewood consumed or, at least a reduction in the consumption of non renewable energy resources.
The industries in question also have a considerable consumption of water and offer several opportunities to contribute effectively to overall water resource management efforts.

- Energy Auditing of and Conservation in Existing Kilns, Furnaces and Dryers;

- Development of Energy Saving Production Technologies;

- Promotion of the Use of Alternative Fuels such as Agricultural Wastes;

- Introduction of Water Saving Production Technologies.

## ◘ *Environmental control including use of industrial and agricultural wastes*

A positive contribution to good ecological management is made by the building materials industry through the use of certain industrial and agricultural wastes in the production of materials like heavy clay and concrete products. Introduction of, for instance, fly ash as a raw material in building materials production not only removes it as a waste material but also contributes to improving the quality of the product. And the use of materials such as rice husks, coffee shells, cotton stalks, etc. as fuel for the firing of bricks and tiles represent a double contribution towards a better environment since it allows firewood to be saved.
A quite different environmentally related activity is, however, the application of mineral sorbents such as bentonite, perlite, zeolite and diatomite for soil upgrading and waste water treatment. The effectiveness of these minerals, especially after beneficiation, is due to their high water retention capacity as well as their ability to adsorb a variety of cations in a very selective way.

- Promotion of Manufacturing Technologies using Industrial and Agricultural Wastes;

- Development of Mineral Beneficiation Technologies to maximize the Absorptive Capacity of Beneficiated Products;

- Agricultural Field Experiments demonstrating the positive Effects of Rural Sorbents on Plant Growth and Water Managemet;

- Design and Promotion of appropriate small-scale Waste Water Treatment Plants for Domestic and Industrial Use.

## ◘ *Promotion of construction technologies*

Building materials can only serve their intended purpose in a satisfactory way if appropriately used. The building or civil engineering structure is the final product and the technologies applied are just as important for the end result as the quality of the building materials. The construction industry is therefore

closely interlinked with the building materials sector and in most technical co-operation programmes they must be considered together.
Achieving a balance between the requirements of the construction sector and the supply possibilities of the building materials industry and ensuring that building techniques are based on materials specifications and vice versa is one of the most crucial and complex problem of activities in this field.

- Hands-on Group Training Programmes for Builders and Artisans;

- Technical Workshops for Engineers, Architects and Entrepreneurs;

- Preparation of Technology Manuals;

- Establishment of Regional or Sub- Regional Networks;

- Construction of Demonstration Houses.

### ◘ *Introduction of structural systems*

Traditional housing technologies as well as conventional "modern" building systems are normally well understood and applied. However, they may not offer the appropriate solution to a range of problems faced by the construction sector. Durable lower cost urban and rural housing at affordable cost may in certain cases only be possible through introduction of entirely new structural systems or through adaptation of traditional and often discarded systems to the new requirements. Construction in areas of seismic, cyclone or flood risks will become more resistant to such natural disasters through application of special structural systems or details. And should a disaster take its heavy tool of buildings, rapid erection of emergency shelter and essential public buildings require their own set of specially designed systems. Industrialization of the building materials sector and, in particular, of the prefabricated elements manufacture if it is to be a financially viable undertaking is favoured by the promotion of certain design principles such as of modular coordination. Standardizing or coordinating the dimensional requirements of the building sector also opens a huge market for small scale producers of materials thus protecting their existence competition with large scale industries and widening the range of products.

- Promotion of Low-cost Construction Methodologies;

- Introduction of Aseismic Construction Techniques;

- Establishment of an Earthquake Engineering Laboratory;

- Promotion of Disaster Resistant Structural Details;

- Introduction of Modular Co-ordination Principles in Element Prefabrication.

# PETROLEUM REFINING AND PETROCHEMICALS

In addition to providing technical assistance to the petroleum refining and petrochemical producing industries per se the programme covers both neighbouring industries such as the treatment and use of natural and associated gas to produce petrochemicals and the transformation of petrochemical intermediates such as monomers and products such as polymers into useful end and carbon products such as detergents, paints, plastic articles, elastomers and synthetic fibres. Also covered are the development of new applications for petrochemical products such as the use of plastics in agriculture, the ecologically sustainable industrial development aspects of the production and use of such products. This includes plastics recycling, elimination of the use of volatile organic compounds for the production of paints and the use of naturally renewable products, oils, fats and resins, as substitutes for petrochemicals in the production of detergents, resins and paints.

**PROJECTS AIM AT:**

- Increasing operating and energy efficiencies of refineries and petrochemical production plants
- Reducing environmental pollution through improved operating efficiency and use of cleaner technologies
- Process and technology selection for new industrial projects
- Establishing indigenous capabilities for chemical engineering design, process optimization and process and product development
- Improving product qualities and efficiency of utilization of petrochemical products
- New applications for petrochemical products
- Developing use of locally available renewable natural products as substitutes for petrochemicals in the production of such things as surfactants, paints and resins.

**IN THE AREAS OF:**

- Petroleum Refining
- Lubricating oil production, distribution, use and recycling
- Natural and associated gas treatment and use
- Production of petrochemical intermediates, polymers and resins
- Synthetic and natural rubbers
- Products made using petrochemicals
- Recycling.

**USING VARIED TECHNOLOGIES RANGING:**

from unit operations and unit processes such as distillation reforming and catalytic processes as are used in the refining and petrochemical intermediate production industries.

to extrusion and injection moulding which are used for the transformation of plastics into finished products and melt spinning used for the production of synthetic fibres.

**PROJECT AREAS**

The major fields covered by the programme's projects are:

**o Petroleum refining**

- Configuration and process selection for complete refineries.
- Optimization of operation of existing refineries.
- Modification of older refineries to improve efficiency and conserve energy.
- Pollution abatement.
- Establishment of refinery product specifications which are best adapted to local requirements.

**o Lubricating oil, production, distribution, use and recycling**

- Lubricating oil basestock production.
- Blending of basestocks with additives.
- Correct handling and distribution of lubricating oils.
- Lubricating oil testing.
- Tribology.
- Used oil recycling.

**o Natural gas treatment and use**

- Recovery of natural gas liquids (NGLs) from wet and associated gas.
- Treatment of natural gas to remove $CO_2$ and $H_2S$.
- Processing of natural gas to produce petrochemicals.

**o Production of petrochemical intermediates, polymers and resins**

This includes bulk intermediates, bulk commodity polymers, speciality products, specialty polymers and resins.

**o Synthetic and natural rubber**

Including:

- Blends of synthetic and natural rubbers.
- Thermoplastic elastomers.
- Improved ways of processing and modifying natural rubbers.
- Transformation of rubbers into finished products.
- Use of rubber for tyre retreading.

**o Products made using petrochemicals**

This includes:

- Plastics transformation industry to make finished products.
- Production of synthetic fibres starting from petrochemical intermediates.
- Development and production of engineering plastics and polymer blends.
- Detergents including detergents made using vegetable oils and natural products.
- Paints with particular emphasis on reducing emissions of volatile organic compounds and development of water-based paints, and
- Development of paints and resins made using naturally occurring products.

**Recycling**

The main emphasis in this area is on the recycling of post-consumer plastic waste and lubricating oils.

## PROJECT EXAMPLES

### *Fielding of senior staff members*

During the recent past staff members have been involved in:

- Evaluating the performance of a country's detergent industry so as to recommend measures to be taken to improve yields and product quality;
- Surveying the operation of a synthetic fibre company and recommending how to optimize capacity utilization and improve product quality;
- Surveying a country's synthetic fibre and textile industry so as to formulate a project aimed at increasing the utilization of synthetic fibre cotton blends and the quality of products made using such blends;
- Diagnostic survey of factories in both the public and private sector of a country's plastics transformation industry to recommend measures to be taken to improve product quality;
- Efficient utilization of plastics and new product development;
- Diagnostic survey of a country's petrochemical and polymer producing industry to determine if the industry is being operated correctly.

In this later case a country which is producing very large quantities of bulk petrochemicals and polymers in joint venture with major multinationals was concerned that as annual throughputs considerably exceeded initial design capacity, the plants might be operated in a way which could shorten their useful life. The UNIDO was chosen as a source of unbiased advice on this matter and in a 3 week mission a senior staff member visited numerous plants in the country and held discussions with the people running these plants. As a result it was possible to provide the country's Government the explanations as to why the plants were operating in excess of their design capacity and provide reassurance that this would not endanger the plants or reduce their useful life. The unbiased report was useful both to the country as well as to good relations between the country and its multinational joint venture partners.

### *Fielding teams of experts*

Teams of technical experts have been fielded to carry out an in-depth diagnoses of the technical reasons for the poor functioning of some countries' petrochemical and chemical fertilizer industries. In the course of these missions these experts have pointed out profitable ways not only of increasing efficiency and capacity utilization of such industries but of drastically reducing the pollution they are causing and the energy being consumed.

More recently a multi-disciplinary team of engineers and experts (in joint ventures and contract negotiations) and economists headed by a senior UNIDO staff member assisted the Government of a developing country in appraising offers for either supplying or entering into a joint venture by multi-national consortia for a billion dollars plus grass-roots refinery. This work involved advising on acceptable refinery configurations, product mix, refinery location, financial, commercial and joint venture conditions and making recommendations as to how the Government should proceed with this major industrial project. The ability of the UNIDO to provide unbiased advice of this nature was of considerable importance to the host Government.

### *Seminars, workshops and conferences*

These have been held in developing countries on:

- Plastics recycling and the diffusion of the results of a successful plastics recycling project using new technology.
- Various aspects of the transformation industry such as improving the efficiency of polymer use and improving product quality for injection moulding, blow moulding and film production.
- Rubber processing, tyre manufacture and tyre retreading.
- Development of modified natural rubbers.
- The use of plastics in agriculture.

A seminar held recently in a large developing country which produces large quantities of basic petrochemicals, but does not have efficient downstream industry to use and process these chemicals, was on profitable opportunities for developing a local industry to use locally available natural materials as well as these petrochemicals.

Speakers at this seminar were internationally reputed experts in their respective fields. Apart from being made very welcome by the host country, that wishes to hold similar seminars in other states, it was possible for the experts in the course of contacts with local industry to give advice which saved these industries considerable amounts of money and made them more profitable. For example an expert in advising a company making polyethylene for plastic film in agriculture suggested they change the additives and stabilizers they use and employ synergistic ones instead. This can double the useful life of the plastic film through virtually no extra expense thus saving the local economy several million dollars a year.

### *Technical assistance to existing companies and Institutions*

Many of the programme's projects are in this area. A partial listing of such projects include:

- Chemical processing of castor oil to produce specialty chemicals.
- Improvement of capabilities of a national detergent development institute so as to enable this institute to assist industry in improving efficiency and reducing wastes.
- Assistance in producing engineering plastics by blending polymers.

- Development of water-based paints and paints with low volatile organic solvent content
- Development of additives for plastics.
- Development of carbon fibres and carbon fibre based composites.
- Development of prosthetics based on composites.
- Development of use of rubber seed oil and dammar resins to replace imported vegetable oils for the production of alkyd resins for paints.
- Improving the country's capabilities for carrying out chemical engineering design by introducing standards and providing advice from experienced international experts.

- Assisting an institution in the development of resins, anti-corrosion paints and high-quality glues based on epoxy resins modified by reacting them with a lac obtained from a tree. The anti-oxidant qualities of the essential element of this as well as the flexibility it confers the glues and resins has made it possible to produce extremely corrosion resistant paints as well as bi-component glues which can very effectively stick flexible products together, such as rubber and steel which is not possible with normal bi-component glues. Considerable interest is being shown in this project and the products being developed by major companies from highly industrialized countries. Discussions are taking place for licensing the technology from the developing country to developed countries.

Similarly zeolite based catalysts developed as part of the UNIDO's project in another developing country have also recently been licensed to companies in the industrialized countries.

A further example is the improvement of lubricating oil usage in a Southeast Asian country. Until recently in this country lubricating oil in automobiles had to be changed every 1,000 kilometers resulting in the country having to import between 5 and 10 times more oil than it otherwise would have had to. It was initially thought that this was due to inadequacy of the additives in this hot and humid country. However, UNIDO investigations showed that the real problem was that the lubricating oils were imported with the additives in them and then stored and distributed in such a way that the additives could become hydrolysed and form a sludge. By aiding an existing Institution to analyze and test imported lubricating oil blending stocks and then add the right additives locally and thereafter prevent hydrolysis by suitable handling and packaging it has been possible to considerably reduce the waste of lubricating oils thus saving a very large import bill for these products. Very valuable assistance was provided to the UNIDO on this project by some major international oil companies.

## *Establishment of new institutions*

There are a number of completed and ongoing projects for establishing new development centers for the
- petrochemical,
- plastics transformation, and
- synthetic fibre industries

in developing countries.

These institutes serve as a source of:

- establishing standards.

- providing analytical and testing facilities.
- training operators and engineers and
- developing new products and new applications for these products in these countries.

As a result of the plastics development centers it is possible for small privately owned plastics transformation companies to improve the efficiency with which they use their raw materials, thus reducing waste and increasing profits. Through the synthetic fibre development centre it possible to improve the quality of products made using synthetic fibres and in particular blends between cotton and polyester. This improved quality results in increased revenues of the country when it exports its products.

The petrochemical development centres result in increased operating efficiency in the countries where they are set up.

## LINKAGES

The activities of the unit have numerous linkages with the activities of other units of the Chemical Industries Branch.

Of particular note are:

- the use of natural gas and other hydrocarbons for the production of ammonia and chemical fertilizers.
- the use of petrochemical intermediates for producing pesticides, and
- the use of plastics for packaging and in particular the handling of pharmaceuticals with such as throwaway plastics syringes.
- The capability of carrying out chemical engineering design can also be of use for the development of other parts of the chemical industry.

Linkages with other Branches which should be mentioned are with Agro-Industries on the use of natural products such as oils and fats for the production of petrochemical products and the mechanical engineering industries for the design and fabrication of plants for the refinery and petrochemical industry, and the design and production of moulds for plastics processing.

# PHARMACEUTICAL INDUSTRIES

The technical assistance programme has as its major thrust the building of indigenous capability for the production of a selected list of drugs within a country. The idea is that the public and private sectors of the pharmaceutical industries in developing countries be enabled to produce the essential drugs, which though they may have very low profit in terms of sales, nevertheless serve the requirements of national health programmes. This approach may not be an attractive one for large producing concerns as the driving force is not an economic one. The intention is to serve the health requirements of the most needy and provide a source of supply to the largest possible segment of the world's population. Thus the dire need for pharmaceuticals is combined with the prohibitive cost of procurement of drugs thereby depriving good health care for millions of people in the developing world. The technical assistance projects are

**IN THE AREAS OF**

- Utilization of medicinal and aromatic plants
- Biologicals
- Basic manufacture - multipurpose pilot plants
- Formulation and packaging
- Control of diarrhoeal diseases
- Products from slaughter house residues
- Biotechnology
- Family planning devices
- Quality assurance and good manufacturing practice
- Reagent chemicals and reference substances
- Pharmaceutical necessities.

The benefits of the technical assistance projects in the above-mentioned areas cannot be evaluated in cost-benefit terms for who can calculate the worth of human lives saved, sick children made healthy, or a work force that is disease-free.

**PROJECTS AIM AT:**

- Savings in convertible currency
- A measure of self-reliance in supplies
- Formulation and packaging to suit local requirements together with instructions in national languages
- Improvement of quality assurance to enhance safety and efficacy
- Strengthen R&D capabilities
- Subregional and regional co-operation in drug production
- Generation of employment opportunities and adaptation of technology as an impetus for ancillary industries
- Manpower development for industry
- Use of natural resources

## PROJECT AREAS

When the pharmaceutical industry is considered in respect to developing countries, one fact dominates everything else. In such countries where approximately three-quarters of the world's population live the share of the global consumption of pharmaceuticals is well below one-quarter. In addition these countries spend collectively over half their health budget in the procurement of pharmaceuticals.

The technical assistance programme in pharmaceutical industries, in order to meet the challenging situation described above, has developed a series of comprehensive projects to meet the needs of the developing countries in two areas of particular importance:

- the ***industrial utilization of medicinal plants*** used in traditional therapies which ostensibly over the years have sustained the health care efforts of 80 per cent of the world's rural population.

- the ***industrial production of biologicals*** to assist developing countries in strengthening the existing production facilities for vaccines and creating additional capability.

## PROJECT EXAMPLES

The major features of the various projects in the areas covered by the programme in the pharmaceutical industries are described below.

### O Utilization of medicinal and aromatic plants

**Problem**: Utilization of local raw material (i.e. medicinal and aromatic plants) for the production of:
(i) Therapeutic agents both for export and for domestic health-care programmes; and
(ii) Essential oils and aroma chemicals for the fragrance and pharmaceutical industries.

**Project**: Four major activities are developed within this programme:

*1. **Promotion programmes***

These are designed to demonstrate the scope for the greater ethnomedical utilization of local flora through a joint programme. For example, a mobile unit was set up which undertook field surveys in developing countries and this has been a major factor in promoting technical assistance programmes.

*2. **Exploratory programmes***

Basically an activity that precedes and paves the way for technical assistance, these programmes comprise of experts missions that assess potential resources and infrastructure and identify the requisite inputs.

*3. **Training and workshops***

These are an indispensable feature of any technical assistance programme. In-plant group training workshops on medicinal herbs and process technologies are periodically organized.

*4. **Direct Technical Assistance***

Major direct technical assistance programmes are provided to generate pharmaceuticals and essential oils from plant raw materials. Emphasis is placed on strengthening R & D institutions so as to facilitate the development of process technologies, chemical and biological assessment methodologies, as well as technical

capabilities at all levels. Programmes also focus on raw material production and utilization, and the development of products for both the pharmaceutical and fragrance industries.
Technical assistance projects are designed to develop new drugs and formulations based on the utilization of medicinal plants as well as for the production of aroma chemicals from essential oils.
The "back to naturals" philosophy in industrialized nations together with environmental sensitivities imply new market potential for all types of industrial natural products including those from marine plants and animal sources. UNIDO is the leading international agency in this sector and will strive to maintain this position.

## Biologicals

**Problem:** Assistance is required by certain developing countries to build up national capabilities for the production of biologicals which are of crucial importance to preventive medicine programmes and also a wide range of veterinary applications.

**Project:** Biologicals are of microbiological, animal or human origin. They include antibiotics, antibodies, antigens (vaccines), blood products, endocrinological substances and other miscellaneous substances. UNIDO is now developing new programmes and encouraging the exchange of information.
UNIDO's strategy is to promote and assist the transfer of technology related to essential biologicals. This strategy is on the basis of two factors:

(i) Only industrial technologies with built-in quality assurance should be transferred; and

(ii) The actual transfer of technology should be followed by a long-term technical support programme, preferably provided by the holder of the technology transferred.

In many developing countries manufacturing units face technical and economic difficulties owing to international competition. UNIDO aims at assisting and rehabilitating units and ensuring their economic viability before embarking on the establishment of new facilities.
The manufacture of human and veterinary vaccine and other biologicals can be carried out using shared facilities, thus economizing on production costs.

## Basic manufacture - multipurpose pilot plants

**Problem:** The need to introduce the basic manufacture of drugs or active ingredients required by the formulation and packaging industry and utilization of locally available raw materials for that purpose.

**Project:** The basic manufacture of drugs may be carried out using chemical synthesis, fermentation or extraction.

1. ***Chemical synthesis***

The manufacture of drugs through chemical synthesis may be carried out at different stages: late intermediates, early intermediates or raw materials. Manufacture based on intermediates involves the last step or the last few steps of the production process, or unit process in chemical synthesis. Chemical synthesis is used, for example, to produce aspirin, chloroquine, ampicillin and sulphadrugs.
In many developing countries, a wide variety of drugs is required in small quantities. This precludes

achievement of the economy of scale in their production. In such cases, a multi-purpose plant offers a suitable means of manufacturing a variety of drugs either sequentially or, to some extent, simultaneously. Furthermore, multi-purpose plants have the advantage of not requiring sophisticated automation or technologies associated with large-scale production, and they require little investment.

2. *Fermentation*

Manufacturing drugs using fermentation mainly involves two stages: fermentation and recovery/purification. Fermentation entails the growth and development of specific microbial cultures under controlled conditions in the course of which the desired drug is produced. Upon completion of fermentation, the microbial culture mass is separated from the liquid. In most cases, the drug is in solution form; in only a few cases it is in solid form. The medium containing the drug is then subjected to a process of recovery and purification in order to obtain the pure drug. Fermentation is used, for example, to produce some antibiotics, hormones and vitamins.

3. *Extraction*

Medicinal plants or animal organs are subjected to the process of extraction in order to obtain a pure extract or drug as the case may be. Morphine and insulin, for example, are obtained in this manner. Some intermediates for synthesis such as diosgenin can be extracted from plants.

## ◘ Formulation and packaging

**Problem**: The need to facilitate the local production of dosage forms of pharmaceuticals in developing countries. Pharmacologically active substances used to prevent and treat illnesses are administered to the patient in different dosage forms, such as tablets, coated tablets, capsules, syrups, lotions, ointments and injections. These dosage forms permit better control of amounts required of the therapeutic agent, while the time and the mode of administration can be monitored more easily.

**Project**: The production of dosage forms includes formulation and packaging. It involves compounding and mixing the therapeutic agent or pharmaceutical/chemical with other substances known as excipients, followed by the packaging of the finished product. The excipients used may vary according to the characteristics desired of the final product. In the case of tablets, for instance, the choice of excipients would depend on the properties required: hardness, disintegration time, absorption rate, short or long therapeutic action, etc. In most cases, the technology for the production of dosage forms is readily available and is not protected by patents. Consequently, formulation and packaging plants are to be found in several developing countries. Most developing countries are forced to import pharmaceutical chemicals from developed countries to meet the needs of their local formulation and packaging units.
For countries with difficult conditions such as transport, storage, distribution of medicines and scarcity of skilled personnel, a new concept of small seed modules for hospital facilities is being developed.

## Control of diarrhoeal diseases

**Problem:** The production of oral rehydration salts and intravenous fluids in developing countries. Acute diarrhoeal diseases are one of the leading causes of childhood mortality and morbidity in the developing countries. It is estimated that some 750 million children below the age of 5 suffer from acute diarrhoea and each year 5 million children die in that age group.

**Project:** It has been established that dehydration due to acute diarrhoea of all etiologies and in all age groups can be safely and effectively treated by means of oral rehydration using a single fluid known as Oral Rehydration Salts Solution (ORS solution). In severe cases of acute diarrhoea, fluids should be fed intravenously. However, treatment should be continued and completed using ORS solution. A survey has also been carried out in eight least developed countries in Africa to identify openings for local production.

## Products from slaughterhouse residues

**Problem:** The need to develop the production of a broad range of pharmaceuticals (enzymes, hormones, etc.) derived from waste products of the meat industry. In many developing countries the meat processing industry is adequately developed. The viscera such as pancreas, liver, lungs and kidneys are sources of insulin, heparin, pepsin, peptone and renin. On the basis of local production a valuable export product could be developed. The technologies are very specific and rapidly changing. Whereas some technologies are easily accessible (viz. insulin), others are not readily available.

**Project:** A techno-economic feasibility could be implemented, especially in developing countries where the meat processing industry is well developed.

## Biotechnology

**Problem:** Assistance to developing countries to build up national applied research capabilities in biotechnology and genetic engineering, in co-operation with the International Centre for Genetic Engineering and Biotechnology.

**Project:** In this area UNIDO provides assistance in the:

(a) Preparation of national policies and strategies for the development of biotechnology;
(b) Establishment or strengthening of research centres for biotechnology and genetic engineering;
(c) Execution of specific research programmes in such areas as health, energy, agriculture, food and pharmaceuticals where biotechnology can be applied.

The assistance described in (b) and (c) includes the services of international consultants and the provision of equipment, as well as the training of scientific and technical personnel at the Centre and abroad.

A Regional Latin American Biotechnology Programme has been developed during the last five years. This programme, which was financed by UNDP and executed in co-operation with UNESCO, has contributed to reinforce national biotechnology institutions in the region as well as the cooperative approach for research and development within the region.

Encouraging results have so far been obtained in research fields such as enzymes and antibiotics production, hydrolysis of lactose, monoclonal antibodies production and development of hybrid plants. Techno-economic feasibility studies are being carried out for future industrial scale up of results obtained.

## ■ Family planning devices

**Problem**: Assistance in the industrial production of suitable family planning devices in developing countries. A variety of family planning methods are currently available. However, developing countries have made little progress in acquiring the technology for the local manufacture of family planning devices.

**Project**: UNIDO assesses the technological feasibility of:

(a) The production of condoms;
(b) The production of intra-uterine devices;
(c) The local production of contraceptive tablets; and
(d) The utilization of available raw materials for the production of hormones.

## o Quality assurance and good manufacturing practices

**Problem**: Need to improve the quality of drugs in developing countries.

**Project**: Technical assistance is provided in the establishment of quality control laboratories, improvement of production quality standards, application of total quality control (quality assurance) for the existing production units and for the establishment of national regulatory and inspectorate bodies, thus setting up national quality control standards and regulations. Technical staff are trained in quality control techniques, use and maintenance of equipment at site, as well as abroad.

The quality of the production of drugs including packaging is dependent on the manufacturing practices. Many developing countries have not taken this aspect of manufacturing seriously thereby leading to the production of poor quality drugs which cannot be improved at the finished stage. Good Manufacturing Practices (GMP) have been incorporated into UNIDO projects involving drug production. Projects for the preparation of process protocols and GMPs to suit the stage of development of the pharmaceutical industry in developing countries are also being implemented.

## o Reagent chemicals and reference substances

**Problem**: Need to establish national reference substances and local production of high purity reagents required for analysis and quality control of pharmaceuticals.

International reference standards have been established by WHO, and most of the developed countries have set up their own standards of reference substances. However, many developing countries still have to rely on the international reference substances which are expensive and which are not tested under their climatic and storage conditions. National chemical and biological reference substances can be established and produced in the developing countries with a minimum of difficulties or cost.

**Project**: To establish national chemical reference substances in keeping with international standards. Although many countries lack the modern analytical equipment required

for quality control, some of the developing countries that have them, and others which still use classical methods, are unable to carry out proper analysis owing to the high costs involved in the purchase of high purity reagents. The cost between the technical grade and the analytical grade of chemicals is very high, although the purification process is not so sophisticated or complex.

## o Pharmaceutical necessities

**Problem**: Need to utilize local raw materials as excipients for formulation. Formulation into dosage forms requiring the addition of other substances such as binders, granulating and disintegrating agents, fillers, lubricants, colourants, sweeteners etc. is made.

**Project**: As many developing countries have the raw materials to produce these but not the technology to enable the production of the pharmacopoeial grade, imports of the pharmaceutical grade adjuvants can be avoided by transferring simple technologies required for their production. Production of pharmaceutical grade gelatin, and inorganic salts such as calcium, carbonate, calcium sulphate, kaolin can also be initiated in developing countries in this manner.

**ECDC/TCDC ACTIVITIES**

The programmes that have been successfully established in developing countries have often served as models for other developing nations and have served as a means of latitudinal transfer of technology.

**NEW AREAS**

New areas of interest to be incorporated into the technical assistance programmes of the pharmaceutical industries respond to the changing situation in developing countries, to wider requirements, as well as to the advances owing to the dynamic nature of the industry.

### *Prevention of AIDS*

The response to the AIDS situation of developing countries by initiating the indigenous production of AIDS-related ancillary medical supplies attempts to address a dire problem in many developing areas of the world. This has particular pertinence to the needs of women in developing countries. The introduction of new technological developments for the production of such essential items as disposable syringes, condoms, sanitary bandages, etc., to assist in the national and regional campaigns against AIDS has also been adopted by UNIDO.

### *Orthopaedic appliances*

Some developing countries have various conflicts and given the present-day disturbances, there is a large proportion of the civilian population in a maimed condition. UNIDO's assistance in the production of orthopaedic appliances addresses this very crucial problem and there is much scope for transfer of technologies from other developing countries where such technologies have already been established.

### *Clinical and diagnostic reagents*

UNIDO's assistance is given in the transfer of technologies to those developing countries urgently requiring technologies in the production of biochemical reagents

and enzymes for clinical and diagnostic tests. As the products used in routine tests, such as blood and urine analysis and pregnancy testing are high cost items, the transferred technology would make these items available at low cost to a larger segment of the population in developing countries.

### *Surgical dressings and medicated toiletries*

Projects designed to set up processing of surgical dressings and medicated toiletries is also an attempt by UNIDO to address a particular developing country's need. In the near future, it is expected that inexpensive formulations will reach much wider sections of the population than at present.

### *Enzyme preparations and monoclonal antibodies*

The staggering advances in biotechnology gives rise to new potentialities which can now be employed to serve the needs of developing countries. UNIDO is developing projects in the production of industrially utilized enzyme preparations and monoclonal antibodies which also gain from the spin-off benefits of advances in biotechnology. These are new technologies with good potential for transfer to developing countries.

# PULP AND PAPER

The technical assistance programme in pulp and paper focuses on improvement of existing mills and development, adaptation and transfer of appropriate technologies related to pulping and papermaking. Special emphasis is attached to indigenous and non-wood fibrous raw materials utilization, introduction of clean technologies, abatement of pollution, water and energy savings and waste paper utilization.

**PROJECTS AIM AT:**

- Choice and selection of technologies and processes including testing of raw materials;
- Production rationalization, waste minimization and pollution abatement measures;
- Improvement of product qualities;
- Pilot or demonstration scale production;
- Development, and/or adaptation of appropriate environmentally-sound technologies;
- Technical co-operation between developing countries.

**IN THE AREAS OF**

- Fibrous raw material collection and preparation;
- Pulping and pulp bleaching;
- Black liquor chemical recovery and lignin utilization;
- Papermaking (different grades of paper and board);
- Handmade papermaking;
- Chemical additives for pulping and papermaking;
- Waste paper utilization;
- Pollution control and abatement.

## PROJECT AREAS AND TECHNOLOGIES

The programme has the primary responsibility for the following technology areas:

### o Fibrous raw material collection and preparation

* Harvesting, collection, transportation and storage of annual plants and grasses for pulp production (e.g. kenaf, hemp, bamboo etc.);
* Collection, transportation and storage of agricultural residues (e.g. wheat/rice straw, bagasse etc.);
* Debarking, chipping, classification and storage of wood and non-wood fibrous raw materials;
* Dust reduction and control in wood yard area;
* Bagasse depithing and storage.

### o Pulping and pulp bleaching

* Development and adaptation of new environmentally friendly pulping and bleaching technologies (eg. non-sulphur pulping process, organosolv process, low-chlorine bleaching sequences, oxygen pulping and bleaching, biobleaching, ozone

bleaching, etc.);
* Restructuring and revitalization of pulping and bleaching facilities with special emphasis on increased operational efficiency, product quality, recycling and waste minimization;
* Remedial measures to decrease the level of pollution discharges;
* Improvement of washing efficiency in non-wood based pulp mills;

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**o Black liquor chemical recovery and lignin utilization**

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* Chemical recovery system for small and medium size mills using non-wood raw materials;
* Development and adaptation of new technologies for non-wood black liquor chemical recovery (e.g. direct alkaline recovery ferric oxygen);
* Assistance to existing mill to improve efficiency and reduce poliutant discharges in the chemical recovery area;
* Development and/or adaptation of processes for black liquor lignin utilization and recycling of black liquor inorganic compounds (e.g. ultrafiltration of bamboo kraft black liquor and production of lignin derivatives);
* Aerobic and anaerobic treatment of black liquor;
* Desilication of non-wood black liquors and utilization of desilicated liquor in a conventional recovery system.

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**o Papermaking (different grades of paper and board)**

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* Selection of paper fibres furnish and chemical additives according to paper or board grade and quality demand;
* Reduction of energy consumption in refining;
* Energy and water savings in papermaking;
* Reduction of fibre losses and pollutant discharges;
* Recycling of paper machine white water;
* Reduction of steam consumption in paper drying;
* Increase of paper machine productivity and efficiency;
* Auditing, monitoring and control of papermaking process;
* Production of coated paper.

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**o Handmade paper**

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* Development of simple and environmentally-compatible pulping technologies for local available fibrous raw materials;
* Assistance in the production of high quality, high priced handmade paper and board;
* Improvements in the efficiency of handmade paper village type mills.

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**o Chemical additives for pulping and papermaking**

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* Evaluation of local pigments for papermaking and coating (clay, calcium carbonate, tale, etc.)
* Increase efficiency of retention of chemical additives (e.g. clay, calcium carbonate, starch, etc.)
* Assistance in the establishment of chemical plants (NaOH, $Cl_2$, $ClO_2$) in existing mills and in improve efficiency of existing chemical products units.

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**o Waste paper utilization**

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* Establishment of a waste paper collection programme;
* Waste paper utilization in

different grades of paper and board or moulded pulp;
* Deinking of waste paper.

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**o Pollution control and abatement**

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* Auditing, monitoring and control of air, water and soil pollution;
* Establishment of waste minimization programmes;
* Technico-economical studies for installation and/or improvement of effluent treatment systems.

## PROJECT EXAMPLES

Some of the projects being handled by the pulp and paper programme are grouped below according to their aims or outputs.

### ◘ *CHOICE AND SELECTION OF TECHNOLOGIES AND PROCESSES INCLUDING TESTING OF RAW MATERIALS*

***a) High level advisory assistance to a paper mill***

**Problem:** The management of a non-integrated packaging paper mill considers installing a semi-chemical straw-based pulp mill to produce basic pulp for corrugating medium production. Straw is available in the region and wood is scarce. Because the factory has insufficient experience and its own technical capability is limited, technical assistance is required in selecting of the most suitable technology and equipment for the planned straw pulp line.

**Project:** Technical assistance is provided to the mill in the following areas:
- study of raw material availability and its suitability for semi-chemical pulping;
- selection of the semichemical pulping technology most suited to the production of straw pulp;
- specifications for the purchase of equipment (these should be sufficiently detailed to allow for international bidding) and a feasibility study on the production of semi-chemical pulp.

***b) Small scale unit for high-yield pulping of kenaf***

**Problem:** In many countries, kenaf is traditionally produced for textile purposes (sacks, cords and ropes) but production declined sharply in the past years owing to competition from other materials. Kenaf can also be used for pulp and paper production. A country with limited capability in the utilization of kenaf for pulp and paper production needs technical assistance for the selection of the most suitable technology for kenaf utilization, and there is also a need for the modernization of techniques used in the kenaf plantation.

**Project:** A project is designed to: advise on the modernization of kenaf cultivation; carry out pilot plant trials of high yield pulping using local kenaf samples (CMP, CTMP); select the most suitable technology taking into consideration the market, paper-grade demand, local conditions, availability of financial resources, environmental impact and cost-benefit analysis.

***c) Assistance to a pulp and paper mill***

**Problem:** An integrated pulp and paper mill constructed for the production of chemical straw pulp and paper using locally collected waste paper, straw pulp and imported pulps. The pulp mill is,

however, not operating properly because of lack of straw in the region and difficulties in the recovery system. The management of the mill plans to modify the pulping mill to process hardwood (poplar) and/or softwood (pine) locally available from manmade forests. Technical assistance is required for selection of the technology, evaluation of the possibility to utilize existing equipment of the straw pulp mill to process wood.

**Project:** Technical assistance is provided to the mill to: evaluate the existing pulp mill and the possibility to utilize as much as possible of the existing equipment to process wood; select wood pulping technology; evaluate the possibility to utilize the fluidized bed reactor for burning wood black liquor; prepare equipment specification for international bidding; assist in the evaluation of the tenders and of investment cost to modify the pulp mill. The project also includes an evaluation of the paper mill and recommendations to reduce the imported fibre in the paper furnish.

## ◘ *PRODUCTION RATIONALIZATION AND WASTE MINIMIZATION*

### *a) Technical assistance to the paper moulding industry*

**Problem:** A local entrepreneur installed a small scale, labour intensive pulp moulding plant based on waste paper. The entrepreneur does not have technical experience in starting up and rationalizing production.

**Project:** Technical assistance is provided with the aim of supporting a local entrepreneur in establishing, commissioning and operating the pulp moulding unit, as well as of rationalizing production and waste paper collection. The products are made to a specific standard. An industry benefiting from such a project is now exporting egg boxes to neighbouring countries.

### *b) Pulp and paper group owned by the government*

**Problem:** A group of Government owned pulp and paper mills need to rationalize production, improve product quality and establish environmental protection programmes. The Government also feels the need to involve itself in training and research work with the aim of supporting the mills.

**Project:** Technical assistance is provided to the mills: to solve in-plant problems in specialized fields such as hemp, linters, and straw/reed pulping; to increase production efficiency and product quality; to assist the energy group to implement an energy conservation programme in the various mills; to assist the investment department in planning an environmental protection and waste minimization programmes after analysing the situation of the mills; to equip the central research laboratory with specialized testing equipment; and to undertake research in such specific fields as pulping, bleaching, mill effluent control, board and paper coating.

## ◘ *IMPROVEMENT OF PRODUCT QUALITY*

### *a) Strengthening the handmade paper industry*

**Problem:** Handmade paper is traditionally made in village type industries and is an important

factor in rural development, helping to prevent migration from rural to urban areas and generate jobs, including work opportunities for women and young people. The actual utilization capacity is low and the quality of the product is unsatisfactory, with the result that many units are either uneconomical or are inviable, despite massive Government support. Since handmade paper currently produced cannot compete with special grade papers available abroad, exports have failed to increase considerably. There is a lack of suitable processes as well as a shortage of equipment similar to that used in other countries.

**Project:** The project is designed to assist in setting up a test laboratory and demonstration plant for handmade paper with a view to helping the industry: to start utilizing a wider range of raw materials that are more versatile; to develop appropriate pulping and papermaking techniques. Technical assistance in the production of high quality handmade paper in selected units is also included as well as local and foreign market studies. This improves the productivity of the industry and makes it economically viable.

## ◘ *PILOT OR DEMONSTRATION SCALE PRODUCTION*

### *a) Desilication pilot plant for bamboo kraft lignin*

**Problem:** Non-wood fibrous raw materials such as straw, bagasse and bamboo normally have higher ash and silica content than wood and most of the silica dissolves during cooking and remains as an undesirable component in the black liquor. The presence of silica is a technical barrier for an efficient chemical recovery of non-wood black liquor. This together with the economic barriers is one of the reasons why most of the small- and medium-sized non-wood pulp mills in developing countries do not have any chemical recovery and thus severely polluted rivers/waters.

**Project:** Technical assistance is delivered in order to develop a process for desilication of non-wood black liquor to be used in small- and medium-sized pulp mills. The process is developed at laboratory scale and subsequently a demonstration plant would be installed in e.g. a bamboo/reed pulp mill. Such an existing pilot plant has been in operation since 1989.

### *b) Pilot plant for production of bamboo kraft lignin*

**Problem:** The chemical recovery of bamboo kraft black liquor is normally less efficient than with wood black liquor because of the higher silica content. For this reason the recovery system has to be cleaned more often and in most mills the pulp production has to be reduced to keep pace with the black liquor recovery system. The increase in capacity of the recovery area normally requires a large investment and many mills cannot afford it. One possibility is to utilize part of the black liquor generated in the pulping process and treat it using ultrafiltration techniques in order to separate the lignin fraction. This technology is used for wood kraft black liquor but still has to be proved appropriate for bamboo kraft black liquor.

**Project:** A pilot plant for the production of bamboo kraft lignin and inorganic compounds is installed in a pulp mill. The

technical viability of separating lignin compounds from the black liquor and producting lignin derivatives is evaluated as well as the recovery of inorganic compounds, under production conditions. Laboratory trials show encouraging results.

## ◘ *DEVELOPMENT AND ADAPTATION OF ENVIRONMENTALLY-SOUND APPROPRIATE TECHNOLOGY*

### *a) Pilot Plant for oxygen pulping and bleaching of non-wood fibrous raw materials*

**Problem:** Oxygen bleaching is a well established technology for reducting the formation of toxic compounds when bleaching wood pulps. Utilization of hydrogen peroxide and ozone is now emerging in developed countries. However, there are practically no experiments in developing countries in using oxygen, peroxides or ozone in pulp mills based on non-wood fibrous raw materials as straw, bamboo, bagasse etc. There is therefore an urgent need to close this technological gap. Oxygen pulping of non-wood raw materials shows encouraging results at the laboratory scale and offers an alternative way to eliminating sulphur emissions during kraft pulping.

**Project:** The project is designed to develop and demonstrate clean pulping and bleaching technologies applying oxygen/ozone/air when pulping and bleaching non-wood fibrous raw materials in small pulp mills. The project includes: strengthening of an R & D laboratory to study and adapt clean pulp and bleaching technologies; establishment and commissioning of a demonstration plant of about 10t/day to pulp and bleach wheat straw with oxidative reagents; and organizating an international seminar to disseminate the results.

### *b) Chemical recovery for small pulp mills*

**Problem:** In about 2000 small pulp mills in developing countries there are no chemical recovery systems and therefore such mills have higher production costs. Often they cannot expand their production, and their effluents heavily pollute rivers. There is lack of know-how and good technology in this specific field of chemical and fibre recovery from black liquors for small mills using non-wood fibrous raw materials.

**Project:** A project is designed to strengthen the capacity of a pulp and paper research centre after conducting applied research to evaluate different technologies for small scale chemical recovery from non-wood black liquor, such as: developing efficient methods of pulp washing, evaporation and mechanically cleaning of weak black liquor; investigating potential application of the ferrite process on a pilot-scale and ultrafiltration and reverse osmosis of weak black liquor in order to separate of organic and inorganic compounds.

## ◘ *TECHNICAL CO-OPERATION BETWEEN DEVELOPING COUNTRIES*

### *a) Research power and human resource development in various countries*

**Problem:** In some developing countries wood is scarcely found and any further development of the pulp and paper industry will have to be based on agricultural residues, such as bagasse, wheat

and rice straw, as well as annual crops such as kenaf, jute, sabai grass, elephant grass, etc. The variety of raw materials results in problems which no single country can solve owing to limited research sources, equipment and manpower training. Some of these problems are solved by using a specific raw material and could be adapted for use in other countries.

Although supplementary research is required for the technology transfer, this can be achieved by promoting co-operation between research institutes.

**Project:** A regional co-operation programme is being developed with the objective of establishing ties between various pulp and paper resarch institutes in order to organize joint research projects, to facilitate technology transfer and to set up a network for the continuous exchange of information.