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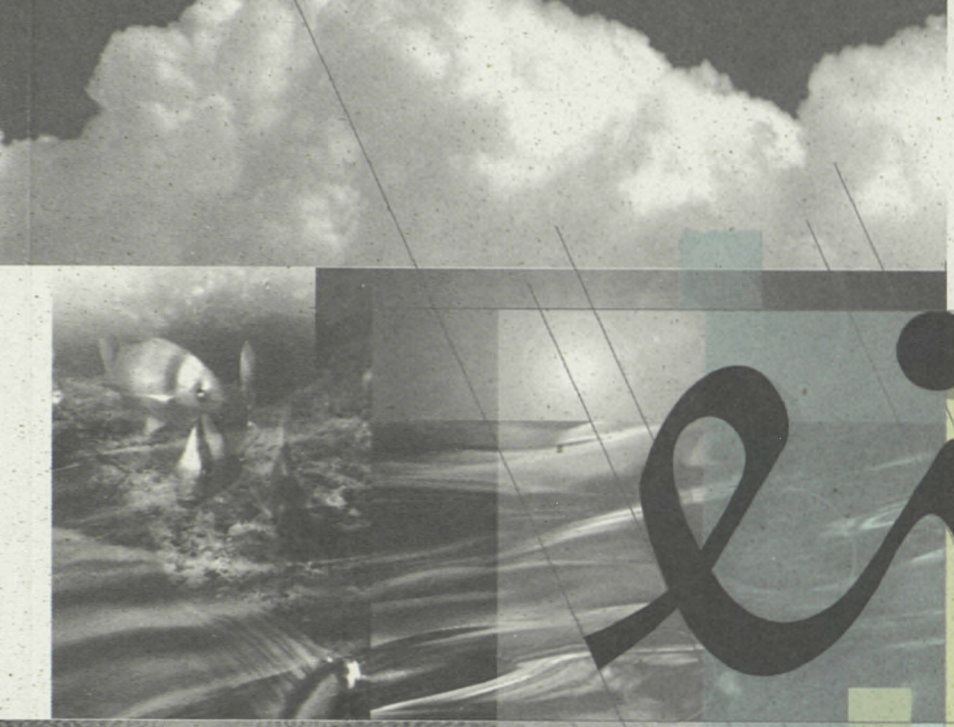

Environment Institute

Annual Report 98

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION
Report EUR 18712 EN

ENVIRONMENT INSTITUTE

Annual Report 1998

JOINT
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CENTRE
EUROPEAN COMMISSION

Report EUR 18712 EN

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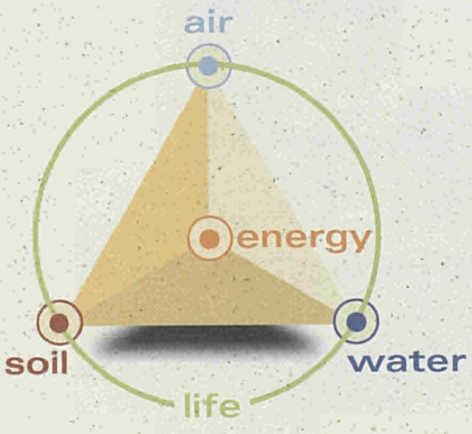
Introduction

Jean-Marie Martin
Environment Institute
Director

Located in Ispra (Italy), the Environment Institute (EI) is one of the eight institutes that constitute the Joint Research Centre of the European Commission. The Environment Institute's prime objectives are to investigate the level and fate of contaminants in the air, water and soil, to assess the effects of those contaminants on the environment and individuals and to promote a sustainable energy supply. The Institute concentrates its efforts on the reduction or prevention of damage to the environment, thus contributing to improving the quality of life of the European citizen.

1998 was the last year of the 4th Framework Programme and, as in the three previous years, the Environment Institute devoted its efforts primarily to the provision of scientific and technical support for the development and implementation of the European Union environmental policy. The main users of these support activities were the European Commission's Directorate-General XI (Environment, Nuclear Safety and Civil Protection) and Directorate-General XVII (Energy).

A judicious balance between research and support activities allowed the Institute to provide effective backing to the development and implementation of EU policies while maintaining its scientific and technical skills at an optimum level. The Institute complemented its own institutional activities with active participation in various competitive schemes, collaborating closely with some of the leading research centres in Europe.



The Institute's Structure.

A year of change and adaptation

1998 was also the year in which the 5th Framework Programme was prepared. To better fulfil its newly defined mission, the JRC undertook the creation of a more rational structure to deal with highly relevant issues, especially the protection of the environment and the consumer. This will allow the EI to better deal with the impact of human activities –industry, agriculture, forestry, commerce, trade, travel and tourism, even modern lifestyles– on the environment, which is becoming a matter of major public concern in Europe and around the world.

The Institute's new structure

The new structure of the Institute, which has been in place since October 1998, now covers all the classical compartments of the environment– air, water, soil and energy. It also pays special attention to life, which is intimately affected by them.

With the ever-growing recognition of the importance of soils and their associated water in the pollution cycle, a new Soil and Waste Unit was created in October 1998, charged essentially with meeting the vital need to undertake watershed-wide assessment of soil and water pollution, of waste emissions and contaminated lands, and soil remediation.

Given the very important role played in the environment by the generation, distribution and use of energy, particularly that derived from the burning of fossil fuels, new activities in the field of renewable energy production were incorporated into the Institute's programme of work, including, in particular, the programmes developed by the Energy

Systems Testing Unit (EST), formerly of the Institute for Advanced Materials (IAM).

One of the most important environmental problems today is the emissions from industrial installations and motor vehicles. To address this problem specifically, another new activity was also introduced into the Institute's work programme: the European Reference Laboratory on Waste Incineration and Vehicle-Emission Measurements (ERLIVE).

In recent years, the Environment Institute developed strong competence in various areas dealing with consumer-protection issues, such as the determination of food quality, validation of alternative methods to the use of animals in laboratory experiments, and the effects of chemicals on human health. In the last quarter of 1998, these activities were transferred to the newly created JRC Institute for Health and Consumer Protection (IHCP).

The 5th Framework Programme: 1999-2002

Preparation of the next Framework Programme was one of the most important subjects on which the Institute worked in 1998.

The work programme is customer-driven, with a project-oriented structure operated on sound project-management principles in accordance with the Environment Institute's Quality Policy, with the aim of optimizing the use of resources and the delivery of usable results to the end users of our research. It comprises eleven major projects which maintain the momentum developed by the Institute in the 4th Framework Programme, now ended.

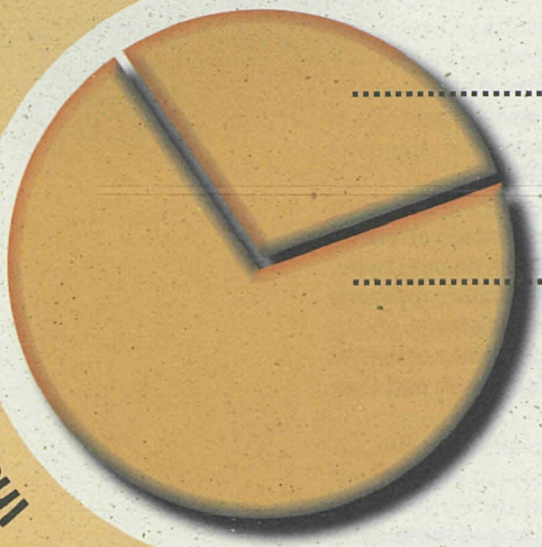
As in the past, the projects will be carried out in close collaboration with official laboratories, research centres and industries of the European Union's Member States, with the objective of creating a bridge between the EU's policies and the European citizen. This close co-operation is achieved to a large extent through the creation and maintenance of active networks of the partners involved in specific activities. Such networks may also include relevant laboratories and research centres in other European countries that are candidates for EU membership in the coming years.

Everyone benefits from a clean, safe and healthy environment, and to this end, my colleagues at the Institute, and I, will continue to help develop practicable policies by seeking to create a sound scientific and technical basis for these policies and, in the longer term, the preservation of Earth's natural resources for future generations.

Finally, I should like to thank all those who made possible the progress and achievements of the Environment Institute during 1998: the staff of the Institute and the Heads of Units, our colleagues in other Commission Services, our partners in the EU Member States and in other countries with which the EU co-operates in the field of environment and which contributed, through their participation in our technical networks, to the implementation of our programme.

Budget 1998 (Executed)

Institutional Activities



44.34 Meuro

Research: **29%**

Support: **71%**

The EI activities are funded through the direct actions of the Framework Programme (Institutional Activities). During 1998 the scientific and technical activities in support of EU policies represented 71% of these resources. The remaining 29% corresponded to research activities.

Competitive Activities

5.58 Meuro

Competitive Support: **18%**

Third Party Work Contracts: **25%**

Shared-Cost Actions: **57%**

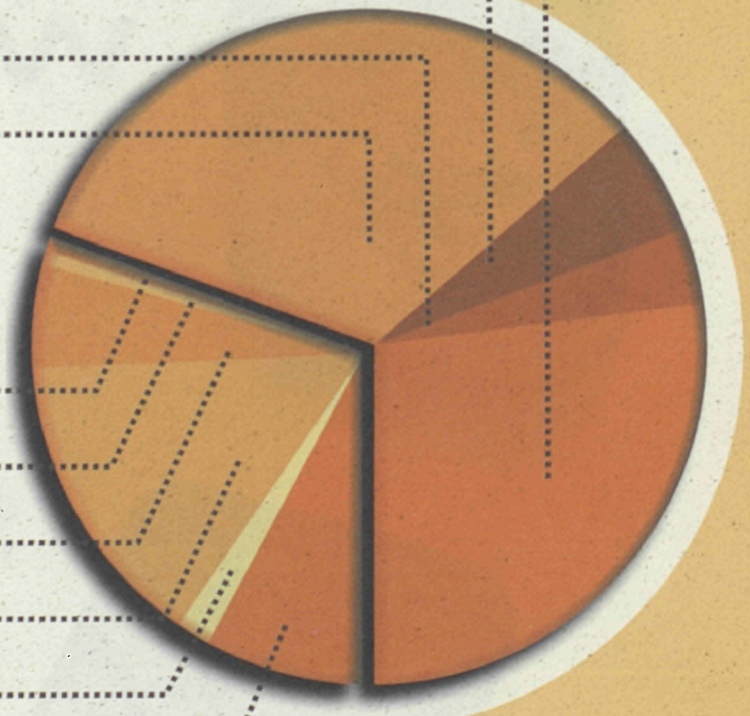
The EI has continued its efforts in participating in competitive schemes in fields complementary to its Institutional Activities, mainly through its participation in Shared-Cost Action projects and through services provided to the Commission (Competitive Support) and to other Third Parties (Third-Party Work).

Officials and Temporary Agents

Scientists:	81
Administrative Support:	11
Secretaries:	17
Technicians:	99
Total:	**208**

Other

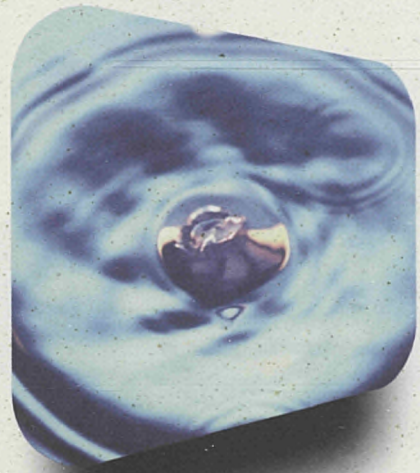
National Experts:	2
Visiting Scientists:	2
Auxiliaries:	15
Trainees:	44
Post Docs:	5
PhD Students:	23
Total:	**91**



air

Air Quality
Unit Head: D. Kotzias

Atmospheric Processes in Global Change
Unit Head: B. Versino
N. Omenetto *f.f.* from 1.3.1998

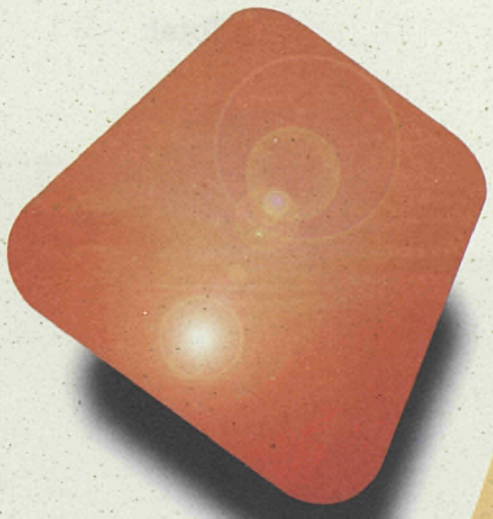


water

Water Research and Monitoring
Unit Head: A. Tilche

soil

Soil and Waste
Unit Head: G. Bidoglio *f.f.*



energy

Renewable Energies
Unit Head: H. Ossenbrink

The Environment Institute

DIRECTORATE

Director: **Jean-Marie Martin**

Deputy Director: **Bruno Versino** till 1.3.1998

Scientific Co-ordinator: **José María Jiménez**

MANAGEMENT SUPPORT UNIT

Unit Head: **Emanuela Rossi**

life

Environmental Impact

Unit Head: P. Pärt

Major results in 1998

air

Air Quality

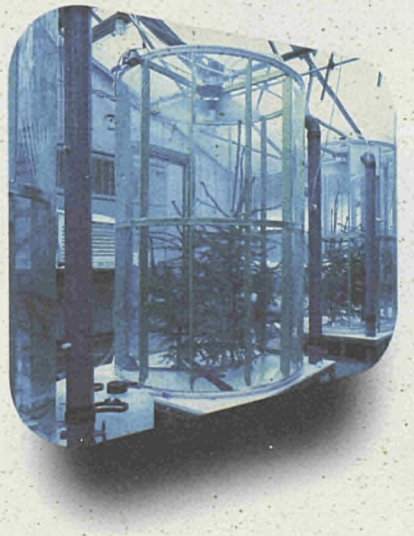
The European Reference Laboratory for Air Pollution (ERLAP) provided technical and scientific support for the implementation of community directives in the field of urban air pollution. In particular, ERLAP contributed to the harmonization of monitoring methods and the development of new techniques for the measurement of priority pollutants (eg, benzene).

The spatial distribution of nitrogen dioxide and sulphur dioxide and, partially, benzene, toluene and xylene, was determined in Athens (Greece) and Bologna (Italy), with a view to the design and optimization of their air-quality monitoring networks.

An integrated Environmental Monitoring, Forecasting and Warning System in Metropolitan Areas was successfully established in four European cities under the EMMA project.

The public Website of the Alpine Observatory was officially opened on the occasion of the Alpine Conference in October 1998.

A pilot-scale incinerator was set up at the Joint Research Centre to study gaseous and particulate pollutant emissions and to develop abatement and measurement technologies.



Atmospheric Processes in Global Change

A major effort was devoted to completing analysis of the data obtained during the field campaigns carried out under the BEMA (Biogenic Emissions in the Mediterranean Area), ACE-2 (Aerosol Characterization Experiment) and EUPHORE (European Photo-reactor) projects.

Chemical box models were successfully applied to BEMA findings to improve understanding of the various chemical pathways and to simulate the impact of emissions on air chemistry and ozone formation.

The first meeting between researchers from Europe and the USA to discuss the data obtained during the 2nd Aerosol Characterization Experiment (ACE-2), which was co-ordinated by the JRC to study the effect of European pollution on climate, was held in Ispra in 1998. An ACE-2 data archive, created in Ispra, is an essential tool for data integration.

WWW and database techniques were incorporated with the support of the Soil and Waste Unit into the development of the On-line Archive System for the ACE-2 Project and the provision of remote access to a series of hydrological models.

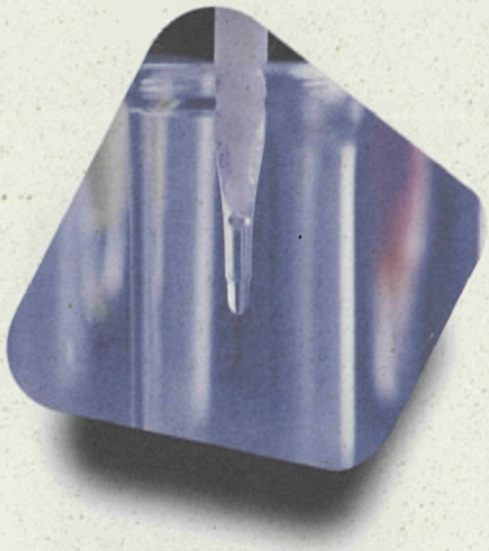
An extensive scientific field study of photochemical smog formation was carried out under the PIPAPO (Pianura Padana Produzione di Ozono) study, a joint effort by scientists from Italy, Switzerland, Germany and France and from the JRC, within the EUROTRAC project LOOP. In a study of the link between the emission of volatile organic compounds from vegetation and aerosol formation, a series of compounds (dicarboxylic acids) was identified for the first time.

In collaboration with the University of Bremen (Germany), a new instrument for field measurements of peroxy radicals, which play a central role in determining the oxidizing capacity of the atmosphere, was developed and tested.

water

Water Research and Monitoring

The work programme for the operation of LEPE, starting in 1999, was developed and consists of five main areas: Water Management, European Observatory on Drinking Water, Sustainable Wastewater Management, Data Quality, and European Watershed-Coastal Zone Pollution Exchange.



Ecological and managerial water-quality objectives were defined for the larger lakes in the Lombardy Region. The effect of different management scenarios on the water quality was simulated using river and lake models. Different existing approaches were compared for the definition of ecologically acceptable flows. A data and information management system was designed.

A Thematic Atlas of Water Resources for the Regione Lombardia was prepared with the support of the Soil and Waste Unit.

The state of the Mekong River, in Vietnam, and its coastal zone were assessed for the presence of inorganic and organic micro-pollutants that can affect the domestic water supply and the fisheries. A start was made to the assessment of the water quality of the Rivers Yangtse and Liao, in China, which are used for drinking-water supply.

A manual on monitoring European lakes using remote-sensing techniques was published.

Waste water was satisfactorily cleaned by membrane filtration and catalysed photo-oxidation in pilot-scale treatment plants. Field tests were carried out with a Mobile Wastewater Treatment Laboratory. The EI's subsurface-flow reed-bed wastewater test facility completed a full vegetation period and the first degradation studies were carried out.

soil

Inter-laboratory exercises on rain water, fresh water, waste water, soil, sewage sludge, fish and mussels, to improve the data on several chemical compounds, were carried out.

Soil and Waste

Several models were developed to improve our understanding of the factors affecting the transport of nutrients in river basins.

A collaborative project (Photo-transformation of Priority List Organic Chemicals) developed a standardized methodology for experimental photo-degradation studies to assess the potential toxicity of photo-transformation products in aquatic and terrestrial ecosystems.

A survey of dioxin in soil and biota from Zone-A of the 1976 Seveso accident (reopened to the public in 1997) was completed. As a final step in the JRC's 20-year involvement on the Seveso site, monitoring was extended to the formerly less contaminated Zones B and R.

The Proceedings of the Workshop on Co-incineration, held in Belgirate, Italy, in 1997, were published.

The Soil and Waste Unit co-ordinated and chaired a Workshop on the Application of Geographic Information Systems for the Management of Anti-Personnel Mines, and organized a Training Course for the JRC's 1998 Demining Technologies–International Exhibition, Workshops and Training Courses.

energy

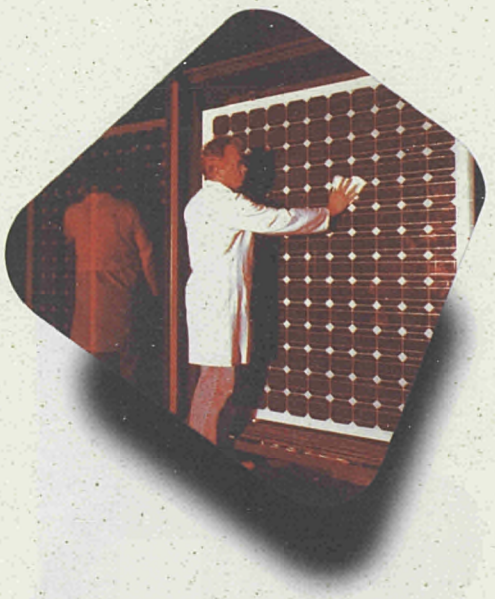
Renewable Energies

The largest photovoltaic power plant in Spain, with an output of 1 megawatt, was tested under standard test conditions. One sub-field of this plant incorporated innovative bifacial cells which collect not only the incoming solar radiation, but also the light from ground albedo (outgoing radiation, to space from Earth's surface).

Two intercomparison campaigns were carried out: one for crystalline reference cells calibrated on the World PV Scale, the other at the Solar Radiation Research Laboratory (SRRL) in Golden, Colorado, USA. Both campaigns served to ensure traceability of calibration measurements and to allow a preliminary assessment of the WPVS. The development of impedance spectroscopy and its application to these new materials led to a fundamental revision of the traditional theoretical models.

Through end-of-life testing, the Unit contributed significantly to the establishment of internationally accepted test standards defining Mean Time To Failure (MTTF), with the probable result that the manufacture of modules can be simplified and thus reduced in cost.

Following the development of an inventory of European building codes and electrical standards, specific experiments on the performance of PV systems incorporated into buildings were carried out in the ESTI solar simulator and climatic chamber.



A procedure for the determination of electrical consumption and analysis of usage patterns for office equipment, especially copying machines and PCs, was developed.

Following a comprehensive review of relevant national programmes on lighting technologies, and in collaboration with Directorate-General XVII (Energy), the Unit drafted a Proposal for a European Green Light Programme.

The Thermie Building Information System (THEBIS) database structure was defined with regard to its possibilities for querying the WWW database (eg mandatory, optional and additional fields), and to the collection of final reports of demonstration projects on template forms.

The JRC contributed to the Building Energy Labelling and Energy Technologies (BEL) project by proposing building energy certification methods based on simplified data sets.

Environmental Impact

The Environmental Impact Unit established the Global Endocrine Disruptors Research Inventory (GEDRI) data base, at Ispra, in collaboration with the International Programme on Chemical Safety (IPCS). Actions were undertaken to implement EU-USA co-operation in the field of endocrine-disrupting chemicals (EDCs).

The Endocrine-Disrupting Activity of Selected Environmental Pollutants (EDAEP) project evaluated such activity by means of the uterotrophic assay and by the use of primary cells from uterine epithelium.

Research on the immunotoxicity of metals encompassed a search for biomarkers of dermal sensitivity to metals, using a human keratinocyte cell line (HaCaT). This research was carried out in close collaboration with the National Institute for Working Life (Solna, Sweden) and the Institute of Medical Microbiology (Milan, Italy). In collaboration with Pavia University and the Autonomous University of Barcelona, the neurotoxicity of mercury compounds was assessed by means of primary culture of cerebellar neurons.

The data-input processors of the REM databank were developed and improved and the data base contents were updated. The Atlas of Caesium Deposition on Europe after the Chernobyl Accident was published in August 1998, concluding more than four years of scientific collaboration with research institutions and competent authorities from almost all European countries.

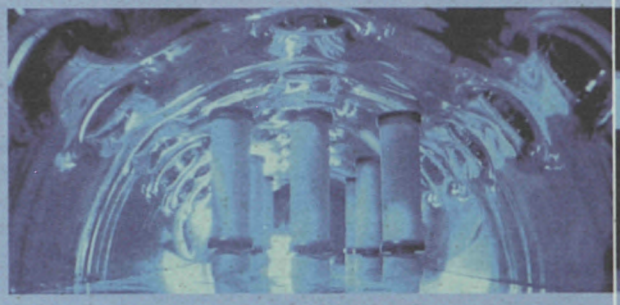
The European Union Radiological Data Exchange Platform (EURDEP), the information platform for automatic exchange of data between national real-time monitoring systems in routine and emergency circumstances, was extended to twenty-one European countries which exchange gamma dose-rate measurements on a daily basis.

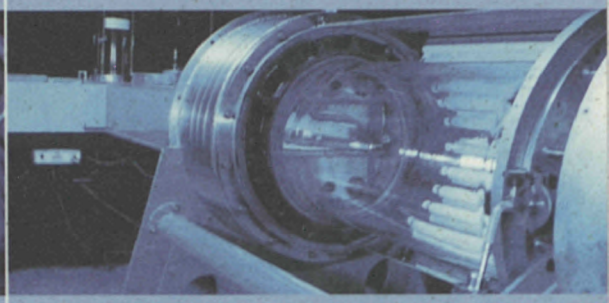
A meso-scale analysis of the second European Tracer Experiment (ETEX) release was carried out with the aim of understanding the reasons for the poor model performances in this experiment.

air

Air Quality

Unit Head: D. Kotzias





Atmospheric Processes in Global Change

Unit Head: B. Versino

N. Omenetto *f.f.* from 1.3.1998

INTRODUCTION

Air pollutants such as benzene and nitrogen oxides and the sometimes substantial load of particulate matter can be bad for our health, for the state of our buildings, and for ecosystems. The non-reactive–water vapour, carbon dioxide, methane–and reactive–ozone–"greenhouse" gases are natural components of the atmosphere, but are considered to be responsible for global warming. Many of these substances play a part in the formation of aerosols, which have a key role in determining climate. It is the task of the Air Quality Unit and the Atmospheric Processes in Global Change Unit to study the quality of the air we breathe and the various processes that determine the composition of the atmosphere.

air

Air Quality Unit

THE UNIT'S MISSION

For the efficient implementation of a European air-quality policy, the European Commission requires:

- sound scientific knowledge on the origins, levels and fates of air pollutants, for the development of new directives
- harmonized and validated monitoring methods and strategies to ensure valid and comparable air quality and emission data over Europe
- practical guidance to the Member States on the implementation of the relevant European directives
- instruments and methods for evaluating/improving the impact of air-quality and emission policies and directives on total human exposure to ambient and indoor air pollution
- modelling tools for the analysis of data, the assessment of abatement scenarios and the development of pollution-control measures.

The Air Quality Unit provides scientific and technical support to policy-makers in the formulation, implementation and monitoring of EU directives in the fields of air pollution, emissions from mobile and stationary sources and observation of the Alps.

The need to refer to an independent laboratory on questions of environmental monitoring led, in 1994, to the creation of the European Reference Laboratory for Air Pollution (ERLAP) to undertake activities relevant to the implementation of Community legislation on urban air quality.

Under the 4th Framework Programme on research and technology, the activity of the Air Quality Unit was mainly directed to running ERLAP, to co-ordinating the modelling part of the Auto-Oil studies on the impact of future vehicle fuels on urban air quality and to supporting and co-ordinating the activities of the Alpine Observatory.

Homepage: http://www.ei.jrc.it/aq/intro

FIELDS OF ACTIVITY

The main focus of the Air Quality Unit is to provide decision-makers with the necessary expertise and scientific means, such as:

- appropriate analytical instruments and methods in terms of precision, accuracy, reliability, cost, etc.
- harmonized data based on comparable measurement methods and strategies
- data collection and information systems with sufficient temporal and spatial response to meet the legal objectives
- modelling tools capable of giving an overall picture of environmental pollution and forecasting the effects of pollution, so as to assess the validity of pollution-control measures.

MAJOR ACHIEVEMENTS IN 1998

- In the context of the implementation of the *Directive on Air Quality Assessment and Management*, ERLAP contributed to the development of the "daughter" directives on ozone, carbon monoxide and benzene, by providing scientific and technical advice on measurement strategy to the Commission's working groups responsible for the elaboration of the directive proposals.
- Concerning the harmonization of air-quality measurements, pilot studies were carried out using the diffusive-sampling technique to assess the spatial distribution of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) and, partially, benzene, toluene and xylene (BTX) in Athens (Greece) and Bologna (Italy), with a view to the design and optimization of the air-quality monitoring networks.
- An integrated Environmental Monitoring, Forecasting and Warning System in Metropolitan Areas was successfully established in four European cities under the EMMA project.
- The public Website of the Alpine Observatory (*http://www.soia.int*) was officially opened on the occasion of the last Alpine Conference on 16 October 1998.
- The EU LIFE project MACBETH produced important information on ambient air levels and human exposure to benzene; ERLAP carried out the validation and the quality assurance of the measurement methodology within the project.
- A pilot-scale incinerator was set up at the Joint Research Centre to study gaseous and particulate pollutant emissions and to develop abatement and measurement technologies.

Practical example of the EMMA project: an indicator in Helsinki showing air quality from good (0) to bad (200).

FUTURE ACTIVITIES

In view of the 5th Framework Programme's orientation towards a more integrated approach to ambient air quality, the structure of the Unit changed during the second half of 1998.

Under the project Integrated Air-Quality Assessment (IAQA), the current ERLAP activities will be extended to include studies to address the impact of ambient and indoor air quality on total human exposure. Concerning the modelling activities that were initiated under the Auto-Oil project, the Clean Air Modelling project will be launched as part of the Clean Air programme, as a move towards a single integrated strategy on ambient air quality in Europe. In addition to this, modelling tools will be developed to support the development and implementation of the upcoming directives on air and noise pollution.

The European Reference Laboratory on Waste Incineration and Vehicle Emission Measurements (ERLIVE) profits from the combination of existing competences, laboratories and facilities in the fields of aerosol physics, engineering and systems (Aerosol Laboratory) and the newly built Pilot Incinerator for Advanced Treatment of Waste (WIND). The main goals of ERLIVE are to develop an accurate and reliable data base on gaseous and particulate emissions from existing and future vehicles and from industrial plants and to contribute to the development of new norms and standards, harmonization of testing methods, maintenance and inspection procedures, in the areas of transport and industrial pollution control.

ACTIVITIES AND PROJECTS

European Reference Laboratory for Air Pollution (ERLAP)

ERLAP was set up in 1994. Its purpose is to contribute, on behalf of Directorate-General XI (Environment, Nuclear Safety and Civil Protection)'s Unit on Air Quality, Urban Environment, Noise, Transport, Energy, to the harmonization of air-pollution measurements in the European air-quality monitoring networks.

With a view to the preparation, by the Commission, of new air-quality regulations, notably the *Framework Directive on Ambient Air-Quality Assessment and Management*, ERLAP assesses the performance of measurement techniques used in the member states in order to establish reference methods for sampling, analysis and calibration of priority air-pollutant measurements. New techniques of sampling, calibration and monitoring are also being developed.

Measurements of gas cylinders with low concentrations of sulphur dioxide.

To ensure quality and comparability of air-pollution measurements in the European air-quality monitoring networks, quality-assurance and quality-control programmes are carried out through round-robin tests, inter-laboratory exercises and spot checks at monitoring stations, with the collaboration of the Member States.

To respond to specific problems of air-quality monitoring, pilot studies are either co-ordinated or conducted by ERLAP. Particular attention is given to the design and optimization of monitoring networks, assessment of air-pollutant levels in urban areas and areas at risk; new air-monitoring techniques are validated and demonstrated.

In the framework of the UN Economic Commission for Europe (UN-ECE), ERLAP has been operating the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP)'s station since 1985, providing information on the deposition and concentration of air pollutants and on the long-range transport of pollutants across national boundaries.

The participation of ERLAP in the LIFE project MACBETH (Monitoring of Atmospheric Concentration of Benzene in European Towns and Homes), funded by Directorate-General XI, continued. MACBETH's aim is to increase our knowledge of environmental pollution in the Member States, with particular reference to the environmental concentrations of benzene and the exposure of human beings to it, indoors and outdoors. Concentration levels ranged from 3 to 40 $\mu g/m^3$ depending on period and city evaluated. Research Institutes from six European countries are participating in MACBETH. The project's quality assurance and harmonization of measurement methodology is ERLAP's responsibility. The project will be completed in 1999.

HAMAQ (Harmonization of Air Quality Measurements in Europe) is a European project funded by the Standards, Measurement and Testing programme. The overall aim of the project is to improve the consistency of air quality measurements of the pollutants carbon monoxide (CO), nitric oxide (NO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and benzene (C_6H_6) throughout Europe. This will be done by assessing and subsequently improving the level of agreement between the various primary calibration methods currently employed at national standards laboratories/institutes in Europe. The partners, from seven European countries; have nearly completed stability tests and two intercomparison exercises for all compounds. The project started in 1997 and will end in 1999 with a workshop at which the results and information on the equivalence of available 'primary' standards, their method of use, stability of the gas cylinders and know-how will be provided to European laboratories.

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AUTO-OIL II

AUTO-OIL II was initiated in 1997 and is scheduled to end in December 1999. AUTO-OIL I identified the best measures that could be introduced in Europe, starting in 2000, to reduce man-made pollutant emissions from vehicles and the oil industry, with a view to reaching specific air-quality objectives by the year 2010.

The main aims of AUTO-OIL II are to extend the range of pollutants considered and to decide emission-reduction targets and air-quality targets in the longer term. Strong reliance is placed on the development of models, based on air-quality analysis, to determine optimum simulation periods, to establish the link between relevant urban studies and region-wide projections, and to predict air quality in terms of ozone, carbon monoxide, benzene, nitrogen dioxide and particulate matter from the 1995 baseline values.

Eleven European city domains of differing characteristics form the core of the data base for this study: Athens, Berlin, Cologne, Dublin, Helsinki, London, Lyons, Madrid, Milan, Reggio nell'Emilia and Utrecht. These domains represent 47% of the urban population living in the 15 Member States.

Current air-quality standards and emission-reduction objectives of these European cities were reviewed. The real-time models for predicting the evolution of air quality under different abatement scenarios took into account the long-term analysis of air quality in various urban situations so as to define air-pollution episodes, evaluate street-level concentrations and to assess, in Europe-wide terms, the representativeness of each of the cities under study with respect to urban ozone, carbon monoxide, benzene, nitrogen dioxide and airborne particles. The functional relationships between emissions and air quality were established for all the pollutants of interest, as well as the tools for projecting regional and urban emission inventories up to 2010.

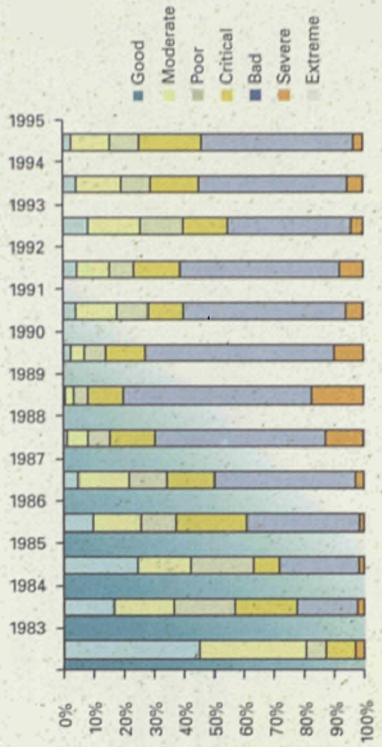
Based on the models developed, an Integrated Environmental Monitoring, Forecasting and Warning System in Metropolitan Areas (EMMA) has been successfully established in four European cities (see EMMA, below). Seven research institutions from six European Member States are contributing to the technical phases of AUTO-OIL II, which is funded by several Directorates-General participating in the European Commission's ad hoc management group, and by contributions from the European automobile and oil-industry associations.

Website: http://www.ei.jrc.it/aq/projects/AUTO-OIL

Integrated Environmental Monitoring, Forecasting and Warning Systems in Metropolitan Areas (EMMA)

EMMA was initiated in January 1996 and ended in June 1998. The establishment of effective metropolitan air-quality warning systems requires the integration of existing monitoring networks for a range of air-quality and meteorological parameters, and the incorporation of the latest communication and multimedia systems, to assemble, quality-control and analyse the data and to disseminate quickly the relevant results and predictions in near-real time.

EMMA has facilitated the development and establishment of the integrated system now operative in four European cities (Genoa, Leicester, Madrid and Stockholm). It serves local-government entities concerned with the environment, traffic/transport and public health, as well as the individual citizen. This system has attracted world-wide attention because of its capability to produce accurate 24-hour air-quality forecasts for most atmospheric pollutants of concern in a modern urban context. It is unique for its ability to report the state of atmospheric pollution irrespective of the particular characteristics of the urban domain in which it is installed and irrespective of the nature and causes of the



Evolution of air quality indicators during 15 years in Athens.

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Skouloudis A N, Bianconi R, Bellasio R (1998). Air-quality prognosis for the implementation of abatement strategies over large urban areas. *Environmental Monitoring and Assessment*, **52**:185-201.

Suppan P, Fabian P, Vyras L, Gryning S E (1998). The behaviour of ozone and peroxyacetyl nitrate concentrations for different wind regimes during the MEDCAPHOT-TRACE campaign in the greater area of Athens, Greece. *Atmospheric Environment*, **32**(12):2089-2102.

Klemm O, Ziomas I C, Balis D, Suppan P, Slemr J, Romero R, Vyras L G (1998). A summer air-pollution study in Athens, Greece. *Atmospheric Environment*, **32**(12):2071-2087.

pollution episode. Moreover, it uses a scale that is easily understood by the general public and which is uniform for all pollutants.

Under EMMA, the 6th International Conference on Highway and Urban Pollution Systems was organized at Baveno, Italy, 19-21 May 1998, and attended by about 250 experts and representatives of the automobile industry and of the regulatory authorities of several cities.

EMMA was funded by Directorate-General XIII (Telecommunications, Information Market and Exploitation of Research) and provided support to the implementation of four European Union directives.

Websites: http://www.ei.jrc.it/aq/projects/EMMA
http://www.tagish.co.uk/ethos/tap/tap/21b2_3a6.htm
http://www.Mediterranean.ac.uk/emma

Emissions from waste incineration

Waste incineration is one of the major sources of gaseous and particulate pollutants. A pilot incinerator was set up at JRC to study these pollutant emissions and to develop abatement and measurement technologies. The incinerator works in batch mode and is able to treat up to 250 kg/h of waste, depending on the material mixture. In the burning chamber, a maximum temperature of 900ºC can be reached, while the post-combustion chamber can be heated up to 1200ºC. The residence time in the post-combustion chamber is more than 2 seconds. Venturi scrubber, centrifugal drop separator, caustic scrubber and wet electrostatic precipitator are the main off-gas cleaning components. At the stack, the on-line measurement of sulphur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOC), oxygen (O_2), carbon monoxide (CO), hydrogen chloride (HCl) and particulate matter (PM) is foreseen. The construction of the incinerator was finished and two commissioning tests with office paper as fuel were performed successfully.

A shared-cost action on gas cleaning and particle removal at high temperatures was initiated in June 1998. The objective is the definition of process parameters and operation limits for a dry gas-cleaning system to reduce gaseous pollutants (hydrogen chloride, sulphur dioxide, nitrogen oxides, and volatile organic compounds, particulate matter and vapour-phase heavy metals). The test configuration will allow comparison between the standard wet gas-cleaning system and the (dry) filtration system. Partners in the project are the University of Karlsruhe (Germany), Solvay (Belgium), Schumacher (Germany), Ciemat (Spain) and JRC's Environment Institute.

In the 5th Framework Programme, tests for the development of a technique for sludge incineration and for the measurement of dioxin precursors are foreseen. The aim of the first series of tests, with mixtures of paper, cardboard, wood chips, non-chlorinated plastics and added heavy metals, will be the determination of heavy-metal deposition in the incinerator. The main objectives of the proposed work are the development of a database of gaseous and particulate emissions, the harmonization of measuring methods and a substantial contribution to the development of new standards and norms in the field of waste incineration. Finally, the toxicological evaluation of the emissions is one of the project's key points.

UV measurement at the JRC

The contribution to the international collection of data on the total ozone column, co-ordinated by the World Meteorological Organization (WMO), started at the Joint Research Centre, Ispra, at the end of 1991, was pursued in 1998. The measurements, made by a Brewer MK-IV spectrophotometer, are also submitted every day, during the cold season, to the WMO Ozone Mapping Centre in Thessaloniki, in the frame of the 1997-1998 and the 1998-1999 northern-hemisphere ozone campaigns managed by the WMO/GO3OS (WMO/Global Ozone Observing System).

Daily spectral measurements of solar ultra-violet-B were continued: the main effort is devoted to improving the quality of the data to be transferred to the data base of the SUVDAMA (Scientific UV Data Management) project, a shared-cost action within the Environment and Climate programme. In this context, a detailed investigation of the effects of ambient temperature variation on the Brewer spectrophotometer's responsivity was carried out. An analysis of the correlation between the variation of the solar UV-B and the total ozone column was completed for the period 1993-1997.

Measurements of the atmospheric aerosol depth by a sunphotometer were pursued and analysed in correlation with analogous measurements taken at shorter wavelengths (300-325 nm) by operating the Brewer with suitable software.

The above-mentioned measurements will be continued, with the addition of the detection of solar UV-A spectra; the correlation between the experimental UV data and radiative-transfer-model predictions will be analysed.

Indoor pollution

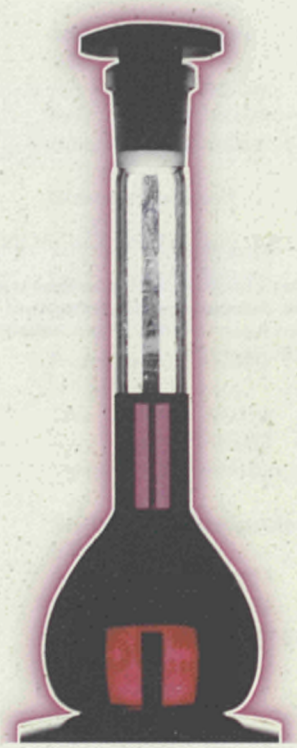
Laboratory investigations of volatile organic compound (VOC) sorption by various building materials (a phenomenon by which they can take up and slowly release organic vapours) yielded, as major result, the fact that diffusion plays a very significant role. A new experimental approach was developed (whereby the test sample separates two constantly ventilated air compartments, to one of which VOCs are added by a microdrop generator; concentrations are monitored in both compartments) allowing the uptake and diffusion of VOCs by and through the material to be quantified simultaneously. Preliminary screening experiments were followed by complementary studies, carried out in collaboration with the Danish Building Research Institute (SBI). Results showed that diffusion of VOCs can be fast and that building materials can take up and release a considerable amount of VOCs. Models are being developed to describe this phenomenon quantitatively and to account for it in the prediction of indoor air concentrations.

A European interlaboratory comparison on the determination of VOCs emitted from building materials, co-ordinated by the Environment Institute in the frame of the VOCEM project (funded by the Standards, Measurements and Testing programme), was concluded. The exercise, which was the largest ever organized on this target (18 participants from 10 countries; 3 materials) achieved the following results: (i) reduction of interlaboratory discrepancies (c.v. 23-91% compared to 33-135% of the previous comparison; for 7 out of 15 compounds c.v. ≤40%); (ii) identification of the major sources of error (chemical analysis, sorption losses on chamber walls, lack of material homogeneity).

Recommendations to the Comité Européen des Normes on the pre-standard on the subject were drafted.

Two working groups within the European Collaborative Action Indoor Air Quality and Its Impact on Man (ECA-IAQ) launched by the Environment Institute have been active. One of them completed the report *Sensory Evaluation of Indoor Air Quality* (in press), which has the consensus of the leading experts and represents an important clarification on a matter still subject to considerable debate. The other group worked on a draft on the theme *Assessing Risks of Indoor Air Pollutants*, which should be finalized in 1999.

Website: http://www.ei.jrc.it/aq/projects/ECA-IAQ



A calibration solution for nitrogen dioxide measurements.

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Meininghaus R, Knudsen H N, Gunnarsen L (1998). Diffusion and sorption of volatile organic compounds in indoor surface materials. In: *EPIC '98*. Proceedings of the 2nd European Conference on Energy Performance and Indoor Climate in Buildings, Lyons, France, **1**:33-38.

Alpine Observatory
(System for the Observation of and Information on the Alps–SOIA)

The Alpine Observatory was set up in 1997 under the Alpine Convention. Its main aim is to provide scientific support to the monitoring of the Convention on the Protection of the Alps and its specific protocols, so as to ensure the sustainable development of the whole Alpine arc. This requires the assembly, quality control and harmonization of a wide variety of disparate data from national sources, to create harmonized environmental-quality and other relevant indicators, maps, catalogues, thesauri, and the preparation of a report on the state of the Alps. Eight alpine countries (Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland) are participating in the SOIA.

The Air Quality Unit provides the Co-ordination Unit, as a form of support to Directorate-General XI.

In 1998, the data collection for environmental indicators–nature, forests, water–as well as socio-economic ones–demography, economy and employment, agriculture, tourism, transport and energy–relevant to the Alps was launched with a view to their publication in 1999. An information service on institutes of Alpine research was established. The Alpine Catalogue of Data Sources progressed towards publication in 1999.

A set of homogeneous demographic indicators of the Alps using harmonized maps was published and an Internet information service (*http://www.soia.int*) was opened on the occasion of the ministerial Alpine Conference.

This service provides information, often in five languages, on: (i) the specification of all the indicators and the results for the assembled ones; (ii) an information system on Alpine research covering research institutes.

Website: http://www.ei.jrc.it/aq/projects/SOIA

SELECTED PUBLICATIONS

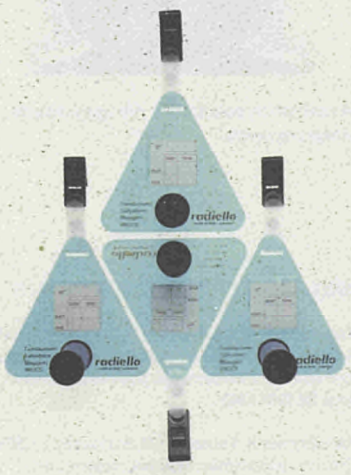
Laurent J, Lieber C, Briquel V (Cemagref) et al. (1998). *Demographic Indicators of the Alpine Region*. Report EUR 18669 EN (also available in IT, SL, GE and FR).

KNOW-HOW, INSTRUMENTS AND LABORATORIES

Air quality in urban and rural areas

The European Reference Laboratory for Air Pollution (ERLAP) answers questions on air quality by using technology and expertise at its disposal to:

- develop and validate new measurement techniques for air samples
- organize pilot studies of air-quality monitoring
- contribute to international air-quality monitoring programmes
- carry out groundwork for air-quality regulations
- harmonize measurement methods and strategies for current directives.



Diffusive samplers for indoor, outdoor and personal exposure measurements.

Mobile laboratories equipped with hi-tech facilities, such as remote sensors for tracking pollutant emissions from tall stacks, differential optical absorption spectrometers, and instruments to calibrate monitoring stations in the field, enable ERLAP to measure air quality and map pollutant concentrations at ground level.

The laboratories are also equipped to measure ozone, nitrogen oxides, sulphur dioxide, ammonia, formaldehyde and aromatic hydrocarbons.

The ERLAP laboratory prepares and tests gas calibration standards and multi-pollutant gas mixtures for intercalibrations and intercomparisons. It also has the facilities and expertise to apply a range of chemical and physical analytical techniques, from wet chemistry to non-destructive spectrometry.

Environmental test chambers for studying emission and absorption of indoor pollutants and for testing analytical equipment and procedures

- four small environmental test chambers (0.074, 0.28, 0.45 (2x) m^3) featuring controlled temperature (18-30° C or 18-150° C), relative humidity (0-90%), air quality and air exchange rate (0-2 ach)
- a walk-in type of environmental chamber, Indoortron, of 30-m^3 volume featuring controlled temperature (15-40° C), relative humidity (20-90%), air quality and air exchange rate (0.1-2 ach); this chamber can also be used for controlled human exposure studies.

Emissions from stationary and mobile sources

With the available facilities, instrumentation and expertise in emissions the European Reference Laboratory on Waste Incineration and Vehicle Emission Measurements (ERLIVE) will:

- develop a data base of gaseous and particulate emissions from mobile and stationary sources
- contribute to the development of new norms and standards, harmonization of testing methods, maintenance and inspection procedures in the areas of transport and industrial pollution control
- develop and improve incineration technologies for special waste
- develop techniques for the measurement of dioxin precursors
- assess potential toxicological impact of gaseous and particulate emissions (diesel engines) on human health.

As its main resources, ERLIVE has available a pilot incinerator (WIND) equipped with all necessary instrumentation for gaseous stack emissions. Additional aerosol instrumentation (single-particle counter, 3-wavelength extinction meter, differential mobility analyser, photoelectric aerosol sensor, low-pressure impactors) is used for detailed particle characterization and subsequent chemical analysis of aerosol samples. A laboratory with glove boxes for sample handling, an optical microscope (x 1500) and an X-ray fluorescence spectrometer allow a first analysis of the samples.

The same instrumentation, available computer codes and test rigs on aerosol transport will be also used in the new laboratory VELA which will study the characteristics of emissions from vehicles. In a first phase, different carbonaceous materials will be evaporated with plasma torches to simulate particles from engine emissions. Thereafter, more representative experiments with full vehicles under static conditions and dynamic cycles will be performed. All these data and the analysis will be used as input for toxicological studies to evaluate the impact of emissions on human health.

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air

Atmospheric Processes in Global Change Unit

THE UNIT'S MISSION

Understanding changes in the chemical composition of the atmosphere, and their effect on regional and global climate, is essential to the formulation of an appropriate environmental policy. The Unit focusses on the study of physical, chemical and biological processes controlling the tropospheric concentrations of reactive (ozone) and stable greenhouse gases, as well as aerosols, and aims at understanding the relationship between these three factors, in order to provide an integrated scientific basis for EU environmental regulatory actions, including the assessment of the application of the Kyoto Protocol.

The Unit is characterized by a unique expertise in the fields of aerosol physics, gas-phase photochemistry, plant physiology, biosphere-atmosphere interactions, advanced organic and inorganic analysis with state-of-the-art instrumentation, and modelling.

Homepage: http://www.ei.jrc.it/ap/intro

FIELDS OF ACTIVITY

Most of the Unit's activities support the Commission services responsible for EU legislation; in particular the Directorate-General XI (Environment, Nuclear Safety and Civil Protection) with respect to the EC directives on ozone. The activities are relevant to international and national bodies and complement the Commission's shared-cost action projects in the Environment and Climate programme.

The Unit contributes to major international programmes such as: the International Geosphere-Biosphere Programme (IGBP)'s IGAC (International Global Atmospheric Chemistry) project for which it runs the European IGAC Project Office (EIPO) and BAHC (Biospheric Aspects of the Hydrological Cycle); the Global Atmosphere Watch (GAW) of the World Meteorological Organization (WMO); and EUROTRAC, a EUREKA environmental project. Altogether, the Unit participated in nine successful shared-cost action consortia.

All the Unit's major activities (Aerosols and Climate, Biosphere-Atmosphere Interactions, Photochemistry and Kinetics) are based on existing large networks in which the Environment Institute is in partnerships with relevant EU laboratories, institutes and industries.

As an example, some activities are carried out in collaboration with the European Photo-reactor (EUPHORE) consortium at the Centro de Estudios Ambientales del Mediterráneo (CEAM) in Valencia, Spain, which was constructed through a partnership between the Unit and seven other European laboratories.

MAJOR ACHIEVEMENTS IN 1998

A major effort was devoted to data treatment and to finalizing the results obtained during the campaigns carried out in 1997, under BEMA (Biogenic Emissions in the Mediterranean Area), ACE-2 (2nd Aerosol Characterization Experiment) and EUPHORE (European Photo-reactor).

Modelling included the application of process models, of chemical box models, and of a 3D-mixed transport/chemical model to BEMA data sets to improve understanding of the various chemical pathways, and simulation of the impact of emissions on air chemistry and ozone formation.

A first meeting between researchers from Europe and the USA was held in Ispra in 1998 to discuss the data obtained during the 2nd Aerosol Characterization Experiment (ACE-2), which was co-ordinated by the JRC and carried out in the summer of 1997 in Tenerife, Madeira, the Azores and Portugal.

Several shared-cost action projects were initiated as a follow-up of BEMA, dealing with the parameterization of environmental and physiological controls of VOC emissions (ECOVOC) and with VOC emission modelling for European forest canopies (VOCAMOD). A new project was initiated to contribute a long-term station in a pine forest near Pisa, Italy, to the MEDEFLU/EUROFLUX project and the global FLUXNET initiative.

The 25-metre high tower was constructed in the middle of a large pine forest and is the core platform of the long-term monitoring site San Rossore (Pisa) of the MEDEFLU/EUROFLUX-project.

During 1998, a series of compounds (dicarboxylic acids) that appear to be an important link between aerosol formation and the emission of volatile organic compounds from vegetation was identified and published for the first time. This work was part of the extensive studies of terpene chemistry and gas-to-particle conversion carried out within the EU projects Nucleation Processes from Oxidation of Biogenic Volatile Organic Compounds (NUCVOC) and Degradation Mechanisms of Biogenic VOC (BIOVOC).

A large scientific field study of photochemical smog formation was carried out in May-June 1998. This campaign, called PIPAPO (Pianura Padana Produzione di Ozono), was a joint effort by scientists from Italy, Switzerland, Germany and France and from the JRC, under the EUROTRAC project LOOP.

FUTURE ACTIVITIES

A scientific workshop was organized in September 1998 in Ispra to discuss the relevance of a new project called PHAMA (Photo-oxidants and Aerosols in the Mediterranean Area) and possible ways of implementing it.

Activities beyond 1998, under the 5th Framework Programme (1999-2002), will essentially deal with two significant research topics: the study of the couplings between photo-oxidants and aerosols, through PHAMA; and the measurement of fluxes of greenhouse gases and aerosols, through a project called GHOGA (Greenhouse Gases and Aerosols).

To improve understanding of the couplings between photo-oxidants and aerosols, PHAMA will undertake a number of integrated modelling and experimental activities, grouped into some interconnected sub-projects. Laboratory studies will focus on key reactions in the formation of ozone and aerosols and on gas/aerosol interactions. Mesoscale experiments will be designed to test model performance with respect to representative situations of Mediterranean circulation and air chemistry.

The aim of GHOGA is to investigate the land-atmosphere interactions of greenhouse gases and their biological controls, as well as global

atmospheric aerosol emissions and distributions, to support European initiatives relative to the Kyoto Protocol. Some of the activities will involve: continuation of long-term monitoring of carbon fluxes and sinks in a pine forest and initiation of a second monitoring site in the Italian Alps; long-term monitoring of aerosol properties in the North Atlantic and in the Mediterranean area; measurement of fluxes of aerosols from industrial/urban complexes; developing integrated data sets of aerosol observations for global aerosol model evaluation; developing and using aerosol models to make radiative forcing calculations.

ACTIVITIES AND PROJECTS

Aerosols and climate

The JRC measuring station in the field during the PIPAPO campaign, Summer 1998 in Versago (I).

Analysis of the data obtained during the ACE-2 campaign in 1997 was a major activity in 1998. The Environment Institute, apart from analysing the data obtained during ACE-2, also organized an ACE-2 data workshop to stimulate and discuss progress in data analysis with all participants. An ACE-2 data archive, using web-based technology for data input and output, was created at Ispra with the support of the Soil and Waste Unit and is an essential tool for data integration.

In the preparation of studies of atmospheric chemistry in the Mediterranean area, the Unit's Aerosol Group participated in the EUROTRAC project Limitation of Oxidant Production (LOOP), through the PIPAPO campaign. The formation and evolution of secondary aerosol in the plume of Milan was studied, highlighting the predominant role of organic aerosol formation within a radius of 30 km of an urban complex.

The modelling studies on aerosol formation on the global scale (under the project Study of the Indirect and Direct Influence on Climate of Anthropogenic Trace Gas Emissions – SINDICATE) yielded the first definite results. It was estimated that, compared with pre-industrial times, the number of pure sulphate particles has increased by 25% (compared to a 300% increase in the total sulphate mass). On the other hand, a 300% increase in number was attributed to mixed soot/sulphate particles from industrial and biomass combustion.

Data archiving for the WMO's World Data Bank on Aerosols continued through the project Synthesis of Integrated Aerosol Data Sets (SINGADS) sponsored by the ENRICH programme. This activity provided data sets that were used for the international WMO-IGAC sponsored intercomparison and validation exercise of 3D models of the global sulphur cycle (COSAM).

Websites: http://www.ei.jrc.it/ap/projects/ACE-2
http://www.ei.jrc.it/ap/projects/SINDICATE2
http://www.ei.jrc.it/ap/projects/SINDICATE3

Biosphere-atmosphere interactions

The Biosphere-Atmosphere Interactions Group focussed on gas exchanges between terrestrial plants and ecosystems and the atmosphere. The emission of volatile organic compounds (VOCs) of biological origin, and of nitrogen oxides from soil, leads to the formation of photo-oxidants and aerosols.

The project Biogenic Emissions in the Mediterranean Area (BEMA), initiated in 1993, ended in 1998 with a synthesis of the data obtained in the latest measurement campaigns in the Valencia/Castellón region of Spain.

Runs of the dynamic chemistry model developed in BEMA were based on campaign data and were performed for the 140 x 110 km domain. They showed that a significant contribution to ozone formation was

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Virkkula A, Van Dingenen R, Raes F, Hjorth J (1999). Hygroscopic properties of aerosol formed by oxidation of limonene, alfa-pinene and beta-pinene. *Journal of Geophysical Research*, **104**:3569-3579.

Putaud J P, Davison B M, Watts S F, Mihalopoulos N, Nguyen B C, Hewitt C N (1999). Dimethylsulfide and its oxidation products at two sites in Brittany (France). *Atmospheric Environment*, **33**:647-659.

Van Dingenen R, Raes F, Putaud J-P, Virkkula A, Mangoni M (1999). Processes determining the relationship between aerosol number and non-sea-salt sulfate mass concentartions in the clean and perturbed marine boundary layer. *Journal of Geophysical Research*, **104**:8027-8036.

made by secondary organic compounds, such as volatile carbonyls (ie, compounds derived by transformation of VOCs) emitted by the vegetation.

The application of the model to the regional level suffered from the lack of reliable maps of land cover and biomass densities. Therefore, a pilot emission inventory with a grid resolution of 1 x 1 km for the modelling domain was initiated in collaboration with the Centro de Estudios Ambientales del Mediterráneo, in Valencia, Spain, in the frame of the shared-cost action Biogenic VOC Emission Modelling for European Forest Canopies (VOCAMOD). Advanced algorithms developed under the project Parameterization of Environmental and Physiological Controls of VOC Emissions from European Forests (ECOVOC) are used to predict seasonal and diurnal changes in VOC emissions for the individual grid cells of the model. Within ECOVOC, an information system and data base were developed and are available on a JRC-server (*http://www.eurovoc.ei.jrc.it*), among others, to provide to the scientific community a compilation of emission factors for all plants investigated so far. The dominant contribution of oaks to the overall emission of terpenoids was confirmed.

A second research activity, considered essential to the implementation of the Kyoto Protocol, involves the study of the carbon/water fluxes of a Mediterranean pine forest near Pisa, Italy. It is a contribution to the European project MEDEFLU (Carbon and Water Fluxes of Mediterranean Forests), to the EUROFLUX project, to the global FLUXNET initiative, and to the IGBP programme Biospheric Aspect of the Hydrological Cycle (BAHC).

MEDEFLU comprises a European network of eleven laboratories. The Environment Institute contributes a long-term test site in a Mediterranean pine forest in the San Rossore Natural Park near Pisa, Italy. The site is equipped with a 25-m tower and cabin, photovoltaic power supply and the instrumentation to monitor continuously the full set of meteorological, micrometeorological and ecophysiological parameters. Fluxes of carbon, water and energy are monitored by the eddy-correlation method in combination with profiles of temperature and wind, soil-heat plates and TDR-soil water probes to allow assessment of carbon reservoirs in the different compartments. An inventory of pine plantations in the Natural Park and in complementary bioclimatic zones of Italy was initiated to enable upscaling of carbon fluxes and stocks from the test ecosystem to the region.

Websites: http://www.ei.jrc.it/ap/projects/BEMA
http://www.ei.jrc.it/ap/projects/VOCAMOD
http://www.ei.jrc.it/ap/projects/ECOVOC
http://www.ei.jrc.it/ap/projects/MEDEFLU

Photochemistry and chemical kinetics

The objective of this activity is to contribute to the understanding of the chemical processes involved in photo-oxidant production and aerosol formation from the natural and man-made emissions to the atmosphere.

The work performed in 1998 focussed on photolytic reactions, the formation of aerosol mass by chemical conversion of gases in the troposphere, and field studies of radicals involved in the formation of tropospheric ozone (peroxy radicals). The studies were carried out within the framework of European Union collaborative international projects, as well as within the EUREKA project on tropospheric pollution, EUROTRAC.

Experimental investigations of the mechanisms and rates of the photolysis of carbonyl compounds were carried out in Ispra and in the large European photoreactor (EUPHORE) in Valencia, Spain. The work, which was carried out under the shared-cost action project Evaluation of Radical Sources in Atmospheric Chemistry through Chamber and Labora-

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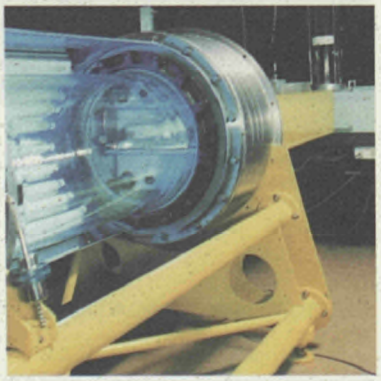
Loreto F, Ciccioli P, Brancaleoni E, Valentini R, De Lillis M, Csiky O, Seufert G (1998). A hypothesis on the evolution of isoprenoid emission by oaks based on the correlation between emission type and Quercus taxonomy. *Oecologia*, **115**:302-305.

Loreto F, Foster A, Durr M and Seufert G (1998). On the monoterpene emission under heat stress and on the increased thermotolerance on leaves of Quercus ilex L. fumigated with selected monoterpenes. *Plant, Cell and Environment*, **21**:101-107.



480-litre reaction chamber for simulating atmospheric photochemistry.

tory Studies (RADICAL), using natural as well as artificial sunlight, led to interesting information about these reactions, in particular about the yields of the highly reactive radicals produced compared to the yields of stable, less reactive products.

Laboratory studies of chemical reactions relevant to aerosol formation showed that dimethylsulphide, terpenes and aromatic hydrocarbons appear to be the classes of volatile organic compounds that are most important as gaseous precursors of aerosol in the troposphere.

Detailed analyses of condensable terpene oxidation products were carried out (see below: Organic Analysis). The studies on aromatic hydrocarbons were focussed particularly on the formation of nitro-derivatives, which, apart from being aerosol components, are also of concern because of their phytotoxic properties. The projects involved were the shared-cost action project Dimethylsulphide Oxidation Mechanism in Relation to Aerosols and Climate (DOMAC), the shared-cost action project Uptake and Nitration of Aromatics in the Tropospheric Aqueous Phase (UNARO), and Chemical Mechanism Development (CMD, under EUROTRAC).

Peroxy radicals are key intermediates in the photochemical formation of ozone in the troposphere, but no routine technique for their measurement under ambient conditions is available. The JRC is involved in the testing and development of a new technique for such measurements, the modulated chemical amplifier instrument. Such an instrument, built at the University of Bremen (Germany), was applied by the JRC as one of its contributions to a large field campaign in the pre-Alpine area north of Milan to investigate factors limiting photo-oxidant production. The projects involved were Limitation of Oxidant Production (LOOP), a EUROTRAC project, through the study Pianura Padana Produzione di Ozono (PIPAPO), and the shared-cost action project Peroxy Radical Initiative for Measurements in the Environment (PRIME).

Websites: http://www.ei.jrc.it/ap/projects/RADICAL
http://www.ei.jrc.it/ap/projects/DOMAC
http://www.ei.jrc.it/ap/projects/UNARO
http://www.ei.jrc.it/ap/projects/PRIME

Advanced analytical and modelling tools

The Unit is also active in specific research projects emphasizing the use and the development of advanced analytical tools in the fields of laser spectroscopy, organic analysis and modelling. These projects and activities are linked to the major projects described before.

Laser laboratory for atmospheric studies

Several experimental techniques, based on laser spectroscopy, are presently under development in the Unit's laser laboratory, with a view to addressing problems of interest in homogeneous and in heterogeneous atmospheric chemistry. Within the shared-cost action DOMAC, laser photofragmentation and laser-induced plasma emission are being used to quantify the formation of sulphuric acid aerosols resulting from the oxidation of reduced sulphur compounds. The former technique is applied to sodium chloride aerosols mixed with sulphuric-acid aerosols whose presence quenches the atomic emission of sodium, whereas the latter technique monitors directly the atomic emission of sulphur occurring in the plasma induced by the laser. The sensitivity of these methods allows for a relatively fast analysis (a few minutes), providing sufficient temporal resolution to follow the oxidation in near-real time. The selectivity of both techniques is still under investigation.

In 1998, a laser-ionization mass spectrometer for the real-time characterization of single aerosol particles was developed. This single-particle mass spectrometer (SPMS) is capable of providing the aerodynamic diameter and chemical composition of a single particle in real time, for

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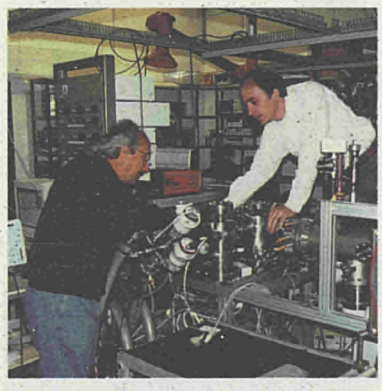

P Cavalli and G A Petrucci working on the dual time-of-flight mass-spectrometer system used to characterize single atmospheric particles.

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particles with diameters down to about 10 nanometres. The chemical composition is obtained with a unique bipolar time-of-flight mass spectrometer that measures the positive and negative ion mass spectra of each particle. The particle diameter is estimated by a laser velocimeter, for particle diameters >150 nm. A unique particle inlet design, based on the variable-pressure focussing orifice, is under investigation for particle diameters <150 nm, where the laser velocimeter approach does not work. This particle inlet, under appropriate pressure operating conditions, should act not only as a concentrator, focussing a narrow beam of particles along the axial direction, but also as a segregator, thus focussing a beam only for particles of a given diameter.

Work is also presently underway to complete the adaptation of the laboratory instrument to operation in the field.

Website: http://www.ei.jrc.it/ap/projects/DOMAC

Organic analysis

A broad experience in mass spectrometry has been built up in the Organic Analysis Group in recent years. Based on this, a large number of chemical analyses were performed in 1998 to support projects in this Unit and in other Units of the Environment Institute. It is planned to consolidate this expertise, in the near future, into a Centre of Competence in Mass Spectrometry.

The shared-cost action Biogenic and Anthropogenic Contribution to Ambient Volatile Organic Compounds (^{14}C-VOC) was completed in 1998. It led to an increased understanding of sources of formaldehyde, acetone and other carbonyls in ambient air. The results showed that, in semi-rural and semi-urban air in Europe, these compounds have a biological origin or result from human activities, with biological sources being more important than expected. Experimental results indicate that reactions of air components such as ozone with vegetation surfaces are a major source of carbonyls in the troposphere.

Under the shared-cost action Nucleation Processes from Oxidation of Biogenic Volatile Organic Compounds (NUCVOC), an important step was taken towards a better understanding of aerosol formation. A novel method for the analysis of non-volatile, polar compounds in aerosols was developed at JRC in 1998 based on liquid chromatography interfaced with tandem mass spectrometry (LC-MSn). A family of hereto unknown compounds, formed by oxidation of natural compounds (terpenes) emitted in high quantities by vegetation, was discovered in the aerosol phase. It is planned to apply this new methodology to the study of the chemistry and physics of aerosol formation during the second phase of the project.

Under the shared-cost action Characterization of Engine Exhaust Particulate Fingerprints and Their Contribution to Air Quality (PARFIN), new selective and sensitive methods for analysis of nitrated polycyclic aromatic hydrocarbons (PAH) in ambient air and engine-exhaust particulate matter were developed. These methods were validated through a European inter-laboratory comparison and will be used in the second phase of the project during planned engine tests and field campaigns.

Websites: http://www.ei.jrc.it/ap/projects/14CVOC
http://www.ei.jrc.it/ap/projects/NUCVOC
http://www.ei.jrc.it/ap/projects/PARFIN

Modelling

The JRC Integrated Modelling System for Air Quality was further developed through the incorporation of two chemical-reaction mechanisms – Regional Atmospheric Chemistry Model (RACM) and the Lurman-Carter-Coyner (LCC) mechanism – into the meteorological-transport module, the Thermal Vorticity Mesoscale Model (TVM).

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The system was applied and validated with respect to the meteorological and chemical situation on the east coast of Spain (BEMA project) and with the aim of determining the relative contribution of emissions of vegetal origin to the formation of tropospheric ozone. The modelling study was carried out on the basis of data collected during the 1997 BEMA measurement campaign. Using the Integrated Modelling System, reliable estimates of the biological contribution were obtained by performing simulations with and without such emissions, while keeping constant the emissions arising from human activities. The results indicated that the contribution of biological emissions to ozone formation represented at most 10 parts per billion (ppbV) of ozone, whereas maximum ozone values are around 100 ppbV. The carbonyl species seem to be the most efficient in producing ozone. The impact on ozone formation was also investigated in combination with man-made nitrogen oxides (NOx) and/or VOC emission-reduction scenarios.

The aerosol module SEQUILIB was incorporated into the Integrated Modelling System. Validation tests against field measurements are planned for the near future.

The Integrated Modelling System was also applied to support the activities of the Steering Group on Ambient Air Quality (of Directorate-General XI) in the planning of legislation and strategy for future ozone directives.

The Environmental Modelling Task Force (EMTF) was established at EI as an inter-Unit entity with the following aims: (i) to co-ordinate research and support activities based on modelling; (ii) to serve as the Institute's modelling reference point for the preparation, formulation and follow-up of air-quality directives; (iii) to apply modelling in the field of environmental quality in support of EU environmental policy-making.

KNOW-HOW, INSTRUMENTS AND LABORATORIES

The discovery, at the Environment Institute in 1998, of a new class of chemical compounds has significantly improved our understanding of smog formation. M. Duane is preparing the HPLC-MS^n for smog analysis.

The Atmospheric Processes in Global Change Unit can organize and conduct atmospheric field studies and laboratory experiments on the transformation of organic and inorganic compounds in air (natural and human emissions), as well as on the formation and characterization of atmospheric aerosols.

The study of the aerosol properties includes:

- complete chemical analysis of the atmospheric aerosol load, using ion chromatography, total organic and black-carbon and mineral-dust analysis
- high-resolution size-distribution determinations in the range 3 nanometres to 20 micrometres
- differential mobility analyser technology (H-TDMA, V-DMA)
- on-line single-particle analysis using time-of-flight mass spectrometry.

Automatic aerosol-observing stations have been constructed and are run by the Unit. These take samples and measure aerosol numerical concentration and light absorption, as well as standard meteorological parameters. The stations can operate on-line, sending data back to a control centre. An atmospheric pressure ionization mass spectrometer (API-MS^n) for the direct analysis of polar and non-volatile organic compounds in aqueous matrices, such as aerosols, is also available.

The Unit has advanced instrumentation for analysing atmospheric field samples, including:

- gas-chromatography/ms, ion chromatography for analysis of VOC and DMS, and water-soluble fraction of aerosols
- a home-made field instrument for measurement of sulphur dioxide (Saltzman method, high-performance liquid chromatography–HPLC, with fluorescence detection)

- field instruments for measurement of peroxy radicals ("chemical amplifier"), developed in collaboration with the University of Bremen, Germany.

The Unit has advanced facilities for laboratory studies of rates and products of gas-phase chemical reactions relevant to atmospheric chemistry. The instrumentation for these studies includes:

- a photochemical reaction chamber (480-litre capacity) which is evacuable and equipped with on-line long-path Fourier-transformed infrared spectroscopy (FT-IR), tunable diode laser (TDL) and UV/visible spectrometers
- Teflon bags (1.5-cubic-metre capacity) for simulation of chemical and photochemical reactions under close-to-natural conditions
- laminar photochemical flow reactors (5 m or 8 m long) for studies of gas-to-particle conversion and gas-particle interaction
- a flow-tube cell with chemical-ionization mass-spectrometry detection for studies of gas-phase radical and heterogeneous reactions relevant to photo-oxidant and aerosol studies.

The Unit has the know-how and advanced instrumentation to study physiological aspects of vegetation-atmosphere trace-gas exchange in controlled conditions in a greenhouse laboratory and in the field:

- A system of six tree-exposure chambers made of Teflon (each of 1.2-cubic-metre capacity) designed as dynamic continuously stirred tank reactors (CSTR), installed in a temperature-controlled greenhouse, to analyse tree canopy-atmosphere interactions. A similar system of smaller cuvettes (20-100 litre capacities) is installed in a controlled-environment chamber suited to simulating extreme conditions (of radiation, temperature, humidity, drought) for the study of plant physiology and gas-exchange.
- A mobile off-road laboratory equipped for gas-exchange measurements of plants and canopies, including a portable CSTR system with control of atmospheric turbulence and of air temperature in mobile Teflon enclosures of variable forms and volumes to study gas exchange at the individual source level (eg, branches, shrubs, and soils). Additional field instrumentation includes a canopy analyser and an image analysis system to characterize radiative properties and leaf areas of plants and canopies.

The Laser Laboratory for Atmospheric Studies has developed laser fluorescence and ionization methods for ultra-trace-elemental analysis at volumetric concentrations below the picogram per millilitre level and microanalysis at concentrations below the femtogram level (< 10-15 g). A laser-ionization time-of-flight mass spectrometer is now operative in the laboratory.

The mesoscale modelling system has been further developed by the incorporation of the two chemical mechanisms: Lurman-Carter-Coyner mechanism (LCC) and Regional Atmospheric Chemistry Model (RACM) into the meteorology/transport module, the Thermal Vorticity Mesoscale Model (TVM).

Website: http://www.ei.jrc.it/ap/facilities

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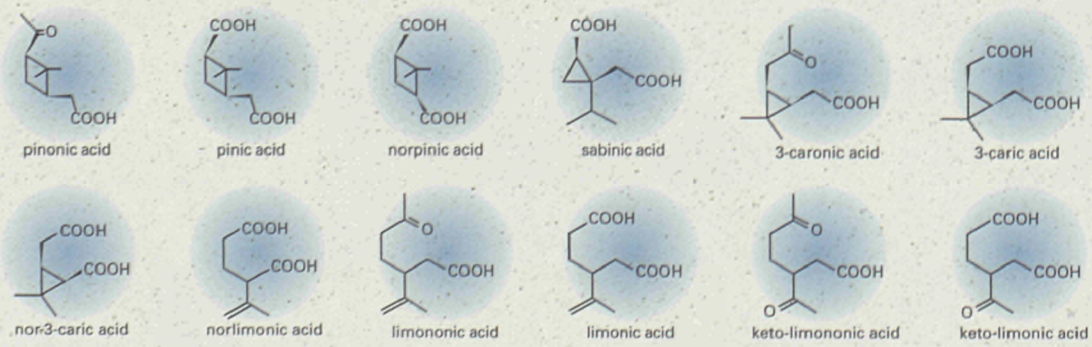
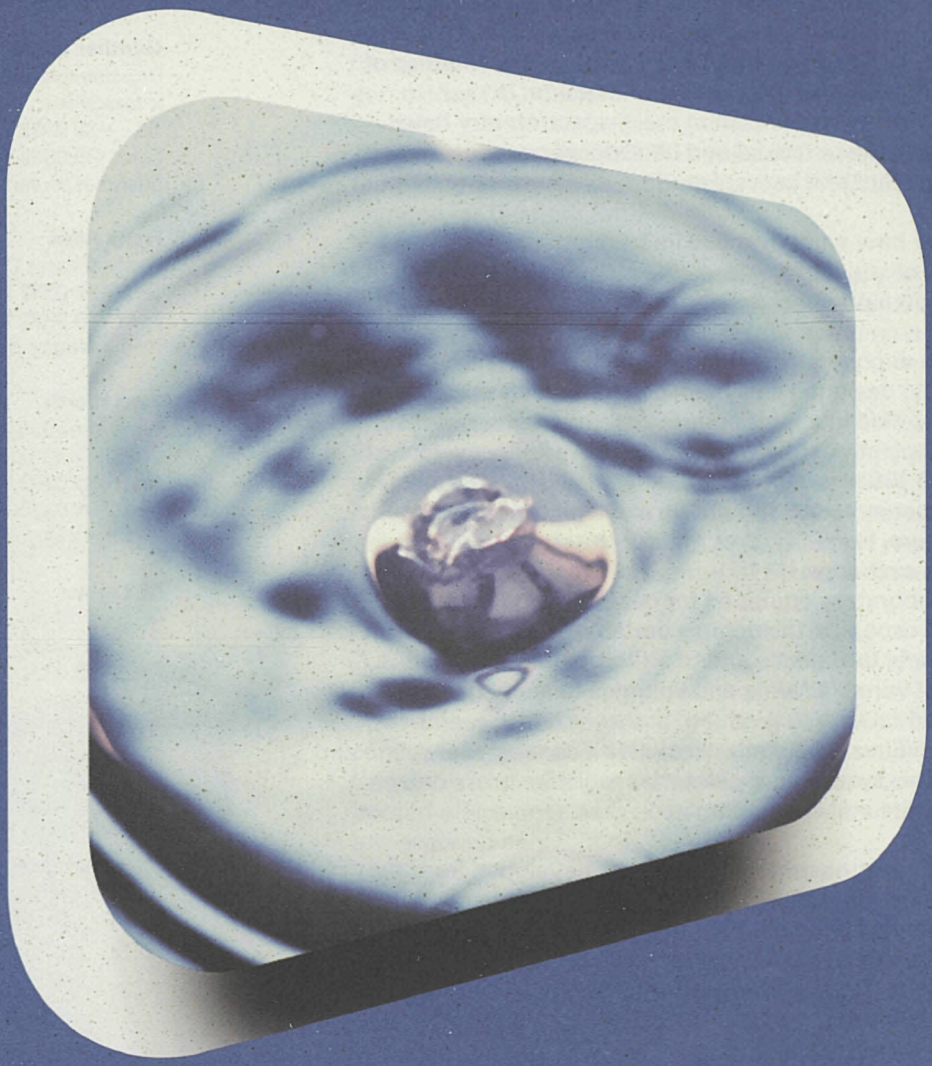
In 1998, the Atmospheric Processes in Global Change Unit identified for the first time a series of compounds (organic acids) that link natural emissions from vegetation to photochemical smog formation, via the O_3 and OH oxidation of monoterpenes.





water

Water Research and Monitoring

Unit Head: A. Tilche

INTRODUCTION

Since the demand on water resources is increasing steadily, for domestic, agricultural and industrial purposes, the availability of naturally occurring good-quality fresh water is decreasing, and more and more attention has to be paid to recovering clean water from used water. It is the goal of the Water Research and Monitoring Unit to develop instruments and methods of water-resource management to obtain good-quality water, including adjacent coastal seas.

water

Water Research and Monitoring Unit

THE UNIT'S MISSION

The Water Research and Monitoring Unit was created from the splitting of the former Soil, Water and Waste Unit. Given the participation of the Unit in the European Laboratory for Water Protection (Laboratoire Européen pour la Protection des Eaux–LEPE) which was established in 1997, the Unit defines its mission as follows:

The Water Research and Monitoring Unit provides scientific and technical support and carries out research for the implementation of European water policy and, in particular, the implementation of the relevant directives.

Homepage: http://www.ei.jrc.it/wrm/intro

FIELDS OF ACTIVITY

The Water Research and Monitoring Unit carried out research and studies in the following fields:

- drinking-water quality
- inland water management
- wastewater re-use
- data quality
- land-ocean interaction studies.

MAJOR ACHIEVEMENTS IN 1998

- The work programme of the Unit for the operation of LEPE that started in 1999 was established.
- The state of the water quality of the Mekong delta and its coastal zone and of the Yangtse and Liao Rivers was assessed.
- The definition of the water quality objectives and the simulation of different water-management scenarios on water quality were completed.
- The procedure for monitoring algal blooms and other indicators of exceptional trophic states by remote-sensing techniques was completed.
- Membrane filtration and photo-oxidation was used to clean waste water on a pilot-scale.
- The subsurface-flow reed-bed wastewater treatment facility has been used for the first degradation studies.
- Inter-laboratory calibration exercises on the analysis of several compounds in rain-, fresh- and waste water were completed.
- Reference materials of sediment, soil, sludge, plant material, mussel tissue, road dust and coal ash for the analysis of several compounds were produced.
- The ELOISE project office was closely involved in developing the programme and activities of the 2nd ELOISE Open Science Conference in Huelva (Spain).

FUTURE ACTIVITIES

The availability of water for human activities strictly depends on its quality. In its turn, water quality is affected by human activities. The implementation of the new *Framework Directive on Water* aims to close this cycle by the introduction of the concept of sustainable water management into regulations. This raises the need for tools to predict the evolution of water quality, guidelines for water recycling and re-use, sustainable wastewater treatment systems and improvement of data quality. The increasing demand for support to the Commission in this field resulted in the establishment of LEPE and in the proposal of the Water Quality project for the 5th Framework Programme, comprising the following closely related sub-projects:

Water Management (WAMA) in support of the EC water directives, with the aim of: defining instruments for the optimization of water-resource planning and management; studying instruments for managing eutrophication of lakes and reservoirs; and defining quantitative means for assessing the quality status of water bodies.

European Observatory on Drinking Water (EURODWA), which should become an efficient communication link between interested parties and should promote research and related initiatives on emerging priorities (eg, disinfectant by-products, endocrine disruptors, biotoxins, construction materials in contact with drinking water).

Sustainable Wastewater Management (SWWM), with the aim of studying new options for the re-use of waste water and contributing to the definition of new European reclamation standards for irrigation, artificial aquifer recharge and households.

Data Quality (DAQUA), with the aim of improving the quality of analytical data through the harmonization of methods, in connection with the European Committee for Standardization (CEN).

European Watershed-Coastal Zone Pollution Exchange (EW-CZPE), with the aim of studying the influence of watershed management on coastal pollution–particularly eutrophication–in different European areas, discriminating between local and global changes.

ACTIVITIES AND PROJECTS

Drinking-water quality

Yangtse and Liao Rivers

The rapid industrial development of China has given rise to serious water-resource problems well illustrated by the cases of Nanjing on the lower reaches of the Yangtse River, and of Liaoning Province on the Liao River. The shortage of phreatic and other water resources makes it necessary to use river water to produce drinking water. However, the river water is subject to pollution by waste water and agricultural run-off, and an assessment of the river water quality is therefore required.

To set up an extensive monitoring programme on the water quality of the Yangtse and Liao Rivers, a pilot sampling campaign was carried out in May 1998 to develop a preliminary inventory of contaminants, with particular attention to polychlorinated organic compounds. To facilitate the fieldwork, the Environment Institute and the Technical University of Graz (Austria) developed a transportable robust multiple-use filtration/extraction device, which was set up to pre-treat the samples prior to despatch to the analytical laboratories. The first sampling excursion was made to the Liao River near the town of Xinmin where the river water and sediments were sampled precisely near four bridges. The first indications were of a highly endangered river system.

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The sampling of the Yangtse River was done from a river patrol boat of the local water police. Each sampling point was geo-referenced using the Global Positioning System (GPS). Numerous river water and sediment samples, and raw material for the production of a sediment reference material, were taken to the University of Nanjing. The reference sediment will be used throughout the project for quality control and comparability of analytical measurements.

Apart from the Environment Institute, four research institutions from Austria, Germany and China (University of Nanjing, Dalian University of Technology) are participating in this project which is funded by the International Co-operation Developing Countries (INCO) China programme. It was initiated in April 1995 and is scheduled to end in April 2000.

Inland water management

Managing Water Resources in Lombardy

The main goal of the project is to define methods and instruments that will assist the regional authorities in managing, restoring and protecting Lombardy's water resources. The Lombardy Region is characterized by numerous lakes, rivers and canals, all tributaries of the River Po, supplying all the domestic, agricultural, industrial and power-generating water of the region.

Water-quality objectives, ecological and managerial, have been defined for the larger lakes. Surveys of the socio-economic set-up in the lakes' drainage basins, state-of-the-art sewage treatment and the application of mathematical models allowed (i) the quantification of residual nutrient loads, (ii) the evaluation of compatible load with water uses, and (iii) the estimation of the time required to reach the restoration goals of the Regional Water Clean-up Plan. Two types of models were applied at a test site on a river-basin scale to simulate the probable impact of several water-quality management scenarios: the DESERT water quality/river model and the EVOLA lake models.

A feasibility study for a lake observatory was completed. The general framework will be discussed with the regional authorities, with a view to formulating lake-monitoring strategies and data-analysis guidelines.

For the definition of ecologically acceptable flows the different existing approaches were compared. In making recommendations to formulate minimum flows, three basic steps were considered: ecological and hydrological effects and the conflicts resulting from river regulation; socio-economic effects; and applicability in the boundary context.

The conceptual design of a possible data and information management system was finalized. It includes a description of some of the technology needed to implement the proposed system. A number of thematic maps covering wastewater plants and water quality of surface waters (drinking, bathing, etc.) have been set up.

The project is funded by the Regione Lombardia (Italy) and the Environment Institute. It was initiated in 1997 and is scheduled to end in 1999.

Website: http://www.ei.jrc.it/wrm/projects/WaterManagement

Lake Maggiore (Italy).

Satellite Remote Sensing for Lake Monitoring (SALMON)

The purpose of the project is to develop cost-effective satellite remote sensing tools for monitoring environmental emergencies (especially algal blooms and other indicators of exceptional trophic states) in European lakes. In view of their different climatic conditions, three different ecoregions are being considered: sub-Alpine (Italy), boreal (Sweden and southern Finland) and sub-Arctic (Finnish Lapland), from each of which, representative lakes are being studied.

Sampling was done co-incidentally with the overhead passage of the satellite LANDSAT-TM to obtain the necessary ground-truth data needed to calibrate and evaluate the satellite remote-sensing data. Aerial remote-sensing observations from an aircraft are also made. The collection of lake-truth data was completed. Consequently, the first correlations between the limnological variables and the remotely sensed data were determined.

Supplementary laboratory studies are also being carried out to compare methods for quantifying freshwater algal pigments (ie, chlorophyll-a) and to compare the different methods used by the participating institutions. As a result of the comparative analysis of different chlorophyll-extraction methods, a recommendation for its application in accordance with the lakes' trophic status and the season of sampling was made.

Eight public and private water-management agencies from Finland, Sweden and Italy are participating in this project with the Environment Institute (EI), which is charged with monitoring the Italian sub-Alpine region, in particular lakes Garda and Iseo. This project is a co-funded EC research project within the Environment and Climate programme. It was initiated in September 1996 and ended in February 1999.

Website: http://www.ei.jrc.it/wrm/projects/SALMON

Lake Iseo: TM image of the lake (SALMON project).

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Wastewater re-use

Flumendosa Project

The Flumendosa project is a pilot study of the contamination of the Flumendosa-Campidano hydraulic system and of the feasibility of recovering clean water from the waste water. The system comprises a series of artificial lakes linked by channels and galleries.

Attention is being given to selected industrial chemicals, eg nitrophenols, ethanol, acetaldehyde and dyestuffs, triazine pesticides and their degradation products. For the removal of industrial chemicals from waste water, membrane filtration and catalysed photo-oxidation have proven to be useful techniques on a laboratory scale. Triazines can be efficiently removed by photochemical and oxidative degradation.

Photocatalytic degradation onto membranes immobilizing titanium dioxide was investigated as a possible technique for removing triazines to yield a satisfactorily mineralized water.

In preparation for field experiments at Is Arenas/Cagliari, waste water in the effluents of a treatment station was spiked with chlorophenol and surfactants, and passed through cross-flow membrane filtration followed by catalysed photo-oxidation, which led to acceptable removal rates.

A Mobile Wastewater Treatment Laboratory (MOLAB), equipped with a compact filtration/photo-oxidation device and able to remove particles, colloidal matter, macromolecules (all by filtration) and smaller organic molecules (by photo-oxidation), was used in two field studies in May and October 1998. The objective was to test the dephosphatization pilot plant near Lake Simbirizzi, in terms of its efficacy.

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Kalajzic T, Bianchi M, Muntau H, Kettrup A (1998). Polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) in the sediments of an Italian drinking water reservoir. *Chemosphere*, **36**:1615-1625.

A subsurface-flow reed-bed wastewater treatment facility, built at the JRC, completed a full vegetation period; the bacterial community has been tested with glucose as a simple carbon source. The microbiological studies showed a total bacterial concentration of 0.5 to 2 million per millilitre of water. Of these, 5% are potentially pathogenic (*Enterobacter* spp.); 20% are common environmental bacteria (eg *Bacillus fluviatilis, Pseudomonas* spp.); 30% are micro-fungi and yeasts. The reed bed proved to be effective in the removal of certain chemical and microbiological pollutants. Such pollutants may be present only in low concentrations but may have a disproportionately large effect.

Two research institutions from two European member states are participating in this project which is funded by the Ente Autonomo Flumendosa. It was initiated in May 1995 and is scheduled to end in November 1999.

Website: http://www.ei.jrc.it/wrm/projects/WaterReuse

Data quality

Environmental data quality assessment studies

The Institute has a long experience in organizing analytical inter-laboratory comparisons for third parties (public and industrial laboratories), which qualified it to develop and co-ordinate, in 1991, the AQUACON-MEDBAS Project (Analytical Quality Control and Assessment Studies in the Mediterranean Basin Countries). In 1994, this project extended its activities to the accession countries of central and eastern Europe through co-operation under the EU's PHARE Programme. The project aimed at the identification, quantification and reduction of measurement uncertainty components hidden in the methods and procedures applied in the analysis of environmental samples. The modus operandi of the project, developed and refined over the years, was based in all cases on collaborative studies at all levels, from simple laboratory performance studies to proficiency-testing exercises for peer laboratory groups.

Inter-laboratory exercises on rain water, fresh water and total mercury analysis in fish and mussels were completed. The latter study produced the explanation that results based upon total mercury concentrations were systematically under-estimated and, hence, false-negative decisions may be produced, probably owing to high organic-carbon content of unknown nature in the nitric acid digests. An additional oxidation step applied to the digest produced data comparable to those obtained by direct methods such as neutron activation analysis (NAA).

Inter-laboratory exercises on soil analysis (metals), sewage-sludge analysis (organochlorine compounds), wastewater analysis (group parameters such as adsorbed organohalogen compounds–AOX) have been completed with extraordinarily high participation of up to 183 laboratories per exercise.

Uncertainties caused by sampling and sample pre-treatment can be orders of magnitude higher than the analytical instrumental uncertainties. Within the framework of the Commission's Standards, Measurement and Testing (SMT) programme, one laboratory from each Member State was invited to sample a well tested area for half a day, applying the sampling protocols and directives in force in its country. All samples were analysed by the EI, thus eliminating the laboratory-specific analytical influences. First evaluation of results showed a wide range of differences between the present methods applied in the European Union, as well as systematic influence of individual operators in sampling and sample-handling methods.

Large parts of the project work were funded by the EI itself. Additional resources were provided by the SMT programme, the PHARE programme and a large number of third-party-work contracts.

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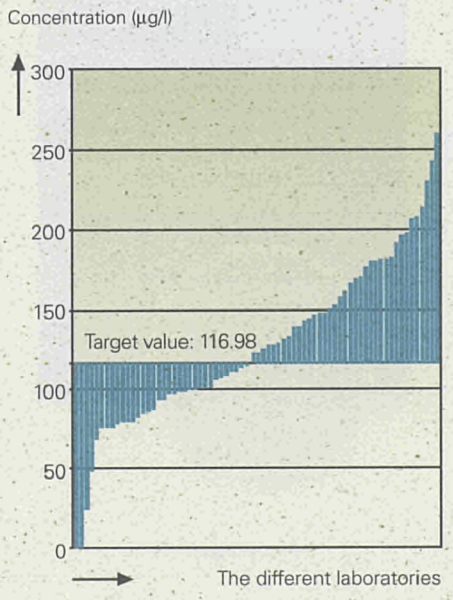

The measured concentration of PCB-180 in a sediment extract shows the performance of the laboratories participating in the inter-comparison exercise.

Environmental reference material production

The Environment Institute has an extensive experience in producing environmental reference materials. In collaboration with the Institute for Reference Materials and Measurements (IRMM), the EI carries out projects assigned to it for execution by the SMT. In 1998, work was carried out on the following projects:

- CARMEN: cabbage powder for trace metals
- SEPHOS: sediments for phosphorus fractionation by sequential leaching and sludge-amended soil for the determination of "available metal", by the single-step extraction method
- REE: sediment for the determination of rare-earth elements
- PACEPAC: road dust for the determination of platinum
- MULSPOT: mussel tissue for the determination of chemical species of tin, arsenic, mercury, lead and selenium
- CREAM: reference materials for laboratory-internal quality control exercises.

The INCO-China shared-cost action ERB requested the preparation of a river-sediment reference material (Yangtse) for the determination of organochlorine pesticides, polychlorinated dibenzo-p-dioxines and dibenzofuranes, and polychlorinated biphenyls (PCBs). The PHARE-II programme supported the preparation of a road-dust material for the determination of lead, mercury, arsenic, cadmium and titanium and the priority polycyclic aromatic hydrocarbons (PAHs), and of a sewage sludge material for the determination of total metals, organochlorine pesticides and PCBs.

A number of third-party work contracts were also carried out:

- two industrial sludges for the validation of solid-waste dissolution methods requested by the CEN
- two coal ashes and an industrially contaminated soil for the validation of extraction methods (ANALEACH)
- spinach powder and pea powder for the analysis of two insecticides, diazinone and chlorotalonyle, under the Piemont Region contract.

In 1986, the EI in close collaboration with DG XI, the German Umwelt Bundesamt and some other European partners, produced a set of the five most frequent European soils to form a common basis for the comparison of data on adsorption/desorption of chemicals in soil. A second generation of EUROSOILS was prepared using soil material sampled in the same locations; all the new EUROSOILS were characterized with respect to their chemical composition and pedological properties. The comparison of the relevant data, as well as the sorption study of more than 40 compounds belonging to different classes of chemical substances, showed that the properties of the two EUROSOIL sets matched very closely. Following the last expansion of the European Union, the EI produced a new EUROSOIL taking into account the pedological particularities of the Alpine region, and several candidate soils were selected for consideration as being representative of the Scandinavian zone. After consideration of the particular geomorphology of this zone, a reference soil set–the Nordic Soils–is in preparation in co-operation with colleagues in Scandinavia. One representative of this sample set will be included in the EUROSOILS.

To tackle the problem of reliable and comparable adsorption data for the existing substances, numerous alternative methods, which were developed for the prediction of soil adsorption coefficients, were evaluated in this project. From this evaluation, an octanol-water distribution coefficient and the capacity factor obtained from reversed-phase high-pressure liquid chromatography proved to be the most promising basis for the prediction of the soil organic carbon distribution coefficient.

Research on the production of "living", that is, not sterilized, soils and of wet aquatic sediments as reference materials for biological studies is currently under consideration.

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Land-ocean interaction studies

Mekong River Project

The project aimed at investigating the actual environmental state of the Mekong delta and its coastal zone with respect to sediment transport, hydrological properties, inorganic and organic contamination, eutrophication and other characteristics.

Two field campaigns to characterize the Mekong River and the adjacent coastal zone were organized. These campaigns, on board ships of the Vietnamese fishery protection service and the Vietnamese navy, were carried out during the dry (March) and the wet (October) seasons in 1997. Extensive sampling of sediment, water and particulate suspended matter, for analyses of inorganics (eg, Cd, Pb, Zn) and organic trace compounds, such as chlorinated pesticides, aliphatic hydrocarbons, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls, was carried out. The samples and extracts were brought to Ispra and processed in the laboratory.

Final measurements of sediment and water extracts were performed in 1998. Concentrations of inorganic and organic contaminants are within the range of concentrations for non-contaminated regions. The Mekong River proved to be a source of PAH and aliphatic hydrocarbons for the coastal zone. Concentrations of PAH in the water proved to be about ten times higher in the dry season than in the rainy season, indicating that dilution increased during rainfall. Saigon River is likely to be an important source of contamination in the Mekong delta coastal zone. The coastal zone shows a decreasing concentration of PAH with increasing distance from the coast. There is evidence that, although the coastal zones show little impact, the river systems already exhibit symptoms of environmental contamination.

This project was funded by the International Co-operation (INCO) Developing Countries programme and ended in 1998.

European Land-Ocean Interaction Studies (ELOISE) Project Office

ELOISE Project Areas.

ELOISE is an action (Thematic Network) in which coastal-zone research projects in the Commission are focussed on the important question of how land-ocean interactions operate and on how these are influenced by human activities. It is an initiative of DG XII. The Science Plan for ELOISE was developed in late 1994. The specific objectives of ELOISE are:

- to determine the role of the coastal sea in land-sea interaction, with particular stress on the carbon, nutrient and elemental cycles and on fluxes of bio-gases from the coastal sea
- to determine regional and global consequences of human impact on the coastal zone due to pollution, eutrophication, and physical disturbance
- to formulate a strategic approach to the management of sustainable coastal-zone resource use and to investigate the information, policy and market failures hampering sustainable coastal-resource management
- to determine which methodology and instrumentation is needed to carry out ELOISE.

The importance of the contribution of ELOISE to coastal ecosystem research was underlined in July 1998 when it was agreed that it would contribute to the Land-Ocean Interaction in the Coastal Zone (LOICZ) project of the ICSU International Geosphere-Biosphere Programme. It has recently been officially accepted as a core activity of LOICZ.

In October 1997, an ELOISE Project Office was established at the Environment Institute. Its work comprises, among other activities, supporting the ELOISE thematic network through the promotion of workshops and meetings, and the preparation and circulation of information, so as to favour collaboration and the exchange of information on coastal-zone research within Europe and between ELOISE and other international communities. The Project Office was closely involved in developing the programme and activities of the 2nd ELOISE Open Science Conference, which was held in Huelva, Spain, 30 September–4 October 1998. About 130 scientists participated and reported results from 30 projects being carried out within the ELOISE thematic network. Reports from four Working Groups outlined the major advances made in the understanding of different aspects of European coastal ecosystems being studied by ELOISE projects.

Some 230 research partners from 24 European countries are participating in ELOISE. This project is funded by the Environment and Climate and the Marine Science & Technology (MAST) programmes in concert with the INCO programme and with the research programmes of the Member States.

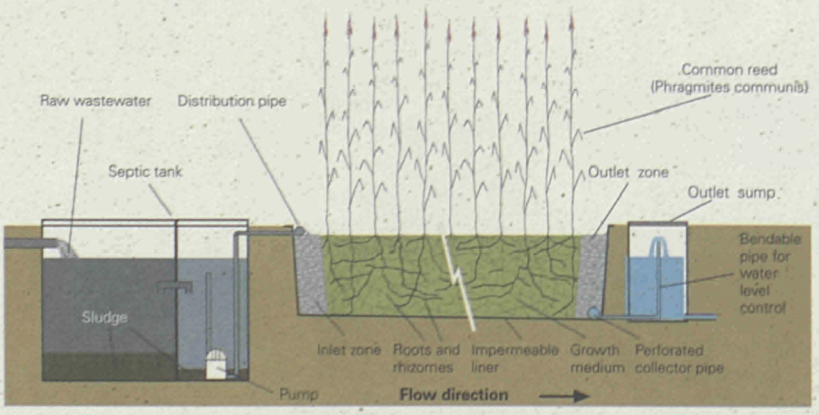
Website: http://europa.eu.int/comm/dg12/eloise/eloise-h.html

KNOW-HOW, INSTRUMENTS AND LABORATORIES

The Unit's laboratories can perform analyses of organic and inorganic compounds at trace levels in all environmental matrices, including isotopic analysis of stable isotopes. The specialized laboratories of the Unit include:

- a clean room (class 100) for sample handling, preparation and measurement of contaminants at very low concentrations (less than a nanogram per kilogram)
- a laboratory for the production of reference materials for the analysis of various environmental matrices, such as water, soils, sediments, biota and waste materials
- a limnological laboratory for the performance of aquatic ecology research and biological monitoring (phytoplankton biomass and density) of inland and marine waters; an axenic algal culture room is also available
- a laboratory equipped for studying wastewater treatment
- a sub-surface flow reed-bed wastewater treatment system.

The Unit has two mobile analytical laboratories, the Mobile Inorganic Analytical Laboratory and the Mobile Organic Analytical Laboratory, to carry out on-site analyses of soil, sediment and water. They can be accompanied by a trailer that is equipped for microbiological analysis, two 32-kW generators, trailers for transportation of material and a four-wheel-drive vehicle for sampling purposes. The mobile laboratories are completely equipped for screening contaminated sites, land as well as water.



Design of a sub-surface flow reed-bed wastewater treatment system.

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soil

Soil and Waste

Unit Head: G. Bidoglio *f.f.*

INTRODUCTION

Many dangerous chemicals in industrial, urban, agricultural and other wastes reach the soil by various pathways and may contaminate ground water, rivers, lakes and reservoirs. The soil also emits some chemicals into the atmosphere, including the "greenhouse" gases–methane and nitrous oxide. It is the task of the Soil and Waste Unit to study the various processes that determine the state of soil contamination, hence the quality of the soil itself and of the water bodies associated with it.

soil

Soil and Waste Unit

THE UNIT'S MISSION

The Soil and Waste Unit was established on 1 October 1998 to bring together a range of expertise from within the Environment Institute to address the impact of industrial, urban and agricultural wastes on soils, and related matters.

The mission of the Soil and Waste Unit is to carry out research in support of EU policies on the impact of waste emissions on soils and on soil protection. The primary objectives of the Unit are to establish relationships between pressures from specific waste treatment and disposal activities and soil pollution, and to understand better the role of soils in the production of greenhouse gases.

Homepage: http://www.ei.jrc.it/sw/intro

FIELDS OF ACTIVITY

The Soil and Waste Unit places particular emphasis on the following themes:

- Integrated approaches to the management of soil and water pollution on a river-basin scale (with links to interaction with coastal waters)
- Assessment and characterization of contaminated lands with special focus on central and eastern European countries
- Improving understanding of the deposition onto land of airborne dioxins and heavy metals released from the co-incineration of waste used as additional fuel
- The spatial and temporal distribution of greenhouse-gas emissions from agricultural ecosystems.

These activities are supported by the development of integrated information systems using models, data bases, geographic information systems (GIS) and Internet technology.

The Soil and Waste Unit collaborates closely with the European Commission's Directorate-General XI (Environment, Nuclear Safety and Civil Protection), the European Soil Bureau (Space Applications Institute, JRC) and the European Environment Agency and its Topic Centre on Soil.

MAJOR ACHIEVEMENTS IN 1998

These were:

- adaptation of a series of models that improve our understanding of the factors affecting the transport of nutrients in river basins
- conduct of a collaborative project Photo-transformation of Priority List Organic Chemicals which developed a standardized methodology for experimental photo-degradation studies to assess the poten-

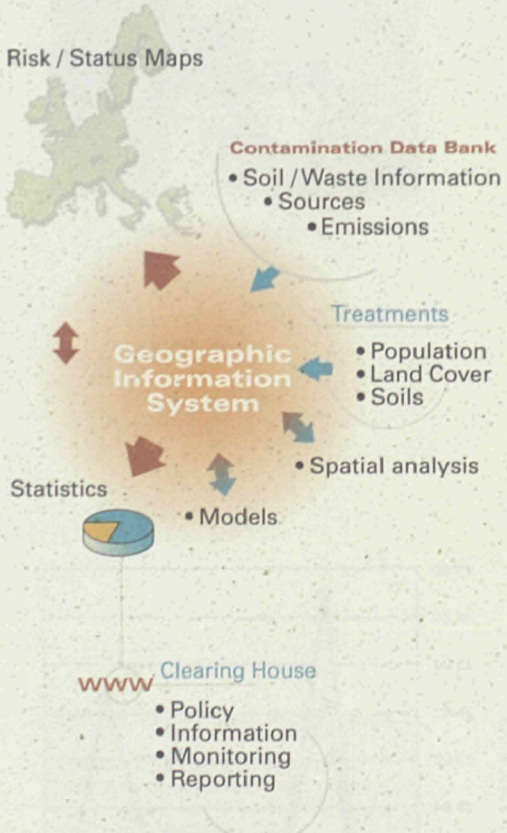
tial toxicity of photo-transformation products in aquatic and terrestrial ecosystems
- completion of the survey of dioxin in soil and biota from Zone-A of the 1976 Seveso accident (reopened to the public in 1997); as a final step in the JRC's 20-year involvement on the Seveso site, monitoring was extended to the formerly less contaminated Zones B and R
- preparation and publication of the Proceedings of the Workshop on Co-incineration, held in Belgirate, Italy, in 1997
- the novel integration of WWW and database techniques into the development of the On-line Archive System for the ACE-2 Project and in the provision of remote access to a series of hydrological models
- a Thematic Atlas of Water Resources in Lombardia was prepared, in conjunction with the Environment Institute's Water Research and Monitoring Unit, for the Regione Lombardia
- co-ordination and chairmanship of a Workshop on the Application of Geographic Information Systems for dealing with areas affected by Anti-Personnel Mines for the JRC's 1998 Demining Technologies International Exhibition.

FUTURE ACTIVITIES

The Soil and Waste Unit will, during the 5th Framework Programme (1999-2002), provide support for European Community policy in the field of soil protection. The activities of the Soil and Waste Unit under this Programme will focus mainly on the project Impact of Waste Emissions on Soils (IWES). This project will evaluate the area of land that has been chemically degraded by agricultural, urban or industrial activities and wastes or by the deposition of air-borne pollutants (eg, heavy metals and dioxins from waste co-incineration). Demonstrations of the assessment and characterization of contamination in soil and ground water will be carried out in several European countries. Research will be undertaken on the mobilization of chemicals from soils, so as to better understand their toxicological effects.

In the broader frame of the European Laboratory on Water Protection (LEPE–Laboratoire Européen pour la Protection des Eaux), the IWES project will contribute to an integrated soil and water pollution management system at river-basin level. It will strengthen existing networks and create new ones for catchment case studies to investigate the consequences of changes in land use, climate, policy and legislation on soil and water quality. An integrated information system based on GIS and networking technologies will be developed to provide validated pan-European maps detailing soil pollution.

A state-of-the-art adaptation of the Unit's high-resolution mass-spectrometry facility was started in 1998 to satisfy the demands of the 5th Framework Programme concerning the risk assessment of dioxins and related compounds in industrial emissions such as those from waste incineration. The facility, which has been working successfully on dioxin contamination of soil and biota in the past (eg, the Seveso study), will expand its activities to the assessment of fluxes of atmospheric deposition onto soil and from the air into biota and to the characterization of industrial processes. Specific sampling methods (eg, isokinetic in-stack sampling, bulk-deposition networks), as well as appropriate analytical tools (HRGC/MS instrumentation and laboratories), are "under construction" for this reason. The Unit's high-resolution mass-spectrometry facilities will also be involved in "horizontal" activities within the Institute, notably through the European Reference Laboratory on Waste Incineration and Vehicle Emission Measurements (ERLIVE).



Information System for Soil Contamination.

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ACTIVITIES AND PROJECTS

Soil and water pollution at river-basin scale

This activity comprised various approaches to the management of soil and water quality on a river-basin scale by investigating the possible consequences of modifications to EC legislation and policy.

Modelling the hydrochemical response of agricultural coastal catchments to various levels of nitrogen loading

This collaborative project studied the development of an integrated, large-scale modelling system that describes the hydrology and nitrogen-leaching in a coastal agricultural catchment draining into a eutrophic lagoon of the Adriatic Sea. In 1998, the work focussed on calibrating two models: the fully distributed hydrological model, MIKESHE; and a one-dimensional nitrogen model called DAISY. The study areas were intensively monitored to provide the required input and calibration data for the models. The MIKESHE model was calibrated to the catchment scale against observed groundwater levels and river discharges to the lagoon. The DAISY model was calibrated to a field scale against crop growth and plant nitrogen uptake, soil humidity, soil temperature, and inorganic nitrogen concentration in the soil. In tests, the outputs from the DAISY simulations were generally consistent with observed data, indicating that the model gave a good description of the soil nitrogen dynamics. However, the results highlighted some inadequacies of the model, particularly in describing the transformation and transport of urea shortly after fertilizer application.

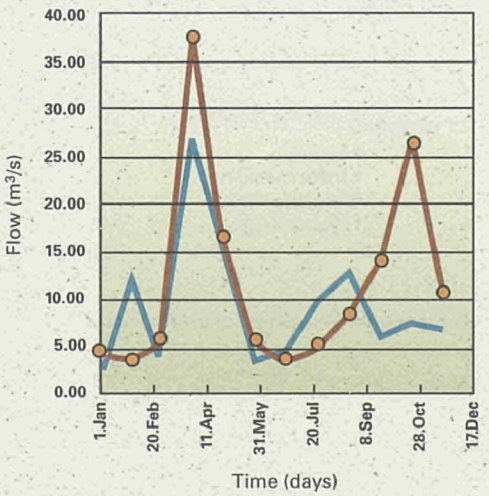
The next step in this project will be to apply DAISY on a larger scale: the leaching output from DAISY will be distributed over a whole river basin. The MIKESHE model will further simulate the transport of nitrogen within the catchment. The combination of the two models gives a modelling system capable of describing the nitrogen cycle along the aquatic continuum in the catchment. Such a system is expected to improve the understanding of many factors (eg, changes in land use, socio-economic conditions) affecting the export of nutrients to coastal areas.

Website: http://www.ei.jrc.it/sw/projects/Watershed

The Climate, Hydrochemistry and Economics of Surface-water Systems (CHESS)

The general objective of the CHESS project is to study how climatic changes could affect the quality of freshwater resources in Europe. The action of the Soil and Waste Unit within CHESS focusses on the development and validation of a model of catchment processes and the transfer of diffuse sources of pollutants to river systems. The model uses GIS software to process a range of data sets for soils, crops and basin topography. The model selected for the present study is known as SWAT (Soil and Water Assessment Tool). It is a watershed-scale, continuous-time, distributed-parameter model.

In 1998, the Finish Environment Institute (FEI) provided the JRC with some initial data sets to enable a preliminary model of the Vantaa River basin (in Finland) to be set up. Based on preliminary results, the JRC was charged with adapting the SWAT software for alternative model simulations based on a nested approach which focussed on the hydrological and water-quality calibration of the model on scales smaller than the whole Vantaa catchment. Initial results from the revised SWAT model show that simulation results underestimate hydrological outflows. The availability of measured precipitation and temperature data was found to be a key point for the hydrological calibration. Applying interpolated series may cause loss of accuracy in peak events. Preliminary attempts have been made to characterize the interactions between river channels and the aquifers, and the flows between the Kerava basin and the neighbouring ones.



Plot of predicted against actual measured river flows (Kerava River, Finland).

CHESS is being undertaken in collaboration with the Institute of Hydrology (UK), the Finnish Environment Institute, the Technical University of Athens, Vrije Universiteit Brussel and the Istituto di Ricerca sulle Acque (Italy). CHESS is a shared-cost action funded by DG XII (Science, Research and Development).

Website: http://www.ei.jrc.it/sw/projects/CHESS

Waste from industrial installations and biogas emission from soils

The increase in emissions of pollutants from industry and greenhouse gases from soils can have a major impact on local, regional and global environments. The Soil and Waste Unit is active in several studies of such problems.

Assessing contamination from industrial installations using waste as fuel

The proceedings of the successful Workshop on Co-incineration, held in Belgirate (Italy) in 1997, were published (as document EUR 18068) and requested by over 400 international experts. This workshop was organized at the request of, and in collaboration with, Directorate-General XI (Environment, Nuclear Safety and Civil Protection) to rally scientific support for the preparation of a proposal for a directive on the emission and deposition of heavy metals and dioxins.

Contacts with the European Federation of Cement Industries (CEMBUREAU) were intensified during 1998, to prepare a collaborative project to study the proposal that the use of waste material as fuel for industrial incinerators could be a clean technology. For this purpose, a sampling campaign to measure deposition and contamination around a number of major European cement plants burning waste as an additional fuel was planned.

Emission of greenhouse gases from soils and coastal waters

The overall objective of this activity was to improve our understanding of the mechanisms that control the emissions of greenhouse gases, such as methane (CH_4) and nitrous oxide (N_2O), from agricultural and coastal ecosystems.

In 1998, the Unit undertook experimental work and a field campaign on the Goro lagoon to study nitrous oxide emissions in the Po delta, in collaboration with the WATERSHED project which had established a procedure for modelling nitrous oxide emissions from soils (ie, the simulation of general nitrogen and carbon turnover). The DAISY model was expanded to include routines to calculate N_2O production in the soil, transport of N_2O through the soil, and N_2O emission from the soil surface.

It was found that N_2O emission appeared to be strongly influenced by the structure of the soil surface which, in turn, is determined mainly by management practices. Total N_2O efflux was found to vary between 0.2 and 1.2% of the applied nitrogen, or 1-5 kg $N\text{-}N_2O$ per year.

The Soil and Waste Unit also studied the production of methane and nitrous oxide by the rice fields of Vercelli (Europe's largest rice-growing area), in collaboration with the University of Edinburgh, the Institute of Terrestrial Ecology (UK), the Fraunhofer Institute for Atmospheric Research (Germany), the Max Plank Institute for Chemistry (Germany) and the Max Plank Institute for Terrestrial Microbiology (Germany) under the RICEOTOPES shared-cost action, funded by Directorate-General XII (Science, Research and Development).

Air samples were collected from representative fields throughout the growing period (July to September) to determine the proportion of methane emitted by rice paddies. Fluxes were measured using the mi-

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Waste for incineration.

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Static rooms used to measure methane flows in the Vercelli experimental site (collaboration with University of Edinburgh).

Advanced Mobile Analytical Laboratories.

T: Toxic
T+: VeryToxic

crometeorological eddy-correlation method (done with the Air Quality Unit) and combined with the high-resolution tunable diode laser (TDL) spectroscopy technique.

The results showed that: (i) Daytime methane concentrations were about 2 parts per million by volume (ppmv), which is higher than the current global background level (1.7 ppmv). (ii) Fluxes did not show a daily cycle but they were stronger in July than in September when the water was being drained from the paddies. (iii) Night-time methane concentrations rose to values of 8-10 ppmv in July, falling to 3-4 ppmv in September. (iv) During July, the ^{13}C content of emitted methane rose continuously to a peak in August then declining at the end of the sampling period.

Nitrous oxide gas samples were also collected. A very high peak of nitrous oxide emissions, lasting only a few days, was observed immediately after the application of nitrogen fertilizer and before flooding of the rice fields. Background emission from a late-flooding field, prior to flooding, was at least one order of magnitude higher than the background emission from the early-flooding field. About 9 kg N per hectare, as nitrous oxide emissions, were attributable to the management practice. The large differences in nitrous oxide emissions from two rice fields with different water-management regimes indicated that measures for reducing CH_4 emission might increase N_2O emissions. Therefore, the methane and nitrous oxide fluxes have to be considered together.

Screening for biogas emissions in agricultural areas

The aim of this third-party work contract was the evaluation of the eventual impact of biogas on an agricultural area close to a landfill. Biogas emissions had been suspected of causing subnormal crop growth.

Four field campaigns were carried out in Summer and Autumn 1998. Methane, carbon dioxide, hydrogen sulphide and oxygen concentrations were determined in situ. High concentrations of biogas were found in the soil gas (>40%). Spatial distribution of biogas emission was determined and hot spots were identified. The trace-organic-compound composition of biogas emitted in the agricultural area and from a nearby waste-disposal site were compared. Results were evaluated using a GIS and the different scenarios for the biogas source were presented to the local authorities.

This project was funded by the Province of Pavia (Italy) and was carried out by the Water Research and Monitoring Unit using the EI's Mobile Organic Analytical Laboratory.

Investigations of contaminated lands

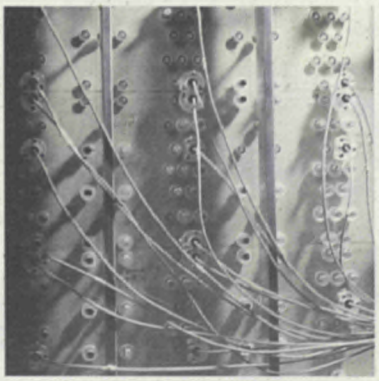
Soil pollution occurs when pollutants are deposited on their surface or buried in them. This deposition can be direct, by dumping or by fall-out from the atmosphere. Dumping is usually as mine tailings and industrial waste or the discharge of urban and other domestic wastes into land-fill areas. Agricultural chemicals, especially pesticides, when applied excessively to the soil or washed onto it, may also be a cause of soil pollution. The contaminant compounds may be distributed in the surrounding soil by leaching by rain and ground water and some compounds may reach rivers, lakes and aquifers from which drinking or irrigation water may be drawn. In such ways, the contamination is spread and may pose a serious risk to human health, to animals, crops, forests and other vegetation. At industrial sites, many compounds may remain in the soil and if the installation later becomes derelict, a new land use may be decided; but this may depend heavily on the quality of the sub-soil. The determination of the nature and extent of soil and groundwater pollution at a contaminated site is essential to the provision of sound information for remedial action and to the elaboration of risk assessments.

In this context, the Unit has undertaken a number of studies.

Integration of field characterization and risk assessment procedures for contaminated sites

The determination of the nature and extent of soil and groundwater pollution at a contaminated site is essential to provide information for remedial action and to elaborate risk assessments. During 1998, the Unit assessed the potential risks to human health associated with the presence of lead alkyls at an abandoned industrial site. On-site chemical analyses had found very high soil concentrations of residual tetraethyl. A demonstration exercise to quantify risk levels for workers involved in the redevelopment of the site was made in collaboration with Mott MacDonald Ltd. (UK) using the Risc Human Model. The outcome of this exercise led to advice being given against a proposed clean-up strategy which involved the removal of the top soil layer, because of the danger of airborne dispersion of the lead alkyls. In addition, the groundwater monitoring identified a plume of aliphatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs) originating from a nearby refinery.

The Unit was requested by several third parties to undertake analysis of soil and biota samples from various contaminated sites. Of particular significance were the analyses of dioxins from the area of the 1976 ICMESA accident (in Seveso, Italy) in order to check whether legislative thresholds were still exceeded in the affected area. The work demonstrated that the soil exchange programme carried out for the most contaminated A-Zone had reduced the dioxin levels sufficiently to reopen the land to the public. The project was then extended to undertake a detailed assessment of the adjacent but less contaminated B and R-Zones where no soil had been removed. Since the Zones B and R are partially populated, these studies were conducted in close co-operation with epidemiologists and the local authorities.



EI Geometrical Advection Facility. View of Soil Monolith or CUBE .

Evaluation of depositions on soils using mosses

The Unit has undertaken a series of studies to assess the effectiveness of evaluating depositions of contaminants on soils using mosses in macro- and micro-areas. Mosses of the species *Hypnum cupressiforme* were used as bio-indicators in two test sites in northern Italy. Two techniques were used: indigenous mosses to study the "past memory" (about 10-15 years of depositions) and transplanted mosses to evaluate future depositions (about 1-2 years). The elements analysed were cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), nickel (Ni), lead (Pb), vanadium (V) and zinc (Zn). A proposal for a normative methodology for the use of mosses to evaluate air quality on Italian territory was submitted to ANPA (Agenzia Nazionale Protezione Ambiente).

Photo-degradation of organic chemicals

This study has developed a standard experimental methodology for photo-degradation studies to allow assessment of the potential toxicity of the photo-transformation products in aquatic and terrestrial ecosystems.

The methodology of photochemical reactions and chemical analysis was established in the participating laboratories (University of Aubière, France, and the Environment Institute's Atmospheric Processes in Global Change, and Soil and Waste Units). The investigation of naphthalene and 4-chloro-2-methylphenol (a pesticide) in distilled water and natural waters was completed using this methodology.

The project supported the European Chemicals Bureau by providing data on the rate, the nature and extent of photochemical transformation, as well as the identification of photo-degradation products of organic chemicals mentioned in the priority lists of the EU Member States (*Council Regulations EEC/793/93* and *EEC/414/91*).

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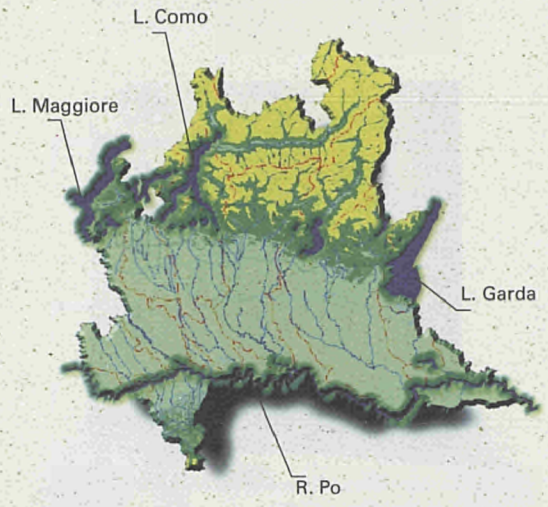
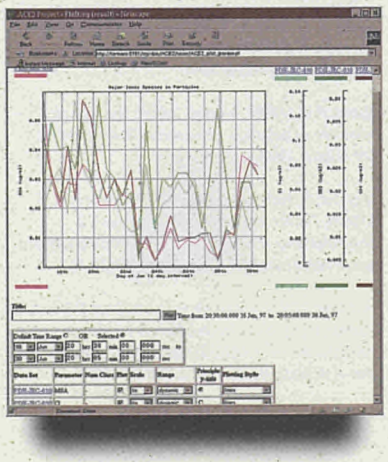


Physical map of Lombardia from GIS.



Example of WWW developments: interface to on-line archive.

Development of environmental information systems

An important element of any project is the ability to organize, manage and process information and data in an effective manner. High-quality information can lead to improved policy development, monitoring practices, prioritizing and more effective co-ordination, improved accountability and faster decision-making. Consequently, information should be regarded as an asset and should be managed accordingly. To help users achieve such an objective, the Unit is developing a range of information management solutions that address data management, analysis and dissemination. These solutions involve the merger of database management systems, geographic information systems (GIS) and the Internet/World Wide Web (WWW).

During 1998, the Unit provided support to a number of other Environment Institute activities in the domain of information management. Of particular interest was the continued development of an On-line Archive System for the Aerosol Characterization Experiment (ACE)-2 field campaign (see Atmospheric Processess in Global Change Unit).

Additionally, a number of activities were undertaken as part of a third-party work contract on behalf of the Regione Lombardia (see Water Research and Monitoring Unit). These included a study of the requirements for an information system on water-resource management, a Thematic Atlas of Water Resources in Lombardia, and the development of access via the WWW to computer models that predict the temporal evolution of phosphorus and heavy metals in lake waters and sediments.

During 1998, the Unit was successful in three proposals to provide competitive support to the Commission. These activities involved:

- providing access to map-based statistical data in GIS via the WWW for the European Statistical Office (EUROSTAT)
- the use of GIS in spatial analysis of EUROSTAT data to assess the impact of transport systems on the environment
- the development of a Land-Mine Information System to support JRC mine-sensor testing and research facility (with the JRC's Space Applications Institute for Directorate-General III (Industry/ESPRIT); in a connected activity, the Unit organized a Training Course and Workshop on the Use of GIS for Demining Activities during JRC's International Symposium and Exhibition on Demining Technologies.

Website: http://ultra.ei.jrc.it:8080

Other activities

During 1998, the Soil and Waste Unit participated in a number of Working Groups of the Comité Européen des Normes (CEN) which aims to standardize analytical methods within the EU.

- CEN/TC264 WG 8: Determination of the mass concentration of total mercury in stationary source emissions
- CEN/TC264 WG 9: Quality assurance of automatic measuring systems
- CEN/TC264 WG 10: Determination of the total emission of specific elements
- CEN/TC19/WG 22: Determination of PCBs in lubricating oils, petroleum products and used oils
- CEN/TC/264/ad-hoc WG Dioxins: Validation measurements of the EN 1948 1-3 method "Stationary source emissions–determination of the mass concentration of PCDDs/PCDFs".

The Unit's Organic Laboratory provided support to the Commission for the EUROMARKER project (competitive support to Directorate-General XXI–Customs and Indirect Taxation) which aimed at selecting a uniform marker for rebated gas oils and kerosene, and validating analyti-

cal detection methods. The task of the Unit was to organize inter-laboratory tests with custom laboratories in different member states, thus investigating the applicability of different types of markers and the corresponding analytical methods to different types of oil. Furthermore, tests on stability of the marker against aging and laundering were co-ordinated. Finally, the risks relating to the handling of the marker, as well as toxicological aspects of its combustion products, were assessed.

KNOW-HOW, INSTRUMENTS AND LABORATORIES

As a result of its diverse composition, the Soil and Waste Unit possesses a range of scientific and technical capabilities.

The Unit's laboratories have at their disposal a wide variety of analytical instruments. These include gas chromatographs coupled to low-resolution mass spectrometers with different ionization sources (GC-MS), liquid chromatographs (LC), sodium iodide and liquid scintillation systems for counting beta and gamma radiation, a duel-energy gamma-ray scanner and laser-based spectroscopic instruments. The Unit has advanced facilities for laboratory studies of organic and inorganic compounds; in particular, dioxins. The instrumentation for these studies includes low- and high-resolution mass spectrometers and automated devices for sample purification. Besides the pure analysis of various types of matrices, the available equipment allows sampling campaigns to be carried out to monitor dioxins in soil, water and biota, as well as in-stack measurements in industrial installations and source-related impact studies. A tunable diode laser (TDL) working at high repetition rates is available for point measurement of greenhouse gases in the atmosphere (CH_4 and N_2O). The TDL can be coupled with micrometeorological instrumentation (see Air Quality Unit) to estimate fluxes and open-path measurements. Applications also include the measurement of atmospheric emissions of methane from landfill sites.

Analysis of major and trace elements in a variety of matrices (vegetal, animal or mineral) can be done by flame atomic absorption, x-ray fluorescence and diffraction. The Unit can draw on the considerable resources of the Environment Institute's Advanced Mobile Analytical Laboratories (AMAL) to carry out on-site inorganic and organic analyses of soil and water samples.

The Unit is active in the modelling and prediction of the hydrological transport of compounds from point and non-point sources of nutrients and pesticides in soils and ground water in river basins. To support this activity, the Unit can undertake comprehensive collection of field data and provide a range of laboratory facilities, including:

- a geo-chemical laboratory equipped with anoxic chambers for the simulation of variable redox conditions
- a soil monolith facility for 3D migration studies of organic compounds (CUBE).

The Unit posses considerable experience in the use of geographic information systems (GIS), data bases, spatial analysis and World Wide Web (WWW) technology for developing knowledge-management solutions for a range of environmental applications.

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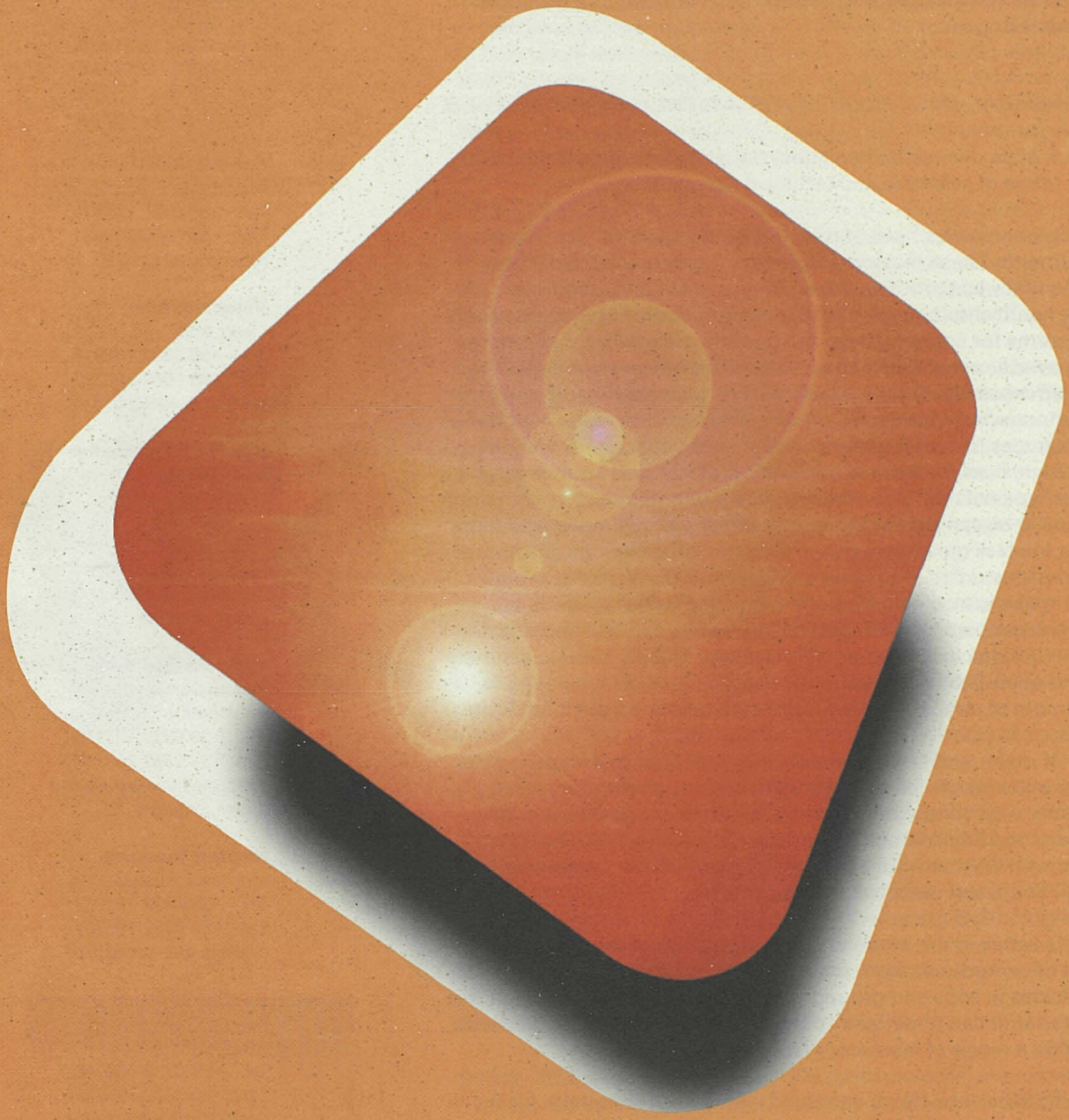
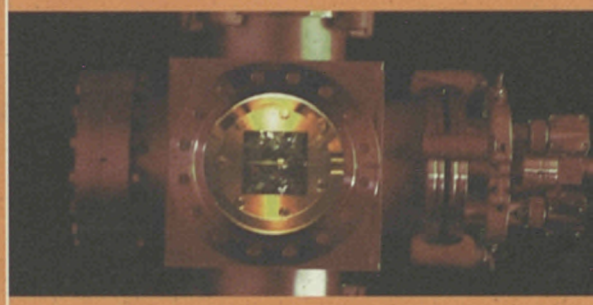


energy

Renewable Energies

Unit Head: H. Ossenbrink



INTRODUCTION

Since burning or processing of fossil fuels causes air pollution, it is increasingly necessary to seek alternative, "cleaner" and renewable energy sources. Solar-energy conversion by photovoltaic panels and the production of hydrogen from biomass (via bio-ethanol) will increasingly contribute to renewable energies in future. There is a great need to improve the associated technology in terms of efficiency, life time and cost. It is the task of the Renewable Energies Unit to develop, test and apply more advanced techniques of energy conversion, transfer, storage and use, and to promote the practical application of all potentially efficient forms of renewable energy.

energy

Renewable Energies Unit

THE UNIT'S MISSION

By giving advice on relevant technological issues, the mission of the Renewable Energies Unit is to support European policies on the introduction of renewable energies into the energy-supply system.

The Unit undertakes in-house research in carefully selected fields requiring further European effort, so as to increase the renewable-energy share of the competitive energy market.

The post-Kyoto Protocol and the European Commission's *White Paper on Renewable Energies* call for increased penetration of renewable energy supply, in particular of photovoltaic solar energy and biomass.

Homepage: http://iamest.jrc.it

FIELDS OF ACTIVITY

- Photo-voltaic (PV) Device Technology and Characterization–Calibration Services.
- PV Module Test Operation–IEC 1215–Crystalline Silicon Terrestrial Photovoltaic Module Design Qualification and Type Approval–CEC Specification 701: Qualification Test Procedures for Thin-Film Photovoltaic Modules–Additional Services, such as Prototype Development, Time of Stabilization of Thin-Film Modules, Effects of Changing Test Levels, Qualification of Module Product Ranges.
- PV Systems–On-Site Tests–Monitoring–European Solar Test Installation (ESTI) Sensor II: PV Stand-Alone Monitoring System.
- Renewable Energy in Buildings.
- Electricity Savings–Office Appliances and Lighting–Rational Use of Energy in Buildings.
- Desalination Assisted by Solar Energy.

MAJOR ACHIEVEMENTS IN 1998

- In 1998, calibration measurements were made for BP Solar to adjust the company's calibration to the World Photovoltaic Scale (WPVS) standard; 20 modules, from all their manufacturing plants, were recalibrated to the international standard.
- The largest photovoltaic power plant in Spain, at San Agustín del Gualix, near Madrid, with an output of 1 megawatt, was tested under standard test conditions. One sub-field of this PV plant incorporated innovative bifacial cells which collect not only the incoming solar radiation, but also the light from ground albedo (outgoing radiation, to space from Earth's surface).
- A 20-kilowatt PV array at Dachstein (2900 m altitude) in the Austrian Alps was measured to verify peak performance following several years of operation (powering a radio relay station).
- Two intercomparison campaigns were carried out: one for crystalline reference cells calibrated on the World PV Scale, the other at the Solar Radiation Research Laboratory (SRRL) at the National Renewable

Energy Laboratory (NREL) in Golden, Colorado, USA. Both campaigns served to ensure traceability of calibration measurements and to allow a preliminary assessment of the WPVS.

- The laser-scan facility for large-area (>100 cm^2) cells and modules (arrays of cells) allowed device operation to be examined to a spatial resolution better than 100 µm. The development and application of impedance spectroscopy to the new materials led to a fundamental revision of the traditional theoretical models.
- End-of-life testing is leading to the establishment of internationally accepted test standards defining Mean Time To Failure (MTTF), with the probable result that the manufacture of modules can be simplified and thus reduced in cost.
- A new large-area ultra-violet (UV) radiation facility for conducting the CEI/IEC 61345 UV-radiation test was completed and brought into operation. Intensities of 30-40 W/m^2 can be attained for the UV-B wavelength band and the irradiated area has been increased from 1.5 m^2 to 6 m^2.
- Module qualification tests were carried out under contract to various manufacturers, providing revenue of some 160,000 euros. The Internet is now used to provide a public listing of the module types qualified by the European Solar Test Installation.
- Driven by the Photovoltaic Global Approval Programme (PV GAP), the Unit drafted the measurement standards section of the PV-GAP Reference Handbook. These interim standards describe qualification procedures for small photovoltaic systems as performed in the ESTI Laboratory. They aim to improve significantly the quality of such systems by a comprehensive set of tests, which are to be introduced into the IEC Quality Assurance system (IECQ).
- Laboratory measurements on copying machines and PCs led to consensus on a procedure for the determination of electrical consumption and analysis of usage patterns for office equipment.
- In collaboration with Directorate-General XVII (Energy), the JRC drafted a Proposal for a European Green Light Programme for the EU (Special Publication No I.98.137). This draft is the result of a comprehensive review of similar national programmes on lighting technologies.
- The EuroDEEM electric-motor data base was extended to allow remote and secure update procedures by motor manufacturers via the Internet.
- Different energy certification schemes, in use in participating countries, were compared and discussed. The JRC contribution to the project Building Energy Labelling and Energy Technologies (BEL) was to propose building Energy Certification Methods based on simplified data sets.

Website: http://iamest.jrc.it/projects/bel/belindx.htm

Inspection of PV Modules after 20-year lifetime simulation.

FUTURE ACTIVITIES

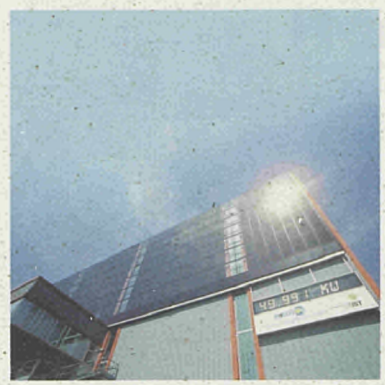
In the 5th Framework Programme (1999-2002) focus will be placed on closing some of the technological gaps in the fields of renewable-energy production and storage.

Four projects will be run:

SOLAREC

- Solar electricity generation, aimed at: establishing quality standards in production, supply, deployment and use of solar electricity; assessing options for solving the materials supply problem of solar cells; reducing costs in PV-module production; contributing to the solution of system-integration problems in the built environment and in water production.
- Materials and device technology, aimed at: resolving problems of availability of materials of current technology, such as extending limits of crystalline-silicon supply, and improving cadmium-telluride and copper-indium-diselenide thin-film structures; investigating

emerging technologies of organic and highly molecular materials, such as organic solar cells and fullerenes.
- Reference measurements, aimed at: establishing the traceability of the WPVS to SI units, using concepts similar to those of the lux-dimension; increasing the precision of measurements in order to meet the requirements of the market, thus influencing directly the profits or losses of industry.
- Module improvement, aimed at: developing concepts that will decrease substantially the cost of module production (roll-to-roll processes for conventional technology, market-tailored encapsulation techniques); harmonizing the power and energy rating of flat-plate and concentrating devices (focus on rating service output using advanced monitoring techniques, a new initiative on concentrators for PV and thermal systems); mirror qualification for concentrators.
- Solar systems, aimed at: demonstrating cost-effective solutions for integration into the built environment; evaluating thermal solar electricity concepts for large, centralized plants; harmonizing quality standards for small, decentralized systems (quality, reliability, user satisfaction, integration of PV in the IEC-Quality System); validating balance-of-systems concepts in power control and hybrid systems for successful integration of demanding applications. The application focus will be on water production and purification.



Ispra: Largest PV-façade in amorphous silicon.

Advanced Electricity Storage (ADELS)

The goals of this project are: to assess the suitability and lifetime of advanced battery concepts for renewable electricity (in particular lithium-ion technologies); to improve efficiency and power coupling of high-rev flywheels; to develop nano-structures for storage of hydrogen and as electrode material for metal-hybrid accumulators.

Technologies for Efficient and Environmental Energies (BATEEE)

The goals of this project are: to transfer knowledge of energy efficiency in information technology; to prepare for the deregulated electricity market and energy-service providers; to assess strategies for smart, zero-energy buildings.

Hydrogen from Biomass (HYDRA)

The goals of this project are: to demonstrate hydrogen production from bio-ethanol in terms of production rates, costs and efficiency; to integrate the project from bio-ethanol production to electricity production using fuel cells; to use "cold" bio-electricity as an avenue for the ethanol-powered electric car.

ACTIVITIES AND PROJECTS

Photovoltaic technology

Photovoltaic solar cells convert sunlight directly into electricity. Photons coming from the sun are absorbed in a semiconductor diode and converted into electrons. Most of the solar cells produced today use silicon wafers as base material but, increasingly, thin-film semiconductors are used as well. These sensitive photovoltaic devices are packed in a module to withstand more than 20 years under any meteorological conditions. The European SolarTest Installation measures the performance and life-time of these products, in order to contribute to cost-reduction of production processes and to provide the reference data to manufacturers and end users.

Photovoltaic module testing and development

The manufacturing techniques used in the production of solar cells, modules and panels are still very variable from one manufacturer to another, leading to incompatibilities between cells from different

manufacturers and between different formulations of the encapsulant used to mount the cells in the modules and panels. Some of the new fast-curing grades of ethylene vinyl acetate apparently accelerate corrosion in certain types of solar cell.

Four specific projects have studied, or are studying, some of these problems:

- The Multicrystalline Electromagnetic New Material and High Production Rates–Joule MENHIR–project, which is nearly completed, aims at developing continuous casting techniques for silicon and at reducing module manufacturing costs. New cell-processing steps (eg, use of silicon nitride coating) and improvements in the quality of the cast material have resulted in cells with a 14% efficiency.
- The Advanced Module-Integrated Inverters for Grid-Connected PV Systems–Joule AMIGO–project was completed, resulting in a test stand for measuring inverter efficiency.
- The Advanced Reliability Improvement of AC-modules–Joule ARIA–project, which will use the above-mentioned test stand, is aimed at increasing inverter reliability and assessing strategies for protection against hot-spot heating. A simulation of hot-spot effects using the standard SPICE package was implemented.
- The Hybrid Photovoltaic Module for Roof Integration–Joule HYPRI–project developed a photovoltaic (PV) module optimized both for solar thermal heat recovery and roof integration. The development of such a multi-functional module means an increase in overall solar conversion efficiency, increased acceptance by home owners, reduced module and area-related costs.

A specific reference PV module was also designed and a reference environment for a typical building-integration application of PV was designed and created.

The Solar Roof Tile project of Directorate-General XIII (Telecommunications, Information Market and Exploitation of Research) will start in January 1999 and will develop a novel encapsulation technique using fluorpolymers, with the aim of achieving excellent integration of PV elements into tiled roofs.

Precision solar energy measurements with a cavity radiometer.

Device calibrations

The conversion efficiency of solar cells depends on their operating temperature, the spectral distribution of the sunlight and, to a lesser extent, on the level of irradiance. In real sunlight conditions, all these parameters vary with the time of day, season, geographical location and installation. To make the performance of these devices comparable and to achieve a common standard for the performance assessment, ESTI performs calibration of solar cells and modules under a set of standardized conditions. This requires not only precise solar simulators, but also standard reference cells, against which, other devices can be calibrated. The JRC, through its Renewable Energies Unit, has developed an internationally recognized World Photovoltaic Scale (WPVS) to calibrate photovoltaic devices. This reference device serves primarily to maintain traceability to national standards in other calibration laboratories. For the continuous measurement of the performance of installed photovoltaic plants in the field, the European Solar Testing Installation developed the ESTI sensor, a very practical reference cell which survives even 20 years in the field.

The ESTI sensor measures incoming irradiance (in watts per square metre) to an absolute accuracy of ±1.5% and its own temperature to an accuracy of ±1.5° C for irradiance levels above 200 W/m² (the solar irradiation of the land surface on an average day is about 700 W/m²). Over 800 sensors have been marketed world wide.

In the frame of the JOULE-ASPIRE (Absolute Silicon Primary Irradiance) project, a new technology for primary standard cells was pro-

posed. The practical accuracy and stability of this new primary standard was demonstrated and will be presented to standards committees. The new procedure relies on the fabrication of cells whose internal quantum efficiency approaches unity over a range of wavelengths. Such cells are today technologically possible through recent developments in the fabrication of high-efficiency silicon cells.

Device characterization

Solar-energy conversion is conveniently achieved by solar cells grouped in panels to constitute solar-energy conversion (or photovoltaic) devices. These have traditionally been, and still are, based on the single- and poly-crystal silicon and gallium-arsenic alloys, but there is a continuing need to improve conversion efficiency, through the development and testing of new materials and manufacturing techniques as, for example: micromorph and microcrystalline silicon cells; and new alloys, such as cadmium-tellurium, copper-indium-gallium-selenium, copper-indium-selenium alloys and amorphous silicon.

Photovoltaic systems

European PV system monitoring and quality assessment

Since 1984, operational monitoring of PV systems has provided feedback to system manufacturers and operators and thus developed into a key element for good maintenance which is crucial for supply quality, economy and user satisfaction. This led to the most comprehensive database world-wide on PV systems.

The PV-monitoring continuously supports the THERMIE photovoltaic systems demonstration by carrying out analytical monitoring of all ongoing projects for two years. Detailed monthly reports on performance and availability are provided as feedback to eliminate malfunction and improve supply quality and economy. The whole conversion chain from in-plane irradiation to supplied electricity is analysed on an hourly basis. Technical visits, including on-site measurements, are made.

Guidelines for monitoring, evaluation and the standard file have been widely adopted in and outside Europe. Technical support is provided to the co-operation of Directorate-General XVII (Energy) with the International Energy Agency (IEA) and for the pre-normative work of the International Electrotechnical Commission (IEC) on PV systems. To render the methods used and the results from selected projects more accessible to a general audience, a series of Web pages have been prepared.

PV standards

Several new standards proposals were prepared for the European Committee for Electrotechnical Standardization (CENELEC) and the IEC. A new work-item proposal, concerning the traceability of reference cells, was approved. This proposed international standard concerns the calibration of reference cells in the context of national standards for SI units and is the outcome of the Unit's calibration procedures under its laboratory accreditation. Driven by the Photovoltaic Global Approval Programme (PV-GAP), the Unit drafted the measurement standards section of the PV-GAP Reference Handbook. These interim standards describe the qualification procedures for small photovoltaic systems as at ESTI. They aim to improve the quality of such systems significantly, by a comprehensive set of tests, which will be introduced into the IEC Quality Assurance system (IECQ). PV-GAP is a global, photovoltaic industry-driven organization that strives to promote and maintain a set of quality standards and certification procedures for the performance of PV products and systems, to ensure high quality and reliability.

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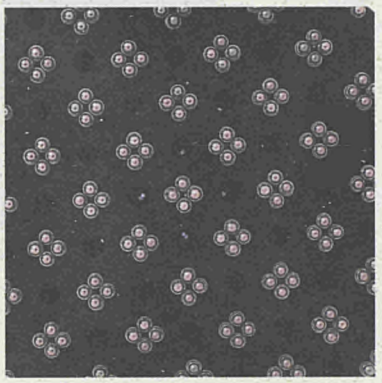
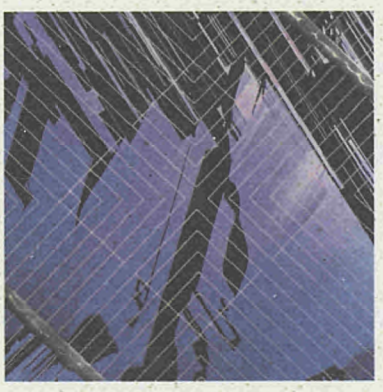


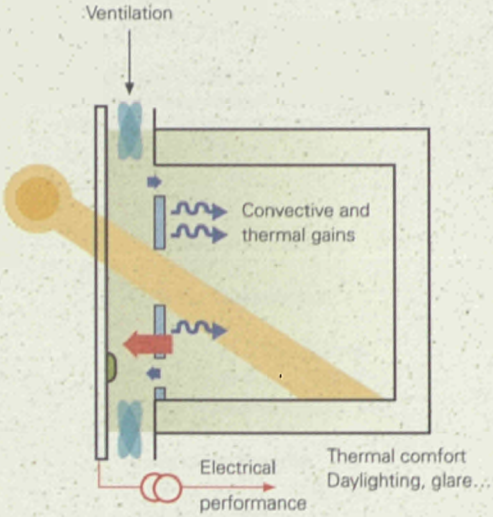
Multi-channel spectrum analyzer.



Multi-crystalline solar cells.

Hybrid Photovoltaic Building Components (PV Hybrid Pas)

PV Hybrid Pas, a Joule Project, was completed in June 1998. A series of technical reports, papers to conferences and working documents were produced. The Final Report was submitted. The project's aim was to develop a standard scheme for the evaluation of the electrical and thermal performance of hybrid PV components of buildings. Besides the JRC, ten research institutions from ten European Member States participated in this project.



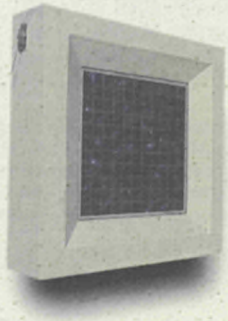
Energy flow concept of hybrid PV building components.

Building Implementation of PV with Active Control of Temperature (IMPACT)

IMPACT, a Joule Project, was initiated in September 1998. Its aims are to investigate and develop, first of all, effective methods of increasing the primary heat transfer from the photovoltaic device to the ambient air in buildings in which such devices are incorporated into the building's structure (eg, roof panels or façades); and then to develop a PV module with improved heat-transfer characteristics. Besides the JRC, five research institutions from four European Member States are participating in this project.

European Pre-standardization of Building-Integrated Photovoltaic Components (PRESCRIPT)

PRESCRIPT was initiated in June 1997 and is scheduled to end in May 1999. The project is carrying out the prenormative design of European standards for PV roofs and façades. It focusses on: construction performance as a building component (eg, water tightness, durability, fire resistance, thermal properties, etc.) and on electrical performance as a building-integrated power source. Pre-standards are being derived from: conventional well accepted building codes in all EU countries, JRC guidelines concerning the electrical performance, as well as IEC/TC 82 documents. Besides the JRC, five research institutions from five European member states are participating in this project which is funded by the JOULE programme.



Reference IMPACT PV module in the reference BIPV environment.

Desalination by condensing air moisture, assisted by solar energy

Sea-water desalination is carried out world-wide, using either electricity or heat as the energy source. Very few desalination plants use solar energy as a primary or back-up energy source, however. This is mainly because solar desalination units for a low daily production (10-100 cubic metres) must be designed for use in remote areas where the technical skills required to maintain the units are scarce. Therefore, solar-energy units must offer, besides economy, adaptability of the unit operation to large transients, low inertia at start-up, easy maintenance, easy availability of parts in the standard market. In 1998, the design stage was accomplished and various tests on evaporation-condensation and mass-heat exchangers were carried out in mock-up tests (producing about 1 litre per hour).

A patent application was filed for a new design which comprises four main subsystems:

- energy supply based on the use of exposed flat-plate solar collectors and a photovoltaic array
- desalination unit incorporating seawater piping and condensation chamber
- rejected-seawater unit
- control unit.

It is considered to be capable of delivering ten thousand litres of fresh water per day while remaining ecologically acceptable.

Two research institutions, the JRC-Ispra (Italy) and Geohabitat S.A. (Spain) are participating in this project which is funded by the THERMIE Action Programme on Renewable Energy Sources (RES).

Applications of energy efficiency

Electricity and energy savings

Office appliances and lighting

At the request of Directorate-General XVII (Energy), the Renewable Energies Unit initiated a laboratory campaign on the consumption of electricity, power levels and power quality of office appliances, in order to establish procedures for in situ measurements and monitoring of these appliances. The measurements are required to enable a standard test and measurement procedure to be established for various types of office appliance, with a view to stimulating further electricity savings. The laboratory procedures developed will be proposed as European standard procedures. In 1998, an analysis of the energy consumption of office equipment (mainly PCs and peripherals) and of measurement methods was made at laboratory level. In situ measurements of PCs were performed to assess the energy consumption patterns and saving potential in real conditions. Technical know-how was gathered and structured on lighting and office equipment energy upgrade as an essential part of the Commission's envisaged energy-efficiency programmes, such as the Green Light and Energy Star programmes.

Data base on electric motors

In 1997, a first European data base on energy-efficient electric motors was produced as a decision-support tool to help European utilities, companies and institutions in carrying out a demand-side management programme as a new service to a competitive electricity market. This effort revealed a need for a much enhanced data base. The project has been developed in close co-operation with leading Universities and experts in the field of electric motors and with the European manufacturers' association CEMEP. The version EuroDEEM'98 can be downloaded from the website *http://iamest.jrc.it/projects/eem/eurodeem*.

A European Ex-Post Evaluation Guidebook for Demand-Side Management (DSM) and Energy-Efficiency (EE) Service Programmes

A first draft of a *Guidebook on European Methodology of Ex-Post Evaluation of DSM and Energy-Efficiency Service Programmes* was prepared. Compatibility of the outcome of the SAVE/DSM projects with the evaluation methodology was checked. General support was given to Directorate-General XVII (Energy) on various aspects of Demand-Side Management SAVE programmes.

Rational use of energy in buildings

Support to DG XVII–Rational Use of Energy (RUE) in Buildings

Development of a procedure for project contracts took place by means of a critical assessment of a Measurement & Verification (M&V) Protocol for Energy-Saving Performance Contracts (ESPC). The EC-SESAME data base was updated with new, completed and on-going THERMIE projects. The JRC actively participated in the Executive Committee of the IEA Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS). A simple methodology was developed for building-data collection to foster the implementation of Building Energy Certification in EU Member States. There was a follow-up of new applications of information technology to building-energy services. Support was given to the organization of the Workshop on European Green Buildings, and related information was disseminated.

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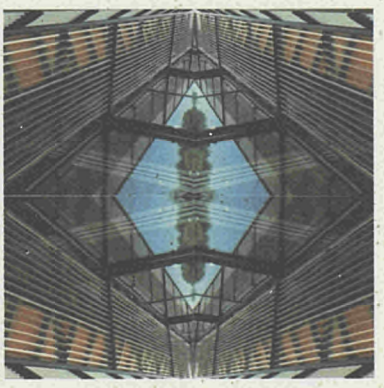
Bloem J J (1998). *The use of dynamic analysis techniques for the thermal characterization of building components*. PLEA '98 Conference on Passive and Low Energy Architecture, Lisbon, 1998. London: James & James (Science Publishers), 1998.



Artist's view of smart sensing and control for optimizing shading in buildings.

Monitoring of Supermarkets and Restaurants (MONISER)

This project, funded by the SAVE programme, started in March 1996 and was completed in August 1998. Energy consumption was monitored in service enterprises, such as restaurants and small supermarkets, powered with low voltage. Energy-efficiency measures in these sectors were identified and assessed. The results and final reports are available at the website *http://www.ei.jrc.it/projects/moniser/localweb/moniser.htm.*

Rehabilitation of Old Tenement Housing in Europe (ROTHE) Project

This SAVE project started on 1 January 1997 and ended on 31 July 1998. Information was provided about financial costs, energy savings and environmental impacts of the global rehabilitation of old tenement buildings built in European cities between 1880 and 1940. Old multi-family buildings which were eligible for overall rehabilitation were analysed as case studies and already restructured old multi-family buildings were analysed to draw up a picture of actual restructuring practice. The data were used to evaluate ecological and economic advantages and disadvantages of different rehabilitation demand and retrofit options for typical old multi-family buildings..

KNOW-HOW, INSTRUMENTS AND LABORATORIES

The European Solar Test Installation (ESTI) is a calibration and testing laboratory for photovoltaic solar-energy components. It assists the manufacturing industry and consumer in assessing the performance and reliability of photovoltaic systems. With independence of judgement and neutrality, ESTI is committed to quality in the execution of its calibration and testing procedures so as to give its clients the highest degree of confidence in its measurement results. The Quality Assurance Programme of ESTI is one of the keys to the successful global implementation of photovoltaic solar energy. In line with the mission of the JRC, ESTI provides the scientific and technical basis for the harmonization of standards within the single market of the European Union and acts as the technology centre supporting the European Commission's research, development, demonstration and dissemination policy in the field of clean and efficient energy technologies. The strategy of ESTI is to maintain and expand its leading position as a laboratory for renewable energy technologies and to continually develop its excellence. ESTI was awarded Accredited Laboratory Status in September 1996 by COFRAC Essais, France. The Quality Assurance Programme implemented by the ESTI Laboratory conforms to EN 45001/ISO/Guide 25.

Ultraviolet exposure.

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Conti F, Cocchi S (1998). *Proposal for a European Green Light Programme for the EU.* Special Publication I.98.137, Joint Research Centre.

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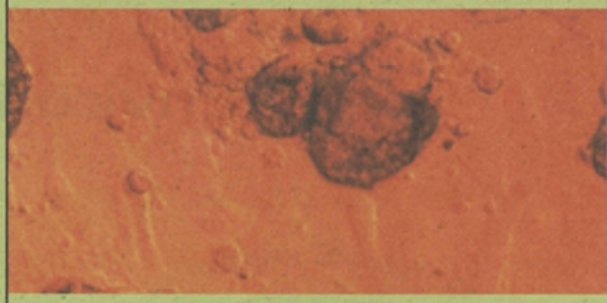
life

Environmental Impact

Unit Head: P. Pärt



INTRODUCTION

Many environmental pollutants pose risks to wildlife and human health, as they find their way into water supplies, the atmosphere and the food chain. Particular concern is caused by situations of long-term exposure to chemicals at low concentrations and to complex mixtures, as well as to the dispersion of radioactive elements. The role of the Environmental Impact Unit is to provide scientific assessment to regulatory authorities in these fields.

life

Environmental Impact Unit

THE UNIT'S MISSION

Environmental and human health issues have a high priority on the political agenda. In this respect, the Commission of the European Union has a responsibility to protect both the European citizen and the environment by providing transparent information and guidelines. Of particular concern is the impact of chemicals on human health, the effect of environmental pollution on wild species, and the presence and dispersion of radioactivity in the environment.

The mission of the Unit is to develop tools and strategies to assess population hazards and the risk of environmental contamination in order to provide high-quality scientific support to the Commission in defining its policy.

Homepage: http://www.ei.jrc.it/ie/intro

FIELDS OF ACTIVITY

The work is organized under two main headings:

Environmental toxicology and human health

The work foresees the development of new methodologies for integrated toxicological evaluation of environmental pollutants, as well as an improved contribution to accurate risk-assessment exercises. In support of EU regulatory activities, different exposure situations are considered (air and water quality) to evaluate the impact of environmental risk factors on the health of the environment and on human well-being. Particular attention is given to on-going EU environmental policies (eg, Strategy Paper on Endocrine-Disrupting Chemicals), to assess the combined risks in complex exposure situations. A biomarker-oriented approach based on the identification of critical endpoints representing cumulative molecular and cellular effects will be developed and incorporated into test paradigms. Hereby, a more realistic evaluation of human health risks in support of new orientations in risk-assessment procedures can be achieved (eg, hormonal equivalent factors in water-quality criteria).

Radioactivity environmental monitoring (REM)

REM supports the Commission in its responsibility to provide qualified information on the levels of radioactive contamination of the various environmental compartments (air, water, soil) via exchange of monitoring data and modelling results. REM collects, assembles, analyses and provides this information for normal and for emergency situations and ensures the availability of tools for communication between, and access to, users from EU Member States and other European countries. Underpinning research consists of the development and inter-comparison of real-time atmospheric-dispersion models, as well as the development and implementation of advanced statistical tools for data-quality assurance. Based on these activities, a consistent operational support

system for exchanging radioactivity information (data and model results) will be established over the next few years. In this context, tools (eg, environmental pressure indicators) will be developed for analysing the significance of this information, with a view to assisting the Commission in defining the kind of information needed to meet its requirements.

MAJOR ACHIEVEMENTS IN 1998

In the field of **environmental toxicology and human health**:

- A pivotal role was given to the Unit, with the establishment, at Ispra, of the Global Endocrine Disruptors Research Inventory (GEDRI) data base, in collaboration with the International Programme on Chemical Safety (IPCS).
- Actions were undertaken to implement EU-USA co-operation in the field of endocrine-disrupting chemicals (EDCs), following the recommendations of the Conference on New Vistas in Transatlantic Science & Technology Co-operation, Washington DC (June 1998).
- Suspected EDCs, which may pose risks to human health, were evaluated by the rodent uterotrophic assay and by the use of primary cells from uterine epithelium. This research also took advantage of a shared-cost action, Endocrine-Disrupting Activity of Selected Environmental Pollutants (EDAEP), which was funded within the Commission's Environment and Climate programme.
- Research on biomarkers of environmental chemicals known to be immunotoxic or neurotoxic was carried out. The search for biomarkers in dermal sensitivity to metals, using a human keratinocyte cell line (HaCaT), was oriented towards differential cytosolic protein expression and metal-binding proteins, as well as towards the (early) expression of pro-inflammatory cytokines (IL-12); it was carried out in close collaboration with the National Institute for Working Life (Solna, Sweden) and the Institute of Medical Microbiology (Milan, Italy). Primary cells (cerebellar granule neurons) were studied, in collaboration with Pavia University and the Autonomous University of Barcelona, to assess the neurotoxicity of inorganic and organic mercury compounds. These research activities obtained additional funding from two shared-cost action contracts within the Environment and Climate programme.

Websites: http://www.ei.jrc.it/ie/projects/GIRED
http://www.ei.jrc.it/ie/projects/EDAEP
http://www.ei.jrc.it/ie/projects/Neurotoxicity

In the field of **radioactivity environmental monitoring**:

- The data-input processors of the REM data bank (MS Windows version of Easy-Proteo and data converters) were developed and improved and the database contents were updated. The Atlas of Caesium Deposition on Europe after the Chernobyl Accident was published in August 1998, concluding more than four years of scientific collaboration with research institutions and competent authorities from almost all European countries.
- The European Union Radiological Data Exchange Platform (EURDEP), the information platform for automatic exchange of data between national real-time monitoring systems in routine and emergency circumstances, was extended to twenty-one European countries which exchange gamma dose-rate measurements on a daily basis. In the context of the Nuclear Fission Safety programme a shared-cost action project, Real-time On-line Decision Support (RODOS), an interface between EURDEP and RODOS is being developed.
- A meso-scale analysis of the second ETEX release was performed, aimed at improving the model performances in this experiment. A detailed reconstruction of the wind field was made, taking also into account the characteristics of the soil in the vicinity of the release point. Results indicated an improvement in the simulation of the cloud evolution.

Sampling columns used with the samplers shown in p. 67 for the ETEX exercise.

- Two meetings of modellers participating in Real-time Modelling (RTMOD) were organized in 1998. During the second, the results of the two model inter-comparison exercises were discussed, with an attempt being made to estimate the uncertainty related to the behaviour of the two models in the two sets of meteorological conditions. A dedicated Internet website for the mesoscale flow-model evaluation (MESOCOM) was prepared.

Websites: http://www.ei.jrc.it/ie/projects/REM
http://www.ei.jrc.it/ie/projects/eurdep
http://www.ei.jrc.it/ie/projects/ETEX
http://www.ei.jrc.it/ie/projects/Rtmod

FUTURE ACTIVITIES

The future activities, under the 5th Framework Programme, are grouped into two projects, one for each field of activity.

Environmental Integrity and Human Health (EIHH)

The project has two main approaches, whose general objectives are:

- To improve mechanistic methodologies for integrated risk assessment of chemicals suspected of being harmful to human health and wildlife, including chemical mixtures and mixed-exposure situations (eg, water and air pollutants, pesticides and hormone residues, materials and goods). In particular, the following is envisaged:
  - the establishment of models and strategies agreed by international experts
  - the development of cellular and molecular biology techniques oriented towards the identification of biomarkers.
- To identify critical end-points in the establishment of potential endocrine disrupting (ED) effects in different situations of environmental exposure, in close collaboration with international organizations. In particular through:
  - the Global Endocrine Disruptors Research Inventory (GEDRI) data base, which will be located at the Joint Research Centre, Ispra (*http://endocrine.ei.jrc.it*)
  - the EU-USA Transatlantic Co-operation in Human Environmental Health, through research programmes on endocrine disruptors
  - experimental research on EDCs, including application of a QSAR approach, integrated by in vivo/in vitro assays on sensitive end-points in wildlife; particular attention will be given to aquatic organisms, as recommended by the EU Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE), and to water-quality criteria, following the EU Task Force Water.

A major objective will be the development of biochemical assays for specific biomarkers in wildlife and of hormonal equivalent factors (HEF), to assess their effects in continuous low-level exposure.

This project will have links with other JRC projects:

- Projects on water quality (LEPE) and industrial/vehicle emissions (ERLIVE)
- Projects on environmental chemicals and health effects, and on risk assessment.

Radioactivity Environmental Monitoring (REM)

The EC has the obligation to provide information to the European Parliament and to the Member States on the levels of radioactivity in the environment. This obligation has lead to the creation of the REM

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Pärt P, Wood C M, Gilmour K M, Perry S F, Laurent P, Zadunaisky J, Walsh P J (1999). Urea and water permeability in the ureotelic gulf toadfish (*Opsanus beta*). *Journal of Experimental Zoology*, **283**:1-12.

project, with a view to exchanging monitoring data and evaluating model predictions (eg, ATMES, ETEX, REMdb, ECURIE, EURDEP). Based on this experience, a consistent operational support system for exchanging radioactivity information (data and model results) in normal and in emergency circumstances will be established. Moreover, tools will be developed for analysing the significance of this information, in order to assist the EC in defining:

- the nature of information needed to meet EU requirements in routine and emergency circumstances
- environmental-pressure indicators.

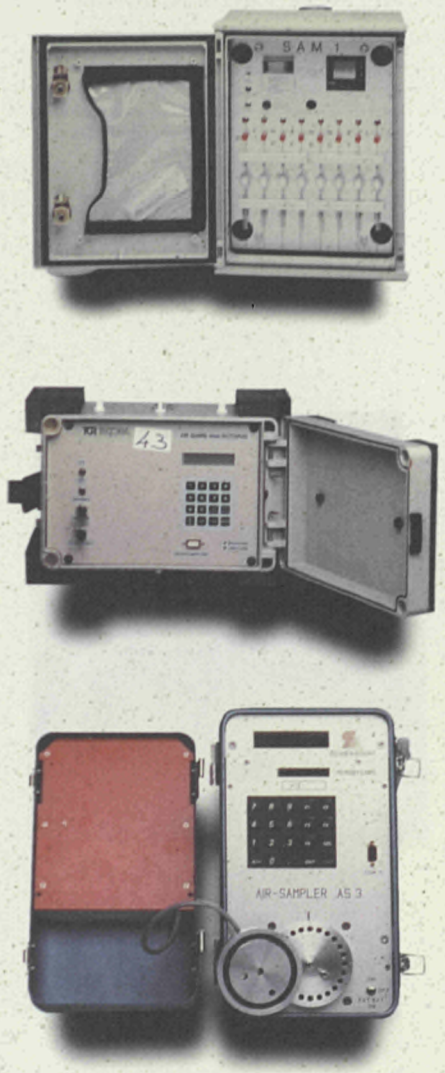
There will be important relationships with other JRC projects:

- Atmospheric Processes in Regional and Global Change
- Integrated Air Quality Assessment.

The networking activities developed in the context of competitive activities will be continued:

- Real-Time Model Evaluation System (RTMOD); co-operation with the Real-time On-line Decision Support System
- The Centre for Information and Valorization of European Radioactive-contaminated Territories (CIVERT)
- Mitigation of Volcanic Risk Using Remote Sensing Techniques (MVRRS) and WEBHazard: an Internet-based Modelling System for Preventing and Managing Accidental Industrial Releases (WHAZ).

These projects will have interests in common with DG VI (Agriculture), DG XI (Environment, Nuclear Safety and Civil Protection), DG XII (Science, Research and Development) and DG XXIV (Consumer Policy and Consumer Health Protection), and collaboration with IPCS-World Health Organization (WHO), the European Council of Chemical Manufacturers' Federations (CEFIC), the US Environmental Protection Agency (EPA), university and research institutes from various EU Member States, as well as more than eighty competent authorities and scientific institutes world-wide, for data provision, information exchange and model development.



Types of samplers (SAM1, Tecora and Seimbersdorf) used for the ETEX exercice.

ACTIVITIES AND PROJECTS

In the field of **environmental toxicology and human health**, activities have been concentrated in the fields of biomarkers (in immunotoxicity and in neurotoxicity) and endocrine disruptors. Research has been carried out in collaboration with EU Member States' organizations in connexion with the following three shared-cost action projects under the Environment and Climate programme:

Biomarkers for Risk Assessment in Human Metal Sensitivity (BRAHMS)

This project is a multidisciplinary collaboration (there are six partners from various European countries) aiming at elucidating molecular and cellular responses of human skin exposed to immunotoxic metals such as nickel, cobalt and chromium. The project will end in April 1999.

The role of the JRC has been to carry out cellular toxicological studies to ascertain the immunotoxic effect of metals (nickel, cobalt and chromium) on a human keratinocyte cell line (HaCaT). These studies also included the evaluation of molecular end-points (expression of selected cytokines, induction of specific proteins and/or of metal-protein complexes) by molecular biology and protein chemistry techniques. The assessment of selected proteins and/or pro-inflammatory cytokines (ie, IL-12) as biomarkers of exposure to the metals will be carried out.

Website: http://www.ei.jrc.it/ie/projects/BRAHMS

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Colombo I, Monteggia E, Moretti S, Mangiarini I, Sacco MG, Villa A, Rapelli S, Clerici LA, Berra B (1998). Oncogene transgenic mice: a useful model to study in vivo the relationships between gangliosides and oncogenes. Cancer Biochemistry and Biophysics, **16**:229-242.

Neurotoxicity of metals

This project is an in vitro mechanistic approach to risk assessment and biomonitoring of neurotoxic metals. By using in vitro models and methods, the general aim is to characterize the neurotoxic effects elicited by manganese, aluminium and mercury. The main goal of the project is to better define risk-assessment procedures in neurotoxicity, by providing mechanistic information on the action of toxicants at cellular and molecular levels. The development of peripheral markers as surrogate indicators of neurotoxicity, to be used in epidemiological studies on populations at risk, is a complementary objective. The project, which includes five partners from different European countries, will end in March 1999.

The role of the JRC has been to carry out cellular toxicology studies to ascertain the effective dose of neurotoxic metals (mainly manganese and mercury). Different cell models, established cell lines (PC12), as well as primary cell cultures (cerebellar granule cells, CGC), were selected to study cellular and molecular targets of neurotoxic effects. The search for specific biomarkers of exposure to mercury compounds will now be focussed on the induction of a heat-shock protein (hsp70) in target neurons, taking advantage of CGC derived from transgenic mice.

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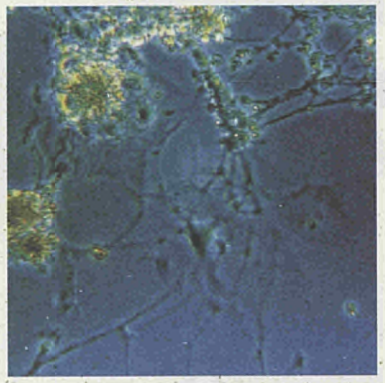
Sacco M G, Zecca L, Bagnasco L, Chiesa G, Parolini C, Bromley P, Mira Catò E, Roncucci R, Clerici L A, Vezzoni P (1997). A transgenic mouse model for the detection of cellular stress induced by toxic inorganic compounds. *Nature Biotechnology*, **15**:1392-1397.



Cerebellar granule cells derived from transgenic mice.

Endocrine-Disrupting Activity of Selected Environmental Pollutants (EDAEP)

The main objectives of this project are: to develop and apply QSAR techniques and models to the screening of high-production-volume chemicals according to their capacity to bind to oestrogen, androgen and thyroid hormone receptors, based on the existing experimental data; to develop and implement an in vitro and in vivo testing strategy for endocrine-disrupting chemicals; and to establish a list of potentially endocrine-disrupting chemicals to be considered in validated testing systems. The project will end in February 2000.

The project is co-ordinated by the JRC (Environment Institute) and involves the participation of seven partners from different European countries.

In the field of **radioactivity environmental monitoring** the current activities and projects are:

Data banking, handling and reporting

The Radioactivity Environmental Monitoring (REM) data bank contains more than 1,300,000 measurements on radioactivity levels in the environment from 1984 onwards for almost all European countries. It is freely accessible via the Internet (*http://java.ei.jrc.it*).

Most of the information was provided by the EU member states in the framework of the Euratom Treaty, with a view to preparing EU environmental monitoring reports. For this purpose, a new version of the data input software (Easy-Proteo) and additional conversion processors developed by the Environmental Impact Unit are being used by the majority of the EU Member States. In this way, improved data-quality checking and a standardized data-exchange format leading to accelerated reporting is ensured. A report describing the radioactivity in the environment of the EU in 1993 was published. The 1994 report was completed and will be available in early-1999.

REM also contains a large data set related to the Chernobyl accident and intended for further scientific study. As part of the European Commission-Confederation of Independent States (EC-CIS) Collaborative Programme on the Consequences of the Chernobyl Accident (DG XII, Unit F6: Radiation protection), the Atlas of Caesium Deposition on Europe after the Chernobyl Accident was prepared (using a geographic information system and advanced spatial-interpolation techniques)

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De Cort M, Dubois G, Friedman S D, Germenchuck M G, Izrael Yu A, Janssens A, Jones A R, Kelly G N, Kvasnikova E V, Matveenko I I, Nazarov I M, Pokumeiko Yu M, Sitak V A, Stukin E D, Tabachnyi I Ya, Tsaturov Yu S, Avdyushin S I (1998). *Atlas of Caesium Deposition on Europe after the Chernobyl Accident*. Report EUR 16733.

and was published in August 1998. This publication is the result of four years of scientific collaboration with research institutes and competent authorities in almost all European countries, in particular in central and eastern Europe.

Under the shared-cost action Centre for Information and Valorization of European Radioactive-contaminated Territories (CIVERT), a valorization support system (VSS) is being developed which will provide temporal and spatial statistical tools to perform data-quality assurance and to interface the results to a geographic information system (GIS).

International nuclear emergency data exchange systems

In case of a nuclear emergency with transboundary effects, it is essential that relevant information be quickly and accurately exchanged at an international level. In the REM project, two systems have been developed:

- The European Community Urgent Radiological Information Exchange (ECURIE) system, by which coded messages are exchanged between national contact points in the EU Member States and the Commission (DG XI Unit C1: Radiation Protection) in case of nuclear emergency.
- The European Union Radiological Data Exchange Platform (EURDEP), a system by which automatic monitoring data are continuously exchanged, currently on a daily basis with twenty-one countries.

During 1998 work was focussed on:

- further development and maintenance of CoDecS, a PC encoding-decoding software, including modules for automatic transfer of messages
- development of an automatic interface to the Real-time On-line Decision Support System (RODOS) under a shared-cost action with Directorate-General XII
- design and implementation of the central data structure and development of the overall interface for the Centre for Information and Valorisation of the European Radioactive-contaminated Territories (CIVERT) under a shared-cost action with Directorate-General XII.

National gamma dose-rate monitoring stations participating in the EURDEP system (situation of 1998).

Modelling

In the Real-Time Modelling Evaluation Study (RTMOD), twenty-two participants were required to forecast the evolution of the pollutant-cloud tracer plume every 3 hours at the approximately 5,000 intersections of parallels and meridians (with an interval of 0.5 degrees) over Europe, using forecasted and analysed meteorological fields as input. Two virtual releases were planned during the year. The characteristics of the releases and their locations were supplied to the models by an alert message.

For both releases, the concentrations calculated by the models were often in the same range of values, indicating that the main features of the flow and of the dispersion were similarly reproduced by some of the participants. Even in this case, however, there were large differences in concentrations given by the models. In some cases, differences between model results were much larger, indicating that the links between meteorological and long-range dispersion models have still to be improved.

For the shared-cost action Mitigation of Volcanic Risk, modelling was used to estimate the concentration field generated by volcanic emissions at Vulcano Island and Etna. The results of the simulations were compared with some of the available observations. The advantages of using atmospheric models are consistent, since the 3D results obtained are an important complement to the remote-sensing observations, usually consisting of concentrations integrated on the plume vertical or

lateral cross-section. Furthermore, the method allowed re-construction of the source intensity to forecast the effect of new emissions of variable intensity and to estimate the hazard to the population in the area close to the source.

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KNOW-HOW, INSTRUMENTS AND LABORATORIES

Environmental toxicology and human health

Animal house: allows small animals (mice, rats, rabbits, etc.) to be kept and in vivo short-term toxicological experiments to be carried out in full accordance with EC Directives (in particular, *EC 86/609*). Facilities for work on aquatic animals are under construction. Furthermore, this facility is equipped for:

- cell isolation and primary-cell culture
- cell toxicology studies, in vitro or ex-vivo/in vitro.

Cell-culture laboratory: allows primary cells and established cell lines to be cultured and is equipped with suitable apparatus (microplate technology, chemiluminescence, fluorescence, etc.) for the study of relevant end-points (eg, apoptosis, intracellular signalling) by means of molecular toxicology and cytotoxicity methodologies.

Molecular biology and biochemical laboratory: designed to set up and hold standard and refined methodologies for the study of relevant molecular end-points of interest in environmental toxicology studies. In particular:

- the study of selected gene activities is a first priority, taking advantage of polynucleotide-chain-reaction (PCR) analysis followed by electrophoretic detection of amplified sequences (such as randomly amplified polymorphic DNA–RAPD–and arbitrary fragment-length polymorphism–AFLP)
- equipment for protein chemistry and enzymological studies is available, such as chromatography (including a versatile Fast Performance Liquid Chromatograph–FPLC), spectrophotometry and 1D and 2D electrophoresis
- post-electrophoretic analysis run by a computerized video-documentation system.

Radioactivity environmental monitoring

Centre of excellence for collection, exchange and handling of environmental radioactivity data. In this context, REM has a wide experience in data banking and data transmission in routine and emergency circumstances, as well as in the use of geographic information systems and spatial-data handling. It provides services by making this information available, as far as possible, to external services and the general public by means of reports and Internet (on-line access).

Mesoscale flow models allow the reconstruction of the wind and temperature field in the hypothesis of separation of general circulation from local effects. Mesoscale flow models are used with terrain-dependent co-ordinates.

Atmospheric dispersion models range from long-distance dispersion, in which some of the features of the turbulent transport of the material in the atmosphere are simplified, to the local-mesoscale lagrangian particle models that take into account the complexity of the ground.

Statistical model evaluation packages are used to quantify, in statistical and graphical terms, the level of agreement between model results and observations.

Reconstruction of the turbulent field within the atmospheric boundary layer allows the evaluation of the interaction between turbulence itself and chemically (or radioactively) transforming species.

SELECTED PUBLICATIONS

Mosca S, Graziani G, Klug W (1998). A statistical methodology for the evaluation of long-range dispersion models: an application to the ETEX exercise. *Atmospheric Environment*, **32**:4307-4324.

Galmarini S, Thunis P (1999). The validity of Reynolds assumptions for Running-Mean filters in the absence of a spectral gap. *J. Atmos. Sci.*, **56**(12):1785-1796.

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From left to right: Stylianos Kephalopoulos (Webmaster), José M. Jiménez (Directorate), Annette Borowiak (Air Quality), Emanuela Rossi (Management Support), Jennifer Rundle (Renewable Energies), Eddo Hoekstra (Water Research and Monitoring), Niels Jensen (Atmospheric Processes in Global Change), Arwyn Jones (Soil and Waste), An Lievens (Directorate), Miguel Ángel Serra (Environmental Impact).

The EI Communication Task Force

The Environment Institute's Communication Task Force was established in 1997, in line with the policy of making the scientific and technical information produced at the Institute widely available.

Co-ordinated by the Institute Directorate and the Management Support Unit, it is composed of one member of each of the Institute's scientific Units and its Webmaster.

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