Project Progress Summary

European Mercury Emission from Chlor-Alkali Plants		
EMECAP		
R&D		**Total project cost: €3.322.589**
Contract number: QLK4-CT-2000-00489	**Duration (in months): 36 Months**	**EU contribution: €2.201.994**
Commencement date: 1st April 2001	**Period covered by the progress report: (1 April 2001 – 31 March 2004)**	
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World wide web address (the project's www address) **www.emecap.com** **List of participants** **Scuola Superiore di Studi Universitari e di Perfezionamento S. Anna (SSSA), *Coordinator*** **Consiglio Nazionale delle Ricerche (CNR.IB), *Contractor*** **Swedish Environmental Research Institute Ltd. (IVL), *Contractor*** **Goeteborg University (UGOT), *Contractor*** **Jozef Stefan Institute (IJS), *Contractor*** **Norwegian Institute for Air Research (NILU); *Contractor*** **Lund University (LUND), *Contractor*** **KAYSER ITALIA s.r.l. (KAYSER), *Contractor*** **Synapsis s.r.l. (SYNAP), *Contractor*** **Institute for Ecology of Industrial Areas (IETU), *Contractor*** **Institute of Occupational Medicine and Environmental Health (IOMEH), Contractor** **University of Bucharest (UB), *Contractor***		

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Actual delivery date: June 25, 2004

Section 2: Project Final Report **NOT CONFIDENTIAL**

Objectives:

The EMECAP Project aimed to provide decision makers with an innovative and multidisciplinary methodology to manage environmental problems and to safeguard citizens' health and environment from mercury pollution. The project, which involved twelve partners from six European countries (Italy, Norway, Poland, Romania, Slovenia and Sweden), tested and validated this new methodology on three different Mercury Cell Chlor-Alkali (MCCA) Plants, located in Italy, Poland and Sweden. The EMECAP methodology included innovative mercury monitoring devices, biomedical and environmental methods and databases, a mercury dispersion model and a data mining software to manage environmental problems and support the safeguard of human's health from mercury pollution. The three selected plants should be considered as demonstration sites and provided a first information on the magnitude of the effect of mercury exposure on human health, since no information of this kind is world-wide available.

The choice of MCCA plants located in three countries, characterised by different climatic conditions, allowed assessment of the changing of mercury volatility and, consequently, difference in mercury emission and re-emissions, mercury transport and deposition.

Results:
The project provided better scientific understanding of risks to human health, increasing the public knowledge through qualitative and quantitative data. The EMECAP Project, including the NAS-EMECAP Extension, contributed to develop S&T co-operation at international level through:

- the realization of a scientific and technological network at European level, aimed at developing adequate environmental and health policy measures, thus envisaging an integrated approach toward the assessment of health risks related to mercury emissions from MCCA plant.
- the cooperation between Western and Eastern Europe, from a technological point of view, aimed at guaranteeing the development of a common approach for mercury monitoring, by utilising innovative dispersion models, high-tech portable devices, ubiquitous access to information, knowledge and databases.
- the creation of a European working group on epidemiological and environmental studies related to mercury emissions from MCCA plants, in order to identify useful approaches for carrying out actions to prevent critical situations to occur, investigate of in force approaches and exchange experiences for the safeguard of citizens' health.
- the identification of appropriate security approaches in work places and the comparison of different policies for the management of environmental problems related to mercury pollution.

In detail, the aim of the Project was reached through two lines, respectively focused on technological and biomedical-environmental issues:

Environmental study
The aim of the environmental study of the EMECAP project was to assess atmospheric mercury levels in the surroundings of the selected Mercury Cell Chlor-Alkali (MCCA) plants. Since April 2001 two selected MCCA plants, one in Italy and one in Sweden, were considered as demonstration sites and provided a first information on the magnitudine of the effect of mercury exposure on human health. Thanks to the NAS Extension, in February 2003 a third chlor-alkali plant in Poland was added in the project. The mercury effects on the environment are determined by the chemical forms and physical properties of this pollutant. Elemental gaseous mercury (Hg°) is the principal form of mercury emitted from MCCA plants. Since these factories produce also chlorine, the emission plume may contain a mixture of Hg°, Cl_2 and $HgCl_2$. Environmental measurements were carried out in air around MCCA plants and four measurement campaigns during the four different seasons were carried out at the two plants located in Rosignano Solvay (Italy) and Bohus (Sweden), while two campaigns were performed at the chlor-alkali plant in Tarnow, Poland.

The main objectives of measurements in ambient air were the quantification of the atmospheric mercury levels in the surroundings of these three selected MCCA plants, the estimate of the deposition of mercury near the sources and the evaluation of mercury re-emission from contaminated areas. Wet and dry deposition fluxes were measured to evaluate the importance of fall-out phenomenon. Atmospheric mercury levels determined around the plants were related with the main meteorological parameters such as direction and wind speed, and ambient temperatures.
Moreover, a new task "Estimate possible impact of mercury from MCCA plants to people via food" was added in the Italian and Polish studies in order to quantify the possible mercury intake caused by the consumption of fish and vegetables coming from exposed areas could represent a source of mercury quantitatively more important than inhaled mercury. Measurements of mercury levels in vegetables and fish were carried out in Rosignano Solvay and in Tarnow. No measurements were performed in Bohus because no vegetables are grown in this area and no fish are caught in the river close to the plant.
The mercury emission into the atmosphere was determined with the remote sensing LIDAR (LIght Detection And Ranging) system. The highest mercury emission was measured in Rosignano (20-54 g/h) while in Bohus values ranging from 6 to 11 g/h were observed. A high value was observed in Tarnow in summer (28 g/h), taking into consideration its low chlorine production. It seems that there is a clear relation between the measured mercury flux and the ambient temperature because this parameter affects the temperature of the cells and the re-emission processes from contaminated soil around the cell and from spills distributed in the cell house structures. Moreover, the mercury flux resulted to be strongly dependent on the wind speed. The impact of chlor-alkali plants in Rosignano and Bohus on the village near the plants evaluated through the measurements of the levels of Total Gaseous Mercury in air is rather limited and influences only the air very close to the cell house. The consumption of local food (fish and vegetables) by citizens living in Rosignano Solvay seems to constitute the most important intake of mercury. It is difficult to draw a conclusion as concern the impact of the chlor-alkali plant in Tarnow, because the observed mercury concentration in air, vegetables and soil are due to the contribution of the different mercury sources present in this area. As the impact on the villages of Rosignano and Bohus is rather limited, it means that part of the mercury is deposited in a small area around the plants, while most of the mercury emitted is dispersed and transported away: so the mercury emitted increases the atmospheric pool, showing the characteristic of this metal as a global pollutant. For this reason, it is crucial to replace the mercury cell as soon as possible, taking into consideration that at present new and ecological technologies avoiding the use of mercury are available. Moreover, it must be taken into account that the mercury chlor-alkali process also produces large quantities of waste containing mercury that at present need to be stored for future treatment.
Epidemiological Study
Inorganic mercury like the metallic elemental form (Hg^0) may cause a variety of adverse effects, but the most classical ones are found in the central nervous system (tremor and mental changes) and the kidneys (e.g. proteinuria). Methylmercury (MeHg) is neurotoxic too and the foetus in particular is at special risk. The genotoxic and carcinogenic potency of mercury compounds seem to be limited, but several studies have indicated a potential for oxidative damage. This has not been very well examined in humans.
The aim of the epidemiological study was to quantify the internal dose of mercury of the general population living or working close to MCCA plants (low-exposed groups) as compared with control groups and more highly exposed groups of workers in MCCA plants. The main hypothesis to be tested was that the general population living close to MCCA plants had higher urinary mercury (U-Hg) owing to increased levels of mercury in ambient air around the MCCA plants. A second aim was to search for possible adverse or subclinical effects of the mercury exposure on kidney function or in terms of oxidative DNA damage or lipid peroxidation. For an optimal power of detecting exposure to

As could be expected, the highest urinary mercury (U-Hg) levels were seen in the MCCA workers, followed by the general population groups with amalgam fillings. The lowest urinary mercury excretion was found among subjects without amalgam fillings.
U-Hg was statistically significantly higher in Italy than in Sweden, and Poland. There was also a clear and significant increase of U-Hg with number of amalgam fillings. For U-Hg and many markers there were statistically significant effects of country, number of amalgam fillings, frequent chewing on amalgams, sex, age, smoking, and total fish consumption. In Italy, the hair mercury levels were highest in MCCA workers, followed by the *control* citizens, and then the subjects from *low-exposed area*. In the general population, hair-hg increased with fish consumption.
Concerning the potential subclinical or adverse effects of mercury exposure, the results show relatively clear effects of mercury exposure on the kidney markers, and possibly some effects on lipid peroxidation in the most highly exposed workers. No such effects were, however, found in the general population.

Technological Activity
Within the technological workpackage the following activities were carried out:
a. Design and development of two innovative mini-devices for atmospheric mercury monitoring;
b. Design and development of an improved diffusion dosimeter to measure mercury personal exposure level;
c. Development of a dispersion model to estimate current and future concentration and deposition around anthropogenic mercury sources;
d. Development of a data mining software to collect and elaborate the epidemiological and environmental data obtained from the performed inquires.

a. Two innovative mini-analysers for gaseous mercury detection were designed and developed within the EMECAP project. One analyser is based on the resistivity variation of a thin gold film and uses a solid state sensor developed ad hoc. The instrument is equipped with a GPS/GSM module for self localization and data link with a remote host computer. A series of tests was carried out in order to evaluate the performance of the sensors and of the analyser. The results of the tests showed good performance in terms of electrical noise, background level, linearity and sensitivity. The background is lower then 1 ng of mercury (in term of concentration less then 1 g/m^3); the analyser is mainly devoted to monitor mercury in industrial areas. The other instrument developed within EMECAP is a non dispersive CVAAS (Cold Vapour Atomic Absorption Spectrometry) mini-analyser for mercury vapours determination in atmosphere based on the absorption of mercury line at 184.9 nm.
The sensitivity of mercury determination in air, by using this mini-analyser is in the domain 0.10 – 60 μg Hg/m^3. The measuring range could be extended to 100 μg Hg/m^3.
b. Two different (tubular and badge) diffusive sampler-personal dosimeters for mercury in air were developed. The two samplers are intended for measurements in environments with elevated mercury concentration. Both laboratory experiments and practical tests at the Swedish MCCA plant revealed an excellent performance of both of the samplers. The tubular sampler allows to perform analyses of mercury in a fast and inexpensive way. Moreover, the sampler can be used again directly after analysis. The principal advantage with the badge type sampler is its simple, low cost design and its high capacity of absorbing mercury.
c. Two types of models were developed/modified and used to estimate concentration and deposition fields for mercury around selected alkali plants in Sweden, Italy and Poland and to estimate the current and future contribution of emissions from alkali plants to the European maps of mercury concentrations and deposition. For the local scale modelling, various physical processes were described, such as deposition and chemistry, and the model was validated against observed concentration data using observed emission data,

d. A web-based platform was developed and installed to allow the partner to access the EMECAP database in a secure way, to extract the desired data, to perform statistical analysis and to transfer the data from the server to the local PC in order to modify/analyse the data downloaded with more efficiency. This platform was developed in such a way as to allow the user to access directly to the Oracle database where all the data collected in the framework of EMECAP were recorded. In this way it is possible to manage in details the right of each single user to access the tables of the database.

Dissemination:
A Web-based project presentation was developed and published at the following address: http://www.emecap.com. The home page of the official project website publishes some general information of public interest, as objectives, partnership, contact persons in charge for the project, downloadable presentations, questionnaires for the subject selection, etc. A members' area was also developed, the access to which is protected by credentials, username and password, assigned to the different partners of the project. The members' area assures a secured information exchange, by utilising the https communications protocol (Secure Hyper Text Transfer protocol).
An EMECAP brochure with a short description of the project and its objectives and structure is available. The brochure is downloadable from the EMECAP website.
Many articles describing the activities and results obtained in the EMECAP context have been drawed up by the partners and published on many different scientific journals and presented in International Conferences.

Milestones Achieved:
M1.1 Project start-up
M1.2 Final report
M2.1 Completion of intercomparison exercise and development of joint protocol for sampling and analysis of atmospheric mercury species
M2.2 First report on atmospheric mercury and on mercury emission
M2.3 Mercury Emission
M2.4 Completion of atmospheric mercury measurement campaigns
M2.4 Completion of soil and fish measurements of mercury
M3.1 Completion of start-up phase for epidemiological research
M3.2 Completion of all field studies in the WP3
M3.3 Completion of all mercury analyses
M3.4 Completion of all other laboratory analyses
M3.5 Completion of the final reports
M4.1 Report on the sensor technology choice criteria
M4.1.1 Report on CVAAS mini-analyser design
M4.1.2 Final Report on the mini- analyser operation and results
M4.2 Final Report on the mini-analyser design, operation and results
M4.3 Data Mining Software
M4.4 Sampler Design
M5.1 Preliminary version of the model and emission data base
M5.2 First results of the model
M5.3 Final model
M6.1 Web site
M6.2 Informative booklet for local and regional Policy Makers

Benefits and Beneficiaries:
The EMECAP Project is addressed to decision-makers, scientists and citizens, in order to provide them with an innovative and integrated tool, including both technologies and methodologies, for the better understanding of the atmospheric mercury pollution problem. Outcomes of the epidemiological researches, carried out in three different regions of Europe (Sweden, Italy, Poland) contributed to improve the information on the overall health and well-being of the European citizens, through the development of current knowledge on environmental exposure to mercury and early markers of biological effects in general population. Identification of citizens and workers exposed to hazardous environmental agents is crucial to develop primary and secondary prevention activities aimed to reduce the exposition phase and, consequently, the occurrence of adverse health effects. Moreover, the innovative analytical devices, designed and developed within LIFE- and NAS-EMECAP, allowed simultaneous analysis over large areas or capillary analysis on specific sites. These devices, which can work in a network, seem particularly suitable to monitor highly and large contaminated areas, in order to improve control and prevention systems at disposal of decision makers and regulatory bodies.
Future Actions (if applicable):
The EMECAP project is, in a world-wide scale, the first step ever done to really understand the problem of MCCA mercury pollution. The natural follow-up will be the extension of the methodological and technical achievements in extra European countries to build a control and remediation world-wide network.