NATIONS UNIES | ОБЪЕДИНЕННЫЕ НАЦИИ | UNITED NATIONS

COMMISSION ECONOMIQUE POUR L'EUROPE | ЕВРОПЕЙСКАЯ ЭКОНОМИЧЕСКАЯ КОМИССИЯ | ECONOMIC COMMISSION FOR EUROPE

SEMINAIRE | СЕМИНАР | SEMINAR

COMMITTEE FOR TRADE, INDUSTRY AND ENTERPRISE DEVELOPMENT

Distr.
GENERAL

Working Party on Industry and Enterprise Development

TRADE/WP.8/AC.1/SEM.7/2003/2
26 August 2003

Seminar on Analysis, Methodology of Treatment and Remediation of Contaminated Soils and Groundwater

Original: ENGLISH

Paris, 1-3 April 2003

REPORT

Introduction

1. The 4th Seminar on Analysis, Methodology of Treatment and Remediation of Contaminated Soils and Groundwater, so-called INTERSOL 2003, took place in Paris, from 1 to 3 April 2003, at the invitation of the Government of France and under the auspices of the ad hoc Group of Experts on the Chemical Industry of the United Nations Economic Commission for Europe (UNECE). It was co-organized by the Association for the International Exhibition of Chemical and Process Engineering (Association Interchimie) of France, together with UPDS, Ademe, INERIS, CNRSSP and SCI. In the margins of the Seminar, INTERSOL 2003 also hosted an exhibition of techniques and services and a "project fair" related to *this* issue.

2. About 650 participants from some 34 countries participated in the Seminar, in particular from the following UNECE member States: Andorra, Belarus, Belgium, Bulgaria, Canada, Czech Republic, Denmark, France, Georgia, Germany, Hungary, Italy, Kazakhstan, Latvia, Luxemburg, Netherlands, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Switzerland, Spain, Tajikistan, Ukraine, Uzbekistan, Ukraine, United Kingdom of Great Britain and Northern Ireland, and the United States of America. Participants from Algeria, Brazil, Cameroon, Libya, Morocco and Syria also participated under Article 11 of the Terms of Reference of UNECE. Experts from 15 countries presented 100 oral and written contributions.

Opening of the Seminar

3. The Seminar was opened by Mr. George Kowalski, Director, Industrial Restructuring, Energy and Enterprise Development Division (IREEDD), UNECE. Mr. Kowalski warmly thanked the Government of France – in particular the Ministry of Economy, Finance and Industry and the Ministry of Ecology and Sustainable Development for co-sponsoring the event, and the Interchimie Association for its excellent organization of the event. Mr. Kowalski then reminded the audience of the serious problem posed by soil and aquifer contamination in almost all countries, in particular the CITs of Eastern Europe because of their past polluting activities. He also pointed out that, because they are facing a severe and long economic crisis, such countries needed to be assisted technically and financially and were looking for realistic, yet economically affordable technical solutions to their soil and aquifer pollution problems. He also reminded the participants of the role of the UNECE as a platform for dialogue and cooperation between countries of west and east Europe.

4. Mr. Pierre Fillet, Secretary General of Euro-CASE (European Council of Applied Sciences and Engineering), was unanimously re-elected Chairman of the seminar.

5. Mr Pierre Fillet expressed the view that soil and aquifer pollution has grown as a societal problem over the past decade and has become a key issue for the political sphere, the business and scientific communities, and the media, and is catching public interest. Polluted sites are seen as a real danger for aquifers that are a main source of drinking water and, consequently, as a threat to human health. Mr. Fillet noted that INTERSOL is to be a place where professionals meet to exchange and confront their views on technical remediation, land use planning, and health and environment problems. This information exchange was completed with the creation of a web site (http://www.unece.org/operact/intersol) and the involvement of a broader audience from different parts of the world, including the United States of America.

6. Mr. Philippe Vesseron, Chief of the Major Risks Service of the Ministry of Ecology and Sustainable Development, presented four conclusions from past experience:

- Prevention is to be seriously considered as the only way of discontinuing past pollution inheritance;
- More information should be disclosed, in particular to the public at large, and all partners should be involved in the decision-making process;
- The risk evaluation step, largely underestimated in the past, has become a key step in the decision-making process;
- The “memory of the past” of industrial sites, their location and types of activities should be carefully kept and registered. This information will help to define the remediation routes and orientate future site uses.

7. Mr. Didier Bureau, representative of MINEFI, reiterated that soil and aquifer pollution is an actual problem and that soil rehabilitation is an essential step toward land planning and further use of rehabilitated lands. He also noted the economic reality that rehabilitation works have stimulated the development of a whole industry in France, generating important investments and encouraging research and development of appropriate prevention and decontamination techniques. Much progress

has already been made in the development of appropriate remediation technologies, particularly with respect to diagnosis and treatment, heavy metals remediation from sludges and effluents, and improvement of risk assessment and risk management. This progress was spurred by the competent national authorities, in particular the Ministry of Industry, the Ministry of Ecology and Sustainable Development, and the ANVAR Agency, which granted support to a series of soil remediation projects.

Session 1: Assessment of risk to people and the environment

Moderator: Mr. Michel NOMINÉ
Co-moderators: Mr. Swartjes
Mr. Loignon

DOCUMENTATION:

- *Bioavailability of soil contaminants in relation with risk assessmen*t, F. Swartjes, RIVM (Netherlands);
- *Definition of acceptable toxicology risk at contaminated sites*, H. Dieter, UBA, Federal Environment Bureau and WaBoLu, Hygiene of water, soils and air (Germany);
- *Emission, transfer and public health impact of polymetallic pollution generated by zinc and lead production*, J.M. Haguenauer, Lille II University (France);
- *German soil protection law and risk assessment as an essential factor in remediation decisions*, V. Franzius, UBA, Federal Environment Bureau (Germany);
- *Impact of regulatory documents and communication on management approaches at contaminated sites*, D. Darmendrail, BRGM (France);
- *International standardization of risk assessment*, M. Nominé, INERIS (France);
- *Assessment of health risks for future site users*, F. Ben Slimane, S. Cardinaud, ICF Environnement (France);
- *Health risks caused by pollution from chlorine compounds in soil and groundwater*, A. Bernard, UCL (Belgium);
- *Pollution for studying natural attenuation in chlorine solvent pollution*, J.R. Mossmann, CNRSSP (France);
- *Microbial and molecular techniques for in-situ evaluation and implementation of biodegradation potential and activity at sites contaminated by aromatic and chlorinated hydrocarbons*, G. Henkler, Planreal A.G. (Switzerland).

8. The first series of lectures showed the difficulties in assessing risk to people and the environment, despite the progress made by research in this field. Risk from toxic components contained in polluted soil is directly linked to the ability of these components to be mobilized and released among humans and into the environment. However, a large range of parameters intervene (such as time-scale, pH, humidity, intrinsic properties of toxic components and soil matrix, etc.), and a number of models have been developed to simulate the sharing/partitioning of the toxicants into the different compartments. However, these models and assessment results are specific to local conditions and thus difficult to use for prediction. Moreover, risk is the result of exposure occurrence to toxicity and also depends on the target pathway (ingestion, inhalation, skin contact, etc.). The complexity of this approach was illustrated through an example of an epidemiological study showing the concentration of heavy metals into cell tissues of people exposed at various degrees to the pollution. While measurements showed the presence of heavy metals in significant quantities, it was

difficult to quantify the risk and reach conclusions about real long-term epidemiological effects on the population.

9. In spite of these difficulties, some competent authorities have attempted to define threshold values above which the exposure/risk would be evaluated, and actions would be undertaken and information given according to the importance of the risk (see federal laws in Germany).

10. Legislation is also seen as an important tool for risk management. At the time being, while risk to underground water contamination can be combated efficiently through the laws on water protection that exist in general in most countries, the gap in soil legislation remains a serious drawback, even in industrialized countries such as the EU at the present (a new law on soil is currently under discussion).

11. Conclusions by the moderator: M. Nominé congratulated the contributors for the high interest and diversity of their lectures and projects. He ended the session with the following remarks: (1) there is broad agreement to recognize the importance of the risks from contaminated sites and to acknowledge the various conceptual approaches and schemes to risk assessment. However, the results of risk assessment methods, even if made following a comparable approach, still vary drastically due to the numerous options available to evaluators in choosing models and parameters; (2) several examples have shown how different conceptual approaches concretely account for the bio-availability of metals, organic substances and gases in soils. The selection of toxicity cut-off values, in determining how efficient the remediation should be, also greatly influences the choice in bioremediation techniques. At the moment there is no harmonized system for the setting of standardized cut-off values, nor are there standard limits for toxicity values corresponding to well-defined further usages of remediated sites. Therefore, there is much uncertainty about what allowable uses can be made of a rehabilitated site based on the results of such evaluations; (3) different case studies also showed how specific each situation is, including for natural attenuation. For the time being the methodology implemented is still closer to research than to development. In such a context, setting international standards for risk assessment would benefit both the regulatory and the research approaches.

Session 2: Land-use planning and the problem of contaminated sites and soils

Moderator: Mr. A. Paquot (Ministry of Ecology and Sustainable Development of France)
Co-moderators: Mr. J. M. Gaspéri (Pôle de compétence sites et sédiments pollués); Mr. F. Karg (UPDS).

DOCUMENTATION:

- *French policy on contaminated sites and soils, and integration in planning operations,* A. Paquot, Ministry of Ecology and Sustainable Development (France);
- *Integration of data on contaminated sites and soils in real-estate operations by Lille Metropolitan Council and in Urban Development Strategies,* F. Brière, Lille Metropolitan Council, and J. Badaroux, SEM Ville Renouvelée (France);
- *Management of real-estate, finance, environment and health issues for urban development of contaminated sites,* J. Gobins, Inogen-Delta (USA), and F. Karg, Inogen-HPC (France);
- *The contribution to site remediation to regeneration in Wales,* S.L. Smith, Welsh Development Agency (UK);

- *The challenge of brownfields: objectives and initial conclusions of Cabernet (European network funded under EC FW 5-City of Tomorrow and Cultural Heritage Key Action),* J. Lowe, Cabernet (UK);
- *Legal risks faced by councils and real-estate companies involved in development of contaminated sites, Precautions to be taken,* C. Huglo, Cabinet Huglo-Leapge (France);
- *Development of contaminated sites at Le Havre: experience in application of Ministry of Ecology and Sustainable Development guidelines on diagnostic, risk assessment and decontamination work,* M. Langlois, Le Havre City Council, Environment Department (France);
- *Epidemiological risks and methodological solutions for planning and development of major industrial areas,* D.G. Auburtin, IHIE Angers (France);
- *Tools for mangement and redevelopment of contaminated land in the city of Stuttgart*, T. Greichgauer, Stuttgart City Council (Germany);
- *Possibilities and limits for RAG within the scope of structural change*, J. Brüggemann, GPE (Germany);
- *Taking into account the problems of contaminated site and soils in the regeneration of Plaine-Saint-Denis,* C. Sphor, Ministry of Infrastructure (France);
- *Possibilities and limits of application of dynamic natural attenuation treatments in urban development projects, examples in France and Germany*, R.D. Henkler, H.C. Henkler, Planreal (Switzerland, Germany), G. Karg, HPC-Envirotech (France);
- *Delta 3: Dourges multimodal platform. Pollution treatment under applicable regulations. Legal and financial solutions for reconversion of former industrial regions*, C. Masse, Projenor (France).

12. This session was devoted to the remediation of polluted sites in urban zones and their further use after rehabilitation. In France, the past approach for the remediation of polluted sites was very drastic, with the objective of rehabilitating soils into their initial status. This has proved to be overambitious and excessively expensive. The national policy is now: (1) to prevent the build-up of any new polluted site; (2) to evaluate the impact and associated risks from polluted sites and keep them under control; and (3) to rehabilitate polluted sites according to their future use. This approach assumes the administration possesses a series of tools. First, a system that keeps track of past pollution cases and polluted sites and their remediation and further uses. To this end, a registration system (BASIAS) was created which maps more than 300,000 industrial sites over the French territory with more than 5,000 of them registered as being polluted. Second, the legal framework needs to be adjusted so that liability questions are clearly defined and innovative financing mechanisms set up to guarantee the financing of remediation in all cases.

13. A further innovation is to foster co-operation at local level and encourage the participation of all interested parties in any rehabilitation project inside urban zones, with municipalities playing a key role in this respect. The best solutions should be worked out in common, adjusting the remediation techniques and pollution removal performances to the future usage of the site, integrating the objectives of both project developers and urban planners. Concrete examples were given of such an approach on various projects in France (Municipalities of Lille and Le Havre), Wales, United Kingdom and the United States of America.

14. In any remediation project, the developer takes into account the historical background of the site, identifies, measures and maps the pollution, and assesses the risks to humans. Until the past decade, polluted sites were mostly restored into green spaces. Many sites that are today rehabilitated

in downtown areas involve the closure of old sites or the transfer of industrial production sites outside of urban zones where the constraints (security, environmental protection, traffic) are less heavy. These former industrial sites located downtown often have a high potential value for commercial and residential development. Therefore, even the high cost of remediation can be economically feasible. Technical solutions are worked out for every project and different rehabilitation solutions shaped for the several specific further uses envisaged for a single site. The new planning and uses of a site are established based on a mapping of the risks. A detailed risk assessment is seen as an unavoidable first step to defining and ranking the constraints and restrictions in any further use of the plots.

15. Another key component of every project is financing. Successful redevelopment projects will optimize the integration of financial-environmental and social performances. At the moment there is a lack of guidance tools to help find the most appropriate and sustainable solution to remediate abandoned polluted sites (brownfields). Models are being developed with a view to facilitating decision-making (see the work of Cabernet, the European network funded under EC FW 5-City of Tomorrow and Cultural Heritage Key Action). A "return-line" or pay-back period should be considered for each project; new innovative ways of financing should be worked out in particular for those cases in which the pay-back period would be too long or not reachable (i.e., in all places where a high risk demands rehabilitation). Public as well as private financing tools are being actively sought and developed in the EU, and the legal framework is being adjusted to encourage co-operation between the different partners.

16. Last but not least, the legal consequences faced by councils and real-estate companies in the redevelopment of contaminated sites are often unclear and difficult to assess. Most of the time this is due to a lack of specificity and gaps in legislation regarding polluted soils. Laws at national and regional (EU) levels still need to be refined, and the obligations of owners, sellers and juridical buyers more clear-cut. However, juridical tools seem increasingly effective.

Case studies:

17. Mr. T. Greichgauer, representative of the Office for Environmental Protection (OEP) of the City of Stuttgart, summarized different "tools of management and redevelopment of contaminated land in the City of Stuttgart". An inventory of contaminated sites was done in the years 1993-1998: about 4,700 sites were ascertained and registered. To handle such a large number of sites, the "Information Atlasten Stuggart" (ISAS) was developed as client-server architecture. Basic spatial information comes "on the fly" from the digital city map and all alphanumeric information is stored in central databases. There are two versions of the ISAS Client application: the ISAS Alpha Client that works solely on alphanumeric database information and the ISAS Mapping Client (IMC), which is based on ESRI's Arcview. Two case studies gave a better understanding of the application and show how ISAS improves the management process and the redevelopment of contaminated land.

18. Mr. Claude Spohr, French Ministry of Infrastructure, analyzed a specific case by "taking into account the problems of contaminated sites and soils in the regeneration of Plaine-Saint Denis". The site, about 700 ha, close to Paris, and for a long time a significant centre of activity, provides over 30,000 jobs and has 1,000 sites of classified industrial installations. Mr. Spohr underlined how taking into account (potential) contamination has become an increasingly important concern in assessing the feasibility of industrial soil remediation schemes from an environmental, economic and legal

perspective. The difficulty in obtaining a comprehensive overview and the complexity involved in taking these problems into account led the mayors of the two local communes and the Prefect of Seine-Saint-Denis to set up a working group (for the period 2000-2001) composed of chemists and cartographic experts to identify any necessary action and consider the compatibility of such action with constraints facing regeneration schemes. The report allows for the identification of risks in each site and the correspondence between cadastre and polluted sites, and provides useful information to those who acquire the right of exploitation. This is, therefore, also a tool for negotiation with the present owners of the sites.

19. Mr. R. Henkler, Senior Manager of Planreal AG, Meggen, Switzerland, focused his presentation on the "possibilities and limits of application of dynamic attenuation treatments in urban development projects, examples in France and Germany". The use of intrinsic bioremediation to degrade aromatic and chlorinated contaminants in soil and groundwater was investigated in sites in France (a site in the north contaminated with heavy metals, BTEX and mineral oils) and Germany (an area previously occupied by an underground hydrocarbon storage tank farm near Dusseldorf), applying natural and enhanced natural attenuation with *in-situ* and *ex-situ* bioremediation techniques. Large-scale bioremediation was implemented after initial screening tests and feasibility studies showed that in most cases constraints to bioremediation could be removed. Toxicity tests are used to indicate areas of low activity and are useful to estimate naturally occurring bio-regeneration rates, to determine if active bioremediation is necessary, and to identify potential constraints to bioremediation.

20. Mr. Charles Masse, General Director of Projenor (France), presented a case study on the "Dourges multimodal platform: pollution treatment under applicable regulations. Legal and financial solutions for re-conversion of former industrial regions". The State establishes constraints to restrict soil use and transfer the responsibility of present pollution to future owners. However, there are problems to be tackled by the application of a regulatory approach: (a) levels of pollution are actually set on the basis of rules and not on the real danger to health; (b) risks to health while cleaning are not considered; (c) the selection of future uses for industrial purposes does not consider market conditions. The specific study was directed at the estimation of the quantity of pollution, the evaluation of risks to health and the environment, and the identification of future theoretical uses of the site for industrial purposes. Hydrogeologists and specialists conducted studies on the site on foundations of the construction and evaluated health impacts. The results of the studies proved that € 27-28 million is needed to clean the site and that a new approach is required.

21. The moderator, Mr. A. Paquot, concluded that the outcome and lessons learned from the lectures and from these case studies might be used to increase the dialogue among different actors dealing with soil contamination. Dialogue is essential to finding solutions to common problems based on agreement, and not only on the imposition and implementation of rules by the State.

Session 3: Treatment of contaminated soils and groundwater
Moderators: Mrs. Agnès LABOUDIGUE (CNRSSP) and Mr. Christian MILITON (ADEME)

DOCUMENTATION:
- *Phytoremediation of radionucledis and potential application in decontamination of uranium mill tailings*, T. Vaněk, Institute of Organic Cemistry and Biochemistry of the Academic of Sciences (Czech Republic);

- *Practical aspects of the phytoremediation*, R. Kucharski, Institute for Ecology of Industrial Areas, Katowice (Poland)
- *Application of soil phyto-remediation to heavy metal polluted areas. Case study: Upper Silesia industrial region of Poland*, A.Sas-Nowosielska, R. Kucharski, J.M. Kuperberg, J.Japenga, Institute for Ecology of Industrial Areas, Katowice (Poland); Florida State University, Tallahassee, Florida (USA), ALTERRA, Wageningen (The Netherlands);
- *Development of an enzymatic amperometric biosensor using cytochromes C3 for the fast quantification of the chromate bioavailability in the environment*, Ignatiadis, F. Battaglia-Brunet, BRGM (France) M. Bruschi, C. Michel, P.Bianco, E. Lojou, CNRS (France) C. Tran Minh, Centre SPIN (France);
- *Development of a biological process for in situ immobilization of the hexavalent chromium contained in an industrial ground*, I. Ignatiadis, S. Foucher, A. Salmon, F. Battaglia-Brunet, D.Morin, BRGM (France);
- *Bioremediation of Kazakhstan soils by Dimethylhydrazin through the use of biohumus and arbuscular-visicular myccorhizal fungi*, K.K. Boguspaev, N.Sh. Alimova, S.E. Batyrbekova, K.S. Baishev, Al-Farabi Kazakh national university (Kazakhstan);
- *Biocleansing technologies for a major contamination by petroleum hydrocarbons*, A. Porta, Battelle Memorial Institute, Centre de Recherche de Genève (Switzerland);
- *In-situ treatment of polluted ground water (COHV, hydro-carbures, aromatic hydro-carbures) through compressed air*, A. Gross;
- *On thermally enhanced remediation of DNAPL contaminated sites*, M. van Zutphen, Th. J.S. Keijzer Tauw (The Netherlands);
- *Electrochemical remediation of soils polluted by PAH, MTBE, and Mercury*, F. Doering (France);
- *Innovative in-situ technologies rehabilitation for organic subsurface contamination, from large-scale experiences to field applications*, H.P. Koschitzky; VEGAS (Germany);
- *Treatment of cynide in the Louvre area*, H. Bonin, D. Lepess, GRS-Valtech (France);
- *Full-scale istd design and construction at former Alhambra, California wood treatment site*, J. M. Bierschenk, R. S. Baker, R.J. Bukowski, TerraTherm (USA), J. King, T. Landler, Southern California Edison (USA);
- *EarthSaw Containment of pits and trenches – final topical report on phase I engineering – study prepared for the US National Energy Technology Laboratory*, E. Carter (USA);
- *Application of dynamic natural attenuation in case of solvent de-pollution (using PCR)*, F. Karg, HPC Envirotec S.A. (France)
- *Comparison of modern techniques for wells samples as result of the neutrality of groundwater*, D. Millette;

22. Twelve speakers focused their presentations on topical issues related to biological treatments or to the use of heavy techniques such as soil thermic treatment. In general terms, following several researches and few field applications (often on a pilot scale), phyto-remediation, natural attenuation and the use of specific bacteria are considered by several experts as appropriate remedies to a large range of pollution types. Five presentations demonstrated the feasibility of these techniques, considering issues such as treatment conditions of vegetal hyper-accumulators, duration of the treatment, medium and long-term evolution of the treatment conditions (e.g. Eh and pH) in the considered sites, and justification for using genetically modified organisms. The phyto-remediation techniques are mainly considered for large areas, while the use of specific bacteria or dynamic natural attenuations are generally recommended in sites where access to pollution is difficult.

23. The feasibility of applying biotechnology using plants to remediate soils, sediments, surface and ground waters contaminated by toxic elements and/or radionuclides in the Czech Republic (old uranium mines) through the use of sunflowers and poplars was demonstrated, as well as in sites which are highly radioactive. These techniques are applied to extract a few micrograms of elements per kilo of soil. The consequent incineration of the plants is considered the most suitable solution.

24. The use of plants to extract organic pollutants was considered in connection with the results of inspections in the territories of a spaceport in Kazakhstan, where the real concentration of asymmetric dimethylhydrazin (ADMH) exceeds the maximum concentration limit in soils, plants and underground and surface waters. ADMH has also been found in animal forages, vegetables, and meat of pets which evidences how it gets into the organisms of people. Reliable data were collected about the reduction of concentration of ADMH in polluted soils from the territory of the cosmodrome "Baikonur" as a result of the use of various doses of biohumus. In the future, other techniques to use biohumus to detoxificate ADMH will be investigated.

25. With regard to the immobilization of metallic pollutants, the development of an enzymatic amperometric biosensor using SMRB cytochromes for fast quantification of chromate bio-availability in the environment was presented. The utilization of cytochromes has been developed through the selection of a technique to immobilize the enzyme which considers the correlation between the Cr (VI) concentration and the intensity of signal; the short time of reaction (1-5 seconds); and the low quantity of enzyme: 372 mg. The perspectives are to test other immobilization techniques; the interference of other metals and metalloids; the regeneration of the bio-captor; validation in the field.

26. Following the explosion of an oil production site in Italy, 20,000 m3 of hydro-carbures inundated agricultural fields: 2,000 hectares of soil have been affected. This area is mainly devoted to rice and corn production. For the characteristic of the rice production, the soil is not very permeable, and the actions undertaken to clean these sites through bio-cleansing technologies have therefore been successful. The fields have now reverted to traditional agriculture practices.

27. These four examples show a demonstrated feasibility of specific biological techniques at different levels and treating different pollutants, although related problems arising in each case vary. In parallel to these soft techniques, other heavy processes have been implemented on pollutants more important to extract/treat. As examples, thermic processes with medium or high temperature, or an alternative system of washing have been outlined during this session.

28. In relation to the use of temperate thermic treatment through the use of hot water flushing, an example for contaminated soils containing non aqueous phase liquids (DNAPLs) is the CS2. The objective is to keep the temperature low (80º C), as CS2 is a highly explosive compound with an auto ignition temperature of 102º C. Three basic heating technologies are available: electromagnetic heating, fluid enhanced heating and conductive heating. The first two methods are the most commonly applied.

29. For more complex organic pollutants (e.g. presence of PAH, PCP, dioxins), a thermic treatment up to 800º C can be considered. This technology utilizes simultaneous application of thermal conduction heating and vacuum to treat contaminated soil without excavation. The applied heat volatilizes both water and organic contaminants within the soil, enabling them to be carried in

the vapour stream toward vacuum extraction wells. Contaminants not destroyed *in situ* are removed with the vapour stream and treated in an aboveground vapour treatment system.

30. Another alternative to treat contaminated soils containing non-aqueous phase liquids (DNAPLs) is, in some cases, the use of co-solvents. In fact, due to their small aqueous solubility, site remediation by pump-and-treat is often inefficient and can be increased by co-solvent flooding, e.g., alcohols. Studies on alcohol flushing are under way, focusing on optimization of field applications for prevalent site conditions. In the last three examples, the need to monitor and treat the migration of pollutants and related gas require expertise and knowledge of both the pollution components and the nature of soil and subsoil.

31. Two other methods summarized below are based on the isolation of soils. The first is based on the excavation and removal of radioactive sites through earth saw cutting action and earth block flood. This system prevents grout from flowing into the soil, grout forms continuous barriers for vault, many size and shape options are possible, there is no intrusion or contact with waste, and it is proved to be faster and safer than baseline methods. The system seems easily applicable, as it can be performed by regular civil contractors, and the computer model indicates a broad application. The other method is using Reactive Permeable Barriers, BPR, with *in situ* remediation. The BPR treatment is used for the treatment of water polluted with chrome but it can be used for the treatment of a wide range of pollutants/ mix pollutants (e.g. arsenic, cyanide). Different filters can be used: active coals, PAHF-BTX-PCP. Two case studies have been presented to show the BPR applications.

32. The last case study presented was on natural dynamic attenuation of solvents contamination. This method underlines the importance of the genetic biotechnology for the microbiological decontamination through the Natural Dynamic Attenuation (NDA). 85-90% of micro-organisms available in the environment are not grown in laboratory and more adaptable to environmental conditions.

33. In conclusion, although the feasibility of several techniques has been proved, many issues and problems still need to be investigated, in particular for bio-treatment techniques. These methods present a high risk of uncertainty, principally with regard to the degradation and/or re-mobilization of pollutants, the environmental impact and economic consequences related to the choice of soft techniques.

Exhibition, posters and project fair

34. An exhibition of equipment, techniques and services supplemented the Seminar. The most up-to-date know-how in assessment, measurement and remediation technologies were presented through the participation of 25 exhibitors from different parts of the world (Denmark, France, Germany and the United States of America). The stands were characterized by numerous contacts and active talks.

35. A large series of posters were also displayed which illustrated how active the research activities and engineering developments were in this field.

36. A project fair was organized on the margins of the exhibition, in an attempt to match requests for technical and financial assistance for the remediation of polluted soils and groundwater with

proposals from the business sector. A number of such project proposals were described, among them a few from eastern countries in transition.

Closure session and recommendations

37. Mr. Jean Francois Loos, Minister of Foreign Trade of France, made a statement on the importance of the decontamination activities in all industrial developments in France, as well as technical advancement and expertise that can be exported to other countries. The Minister expressed his appreciation to the participants in the Seminar for their contribution in developing advanced techniques and highlighted the important role of Intersol in the exchange of technical information.

38. After three days of debates and active exchanges, Mr. Pierre Fillet, Secretary General of Euro-CASE (European Council of Applied Sciences and Engineering) presented the conclusions of the Seminar, together with a series of recommendations that can be summarized as follows:

- Information about analysis, treatment methodologies and remediation for polluted soils and groundwater should be managed in a professional and transparent way, as rapid progress in technical solutions and interconnections between a variety of problems make an effective information exchange necessary. Reliable databases and clearinghouse systems would improve communication between all partners, including decision makers at policy levels;

- Scientists and professionals in the health sector should be considered key partners, in particular on all matters related to toxicology and epidemiology so that risks to human health are better taken into account and minimized when rehabilitating polluted sites;

- The international standardization of hazard and risk assessment should be seen as a necessary management tool towards optimizing the technology and financing of site remediation;

- Further improvements in chemical and biochemical engineering, especially regarding fluid and gas flows through porous media on which micro-organism grow, should be pursued as they can potentially greatly enhance soil remediation;

- Considering the challenging progress which still has to be made on the series of above-mentioned issues, the Intersol conference and exhibit series should be continued. It is recommended that the next event, Intersol 2005, be held no later than in two years' time. The next Seminar would have to continue the work undertaken with this specific and previous events. The wish was to have the Seminar also under the auspices of the UNECE.

39. On behalf of the UNECE, Mr. G. Sambucini closed the Seminar with two concluding remarks. He thanked the French authorities, ministries and the association Interchimie for the excellent organization of the Seminar to which the UNECE provided its technical contribution. The UNECE ad hoc Group of Experts on the Chemical Industry and the UNECE secretariat would consider the outcome of the Seminar and the perspective of a future follow-up. He also pointed out the fact that UNECE was essentially dealing with transition countries where contamination problems are serious and need urgent actions. Considering its normative role and technical advice provided to Governments, the UNECE learn from this technical Seminar focused on past contaminations and on

present solutions also to develop a planning framework for the future. In line with the 2002 Johannesburg World Summit on Sustainable Development, the UNECE is convinced that all industrial (and non-industrial) activities would have to consider environmental and health impacts of possible new contaminations. It is therefore important to foresee additional resources in all development projects in order to allow future generations to have access to the same resources available at the present.