Soil contamination following an industrial accident : towards efficient investigations and assessment

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SOIL CONTAMINATION FOLLOWING AN INDUSTRIAL ACCIDENT: TOWARDS EFFICIENT INVESTIGATIONS AND ASSESSMENT

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1. Summary

When an industrial accident occurs, *e.g.* the explosion or the fire of a chemical facility, soil investigations and subsequent risk mitigation generally need to be decided and performed rapidly. This requires specific organisation and tools:

- Procedures for an immediate and coordinated intervention of relevant actors: industrials, administrations for industrial facilities, emergency and health, local authorities, environmental consultants and laboratories, NGOs.
- Models and input data on emission, atmospheric transfer and deposition on soil, for an accidental source; investigation plans and adequate soil quality references, guidelines…

But the European Seveso legislation, and its application in France and probably in Europe, is focused on the prevention of immediate impacts on health and constructions; and the Integrated Pollution Prevention and Control (IPPC) legislation deals with the chronic impacts of operating facilities. Thus, post-accidental impacts of industrial accidents are hardly dealt with, the specific organisation and tools are lacking, and when accidents occur, the industrials and administrations concerned are largely unprepared for managing their delayed impacts, first of them on soils.

This paper will present the results, as concerns soil contamination, of a research on the "*Organisation of Actors and Tools for the management of Post-accidental impacts of industrial accidents on the population and the environment*" (Orgactoupost, 2007 - 2009).

This research drew up a diagnosis of -and proposed solutions for- the current gap, in France, between the emergency response and the response to post-accidental impacts of industrial accidents on the environment and on human health. It was performed by a multidisciplinary team of health, environment and emergency experts, in relation with a network of relevant actors as mentioned above.

The diagnosis and the solutions were elaborated through three steps:

- Diagnosis, and identification and first formulation of recommendations, through a critical review of the regulations and practices in related fields: accidental and chronic risk management of industrial

- Feed back on other accidents: train transporting fuel (Chavanay, 1990), fires of a warehouse for crop protection chemicals (Sandoz in Basel, 1986; Protex in Auzouer 1988)…
- Feed back on the main tools of prevention and anticipation of the accidents such as the Seveso regulation, the Danger and impact studies for industrial facilities, the medical urgency plans.
- Detailed analysis of the epidemiological approaches after a disaster (Verger and al ., 2005).

For example, a paradox of the Seveso regulation and of its application, is that they address only little the main problematic of the Seveso accident: its post-accidental impact.

The research drew up a diagnosis of -and proposed solutions for- the current gap, in France, between the emergency response and the response to post-accidental impacts of industrial accidents on the environment and on human health.

3.2. Methodology

Numerous actors are involved in the issue of delayed impacts of industrial incidents, operating in very different domains in terms of technical discipline, regulatory framework, functioning modalities, and intervention logics and dynamics (“emergency” vs. "chronic"). The research’s principle was to make these different domains and points of view meet together.

In this view, the research was performed by a multidisciplinary team of health, environment and emergency experts, in relation with a supervising committee and a consultation network where the relevant actors were represented: industrials, administrations for industrial facilities, emergency and health, local authorities, environmental consultants and laboratories, NGOs.

It was conducted through three steps:

1. Diagnosis, and identification and first formulations of recommendations, through a critical review of the regulations and praxis in related fields: accidental and chronic risk management of industrial facilities and contaminated sites, epidemiology, emergency planning and community involvement. This step included an inquiry on past cases through interviews, and a study on the practices of the Agency for Toxic Substances and Disease Registry (ATSDR) and the United States Environmental Protection Agency (US EPA) in the US emergency response.
2. Amendment of the recommendations formulated in step 1, through 4 *focus group* discussions.
3. Test and adjustment of the recommendations, through a case study exercise.

The research was imbedded in two territories: “Provence-Alpes-Côte-d'Azur - Languedoc-Roussillon” and “Nord-Pas-de-Calais – Picardie”.

3.3. General results and conclusions of the research (summary)

The relevance and the importance of the research problematic and of the identified issues were validated. The presence of a gap between the actors and tools of the urgency and the actors and tools of the public health and the environment was widely confirmed. As a consequence of this gap, in numerous cases, when an accident occurs, the site and accident managers are not prepared for assessing, limiting, and managing the post-accidental impacts.

Nuances however appeared. For example, the protection of superficial waters benefits from a detailed system of prevention of post-accidental impacts. Besides, at the time of the accident, emergency services work, in the limit of their possibilities, on the prevention of the post-accidental impacts which they can immediately identify.

Even if it is important to reduce this gap, the organization and actors of the urgency cannot be in charge of the post-emergency: their optics and working dynamics are too different. The question becomes to optimize the delicate articulation between separate systems. The post-accident phase should be animated by persons who are not monopolized by the management of the urgency, but in narrow relation with the management of the urgency and with a network of experts from the various relevant domains.

Consequently, the recommendations formulated by the research team concern the doctrine, the responsibilities, the organization for post accidental situations, and the regulatory and technical tools associated: emergency plans, dossiers for industrial facilities, standards and tools for the evaluation and

limitation of the deferred impacts. The recommendations are given, and commented for soil contamination, in the following section.

The research team recommends that each stakeholder (ministries, local State services and communities, industrials, associations, engineering consulting firms, laboratories,…), at his/her/its level, appropriate these recommendations and decline them in operational terms: organization, systems, procedures and practices, regulation, tools and data.

3.4. Results and conclusions concerning post-accidental soil contamination

The recommendations are organized in 8 "General Recommendations" (GR) subdivised in 29 "Specific Recommandations" (SR). They are given and commented -when useful- for soil contamination.

GR1: Clarify a doctrine for the organization of post accidental situations, define the responsibilities and provide according means.

SR 1.1: Establish, in a concerted way, a doctrine for post-accidental situations, setting the basis of an organization of post-accidental management,

- defining a vocabulary, and the responsibilities of state and local authorities, and proposing the terms of appointment of a leader and a steering body;
- affirming the principles of a consultation with the community, of an *ex ante* preparation, of an articulation and / or a continuity between the emergency and the post-accidental phases to avoid gaps in the transmission of data and information;
- defining a link with the French emergency organization (Orsec), bodies for technical support - post-accidental local cell (CPAL) and national cell of support for post-emergency situations (CASPA);
- deciding the development of methodological guides and support tools and support to players in the post-accident management;
- drawing out an effective policy of feedback on post-accidental situations.

These recommendations are developed below in "technical" terms.
A good transmission of data and information is considered a key for a rapid and adequate investigation of soils and vegetables potentially polluted by the accident.

SR 1.2: Give this body of doctrine a statutory basis and / or regulation.

SR 1.3: Provide a mechanism for funding and allocation of human resources at all stages: preparation stages and phase post-accident management.

GR2: Better articulate the emergency plans with the management of the post accidental situations.

SR 2.1: Develop a general organization of the post-accident management articulated with the ORSEC and with a genuine regulatory and operational base.

SR 2.2: In existing organizations and plans of the country, the cities, the facilities), define a better articulation with the post-accident

SR 2.3: Develop recommendations and tools to identify the needs of launching a post-accident phase and determine its components: typology of encountered situations, "reflex sheets"...

Everything can not be planned in post-accidental situations. Much place will be left to improvisation. But some guidelines can help prepare the actors and tools before the accident, and react correctly during and immediately after the accident. For example:

- The emergency forces or other actors should acquire some images (video) and adequate samples (particles and gas) of the fumes, as well as site meteorological data (installing a weather station), so as to focus the site investigation on the right compounds and the right location. This is especially

useful in the Facility Intervention Plan (for Seveso sites) which is triggered when an important accident occurs on the facility.
- Official instructions regarding the consumption of home-grown vegetable should be readily available.
- The Mobile Cells for Chemical Interventions (CMIC), could possibly be prepared to fume-sampling and equipped with the adequate devices: they currently measure only simple compounds (dust, HCl, SO_2,…) and at high levels, with the objective of protecting the emergency personal.

The typology would help deciding when a site investigation and risk assessment is needed. The reflex sheet would recall those instructions and would tell to whom the site observations and data should be communicated (persons in charge of the post-accidental site assessment).

GR3: Better integrate the delayed impacts of accidents in the administrative dossiers for new industrial facilities.

For a quick but adequate site investigation, site assessment and risk-reducing actions, the immediate availability of relevant site-specific data (inputs and outputs) and tools (see SP 3.1, most of the items are related to soil or vegetable contamination) in relation with possible post-accidental impacts would be very useful.
Currently in France, when an accident occurs, the site manager and the accident manager are not prepared for assessing, limiting, and managing the post-accidental impacts. Those data and tools are not available. They have little information and no definitive answers to provide to the community, which may feel outraged by what they may consider as a failure of the responsible persons.

Actually, in the regulation for industrial facilities, post-accidental impacts belong to the scope of the technological risk study within the authorization dossier. But they are not included in the operational guidance for this study, and then in the practice not considered in the dossiers.

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SR 3.1: In the technological risk studies for new facilities, integrate a risk analysis of delayed impacts of an accident, and also, when the issues at stakes justify it:
- An *ex-ante* and revisable assessment on the basis of scenarios, to which it can be referred to. This assessment would document the key parameters:
    - Terms of the source (relevant compounds, quantities, modalities of combustion and of emission...)
    - Terms of the transfer (especially modeling of the atmospheric dispersion),
    - Toxicological Reference Values for key compounds and delayed impacts.
- A proportionate process for assessment and mitigation in case of an accident, including, depending on the issues:
    - Monitoring plan of the environment around the site for key post-accidental compounds;
    - Technical plan and device for assessing and limiting the delayed impacts of an accident: collecting environmental data, taking care of employees,…
    - Financial guarantees covering the remediation of the possible impacted area (and not only for the immediate safety measures).

When the accident happens, it will not be possible to just take the *ex ante* assessment as it is*:* the accident will not necessarily take place as in the anticipated scenario and conditions, and some data from the dossier of the facility can be obsolete and should be updated (including Toxicological Reference Values). The anticipation through the dossier still remains valuable for:
- Immediate information on possible consequences: intensity, impact area,...
- Immediate availability of key risk factors, which will drive the proportionate assessment and risk mitigation process;
- The rapidity of an adjustment: in the modeling, the most-time consuming operation is the construction of the site-specific model.

A prerequisite is that the concerned actors (industrial, local environmental authority) consult the authorization dossier at the time of the accident. This action shall be included in the reflex-sheet of these actors (RG 5).
The rapid adjustment of the assessment at the time of the accident can be a difficult issue. *A minima,* the industrial should have the initial set of modelling data, ready to be re-injected into an adjusted modeling. Ideally, the contractual relationship between the industrial and its environmental consultant for the

technological risk study could include the possibility of a rapid adjustment (typically 1 day) of the modeling in case of accident. This type of relationship exists in the USA (at least between the US EPA and consultants: Poulet, 2008), but seems much more difficult in France.

The usefulness and the feasibility of a monitoring of the environment around the site for key post-accidental compounds were strongly discussed within the focus groups and the steering committee. The key questions are: how these data actually be used in case of an accident, and what would be the extent of the involved means:

1. For a global comparison with a commonly encountered background level, a documentary approach may be sufficient. This comparison will decide soon after the accident of the existence or absence of a major impact on the environment;
2. When deciding whether the accident impacted (even slightly) the surrounding environment, it is necessary to have more precise data, with measurement points and substances specific to the post-accidental issues[1], monitored more or less frequently depending of the expected time-variability. In case of an observed absence of significant impact, the site assessment can be stopped, particularly avoiding the very uncertain -and easily subject to debate- step of health risk assessment. This assessment strategy is however applicable only to persistent pollutants: metals, dioxins / furans, PCBs, phthalates, PAHs, as opposed e.g. to most plant protection products.

SR 3.2: Based on the feedback and expert judgment:

- identify the types of industrial facilities or activities (transport of dangerous material, ...) not subject to the hazard study and presenting particularly important post-accidental issues.
- and integrate prescriptions to preserve these issues into the standard documents governing these types of facilities or activities.

The reason of this SR is that industrial accidents with major often happen at small facilities, which are submitted to standard documents instead of the site-specific hazard studies imposed on larger facilities. It is nevertheless acknowledged that not all possible cases can be foreseen and prepared (for ex. in France, fire of a wood storage on soils strongly contaminated by PCBs, in 2009).

GR4: Organize the actors concerned to accompany the transition between the urgency and the management of possible delayed impacts.

This recommendation aims at reducing the gap between actors of the emergency and actors of the post-accident, while accepting that the post-emergency must remain separated from the emergency. So the goal is to arise the reciprocal understanding of needs and constraints, and to establish a dialog before the accident, and during and after the emergency phase, with a structure and roles that shall evolve over time. A strong recommendation is to associate health and environmental local authorities in the leadership of these structures.
It is expected that actions concerning delayed impacts that should be realised during or immediately after the accident (for soil quality assessment: visual observation and sampling of fumes,…) would gain better chances to be realized in time,

SR 4.1: In an industrial accident -as soon as possible, at best during the emergency phase- allow to identify post-accident issues, to alert if necessary and to anticipate the associated needs for assessment and management.

SR 4.2: At the level of a department or of a “risk territory”, create an active network of preparation to industrial post-accident.

SR 4.3: In case of an industrial accident, if the issues justify it, create a local post-accident cell.

[1] They will not be the same as those of the monitoring of a normal functioning of a facility, which looks at the “normally” emitted compounds (not combustion sub-products for example) in the main wind direction (whereas an accident can occur while the wind blows in another direction).

If an emergency command centre has been created, the post-accident cell should be directly connected to it: the cell would advise on immediate actions concerning delayed impacts and receive from it the information useful for the investigation plan and the assessment of delayed impacts.
After the suppression of this emergency command centre, the post-accident cell should be enlarged to members from this command centre, so as to ensure the continuity of the action and of the communication.
The research team recommends to immediately open the post-accident cells to representatives of the community and of local organisations.

SR 4.4: Create a national cell of expertise in support of post accidental situations.

GR5: Develop *ex-ante* rules for action and standards and tools for assessing and reducing the various types of delayed impacts.

SR 5.1: Make a list of the reference tools necessary, with their specifications, and prioritize them in term of urgency of completion.

SR 5.2: Develop shared reference tools for the assessment *(ex-ante* and *ex-post)* and the reduction of post-accidental impacts:

- Reflex sheets : Typology and alert criteria for triggering a specific and graduated management of the post accident starting already in the emergency phase; "what-to-do" during the emergency phase, "families of products".
- Sampling Protocols: fumes in a fire, dust deposits,...
- Risk modeling modules: source terms, atmospheric dispersion models for an accidental source, transfer models of fire extinction water towards groundwater and surface water, toxicological reference values including for sub-chronic exposure, standards on human exposure, ...
- Standards for assessing the state of the environment (air, water, plants, soil): regulatory values, soil quality standards, and generic soil background values,...
- Guides of good practices for the impact assessment: choosing correctly values within databases; elaborating the initial description of the area and comparing new site data with this initial state or with local control points; performing the right field investigations during and after the accident (e.g. fire); combining measure and model; gathering health, social and economic data; implementing epidemiological surveillance systems, ...

SR 5.3: Develop a research about the compounds and quantities emitted by industrial fires, explosions,...

SR 5.4: Establish a network of analytical and sampling laboratories that can intervene urgently with a view to assessing delayed impacts (immediate human exposure, impacts on the environment, *bio-monitoring).*

After an accident, conservatory site-use restrictions can be recommended or imposed by the authorities, e.g. not to eat own-grown vegetable. A rapid confirmation or suppression of these safety measures is needed. Sufficiently simple and clear activation and payment rules must be organized, so as to avoid any loss of time in the emergency phase.
This network will necessarily be evolutionary. It will include immobile laboratories and mobile laboratories (fire departments, Civil Security,…).

SR 5.5: Develop a method for calculating financial guarantee for the delayed impacts.

SR 5.6: Develop standards for the local preparation to the assessment of delayed impacts and to the management of post-accidental situations

- Geographic Information System (GIS) of impact areas, of potential targets, relevant actors;
- Preparation for the collection of health data through perennial or *ad hoc* epidemiological systems (hospital data, data collected from the health insurance, or from sentinel physician networks ...)
- Modalities for achieving an exercise and experience-feedback (cf. GR 7 and GR8)
- ...

GR6: Inform and listen to the community and their representatives, involve them in the management of delayed impacts of industrial accidents.

SR 6.1: Systematize the attention to the community, to its intermediaries and representatives, at all stages of the planning and implementation of the management of the post-accidental situation.

The dialog with the community is necessary for more thrust in, and acceptance of, the decisions eventually made. It is also essential to improve the quality of the studies and of the decision. The Comrisk guide and toolbox for organizing community involvement on contaminated sites (INERIS-IRSN, 2008, www.comrisk.fr; Hazebrouck *et al*., 2008) can be used. However, specific difficulties of community involvement for post accidental situations have been identified:

- The outrage felt by the community because of the sudden intrusion in their life of a risk that had been declared "under control", possibly increased by a disorganisation and inconsistencies in the emergency response, and the feeling to be "forgotten" or not considered seriously in the response (during the fire of a warehouse for crop protection chemicals that occurred in Béziers in 2005, a resident outside of the town had to hear on the radio that *fortunately* the fumes had gone in the direction of her home and garden instead of the town).
- The dynamics of the response to the accident or to the post-accidental situation, that is and has to be much faster as for a contaminated site. This is particularly a problem, because establishing a good relationship with the community requires time and should be done before the problem arises, and also because it may prove difficult to find and reach the relevant people in the haste (and possibly confusion, like after the AZF explosion in Toulouse, 2001) of the accident.

These two specific difficulties lead the research project to insist on the ex-ante community involvement on industrial risk (SR 6.2).

It is essential to motivate these stakeholders through the effective demonstration of their influence: as a support to decisions, as a contribution to an efficient and well coordinated "technical" response. This recommendation should be integrated in the implementation of all the other recommendations made here.

SR 6.2: Prepare *ex-ante*, at the scale of a "risk territory", then develop and implement at the site scale when an accident occurs, a scheme for the information and involvement of the community, its intermediaries and representatives, in the management of post-accidental situations, including the followings aspects:

- The information, adapted to the different targets, distinguishing the communities directly affected and those more distant.
- The development of systems / processes for listening and dialoguing, answering, and bringing feedback on what has been done and not done and why.
- The participation of the community to the expertise and to the preparation of decisions, particularly through involvement of representatives in consultation and expertise mechanisms: local network for readiness to the post-accident, post-accidental monitoring committee, post-accident cell.
- The community involvement of people in gathering information relevant to the risk assessment and management, as well as in the preparation of individual prevention or reparation actions.
- The preparation and training of all stakeholders of the management of post-accidental situations, to dialogue and consultation: representatives of local authorities and of the community, administrations, industrials and potential contractors (among others, prepare methodology fact-sheets and guides to help manage situations of uncertainty).

SR 6.3: Integrate post-accident issues (concepts, issues, doctrine) in all existing approaches to information, consultation and training on industrial pollution and risk, as they address the population directly or through intermediaries or through existing consultation mechanisms.

GR7: Integrate the post- accidental phase in a more systematic and better exploited system of experience-feedback.

SR 7.1: Develop a methodological guide for the triggering and conduct of experience-feedback.

A procedure should be implemented in a systematic way to help decide the opportunity of an experience-feedback. Indeed, it is neither possible nor desirable to undertake a process of experience-feedback on each accident situation because it would not be feasible, but it is also undesirable to leave the triggering of an experience-feedback to the appreciation of the political authorities. Trigger criteria should be defined to trigger an experience-feedback for events with significant potential for learning.

Methods and a guide should be developed to allow a smooth conduct of experience-feedback: the purpose of experience-feedback is to understand, not judge. The experience-feedback is a discipline in itself, transverse, with a state of good practices. These good practices should be brought the experience-feedback on post-accidental situations.

SR 7.2: Better take into account the post-accidental phase in the existing experience-feedback on industrial accidents, and document its articulation with the emergency phase.

SR 7.3: Realize an integrated analysis of the different experience-feedbacks (for the same accident or for different accidents)

SR 7.4: Disseminate the experience-feedbacks and their lessons towards the parties who have been involved in the respective accidents, towards the parties preparing post-accidental situations, towards concerned professionals involved, and into the public debate.

SR 7.5: Evaluate regularly the use of the results of the experience-feedbacks (institutional improvements, revaluation of actions).

GR8: Organize the training of actors, the experience sharing and the diffusion of good practices for a better management of post accidental situations.

SR 8.1: Develop training courses and know-how learning, so as to better prepare the different stakeholders to the management of post-accidental situations.

SR 8.2: Train referent persons, who might intervene in all disciplines during accidents, and include this goal in the evolution schemes of training.

SR 8.2: Develop exercises on the change from the accidental to the post-accidental phase, and on the phase of post-accidental management of medium and long term consequences of industrial accidents.

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