Preserving Biodiversity and Reindustrializing France: an Autopsy of the Problem from the Perspective of Accidental Pollution Risks

Pénélope Plot, Marine Boutillon

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Pénélope Plot[a*], Marine Boutillon[b]

[a] Sorbonne Paris IV, France
[b] Ineris, France
plotpenelope@gmail.com

Industry pollutes. This simple observation necessarily poses a problem for territories that intend to conduct a reindustrialization policy and preserve their biodiversity. As part of an internal exploratory study, INERIS approached this issue from the angle of accident risks, with three questions: 1/ If the main process accident scenarios (explosions, fires, toxic clouds) are taken into account in term of human consequences, one may wonder whether are not under-assessed / not assess at all regarding pollution. 2/ Following the logic of French methodological rules to produce achieve safety case, the hierarchy of ecosystem importance is a key parameter in the calculation of acceptability of a potential accident. The issue remains on the establishment of such Environmental scale: which ecosystem should be placed at the bottom of the importance scale, so that it is more permissible to pollute? Who makes such decisions today? On the basis of what knowledge? Within the framework of what legislation and regulatory practices? And what should be the right method and tools? 3/ Are we really prepared to deal with accidental pollution like Lubrizol in 2019 (www.aria.developpement-durable.gouv.fr/le-barpi/la-base-de-donnees-aria/) from a biodiversity perspective? Don't we tend to focus on prevention and, protection of people, without really knowing what to do to avoid and limit impacts on the ecosystems? Through an approach that combined an analysis of the literature on these issues (methods and orientations, theoretical reflections, accidentology) and a series of 21 interviews with key actors in France, the authors question a solution that seems better than the others, based on the notion of absorptive capacity/resilience of ecosystems. This approach would remain to be implemented for terrestrial ecosystems. This article presents the main steps of the demonstration.

1. Introduction

Are the accidental pollution scenarios well studied? Are the ecosystems (environmental issues) well considered in these studies? And are the management practices for these ecosystems satisfactory with regard to the risks of accidental pollution? These three questions led to this article. They refer to field of risk management in France, which is regulated under the regime of classified environmental installations, the ICPE (aida.ineris.fr/liste_documents/1/18016/1), which include Seveso sites. These questions also refer to a literature on environmental ethics, where it is understood that each formulation, each notion, contains a vision of the world that pre-structure the way of posing problems and seeking solutions. Especially when it comes to defining the value of an ecosystem, as it is generally required in risk assessment approaches where decisions are justified on the basis of criticality calculations (that combine several dimensions, including the characterization of ecosystem importance). But, importance for whom? This is undoubtedly the key question, which in fact refers to the following question: what do we want to manage, why, and then how? The question "why" evokes the debate on anthropocentrism and biocentrism in environmental ethics (Afeissa, 2007): do we want to protect ecosystems for anthropocentric reasons, that is because they are resources (aesthetic, spiritual, etc.), or do we want to protect them for themselves. And if we want to reconcile these two ends, which one would be the ultimate end, in pragmatic and ethical terms? The answer to the how depends on the why.

The multiplicity of names is an integral part of the problem: it is difficult to identify what we are talking about, what we are trying to protect. Are we talking about environmental stakes or biodiversity? Protected spaces or areas? Ecosystems? Natural environments? The diversity of terminologies reveals the difficulty of the work: we do not know how to characterize and define what we call "ecosystems" or "natural environments". This difficulty is based on metaphysical conceptions of the world, but it is also relative to the logics of division of reality (to the representations) that we adopt according to our objectives. Each term is a division, a way of apprehending what we call "nature", "the environment" with regard to which we lack knowledge, and criteria, foundations that would allow us to adopt a valid (realistic, coherent) division. In this research, we use the term "ecosystem" as it is generally understood in ecology (the whole formed by the biocenosis and the biotope, that is the living beings and their environment), we start from the assumption that it allows the broadest point of view to take into account the natural entities.
The reasoning that we propose to follow in this article is the following:

- There seems to be a hole in the French regulatory, an insufficient consideration of accidental pollution risks that is not compensated by voluntary practices.
- The current solution, based on the categorization and prioritization of environmental stakes, seems to be an aporia.
- Only an approach based on the notion of absorption capacity seems to be a possible solution, but it presents several difficulties that would have to be overcome to implement it.
- A necessary condition for the adoption of such an approach would be to adopt a territorialized approach.

2. Methodology

This article is the result of multi-actor survey. The panel was composed of engineers from a environmental safety institute, officers of the French administration, safety managers or engineers working in chemical, mechanical and food factories, territory officers, actors of environmental association and insurance providers. The panel distribution is as follow:

Engineers from a environmental safety institute	Actors of environmental association	Industrialists	Officers of the French administration	Territory officers	Insurance providers
5	5	4	2	2	3

The scale of the panel is relatively limited so the quantified results which are presented in this paper have to be understood only as tendency. The present paper attempt to display an overview of high quality of interviews. Along all the discussions, we have selected ideas that seem to build consensus or ideas that retain our attention because they make sense regarding our searching framework. This “exploratory” work, initiated under an engineer approach, has benefited from a philosophical lightening on the on environmental ethics.

3. A hole in the regulatory

"Having looked at the hazard and impact studies, I always thought there was a hole in the racket. Impact study is totally disconnected from the hazard study, it looks at the impact that the plant will have in normal operation, given the discharge authorizations that have given. We are in the chronicle. But, in the event of a major accident, what is the impact on the environment? The hazard study is not interested in this because we are interested in the deaths, the injuries and the damage to the equipment. We have a real hole in the racket." (Actor of an association). This observation is shared by 95% of the people interviewed (20 persons overs 21).
To be more precise, in France, the accidental risk assessment of a Seveso site (or site where major accident can occur) is performed through the so-called “Etude de Dangers” (safety case). It is the central piece of the management system for major accident scenarios (Kontogiannis et al., 2017). Schematically, this study distinguishes two phases of analysis. The first one, the preliminary risk analysis, is qualitative, it is used to scan widely in order to identify, normally, all accident scenarios. The second phase, the detailed risk analysis, is more quantitative (Omega 9, INERIS, 2015). It studies in detail the intensity of the selected dangerous phenomena, their severity and then their probability. Their acceptability is determine using the risk matrix (figure 1). If it is necessary to reduce the risk level, safety barriers can be added. The problem is that scenarios leading to pollution are only retain for the detailed analysis if they also cause damage on humans. Other scenario which “only” cause pollution are not analyzed in detail, and therefore are not properly managed. *"We are not interested (especially in the hazard study) in the ecosystem, around the industrial site, we surely miss some effects. [...] The assessment is only made in relation to the effects on human beings.*
It is true that at present the quantification of the severity (intensity) of major accidents does not take into account the environmental component. This may change following the latest incident at the Lubrizol plant.

We are going to evaluate more things related to post-accident, the deferred impact of major accidents, which will require a qualification of the environmental impact, particularly in terms of crops and potential fallout on the food chain." (Engineer from a environmental safety institute).

Severity of consequences				Probability				
Level	Area defined by the significant lethal effect thresholds	Area defined by the lethal effect thresholds	Area defined by the significant irreversible during a human life effect thresholds	E (event possible but highly improbable)	D (very improbable event)	C (improbable event)	B (probable event)	A (casual event)
Disastrous	More than 10 persons exposed	More than 100 persons exposed	More than 1000 persons exposed					
Catastrophic	Less than 10 persons exposed	Between 10 and 100 persons exposed	Between 100 and 1000 persons exposed					
Important	Maximum 1 persons exposed	Between 1 and 10 persons exposed	Between 10 and 100 persons exposed					
Serious	No one	Maximum 1 person exposed	Maximum 10 person exposed					
Low	Contained witin the establishment		Less than 1 person exposed					

Figure 1. Risk matrix allowing to determine the acceptability or not of an accidental scenario (Circular of May 10, 2010 and decree of September 29, 2005)

: Unacceptable risk

: Risk which can be acceptable after being reduce thanks to safety barriers

: Acceptable risk

It is possible to identify other shortcomings, beyond this lack of detailed analysis of accidental pollution phenomena:

- In the preliminary risk analysis phase itself, in the process of selecting the initiating events, there is a series of regulatory exclusions (Circular of May 10, 2010). Moreover, knowing that the role of this phase is to prepare the second one, the effort to be truly systematic and exhaustive will tend to focus on the causes that may lead to the hazardous phenomena to be analyzed in detail. This may lead to the exclusion or, let's say, the minimization of the probability of certain accidents, especially those that may have environmental consequences.
- Some hazard potentials will not even be studied if they cannot generate fire, explosion or toxicity phenomena likely to impact human beings outside the sites. However, they can be sources of accidental pollution. This is the case of fire extinguishing water. This water can be discharged into rivers for example. There are also cases not always treated thoroughly of waste that can be deposited on the ground. The transport of hazardous substances (on site and outside) can also lead to accidental discharges that are poorly analysed.
- Some natural hazards, that can aggravate certain accidental pollution, are sometimes poorly or not considered. This is typically the case of flooding. The flood will increase the extent of the pollution because the associated equipment retention facilities will not be able to function because they will be flooded. Thus, the very presence of the natural cause (of the flood) aggravates the potential consequences of a loss of containment which, without the flood, would only be local. In this type of event, the consequences can go much further. Not to mention certain hydrocarbon-type product releases with lower densities: the spread of the same slick over the water will be greater than if the product had been spread over the ground, with much larger surfaces of pollutants.
- We can mention the difficulty of considering the cumulative effects of accidental pollution on a territory. We do not do for pollution risks what we do for land use planning where there is a notion of accumulation based on the distance of effects and the associated probability levels, the level of hazard being defined in

relation to the accumulation of probabilities for the same intensity or the same danger zone, we will have a global and cumulative representation of the risks on the same territory but in relation to the same issue (which is human).

4. The aporia of a solution based on the categorization and prioritization of ecosystems

"It's kind of like saying, 'for this ecosystem okay, there's only three species so you can go, but this one's more valuable so you have to be more careful'" (Industrial operator).

Risk management is based on acceptability criteria which combines occurrence and the severity of accidental scenarios. Risks are considered acceptable when severe accident scenarios are sufficiently unlikely or when the severity of a probable accident is very low (Circular of May 10, 2010). This approach implies means of estimating the severity of damage, which is a function of the importance attached to the target. Transposing this way of thinking to ecosystems implies being able to categorize them in terms of importance in order to prioritize them: there must be the most important ones and the least important ones, those that absolutely must not be polluted and those that could be more important. The majority of the engineers (89%) think that it must be possible to find criteria to do this, that's mean to define environmental importance scores, which, combined with substance hazard scores, would make it possible to calculate severity scores for possible/probable accident scenarios, and thus to judge their acceptability. Therefore, it should be possible to answer the following questions: Is it more serious to pollute and thus destroy the fauna and flora of a wild river or of a national park? Are the blue frames more important than the green frames, or than the zones of ecological interest (ZNIEFF) of type 1 or type 2 or 3? And then, do the decrees of protection of biotope or geotope allow to circumscribe even more important spaces that they would be all the more serious to pollute? And what about wooded areas, sensitive natural areas, UNESCO world geoparks, national parks, integral reserves or adhesion zones, regional natural parks, biogenetic reserves, etc.?

For local government stakeholders, this way of thinking seems impossible to apply. They have difficulty identifying the different ecosystems in their territory. In addition, they have difficulty understanding them, delimiting them, and identifying their dynamics. Finally, and above all, they wonder what criteria should be used to rank the importance of environmental issues. *"A hedge, for example, has several functions. What is the priority? Wood energy (bioenergy valorization)? Hydraulics (mudflows - runoff management - mudflows in bays / watersheds - reduction of inputs and therefore preservation of water resources - flooding (but limited effectiveness), green and blue fabric)? Valuation of biodiversity? Carbon sequestration? … How to decide? Perhaps it is up to the communities of communes to freely (arbitrarily?) define their stakes, then their priorities."* (Territory officers).

The difficulty is to find solid criteria. Let's reflect on the concepts of species and protected areas.

- The concept of protected species. The difficulty is that there are a lot of species, like earthworms that are not protected, but that are really needed. The lists of protected species are partial. And this approach does not allow to apprehend the interdependence of ecosystems. The notion of protected species allows us to point out an existing problem, the rarefaction of a species, but it is not a tool for managing problems for the future.
- The concept of protected spaces. Let's take the classification proposed by the IUCN (International Union for Conservation of Nature). The IUCN defines a "protected area" as "a clearly defined geographical space, recognized, dedicated and managed, by any effective legal or other means, to ensure the long-term conservation of nature and its associated ecosystem services and cultural values" (IUCN, French protected areas, 2010). However, if we look at the respective definitions of each protected area, we can see that the aspects of cultural, economic or historical value totally predominate over the ecological value of these spaces (conservation of nature and ecosystem services). There is a risk that only "hand-picked" ecosystems will be considered, since they are selected for cultural and economic purposes, while other natural environments that have no such interest would be overlooked, or their importance would be diminished. Moreover, the notion of protected space or protected area suggests this problem: while there are "protected spaces," other natural spaces are not protected, which does not mean that they are not vulnerable. The notion of protected areas is meaningless if all areas are to be protected. This conflicts with the awareness of the problem of the erosion of biodiversity and global warming which are widespread. And then, what about the constant changes in ecosystems (species migration in particular), accentuated because of the climate crisis? Are these variants satisfactorily considered by the protected area categories defined in 1994? As the ecosystems are strongly affected by climate change, it is a question of protecting them, but also of anticipating their evolutions, and even using them as protection, for example against certain risks related to climate change, such as soil erosion. This is the perspective of "Climpact Data Science" members (www.criseclimatique.com/nous.html). It consists in integrates the potential impact of climate change in order to select the best strategy for nature-based solutions

implementation and management for 2050 by the use of the IPCC (Intergovernmental Panel on Climate Change) climate change scenarios and at a Very High Spatial Resolution, which can go up to 5 meters (Garbolino et al., 2021, 2019, 2016, Hinojos Mendoza and Garbolino, 2020).

5. An absorptive capacity approach

"An industrialist must not pollute in any way. He can release dangerous substances, but the doses must be assimilable by the environment. Pollution is doses that cannot be assimilated." (Industrial operator). Criticality could be related to the calculation of the "assimilation capacity" of such and such quantities of such and such foreign substances by such and such environment/ecosystem. Here, the estimation of severity would be built on the concept of ecosystem resilience. Note that this vision is not new or recent. It appears in the declaration of the United Nations Conference on the Human Environment, at Stockholm (Principle 6, 1972), which says *"The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems."*
This approach implies a monitoring of the pollution which crosses at the same time: the monitoring of the ecosystems initial states and the monitoring of the substances managed by the industrialists of the territory concerned. This starts with an inventory of the pollution already present in the ecosystems. This would be like adopting the water approach for terrestrial ecosystems. The Water Framework Directive (2000) concerns the good ecological status of water bodies, a European directive whose objective was to achieve a good ecological status of water bodies by a certain deadline. For example, the biological indicator for environmental bio-assessment gives an idea of the species present on a site and of the quality, of the good state of the site: if there are only pollutant-resistant species, the site will be classified as highly impacted, but if there is a large diversity of fish, fish of the 1st category, the site will have a good score. There is a scientific follow-up of the species in the environment. With the Law on Water and Aquatic Environments, the latest regulatory evolution, there are even more interpretation keys on the biological monitoring of water bodies.
And the analysis of correlations with industrial activity and hazardous substances is important. For example, it is possible to trace the observed effect on the environment back to the substance or family of substances involved. It is very complicated, the quantity of substances that can be emitted into the environment and the nature of human activities are so large! But there is still a possibility, and important margins of progress. Integrating biological tools into the monitoring of water bodies seems unavoidable in the years to come in order to be able to detect new substances arriving in the environment at a sufficiently early stage and for which the regulations are not yet ready.

6. Major difficulties and proposals

This approach seems the most pragmatic and efficient. But its implementation would pose many difficulties.

- This approach implies first of all improving the knowledge of ecosystems. There is a tremendous work to do, as the environmental knowledge are very low, according to 86% of the interviewed (the insurer did not respond, the industrialists and the members of the risk institute were mitigated 50/50). There is also a lack on research and studies on the characterization of the state and functioning of socio-ecosystems, allowing us to characterize an exceptional event, pollution or industrial accident. There is a particular lack of knowledge about aerial ecosystems.
- There are gaps in knowledge about the substances, according to all the interviewed (except from the insurers who do not adjudicate).
    - When you replace one substance, such as bisphenol A, with two other types of substances, bisphenol, which are just less known. What are the effects? Are they worse or better? The fact of banning a substance generates changes in production or new habits that will make new substances emerge that are not known. These new uses deserve to be looked at from an environmental point of view, and sometimes we do not have the necessary hindsight to say whether the substance is or is not dangerous for the environment. And there are so many substances! And there are no regulatory requirements on certain substances, such as emerging substances, or endocrine disruptors, etc.
    - There are also issues that are not understood, such as the effect of mixtures, the effect of new dangerous substances (micro plastics, etc.).
    - The problem of molecules vs substances. In France and in Europe, we have a marketing authorization system for products, not for molecules. This means that you can have molecules that are prohibited in some products but authorized in others. You may find yourself with certain products that are banned in conventional agriculture but that you find in products that you use at home, such as insecticides, lindanes.
- There are organizational obstacles.

- The compartmentalization of expertise and institutions is an acute problem for the absorptive capacity approach, insofar as it deals with systems whose analysis implies bringing together several disciplines. *"It is one of the major problems that makes that it is not sufficiently treated in France. There are ecologists who deal with the life of batrachians, acologists who deal with the health of domestic plants, wheat and the risk of the nielle on wheat, veterinarians who deal with the health of cattle and pigs in farms and doctors who deal with human health and only that. On the other side, you have Eco toxicologists, and then on the other side, the world of industry, the inspectors of classified installations, etc. There is a compartmentalization of public establishments in France too. It often seems difficult to set up interministerial, interdisciplinary and intersectoral approaches, but this is what is at stake if we rely on the criterion of the capacity of ecosystems to absorb pollution"* (Actor of an association).

Regarding these difficulties, actors with a view on the subject (actors of association and officers of the French administration), strongly suggest to adopt a territorialized approach: "This brings me to the importance of a territorial approach." (Actor of an association).

- According to some experts, it would be at the level of the EPCI (Public Establishment of Intermunicipal Cooperation) that the competence of monitoring pollution of ecosystems should be entrusted. Because the EPCIs have the management of aquatic environments and flood prevention competence (MTES, 2019). It reveals that the integration of a "geo" dimension complicates things considerably (Latour, 2021).

7. Conclusion

The questions we sought to answer through our survey were the following: Are the accidental pollution scenarios well studied? Are the ecosystems (environmental issues) well considered in these studies? And are the management practices for these ecosystems satisfactory with regard to the risks of accidental pollution?
The answer to the first question is negative: in reality, the pollution scenarios are not studied to the end when they do not affect human issues. This first result has modified the rest of our research. Ecosystems are therefore not taken into account in hazard studies. But there are engineering methods that try to compensate for this lack. It is the internal logic of these methods that we focused on. These methods follow a common logic: the approach of categorizing environmental issues, based on the concepts of protected areas and their prioritization by IUCN. We have argued that this approach is an aporia because, in the context of the current global environmental crisis, the notion of protected areas appears meaningless, even counterproductive, for calculating the severity of a potential industrial accident. Moreover, this approach seems difficult to implement in practice and therefore ineffective. On the other hand, some actors have underlined the relevance of an approach based on absorption capacity, which already exists for the management of aquatic ecosystems only (for which the Water Framework Directive is the regulatory framework). It consists in basing itself on the notion of ecosystem resilience to calculate the severity of an industrial accident, and therefore it does not fall into the same dead ends as the first approach. We have identified major obstacles to its implementation for all ecosystems: the lack of knowledge of ecosystems and substances, and the compartmentalization of fields of expertise and institutions. The actors who have an opinion on the subject put forward the importance and the necessity of adopting a territorialized approach.

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