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# From Mining to Phytomining: Bioinspired Practices and Hopeful Forms of Life in a Contaminated World

**Working paper**

Lauren Kamili
School for Advanced Studies in Social Sciences
(EHESS)
Paris

Saint-Laurent-Le-Minier is a village of about 350 inhabitants, located 50 km north of Montpellier, in the south of France. It prospered thanks to the exploitation of two zinc and lead mines. Les Malines, exploited from 1875 to 1991, used to be the most important lead and zinc mine in France, and one of the largest mining sites in the world in the 1950s-1960s. Les Avinières was a mine exploited between 1870 and 1914 and a metal processing plant until 1961. A jewel of French industry for a time, the mines and their closure have left neither the environment, whose waters and soils are now heavily polluted with zinc, lead and cadmium, nor the village, impoverished and exposed to these contaminations, unscathed. In 2004, a study commissioned by a particular revealed significant arsenic and lead pollution in the soil. The next year, a health survey showed significant lead exposure among children in the village; at least two of them have lead poisoning (Cicchelero 2006). In March 2005, a municipal ordinance prohibits the consumption of water from private works and garden vegetables for food. Poverty, pollution, and bad reputation left a village divided between "pro-mine" and "anti-mine".

On February 1st, 2012, the local daily "Midi Libre" published an article on the work of the Laboratory for bio-inspired chemistry and ecological innovations directed by Claude Grison. In 2008, following a question from four biology students, she became interested in plants that accumulate heavy metals and discovered that two of them, Noccaea Caerulescens (from the brassicaceae family) and Anthyllis vulneraria (fabaceae family), grow in the former mining sites of Saint-Laurent-Le-Minier, where zinc concentrations in the soil are 500 to 800 times higher than European standards. The article is entitled "A plant to heal the earth" and refers to the experiments in decontamination and waste recovery carried out by her team since this discovery. Using hyper-accumulative plants that can accumulate and store heavy metals in the soil, they are trying to recreate a vegetation cover and harvest the metal-laden leaves to make ecological catalysts or ecocatalysis. By doing so, the scientists hope to develop a new green

chemistry, while the inhabitants expect to see their living environment decontaminated and an economic revival stemming from these practices. The local article indeed speaks hopefully of "a real environmental, ecological and economic opportunity for the village".

These practices are rooted in bio-inspiration and biomimicry, an approach that consists of drawing inspiration from the forms and functions of living beings to innovate and create new technologies. Bio-inspiration as a technoscientific approach promises a "reconnection" with living beings and their environment (Benyus 1997). Increasingly presented as *the* solution to reconciling economy and ecology, bio-inspiration and biomimicry need to be questioned epistemologically and socially (Kamili, Pitrou & Provost 2020). Bio-inspiration often evokes the idea of being inspired by nature, based on an understanding of living things that would stem from a detached and distant observation, almost deferential to "Life". But in the Avinières project, understanding plants means intervening directly in their living cycle and capturing a vital process, to the point of completely domesticating them.

In the general context of an ongoing discussion on the relationship between life and technique conducted by the anthropology of life since 2016 (Coupaye, Pitrou & Provost 2016 ; Pitrou & Meyer 2019), it is crucial to ask what exactly is bio-inspiration, concretely and materially? To what extent is domestication part of bio-inspiration? What kind of life forms and forms of life do these scientific bio-inspired practices produce? And ultimately, how do they build hope for a less toxic world?

Drawing from long-term ethnographic fieldwork (mostly participant observation, interviews and analysis of local press articles) both in the laboratory and in the village, this paper examines a particular project of bio-inspiration, aiming at recreating a self-sustaining ecosystem in a contaminated environment. Engaging anthropology of nature (Descola 2013), anthropology of techniques (Coupaye 2013) and the STS (Helmreich 2009 ; Kirksey 2015), this proposal questions the interweaving of technical processes, life processes and forms of life in Les Avinières.

## I. Making plants live in a toxic environment

June 2018. At the end of the road leading to the restoration site "Les Avinières" is a large expanse of completely bare, red sandy soil. This is the old settling pond of the zinc mine: clumps of vegetation here and there, plant beds surrounded by wire mesh, row and square plantings. Further on, red metal arbours cover two sections of green squares, two cinder blocks lie next to a strip of geotextile, a rusty metal chair sits in the middle of the field, and the green nets of the shade structures hang sadly from the uprights, when they have not been torn off. The place looks abandoned. However, this was not always the case. Between the period of industrial wasteland and the current vacancy, the Avinières was the site of numerous experiments conducted by Claude Grison's team with the aim of restoring sufficient living conditions for a new autonomous ecosystem to be established.

Bioaccumulation refers to the process by which an organism can accumulate, i.e. absorb and store contaminants such as heavy metals, persistent organic pollutants (POPs) or radioelements, regardless of how they are incorporated. If the plant is aquatic, it is called rhizofiltration; if it is terrestrial, it is called phytoextraction or phytomining. In order to conduct the ecological restoration project, this life process must be captured and mastered. Wild plants grow wherever they want, and their growth and development must be channelled to meet human needs. Described as "modest" and "fragile" by Claude, and subject to extreme stress, Noccaea and Anthyllis[1] required constant care and "help". The slightest mistake, whether it be in watering or in amendment, would result in the loss of the entire patch. Human intervention on the Avinières site became permanent and sought to control the entire reproduction cycle of the hypperaccumulating plants.

Claude insists on the techniques used to "help the plant grow", the end result being a complete domestication of these two wild plants. In order to understand in context how the bioaccumulation process works and to be able to draw inspiration from it, it was necessary to intervene in the local ecosystems. Although they appeared spontaneously near the polluted mine sites, they were not naturally present on the most toxic sites where Claude Grison's team forced them to develop. These plants, which appear very resistant and are truly admired by many of the ChimEco scientists for their ability to live in poisoned environments, become particularly fragile when placed in the most extreme environments. By forcing them to live in toxic soil, chemists caused the plants to demand more care, so they had to work harder to support their development and ended up domesticating them completely.

Although Noccaea had been described as a hyperaccumulator, there was nothing about its behaviour or germination: nobody knew anything about this plant, except that it accumulates zinc. The plants were first grown in the laboratory, then in pots with increasingly high concentrations of zinc to "get them used" to dealing with highly polluted soil. Soon, experiments began on site, on land with "average" contamination. The first crops were a success. Despite the summer drought, which made them suffer, the plants survived, in particular thanks to the installation of a drip irrigation system that provided them with the missing water. They made it to the flowering period, which Claude, showing me photos, describes as "a magnificent field of flowers". The crops were then moved to the settling pond itself. This was more difficult as the soil is highly contaminated. Irrigation, amendment and plant association tests were carried out. One person was assigned daily to monitor and maintain the plants which would not otherwise be able to survive alone in this toxic milieu.

In order to gain a more detailed understanding of the asymmetrical control-dependence relationship that prevails in this domestication process, it is relevant to call upon what Philippe Descola (2013 [2005]) has called the "protection schema". Understanding inspiration requires us to think about intervention, attachment and protection, which are all modes of action that reveal the functioning of living beings. In his chapter on "the forms of attachment", Descola

[1] I use their genus names as proper nouns, because that is how Claude Grison uses them when she talks about plants as people.

explains that there is a protective relationship when “a group of plants and animals is perceived both as dependent on the humans for its reproduction, nurturing, and survival and also as being so closely linked to them that it becomes an accepted and authentic component of the collective” (*Ibid*.: 326). The more plants are implanted in difficult conditions, the more they require human intervention for their survival, and the more the relationship of protection is established, in which plants are not only passive. Although unequal, this relationship is not without mutual benefit (*Id*.). The plants of the Avinières cannot survive without the good care of humans, and the latter ensure that they survive, if only to formulate the hope of being able to restore this damaged environment. The process of soil remediation appears not as a collaboration because the plants are forced to live in extreme conditions where they would not have gone spontaneously, but as the result of a co-activity between plants and humans. Inspiration consists of intervening in the cycles of hyperaccumulative plants to understand them but also to direct their capacities towards the decontamination of a specific site, in a truly domesticatory enterprise. A third hyperaccumulative plant was identified in the Saint-Laurent-Le-Minier sector. This is Iberis intermedia, a hyperaccumulator of thallium, a metal very close to lead and also very toxic, but it is no longer being studied by ChimEco. Its germination proved too difficult to control, "it did not allow itself to be domesticated".

Bio-inspiration appears as a process mediated through several technical actions, that imply intervening directly on the ecosystems, the result being the domestication of two wild plants. But the paradoxical consequence of this domestication process is also the emergence of a self-sustaining ecosystem.

## II. Emerging ecologies

Living beings, including plants, exist in their milieu. The organism constantly modifies its environment to make it liveable, as much as it is modified by the conditions of its environment (Canguilhem 2006 [1965]). Anna Tsing describes fungi as “world builders” that not only adapt to a devastated environment but also make this ecological ruin a place fit for certain life forms (2015 : 138). This world-building activity is one of the hallmarks of what Eben Kirksey calls "emergent ecologies" (2015). Emergent ecologies thrive in unexpected places, such as gaps in ecological ruins, and are shaped by a multitude of agents and forces: machines, industrial supply chains, biological elements, animals, plants, fungi, bacteria, humans, and as in the case of Saint-Laurent-Le-Minier, chemical elements. The living beings in these communities not only build ecological niches for themselves by transforming their environment to their sole advantage, but also integrate the interests of other beings into their ecosystem creation. In doing so, they create the possibilities for future life.

The project came to an end in 2015. Claude and two of her younger colleagues would then come regularly to check on the plants but even these visits eventually stopped. In 2019, the project was officially abandoned by the laboratory – reasons why and how it stopped are described in the next section –, which means no one would come anymore to take care of the plants. However, despite the withdrawal of humans from the Avinières site in 2015, the plants

continued to develop. Two species of tolerant plants have taken over the space, overtaking the hyper-accumulators: the latter, by acting on the shared environment, have “restarted” the plants’ ability to develop by themselves. Claude is convinced that Anthyllis, the legume, has reintroduced nitrogen into the soil and that the tolerant plants have “benefited” from this.

Today, the site remains contaminated, although the level of toxicity has undoubtedly decreased, and apart from the tolerant plants, it is difficult to imagine that other species can really take over. Claude is now fighting to obtain a delay in the containment work planned by the environment state agency that manages the site, and to carry out genetic analyses on the plants, because “we are seeing an interesting response from nature”. What Claude calls “response from nature” is in fact the result of joint action between humans and plants, truly a “co-activity” (Pitrou 2017), which modifies the toxic conditions of a shared living environment: a self-sustaining ecosystem in a highly polluted place. Finally, the ecosystem that develops in Les Avinières is the result of attempts at ecological repair by humans and the action of plants, i.e. ecological relationships resulting from contamination, where the precariousness of the plants echoes that of the village inhabitants.

## III. Hopes and deceits of life decontaminated

For Claude, the plants identified at the Avinières site are “exceptional”. Worldwide, about 450 species of metal hyperaccumulating plants have been identified, a very large number of which are located in New Caledonia (Grison 2015), considered to be one of the most important biodiversity "hotspots" on the planet (Myers *et al*. 2000). It is therefore very rare to observe two hyperaccumulators on the same European site, where biological diversity is much lower. In Claude's view, this remarkable presence should open up the possibility of enhancing the value of the territories beyond rehabilitation projects alone and invites us to rethink the relationship that the inhabitants have with their milieu. The information and outreach missions carried out in Saint-Laurent-Le-Minier between 2008 and 2015 aimed to encourage local residents to see their village as something other than mines, pollution and poverty.

During the meetings and public events organised in the village, the emphasis was placed on the unique character of the endemic plants, which have come to be considered as an exceptional heritage to be preserved. Around Noccaea and Anthyllis, agents who usually do not speak to each other, do not get along or even ignore each other, came together and worked together to carry out the Avinières project. Chemists, ecologists, biologists, local representatives and local residents came to share a common world with the plants, driven by admiration and, above all, the hope of seeing their material living conditions improve.

Stef Jansen (2021) reminds us that there are different types of hope depending on who hopes, and on the particular way in which hope is constituted in a given social configuration. The scientists' hope was to invent new efficient processes for depollution, and a basis for a green chemistry that would renew industrial chemistry beyond this single project through

ecocatalysis. The arrival of a private investor to launch a start-up and the search for clients such as L'Oréal or chemical companies, invites us to replace this desire to contribute to a greener world in a context of capitalist value production. The bio-inspiration here is part of a "political economy of hope" (Novas 2006) in which the promotion of innovative and ecological technologies raises expectations of a better life among the inhabitants. These practices are therefore embedded in a regime of technoscientific promises (Joly 2010) that gives rise to these singular forms of hope: breakthrough discoveries in science, a greener industrial world, an economic revival for the village, and a decontaminated life for the people living there. Annie, a resident of the village and former deputy mayor at the time of the project, recalls with nostalgia "the time of the metalliferous plants": there was hope in the village, someone was "doing something for the village". Over the course of meetings and years, press articles praising the "miraculous plants" and visits on the site, hope did build up. And hope was dashed with what Claude calls "la Bérézina"[2].

A series of events put an end to the project: massive floods in 2014 which destroyed some of the equipment, then thefts of equipment from the plantations, and the fire in a house used by the team to store things. The project fell apart, the state agency for environment that was supposed to carry out safety work dragged on, and the investor who had launched a start-up with the lab ended up withdrawing. In 2015, the funding stopped and so did the project. In the village, many people say they are "disappointed" that the project was stopped. Some mention an "unclear business", and few of them know the actual scientific and economic reasons for the abandonment of the project (notably the lack of money for research in France).

This brings to the fore the dimension of cultural domination and the social hierarchy inherent in the project, despite the scientists' investment in communicating with the inhabitants, and the sometimes personal links forged with them. Many of them are left in a state of misunderstanding, with the impression that they have been promised great things before disappearing. The deception is not the same for the scientists, who have invested 7 years in this project, but have other projects, and for the inhabitants who will keep living in this impoverished and contaminated place.

## Conclusion

Bio-inspiration requires an understanding of life. And the understanding of life here involves domestication, which has been partly shaped in a relationship of "protection" in which the care of plants and the exploitation of their vital capacities are intrinsically entangled. Plants are seen as beings to be cared for, but also as economic resources to be maximised. By partnering with plants to decontaminate this site and « grow livable worlds » (Myers 2018), chemists actually make them live in a toxic environment. In doing so, scientists have contributed to the development of "emerging ecologies" whose functioning is originally based on a regime of co-activity, which is also a regime of co-dependency between plants and humans.

[2] « C'est la Bérézina » refers to a major defeat of Napoleonic troops in 1812 on the Russian river Berezina. A possible translation could be « all hell breaking loose ».

These life forms, the plants that are imputed with the capacity to extract useful though toxic elements, eventually forming a coherent and autonomous ecosystem, are technically constituted in a very specific form of life (Helmreich 2009 ; Pitrou 2017): an attempt to repair the world, ambivalent relationships of domestication, care and control, bio-inspired practices and the hope that stems from them. Hopeful forms of life in Saint-Laurent-Le-Minier actually go hand in hand, can only exist with the exploitation of "the miraculous plants". Ultimately, the toxic worlds inherited from mining extractivism and environmental exploitation are the very condition of possibility for these new bio-inspired practices to be invented, which generate hope for a less toxic future in the village, the lab and beyond.

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