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Multispecies Design and Ethnographic Practice: Following Other-Than-Humans as a Mode of Exploring Environmental Issues

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Abstract: Since the early 1980s, the concept of sustainability has been employed by designers to confront the problems deriving from the emergence of the environmental crisis. On the one hand, if this contributed to generating systemic design approaches and methods to mitigate the human impact on the planet, little has been done to explore sustainability as a concept that extends beyond anthropocentrism. Examining environmental issues by considering other-than-human viewpoints could introduce alternative scenarios compared to those envisioned through technocentric means. This work considers a speculative design project that provides a multispecies reading of the notion of environmental contamination through the engagement of human and vegetal perspectives. The considered methodology focusses on the transdisciplinary tactic of “following” plant collectives across the multiple sites and actors that populate their life. Building on post-humanism theories and Guattari’s concept of “ecosophy”, this paper entails that sustainability should be seen not just as the outcome of a design process, but also as a behavioural attitude, and design as an implementation of that attitude. It is argued that following other-than-humans can teach designers to think sustainably by cultivating relations of reciprocity that help to shed light on the multispecies landscapes of the Anthropocene.

Keywords: sustainability; multispecies theory; multispecies design; constructive design research; speculative design; transdisciplinary; ecosophy; Anthropocene

1. Introduction

1.1. A post-Humanist View of the Environment in the Anthropocene

In 2000, atmospheric chemist Paul Crutzen and biologist Eugene Stoermer coined the term “Anthropocene” [1,2] to indicate the raise of a new geological epoch, dominated by humans and their irreversible actions on the biosphere. This new era, according to scientists, began in the late 18th century, when analyses of air trapped in polar ice revealed growing global concentrations of carbon dioxide and methane. In emphasising what humans have done and could irreversibly do in the future, the concept of Anthropocene has been claimed to serve as a call to action for environmental sustainability, proposing that humans should ultimately “take ownership of a biosphere that has been already altered irreversibly” [3] (p. 446). Advocates of the Anthropocene claim that, as the planet’s anthropogenic transformation is permanent and almost complete, a new model of ecology science should be set: one that supersedes the study of nature as based of natural biomes with humans disturbing them, in favour of anthropogenic biomes, consisting of human systems that embody themselves within natural ecosystems [3] (p. 445).

Although driven by narratives that often proclaim humankind as an exceptional global force, the Anthropocene is still far from a settled idea [4,5]. The concept originated in geology, but rapidly expanded across a diverse range of academic fields, each bringing in different sets of assumptions, especially concerning what humans should do to achieve sustainable modes of interaction with nature. Preiser et al. portrayed the Anthropocene as a polyvocal, interdisciplinary discourse, and suggested a categorisation based upon four ontological framings. If the “Eco-Modernist” and “Planetary Stewardship” positions [5] still entail that sustainability is only possible by embracing human development and technological modernisation, the other two outline a clear point of departure from human-exceptionalist modes of reading this era. The “Pathways to Sustainability” [5] focusses on issues of power relations and how these become formed within actual social–economic–cultural systems. It is concerned with problems of social inequality and acknowledges that sustainability can only be achieved by empowering participation, activism, and practices of contestation, which should ultimately lead to a more equal redistribution of resources. The “Critical Post-Humanism” [5] position builds instead on the post-human aphorism that sees life as emergent from the interaction of multiple natural forces (of both attraction and repulsion) that cause continuous aggregations and reconfigurations of human and nonhuman collectives [6]. Here, humankind represents just one of the many factors that shape our environments, and its agency is seen as constituted by relational processes rather than being determined a priori. The work being done in post-humanist and post-anthropocentric disciplines suggests that, to better understand our planet’s transformations, we should start looking at manmade systems as networks that include a multiplicity of living beings and the agency formations that operate in and around them. What if, asked Dürbeck et al. (2015), we approached this era “not from the normative viewpoint of exclusive human agency, but rather from the perspective that we live in conjunction with our co-species and can interact with the weather, the water flows, the landscapes?” [7]. Preiser’s Critical Post-Humanism framing entails that sustainable transformations can only happen if we learn about ways of interacting differently with the environment—that is, to empower webs of relations that acknowledge agency on multiple levels of existence [6,7].

1.2. Ecosophical Theory and Design

Post-humanism provides a meaningful contribution to both design and ecological thinking, particularly in response to the issues posed by the Anthropocene. When facing the complexities at stake behind the environmental crisis, designers mostly build upon specific research traditions, which suggest pre-determined theoretical models that are mostly based on problem-solving approaches through design. The field of Design for Sustainability [8] has been for years a main reference in the field; however, it was only in more recent times that it shifted the focus from the level of the product towards large-scale systems, where sustainability is understood more as a socio-technical challenge [9]. Many instances of sustainable design still tend to simplify the nature of environmental problems, suggesting a clear immediacy between a problem and its solution, through narratives that sometimes have no impact other than re-asserting human heroism and dominance over the planet. Therefore, it is important to find ways for transiting human societies towards a transformational change in how they think and operate, and this change does not just require technological interventions, but also cultural and behavioural disruptions. As actual environmental issues are in fact profoundly tied to the effects of capitalism and colonialism [10], the Anthropocene calls for design engagements that can question the social, economic, and political implications of human dominancy. In other words, rather than being interpreted as an affirmative discipline, design can function as a process-oriented critical instrument.

One of the areas open to explorations concerns the opportunity of deploying design communicatively, as a way of re-interpreting the relationships that man holds with other species and the environment, and discussing future scenarios of multispecies co-habitation. The recent book of Joanna Boehnert gestures towards this direction, with a focus on ways for practicing communication design to “nurture new perceptive and cognitive abilities in support of relational or ecological perception” [11], and thus re-orient unsustainable ways of living. A shift in mindset towards the environment is

described as the actual fundamental step that should be made to achieve a collective prosperity and move towards sustainable models of societies that do not impoverish the resources on which they depend. In this project, Boehnert's main reference is the work of French philosopher Felix Guattari, which articulates ecological thinking as the intersection of three interconnected ecological spheres: mental ecology, social ecology, and environmental ecology [12]. What is commonly referred to as an 'environmental issue' would derive from a misregulation, if not a complete denial, of these three domains, privileging instead technocratic readings of the environment that respond to the needs of capitalism. Guattari argued instead that only an ethico-political articulation—which he called "ecosophy" [12] (p. 28)—between the environment, social relations, and human subjectivity, can clarify questions concerning the environmental crisis and ultimately transform our ways of thinking and being together. He invokes an ecosophical kind of revolution that rejects traditional concepts of ecology as a discipline for experts or a nature-loving minority, to empower instead the register of subjectivity.

Boehnert suggested communication design as a discipline that responds well to this call, due to its proficiency in "negotiating the intimately intertwined space between self, society and the environment" [12] (p. 2). Hence, Guattari's theory is re-addressed by Boehnert through theoretical as well as practical lenses, with the three ecologies being reframed respectively as registers of design, ecology, and politics: "Design [. . .] mediates the subjective realm (the mental ecology). Politics describes [. . .] the social realm (the social ecology). Ecological theory considers human relations to the environment (the environmental ecology). [. . .] This assembly of ecologies is both a meeting of three domains (the environmental, the social, and the mental) and a recognition that these are orders embedded in each other [that] need to be theorized simultaneously" [11]. The socially responsive design that Boehnert advocated entails principles of design for service, design for social innovation, speculative and critical design, transition design, and design activism. Those approaches not only have the strength of influencing ideas, behaviours, and sensibilities, but they also have a political impact, as they aim at challenging and finally de-prioritising unsustainable practices [12] (p. 182).

1.3. Multispecies Theory and Speculative Participatory Design

Venturing beyond the human and engaging with multispecies worlds as a way of learning about environmental issues implies that researchers become familiar with alternative methodologies, intended not just as ensembles of methods, but also as different ways of acting, thinking, and perceiving.

The term *multispecies* started to emerge more than a decade ago in the biological and ecological sciences, to refer to patterns of co-construction of environmental niches and wildlife management [13]. Its recent entry in the field of Anthropology contributed to providing further readings of the concept, particularly in relation to how more-than-human ecologies around the globe affect (and are affected by) human capitalism. Bringing together approaches from Science and Technology Studies, Animal Studies, and Environmental Studies, the field of "Multispecies Ethnography" (ME) [14,15] recently emerged to investigate "how the human has been formed and transformed amid encounters with multiple species of plants, animals, fungi, and microbes". The discipline points at recent ethnographic studies in which species previously considered as passive matter at the boundaries of anthropology became explored as active cultural agents. Inspired from the sociality of mushrooms [16], the ethnographic work of anthropologist Anna Tsing is an illuminating example of possible tactics of enquiry into more-than-human worlds. Tsing's practice explores how disturbance histories in Japan's Satoyama forest provided different constraints on and life opportunities for the Matsutake, a gourmet species of mycorrhizal fungus; particularly, she investigates how anthropogenic processes of deforestation affected the livelihood of the fungus and, in turn, how a risk of species extinction propped a new reforestation praxis that facilitated a return of the mushroom in the ecosystem [17–19]. Tsing performed her research using a range of empirical strategies, such as that of following "assemblages" and "bodily forms" [18] (p. 32). A multispecies *assemblage* is a dynamic interaction network, which considers all the different entities and processes involved on the landscape and their impact on its configuration [17]. It comes about through what Tsing defined as the "landscape's polyrhythms", i.e., a symbiotic interplay

of multiple interconnected elements. *Bodily forms*, instead, are biographical statements. Just as humans explore the environment through their bodies, the same applies to fungus, plants, bacteria, and any organic being that populates the planet. While exploring the environment, fungi show traces of their paths on their bodies: in this sense, a bodily form is a biography and materialisation of social relations, which often includes humans, with or without their consent or intentions. These research tactics, based on the idea of “following”, allow the multispecies ethnographer to learn about the nature of our relationships with other species in ways that should “make us think, feel, hesitate and wonder” [20].

The notion of multispecies provides inputs for re-thinking the position of other-than-human participants in design and its associated practices. Participation in design can be read as a conversation between different users [21]; however, when participants are different from humans, things can get intricate. Laura Forlano argued that “since at least the mid-1980s, design has been dominated by a human-centered and user-centered paradigm” [22]. Therefore, she wonders, what can actually come after human-centred design? Can we think of alternative, post-human approaches that, instead of acknowledging humans alone, consider also the perspectives of different others and use them to re-imagine our future on Earth? Finally, “who benefits, *qui bono*, when species meet?” [16] (p. 2). Acknowledging agency to other-than-humans requires us first to experiment with design approaches that can help hearing their ‘voices’ and, through these, imagining alternatives to our social, cultural, and economic models. This paper builds on one of such possible approaches, that is, Speculative Design (SD). In recent years, designers have begun to employ speculation as a mode of critique for our societal frames. In maintaining a critical stance towards design as a form of capitalism, SD reinforces the role of design to inform, mobilise, and engage society on and around political issues [23]. As a practice, SD domesticates upcoming ideas in science and technology to discuss their possible implications in future scenarios or alternative contexts of use. Speculative designers often collaborate with scientists and research labs to build prototypes that stem from scientific notions and embed sensors and lab materials (e.g., petri dishes, microscopy, thermal imaging, etc.) [24] (p. 185). Through representations of prescriptive or predictive scenarios [25], SD enters into the world with the scope of moving scientific research out of its comfort zone and into the polyvocal settings of public arenas, making things public and problematising issues. This usually occurs through events and exhibitions, where such works are discussed by means of public presentations, workshops, and debates [26].

2. Materials and Methods

2.1. *Geomerge: Re-Thinking Plants, Soil Contamination, and Metal Commodities*

This paper considers the speculative design installation *Geomerge* (Figure 1), from designer and researcher (author 1) perspectives. The project is used as a method to extend the discourse of nonhuman agency in the era of the Anthropocene and explore the notion of soil contamination through post-human lenses. Therefore, the considered research is seen as a process-oriented practice, where the installation itself is used as a way of inquiring into the participatory activities associated with the circulation of the project.

Conceived as an itinerant installation, the project investigates how the physiological behaviours of endemic flora can provide means to geographically situate issues of soil pollution and imagine alternative agricultural practices to be developed on existing geographical areas. From a socio-cultural perspective, a contaminated site can be seen as a socially constructed milieu, meaning that its forms, processes, and materialities are strictly interwoven with the public perception of risk. Soil pollution produces in fact neglected sites, whose hazardousness suggested to originate biases and emotional concerns, which are themselves related to the issue of contamination [27].

The installation considers a particular kind of plants that are known within the natural sciences for their efficiency at absorbing heavy metals from polluted soil and accumulating them within their tissues and leaves: those species are called hyperaccumulators [28–30]. The metal absorbed by such flora can then be extracted by harvesting the leaves and burning the biomass, which is a process known

as phytomining [31]. As these species' ability to colonise contaminated sites depends on their capacity to evolve metal-tolerant ecotypes [32] as a form of self-defence from external agents, the process of metal uptake can be seen as a mode of vegetal agency. This includes aspects such as those plants' ability to 'witness' histories of human transitions on their territory and facilitate cross-species evolution in multispecies environments [33]. As many of the metals absorbed from those plants are also listed on international financial markets, *Geomerce* re-interprets the contaminated site as a living financial asset. With the support of hyperaccumulating flora, the installation draws a speculative future scenario where agriculture blurs with economy, and farming decisions are the result of the collaborative entanglement of people and plants. While crossing biological and financial data, the purpose of *Geomerce* is to suggest sustainable, more-than-human readings of metal contamination, which is a feature that aligns with Preiser's discourse about post-humanism as a critical stance towards the Anthropocene [5].



Figure 1. The design installation *Geomerce*, which was used as part of the methodological construct.

The installation's main element is a series of three extraction units that accommodate different species of hyperaccumulators, whose roots are immersed in a hydroponic solution consisting of water and pre-determined concentrations of heavy metals. Each unit also embeds a sensor-based technology that monitors in real time the quantity of metal absorbed by each group of plants. The data are subsequently crossed with the real-time value of the extracted metal in the financial market, using information provided from the London Metal Exchange (LME). Then, the resulting data is transmitted to a series of plotting units, which draws infographics that display three interrelated figures: the amount of metal absorbed from the plants, the real-time value of the specific metal in the market, and a digit that assembles the two figures (Figure 2). The latter, drawn hourly, portrays the value-per-year of a hectare of contaminated soil, assuming it was cultivated with hyperaccumulating flora and according to the real-time extraction activity monitored during the performance.

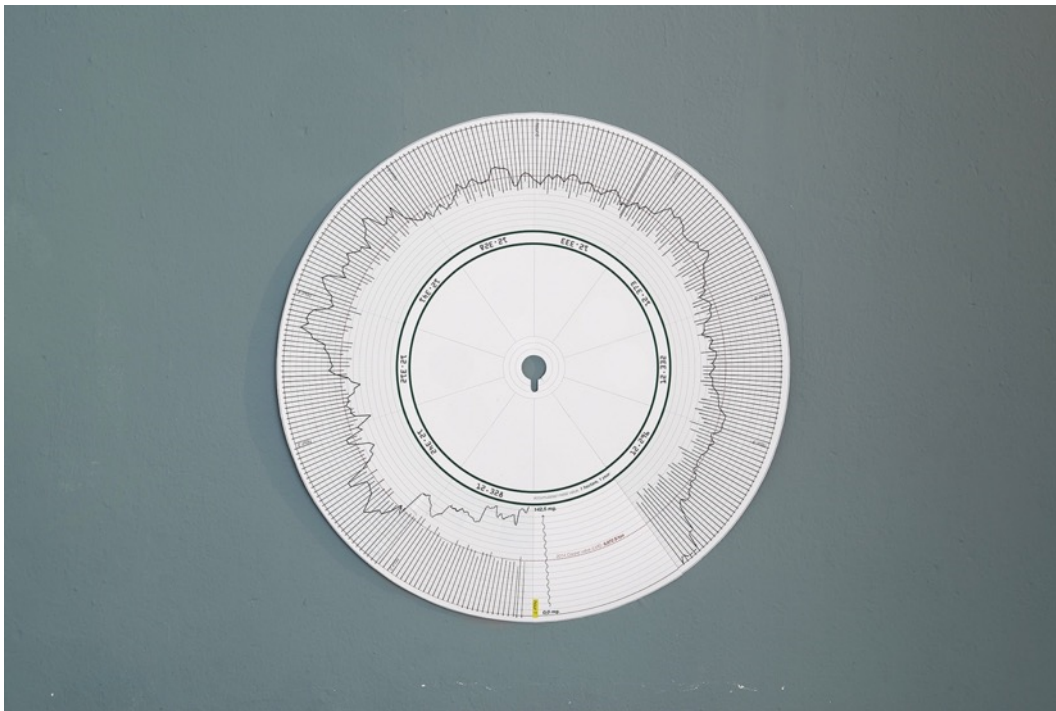


Figure 2. Example of one print, produced from one of the three plotting units, in one day (9 h of operation). The polar, vertical lines visualise the amount of heavy metals absorbed by the plants from the hydroponic medium, at time intervals of two minutes; the segmented line visualises the real-time trend of the absorbed metal in the London Metal Exchange, at time intervals of two minutes; the numerical figures describe the hourly, speculative value-per-year of a hectare of contaminated soil, assuming it was cultivated with hyperaccumulators and according to the monitored plant activity.

2.2. 'Following the Plant' across the Lab, Field, and Showroom

The installation of *Geomerce* during a public event serves here as input to identify a methodology to support a multispecies research in a specific geographical area. Specifically, the presented study reflects on how the direct participation of endemic flora affects the ways in which the problem of soil contamination is re-configured through *Geomerce* and its different publics (intended as both the designer and the visiting audience) into contingent stories and narratives. During this research, the project is used to enter the specificities of different sites, which are chosen from this paper's (first) author on the basis of their proximity to the exhibition venue and become physically inhabited from him for a period of time. This embodied approach entails that when experiences are directly inhabited, they produce different meanings and "situated knowledges" [34], [35], which vary from context to context. Situated knowledges can be complex and contradictory; however, they have the advantage of offering an in-depth analysis of specific experiences in ways that make us think, feel, and behave differently.

The considered methodology starts from a straightforward idea—that is, *following the plant*. This approach was first introduced by philosophers Deleuze and Guattari [36] (p. 11), and recently revitalised by Marder [37], Stark [38], and Bakke [39], who referred to it as an attempt to reinvent human–plant relations, looking into the life of flora as a source of inspiration for learning with and from plants. Following the plant is an approach that invokes an ethnographic reading of design research. During the study, accounts of botanical practices—such as vegetal sampling and transplanting, descriptions of design outcomes where plants co-determined the identity, excerpts of interviews with biologist and visitors, and historical accounts of contaminated environments—are used between the other data as evidence to explain how plants became part of the research process. Hence, "following" involves here the study of phenomena as they appear within a given experience, according to the observer involved in the research.

The approach used to follow the plants recovers the idea of the three programs proposed by Koskinen [40]: the field, the lab, and the showroom. However, these are here interpreted as physical research sites, permeated of developing relationships between people and plants (Figure 3).

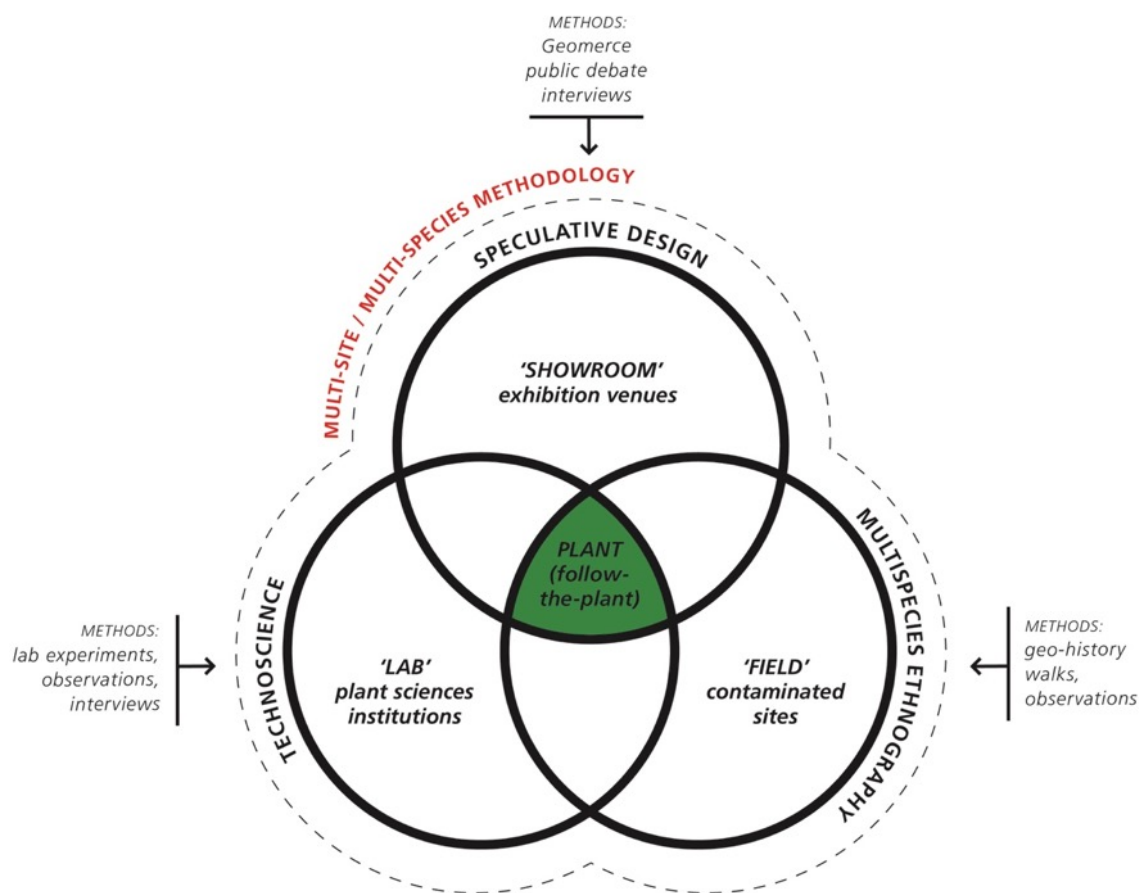


Figure 3. Methodological configuration, based on the ethnographic concept of “following the plant”. The scheme illustrates the intersections of research actors, domains, and methods, involving a scientific lab and scientists; a contaminated site and its ecology; a showroom venue and its multiple publics.

The field is a territory saturated with heavy metals, where hyperaccumulators live and engage in alliances with others. The lab is the locus of scientific research on metallophytes and site-specific botanical knowledge. The showroom is where *Geomerce* provides occasions to explore the agency of plants and discuss its implications within the considered geographical context.

The very beginning of the study presented in this paper starts from an external call from an art and design gallery, which requested to display *Geomerce* on the occasion of a public event. Then, the exhibition is used as a starting point to engage with hyperaccumulators that are endemic of the territory and the ecological, social, and scientific processes at stake behind them.

2.3. A Case Study: *Geomerce* at BIO25

The event considered in this paper is the Biennale of Design of Ljubljana (BIO25), where *Geomerce* was exhibited inside a gallery that was managed by the city council, in order to promote the art and design initiatives in the region. To initiate the research process, a scientist who previously collaborated with *Geomerce*'s designers provided the contacts of the plant biology department of the University of Ljubljana. A first exchange of information with the department's director was initiated via email; then, a Skype conversation and a visit to the lab added contextual details that became useful to the research.

At the lab, scholars researched the species *Thlaspi praecox* [41], which is a hyperaccumulator of zinc, lead, and cadmium, and was grown in response to soil contamination in the Mežica valley, a

territory situated in the southern Slovenian Alps (at an altitude of 550–700 m above sea level). The valley had hundreds of years of mining tradition, particularly for what concerned the extraction and processing of lead. Mining was concentrated particularly in the area of Zerjav, which is a village that counts today about 500 inhabitants. Even though the mine was closed in 1994, metal processing was never disrupted, since the land was later acquired from a company that produced and recycled lead batteries. As a result of decades of industrial exploitation, part of that territory became heavily contaminated from several heavy metals and, in more recent times, acquired the epithet of “Death Valley” [42] due to the impact of pollution on people’s health and the natural ecosystem.

Having assembled such information made it possible to organise the research process around Geomerce’s landing at BIO25, which started one week before the opening and involved research in three interrelated sites: the plant biology department of the University of Ljubljana, the former lead mine of Zerjav and Galerija Kresija, the public gallery of Ljubljana (Figure 4).



Figure 4. Configuration of the study. The three red dots respectively indicate the position of the lab, field, and showroom venues around which the research was performed.

3. Results

3.1. Following the *Thlaspi* in the Lab

The visit to the plant biology department was planned two weeks before the beginning of BIO25. The aim was to become familiar with the plants researched by the scientists and approach their laboratory work. For several years, the focus of the scientists had been on the species *Thlaspi praecox* (Figure 5a,b). The plant is just one of the many ecotypes of *Thlaspi* that accumulates heavy metals. It was identified from the lab’s director in 2005, from some green areas in the vicinity of the former mine of Zerjav. The soil there was deeply affected by zinc, lead, and cadmium contaminants, which is a feature that actually facilitated the adaptation mechanisms later found in the *Thlaspi*, as the plant has the unique capacity of accumulating all of the three metals [41]. As in similar metallophytes, the plant uses the toxicity of heavy metals as a mode of protection and self-defence from external agents such as insects and parasites [43,44].



Figure 5. (a) Photo of a *Thlaspi praecox*. (b) Inflorescence of the plant, with petals and pistils (courtesy of the plant biology lab of the University of Biotechnology of Ljubljana).

Part of the visit was spent inside the lab's greenhouse, where the physiological traits of multiple *Thlaspi* could be experienced more closely. Dozens of plant ecotypes collected from different Slovenian and Austrian places were arranged in multiples rows and individually labelled using text and symbols. In being there, each plant functioned as another-than-human witness of the disturbance history that emerged from the past of a specific territory. The ecotype from Zerjav was grown on a calcareous substrate, so as to replicate its original habitat and facilitate the contingent responses of the plant to technogenic debris.

The experience at the lab also revealed that the expertise of the scientists was politically collocated there, due to the environmental issues that affected part of Slovenia in the previous years. Back in 1998, in fact, the team of biologists gained governmental support to start a new research in the Mežica valley. One of the scholars involved in that project argued that, in those years, applied ecology become very important for the Slovenian government, because the inhabitants of the valley gr[e]w their food on that soil and a third of the children suffer[ed] from heavy diseases and ha[d] more lead in their blood than allowed. Therefore, soil restoration became an issue of political urgency, which motivated those scientists' expertise on the *Thlaspi* and their surrounding territory.

3.2. Following the *Thlaspi* in the Field

The knowledge of the scientists and their wish to participate to *Geomercer's* landing at Ljubljana motivated the lab's director to organise a temporary research team, whose aim was to return to the Metzica valley to find, observe, and sample new specimens of *Thlaspi* to be included in the installation. Since the land had been once owned from a mining company, and was currently owned by a battery factory, it was not possible for us to cross its perimeter without an authorisation, which we did not have. How, then, to geolocalise the plants, in areas outside of the mine's territory? What sort of contamination narratives did we need to consider, in order to trace the deposition of heavy metals on the soil?

With the support of the lab's director, it was decided to follow the plant through geo-speculations [33] that involved the invisible, and yet traceable aerial dissemination of metal pollutants. An interesting aspect, as it was explained from the scientist, is that the contamination on that site was aggravated by the aerial dispersion of mining debris. During most of the mining period, the chimneys of the former smelting site (Figure 6a,b) operated without adequate filters, and their fumes were windblown across the land above the mine, contaminating the soil with heavy metals and sulphur dioxide. The latter in particular was the main factor responsible for the degradation of the land, in that it contributed to form acid rains that deteriorated the soil. To complicate matters, the area was subjected to strong thermal inversions, even during the years of mining activity. At that time, the

morphology of the environment kept the polluting debris on the valley's floor; however, from time to time and depending on temperature and wind changes, the smelter's dusts were blown till its highest limits, affecting the composition of the soil. Those atmospheric patterns led to the hypothesis that, these days, the *Thlaspi praecox* could colonise the valley's apex rather than its inside, in response to the aerial dispersion of mining debris. The walk that was planned with the scientist aimed at exploring such hypothesis—that is, at witnessing the presence of the *Thlaspi* on the land as a vegetal mode of interacting with the aerial dispersion of mining by-products.

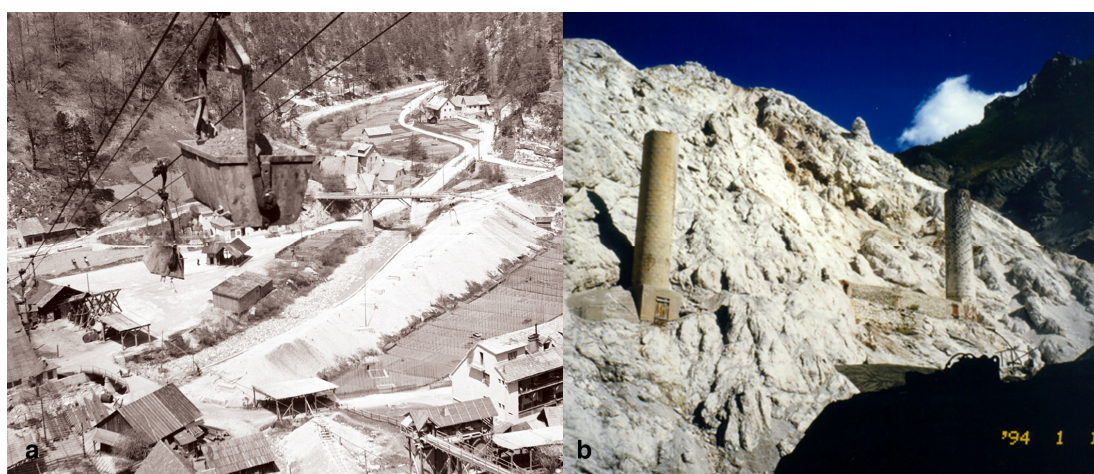


Figure 6. (a) A 1960 photo that shows activities at the mine of Žerjav (photo credits: Jože Gal). (b) A 1994 photo that displays one of the two smelter's chimneys (courtesy of the plant biology lab of the University of Biotechnology of Ljubljana).

The activity was performed on 22 May 2017, three days before the official opening of BIO25, and was documented using a wearable action camera. The team included six scientists (one of whom was the lab's director) and a designer (this paper's first author). To reach the area where, according to the initial hypothesis, a population of *Thlaspi* could be found, the Žerjav valley was accessed from south, walking along an alpine path. Within a one-hour walk, the path led to a narrow ridge that overlooks the village and the battery factory that superseded the mining infrastructure years earlier. From there, as anticipated by the scientists, the environmental effects of years of mining operations were clearly visible (Figure 7). What looked green and lively no longer than a decade earlier was bear rocky land, due to high level of contaminants that precluded a survival of the vegetal ecosystem. That was also able to be experienced by observing the differences between the inside of the valley—where the vegetation just started to take over, and its outside—dominated from healthy spruces and other trees that were not affected by anthropogenic disturbances. It was from there that we began to 'follow the *Thlaspi*', exploiting the ecological knowledge of the scientists to perform observations along the ridge.

The ecological succession in the valley started a few decades earlier with weeds that belong to the Brassicaceae family. The yellow flower buds of *Erysimum sylvestre*—an accumulator of zinc, copper, lead, and cadmium [45], and specimens of *Biscutella laevigata*—which specialise in uptaking lead, cadmium, and thallium [46] carpeted the entire area. Once those plants began to colonise the land, years earlier, other grasses—such as the *Sesleria Caerulea*—appeared in the ecosystem, as the result of a tolerance mechanism developed in response to the metal contaminants. Those plants, according to the lab's director, could prosper there by virtue of the alliances that they managed to form with the underground mycorrhizal network. As a symbiotic organism, the mycorrhiza facilitated the growth of the plant, especially for those species that managed to conquer the land. Furthermore, in exchange for nutrients, the mycelium protected the plants from heavy contaminants such as cadmium, which is considered a toxic element even for the strongest species. The last vegetal arrivals in the ecosystem, the spruces, visually demonstrated the aftermath of a 'late' response to that symbiotic negotiation. Some

of those conifers managed to survive; however, the signs of toxicity on their foliage witnessed all their efforts in remaining alive.



Figure 7. The mountain's ridge. On the left, the spruce forest outside of the valley is visible; on the right, the vegetation grown in response to the fumes of the smelter, as indicated from the lab's director. The village of Zerjav is visible in the top-right part of the photo.

Near the end of the ridge, in proximity of the areas subjected to thermal inversions, grew a population of *Thlaspi praecox*. The plants were distributed across the inner side of the valley, between grasses and rocks, forming a bed of small, white flowers. The population was small; some of the individuals did not even exceed the height of 10 centimeters. The biologist explained the phenomenon as a lack of nutrients in the soil, which occurred as a result of decades of acid rains. That part of the ridge became the sampling site from where we collected different exemplars to be later tested in *Geomerce*.

3.3. Following the *Thlaspi* in the Showroom

Inside the gallery, *Geomerce* was displayed as a solo exhibition, with an area dedicated to the project and another to activities such as presentations and debates, where members from the public could vocalise their own experience of the design. The strategy used to communicate *Geomerce's* landing at BIO25 relied on a multi-modal format. First, there was a joint press release from the two organising institutions: the Museum of Architecture of Ljubljana (the organiser of the event), which counted on a well-established network of contacts in the field of art and design, and Galerja Kresija, which reached a more general public. Second, there was coverage from journalists, such as national TV programs and design editorialists. Last, *Geomerce* was advertised by means of a printed flyer that was distributed door-to-door to the citizenship of Zerjav, introducing the installation to potential audiences and attracting people interested in the topic. This multi-modal strategy allowed communicating the installation at its best, as it targeted different publics, triggering about 550 visitors in four days.

In the showroom, *Geomerce* displayed the relationships that existed between the extraction performances of the collected plants and the settings of the former mine's territory. The main hydroponic unit contained: four specimens of *Thlaspi praecox*, two of *Biscutella laevigata* and one of *Erysimum sylvestre* (Figure 8a), all collected during the fieldwork. The other two units were filled using species that grew on different sites (*Eichhornia Crassipes* and *Helianthus Annuus*), as a way of comparing the abilities of endemic and non-endemic metallophytes. A suitable hydroponic medium for all plants was identified through the support of a scientist from the lab; this consisted of a solution of deionised water with a mix of different nutrients and 195 milligrams of zinc sulphate, which was added manually to the medium (Figure 8b). The performance of *Geomerce* lasted four days, in each of which were printed three infographics relating to the different groups of plants included in the three hydroponic

units. In order to understand the data, at the end of each day, the prints were removed from the plotters and compared to each other. During the first three hours of the opening day, Geomercé's graphics showed that the decrease of zinc sulphate from the hydroponic medium of the plants from Zerjav was relatively low (13.3 mg/3 h). However, at the end of the ninth hour the hydroponic solution had lost 1/4 (52.71 mg) of the total diluted zinc. During the following two days (days 2 and 3), the sensors continued to monitor a steady decrease of metal from the substrate: 41.49 mg of zinc at the end of the second day, and 61.1 mg of zinc at the end of the third day. It was observed that during those days, the physiological condition of the plants remained the same: the turgidity, shape, colour of the leaves, and root system, accompanied by a growing extraction performance, suggested that the hyperaccumulators interacted well with the hydroponic environment. The performance continued that way until the fourth day, when these parameters changed. Before running the installation, on the morning of day four, the hyperaccumulators were found in conditions of physiological stress. This was also documented in the printed graphs: compared to days 1–3, the amount of metal contained in the substrate did not fluctuate, indicating that the extraction activity of the plants had reduced by 100%. The lab's director suggested that the cause of that was the lack of nutrients from the substrate: the large amount of heavy metals in the solution, coupled with a low amount of nutrients, turned the water into an alkaline environment, which affected the health of the plants.



Figure 8. (a) Setup of the group of hyperaccumulator plants; (b) addition of zinc sulphate.

From the graphical plots, it appeared that while non-endemic flora absorbed a very small amount of zinc, the hyperaccumulators collected at Zerjav did sequester up to 155.36 mg of the metal out of the 195 mg that was initially dissolved. In crossing vegetal and financial performances, Geomercé suggested that the metallophytes collected at Zerjav had potentially significant mining abilities, which were developed as a response to the peculiarities of their growth site. For the lab's director, who was interviewed at the end of the exhibition, this reading of the plants' performance was particularly interesting because it combined the advantages of an *in vivo* study of the hyperaccumulator with the possibility of speculating about possible applications of phytoremediation as a geographically situated practice. However, from the plant scientist viewpoint, the experiment had also limitations, particularly from a procedural perspective. Particularly, the lack of data concerning the mechanism of metal uptake: was the metal that was deemed to be missing from the solution accumulated by the plants? Or did it just deposit—for instance, on their roots, or on the glass of the hydroponic unit? So far, the project did not provide answers to such questions. Nevertheless, although not explainable in scientific terms, the performance provided valuable inputs regarding alternative ways of investigating the behaviour of endemic flora and evaluating their possible applications in phytomining processes. Indeed, this was viewed by the scientists involved as a useful result, especially to expand the methodologies currently used to investigate those species.

3.4. Public Understandings of Soil Contamination

In order to comprehend the implications of a direct participation of the plant *Thlaspi praecox* in *Geomerce*, two public activities were planned during the exhibition: a presentation and a debate. The chosen formats mobilised and aggregated different audiences around the project and shed light on the ways in which the participant visitors, through their multiple interactions, engaged with issues of soil contamination. The activities were both planned for the opening day and documented by means of a video clip and pictures taken from two photographers. The presentation was organised according to a standard format, with the designer and the scientist introducing respectively the scientific and design dimensions of *Geomerce* (Figure 9a,b). Although the format was that of a normal speech, the chosen communication method did not require the visitors to remain seated. In keeping the speech informal, with low tables and chairs distributed on the floor and coffees available for the audience, people felt free to roam around the space, engaging with the different elements of the project.



Figure 9. (a) Public presentation in the exhibition space; (b) Public debate in the exhibition space.

The debate took place straight after the presentation and was also a departure from traditional formats in that it was conceived to dynamically encourage people to interact with the design, inhabiting the scientific, ecological, and socio-political aspects of phytoremediation. It first began as a roundtable with questions and answers, where people could talk and bring along their own experience of environmental pollution. For instance, during the activity, a couple of German visitors introduced the problem of industrial exploitation of soil in the Ruhr region and posed questions to the scientist, who provided her perspective about it. However, as the debate continued, people began to stand up and interact with other public members using the different elements of the installation. In doing so, they split into small groups of interest and spread across the exhibit floor. For instance, two inhabitants of the Mežica valley who received at home the flyer about *Geomerce* gathered around the hydroponic unit that hosted the *Thlaspi praecox*, to discuss the ecological functions of that species for the territory with the biologist (Figure 10b). For them, rather than the general presence of flora, it was the performance of that very plant that acquired a particular meaning. In an interview, one of them claimed to have an emotional bond with those plants, as they shared with her an entire life in the valley: “[...] I particularly observed the plants in the middle,” she said, “those [that] came from Mežica Valley, because I could relate more to them, having grown up in that area. I could see the activity inside the water bowl, how [...] the plotters moved up and down, annotating the measurements and comparing them against the value of the metals [...]. That really amazed me. [...] I am very attached to the Mežica Valley, and I now have no doubt in my head that it will keep getting better and the environment will be looked after and protected”. Rather than becoming a cause of concern, aspects of geographic territorialisation, coupled with the benefits from financial metal exchange, leveraged on that visitor’s sense of belonging to the territory and the urgency to plan

a better future for its inhabitants. Experiencing the real-time performances of *Geomerce* brought her to think about alternative agricultural futures for the Mežica valley, which could remediate the soil and at the same time offer opportunities for the generations to come. During the interview, she explained that *Geomerce*'s scenario looked to her as an almost plausible future: “*The installation was useful,*” the visitor argued, “*because it showed that the economic perspective itself is actually huge, but not only that; also, the impact on the environment and how to clean it are huge, too. And the potential employment opportunities—you would need a lot of people to work for this process, planting, harvesting, and extracting. And—at the end, some money could be made by selling these metals.*” Other visitors were more interested in the performative dimension of the hyperaccumulating flora, and knelt around the plotters to observe the prints and the activity of the plants (Figure 10a). An interview with one of them, who was an environmental consultant by profession, revealed that *Geomerce* suggested a re-thinking of contamination through the perspective of metallophytes. This way of reading the exhibition brought him to consider the implications of phytomining on a larger, more-than-human scale, reflecting upon factors that he would have otherwise left aside: “[...] *If you think things through*”, he claimed, “*you can understand that interaction might not just be intended in one-way—such as phytoremediation but also, from a plant perspective [...] such as humans putting more elements into the environment, which might benefit a plant’s growth. In that sense, it seems as if the purpose was to get people to think differently about plants and our interaction with them as opposed to give them information on a particular application of plants [...]. The way you presented it was more about thinking that there is a process happening, which is dynamic and relevant to the market economy. This opens up different parts of the brain and gets people thinking in a more lateral sense.*”



Figure 10. (a) Visitors gathering around one of *Geomerce*'s plotting devices. (b) The biologist discussing *Thlaspi praecox* with two visitors from the Mežica valley around the hydroponic unit.

The format used to exhibit *Geomerce*—which assembled environmental, scientific, and speculative perspectives on phytomining, and the following debate—which allowed the visitors to tune such perspectives according to their own interests and expertise, brought people to engage in multiple encounter experiences with the performing plants. Those activities did not simply involve the biologist and the designer regarding the quality of experts, but rather assembled a new network of participants, including environmentalists, social scientists, and engineers, who could all exchange ideas, opinions, inform each other, and question the issues raised by *Geomerce*. Across this interweaving of encounters, the showroom worked as a forum, in which multiple knowledges could flow horizontally among the actors who participated in the event. In an interview, the biologist claimed that the chosen format led to multiple interactions between the participant visitors, who informed each other through their experiences of the territory that they inhabited: “*These kinds of interactions*”, she argued, “*are very useful. First, you get people with different knowledge. [Through] that, you are enriched, and you enrich them. For instance, people can become aware of living in a polluted environment and that certain vegetables shouldn’t*

be grown there, as they would become intoxicated. This would be important to improve the quality of life, and it's only possible through this kind of debate. Furthermore, if you meet people, if you talk with them and exchange opinions, then their experience becomes your experience, as you carry that with you and start to think about it. Many people informed me about their own individual experiences, and those are the people who thought about possible mechanisms to improve things in the territory. Meeting them, their views, what they think [. . .] is a sort of mode of evaluating the usefulness of my work." During those interactions, it was observed that the visiting audience, in addition to familiarising themselves with plant research, also started to refer differently to plants. While gathering around the hydroponic units, a couple of participants asked if touching hyperaccumulators could be dangerous, others asked if the performance induced stress to the plants, others became curious to know what would happen to the specimens once the exhibition ended, offering to adopt the species to re-pot them in their garden. In this sense, the multispecies design installation with performing plants showed the potential of bringing people closer to other-than-humans, by means of experiences that reveal the hidden vitality of living flora.

4. Discussion

In order to explore the concept of contamination through multispecies lenses, this research considered other-than-humans as more-than-biological agents, opening up to the political dimension of their life. By "political dimension" we mean that those living beings, by affording peculiar bonds with humans, can actively participate in the definition of future scenarios associated with such interconnections. From this research, for instance, it emerged that the accumulation abilities of *Thlaspi praecox* are related to the activities of a former mining company, whose by-products affected a specific geographical area for decades. The contaminants influenced both the aspect of that territory and the life of the human communities that inhabited it. The growth of multiple metallophytes on these places also determined the emergence of peculiar scientific knowledges in a lab that was collocated nearby. This knowledge, it was understood during the study, was politically situated in the lab, as a result of environmental governance's directives that, in earlier years, called for a restoration of the entire area. This network of actors and processes expresses just one part of the *Thlaspi*'s sociality—that is, the one that links with the history of its land [33]. The circulation of *Geomera* enabled a further extension of that network, by linking the extraction abilities of the plant with the economic value of zinc, according to actual financial trends. Through the speculative design format, the political dimension of this plant emerged as a performative construct that was capable of connecting a past era of industrial politics and economics with future scenarios that suggested a multispecies reading of soil contamination. Using design to perform this task has had important implications, most notably because it brought people in touch with unexpected, post-human perspectives that concern the future of a place, alternative to those proposed by the current techno-industrial models of environmental restoration. Learning about and from plants helped people imagine scenarios of collaboration, resource sharing, and rehabilitation, as opposed to logics of individualism, accumulation, and exploitation of resources, opening up perspectives yet unimagined. Given the current ecological crisis, now more than ever it is important to familiarise with these viewpoints, as not only can they help us overcome the fatigue and distress of "living in the ruins" [47], but they can also provide a means to re-negotiate human existence in a broken nature, paving the way to an inversion of thought towards the environment. Approaching the theme of contamination through speculative design lenses can thus open spaces of articulation and negotiation aimed at introducing alternative ways of thinking about the environment and reorganising the spaces and activities within which the human existence gets qualified.

In order to learn how to read a territory through other-than-human lenses, it was fundamental to explore a particular research methodology, which was called 'following the plant'. "Following", it is argued, can be used to explore the intrinsically complex nature of environmental issues, re-configuring its constitutive elements by means of perspectives that mingle the boundaries between individual research traditions and the conventional locus of their practices. This implied that the researcher had to learn about different research methods, which helped him investigate the contexts that were

studied and become familiar with the biologically different actors that orbited around such contexts. In retracing the work done with the plants, it is inevitable to notice that it originated from one of the (many) territories that typify the Anthropocene—that is, the contaminated site. The kinds of plant that grow on these places—whose identity is affected by a persistent dispersion of anthropogenic debris—allowed to explore the relationships that orbited around their capacity to metabolise heavy metals. This suggests that the ecological contexts that emerge from the Anthropocene, rather than being seen through dystopic and technocratic lenses, can lead us to important opportunities of encounter with other-than-humans. The described practice of following came about as a multi-sited and multi-modal research process, performed within the multiple sites that constitute—in this case, a plant’s life: the field, the lab, and—through *Geomerce*, the showroom. The study suggested that following means as first learning to interact, that is, to ‘act-between’, within a physical space situated at the intersection of diverse perceptual universes. By observing a specific research context and the agentic forces involved in it, by walking across a contaminated infrastructure, exploring and speculating about its settings, by observing and monitoring what grew there, and by discussing plants as agents with biologists and other research participants, it was possible to forge a contact zone with the growing places of hyperaccumulators. The process revealed to be an entangled, at times complex research path, in that it forces to accept the friction that humans feel whenever attempting to embrace the unexpected, the difference, the incompleteness. This echoes Anna Tsing’s argument, according to which at the heart of our encounter experiences with other-than-humans does not proliferate the theme of “purity” [47] but that of contamination, the only one capable of changing world-making processes and leading to mutual worlds and new directions.

5. Conclusions

This paper introduced the praxis of multispecies design as a way of performing environmental research that focusses on relational narratives, as opposed to traditional human-centred and human-exceptionalist stances. In particular, a speculative approach to multispecies design suggested to effectively open the concept of sustainability to a multiplicity of diverse actors and processes, human and otherwise. The presented research suggested that, by adopting a multispecies stance and thus decentralising the human from a position of exceptionalism, also other-than-human actors can participate in the design process and become visible through it. It is argued that actively engaging other-than-humans in the design process can help designers to rethink the basics of sustainability as a model that is exclusively centred on people, guiding them towards approaches that are more inclusive and participatory. Observed from such a perspective, the concept of sustainability doesn’t emerge as the sheer outcome of a design process, but first as a behavioural attitude, and design as an instrument for implementing that attitude. It is a behavioural attitude because it refers to the ecology in the thought system, the only one that—echoing Guattari, together with the social and environmental ecological spheres—can lead to large-scale changes. Second, it is an attitude that can be implemented through design by virtue of the fact that design, when used critically, allows exploring consolidated axioms, reformulating them according to new narratives, and making them actionable in the present time.

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