(Non-)Knowledge, slow violence and latent conflicts over mine tailings in the Chilean Atacama region

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Abstract

The "slow violence" arising from mining tailings in Chile spreads cumulatively, slowly and invisibly over time and space. Even those affected are not necessarily aware of it. Toxic substances, which tailings contain in high concentrations, spread easily through water, soil and air, even entering the plants and the bodies of the surrounding population. In this way, they become part of food chains and entire ecosystems, threatening both livelihoods and local economies. This article is based on the conclusions of an empirical investigation of three communities affected by mining tailings in Chile (Pabellón, Tierra Amarilla and Chañaral), conducted between 2014 and 2022, where not only is the severity of the consequences of cumulative exposure in the medium and long term made evident, but also its combination with other socio-ecological and economic inequalities. Material invisibility accompanies the social invisibility of those affected. The focus is the generation of knowledge and ignorance as a principal factor that hinders or facilitates the perception of risk in the face of environmental slow violence, determining the environmental (in-)action of the actors involved and the possibility of resistance by those affected.

Key words: slow violence, environmental inaction, latent conflicts, mining extractivism, environmental injustice

Résumé

La « violence lente » engendrée par les résidus miniers au Chili se propage de manière cumulative, lente et invisible dans le temps et l'espace, sans que même les personnes concernées en soient conscientes. Les substances toxiques, qu'elles contiennent en fortes concentrations, se propagent facilement dans l'eau, le sol et l'air, pénétrant même les plantes et l'organisme des populations environnantes. Elles s'intègrent ainsi aux chaînes alimentaires et à des écosystèmes entiers, menaçant à la fois les moyens de subsistance et les économies locales. Cet article s'appuie sur les conclusions théoriques d'une enquête empirique menée entre 2014 et 2022 sur trois cas de communautés affectées par les résidus miniers au Chili (Pabellón, Tierra Amarilla et Chañaral). Cette enquête met en évidence non seulement la gravité des conséquences de l'exposition cumulative à moyen et long terme, mais aussi sa combinaison avec d'autres inégalités socio-écologiques et économiques, combinant ainsi l'invisibilité matérielle à l'invisibilité sociale des personnes concernées. L'article se concentrera sur la production de connaissances et d'ignorance comme l'un des principaux facteurs qui entravent ou facilitent la perception du risque face à ces phénomènes de violence environnementale lente. Il déterminera également l'(in)action environnementale des acteurs impliqués et la possibilité de résistance des personnes affectées, et analysera les implications théoriques des résultats de cette étude.

Mots clés: violence lente, inaction environnementale, conflits latents, extractivisme minier, injustice environnementale

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Resumen

La "violencia lenta" que surge de los relaves mineros en Chile se expande cumulativa-, lenta- e invisiblemente a lo largo del tiempo y el espacio, sin que siquiera los afectados estén necesariamente al tanto de ello. Las sustancias tóxicas, que estos contienen en altas concentraciones, se expanden fácilmente a través del agua, de los suelos y del aire, introduciéndose incluso en las plantas y en los cuerpos de la población aledaña. De esta forma, se vuelven parte de cadenas alimenticias y ecosistemas completos, amenazando a la vez los medios de subsistencia y las economías locales. Este artículo se basa en las conclusiones teóricas de una investigación empírica de tres casos de comunidades afectadas por relaves mineros en Chile (Pabellón, Tierra Amarilla y Chañaral), realizado entre 2014 y 2019, donde no solo se evidencia la gravedad de las consecuencias de la exposición acumulada a mediano y largo plazo, sino también su combinación con otras desigualdades socio-ecológicas y económicas, combinándose así la invisibilidad material con la invisibilidad social de los afectados. Este artículo se centrará en la generación de (des-) conocimiento como uno de los factores principales que dificultan o facilitan la percepción de riesgo frente a estos fenómenos de violencia lenta ambiental, determinando además la (in-) acción ambiental de los actores involucrados y la posibilidad de resistencia de parte de los afectados, analizando las implicaciones teóricas de los resultados de este estudio.

Palabras clave: violencia lenta, inacción ambiental, conflictos latentes, extractivismo minero, injusticia ambiental

1. Introduction

We generally relate the current ecological crisis to increasingly recurrent and disastrous catastrophic events, with devastating and immediate consequences for those affected. However, mega forest fires, extreme droughts, accelerated desertification and the resulting famines, unprecedented heat waves, as well as increasingly frequent images of floods and avalanches, make visible only a part of what makes up the current ecological crisis. Most socio-environmental disasters are the result of long and invisible processes that often do not present themselves in a tangibly catastrophic way. This article aims to analyze the kind of highly destructive socio-environmental phenomena that expand gradually over time and space, and whose ecological and social consequences often remain invisible.[2] An example is the environmental impact of the Chilean mining industry. Studying this *slow violence*, as Rob Nixon (2011) calls it, is fundamental to understanding, making visible and perhaps mitigating some of these invisible catastrophes before they become irreversible (ibid.; Diamond, 2010).

Slow violence is the appearance that most of the socio-environmental consequences caused by human action take on (Nixon, 2011). Rachel Carson (2000 [1962]) was perhaps the first to describe this phenomenon in detail, based on the observation of the devastating effects produced by the indiscriminate use of pesticides. The direct violence of extractive industries such as mining, whose multiple causes and oppositions have been widely studied (Svampa, 2020, p. 83, 2016; Machado 2014; Alimonda 2011; Martínez-Alier & Walter 2015; Arboleda 2020), are also the source of another kind of violence, invisible but not less devastating in the long term, caused by the immense quantities of toxic waste produced by mining (Ureta *et. al*., 2018; Heikkinen *et. al*., 2023; Lugo-Vivas, 2024; Sandlos & Keeling, 2016). Mine tailings are a finely ground solid extracted during the mining process, that remain once the element of economic interest has been recovered. They are discarded. In the case of copper, a major part of the extracted metals in Chile, tailings are more than 99% of the total material extracted (Sernageomin, 2024). Depending on the composition of the subsurface, and the process for the recovery of the desired metal or mineral, tailings contain high concentrations of different chemicals and heavy metals such as arsenic, cyanide, copper, zinc, chromium, lead or mercury (ibid.). These are potentially harmful to both the environment and human health.

The Chilean economy has a strongly neoliberal, extractivist orientation (Fischer, 2011; Landherr & Graf, 2017), with exports of primary goods recently accounting for 86 percent of total exports (CEPAL, 2021, p. 44). Today and historically, mining has been the most important economic sector, accounting for over 60 percent of

[2] Invisibility in this article refers to a lack of risk perception of the tailings as a problem to be solved at a societal level, leaving open the possibility of some visibility at the local level, as observed for example by Thom Davies (2022). This differentiation is relevant, since the material invisibility of toxics has proved to be the determining factor in rendering the problem invisible not only at the societal level, but also for those affected, as will be seen later.

total exports during the last three decades and making Chile the world's largest copper exporter. Chile also has the third most tailings in the world, with 742 tailing deposits and an annual production of 537 million tons of toxic waste. This is constantly increasing (Sernageomin, 2024). Many of these tailings are inactive (463) or abandoned (173). A significant portion of them are not deposited in a safe and environmentally responsible manner, and/or do not have regulations in place (ibid.).

The toxic components of mine tailings range from direct contamination of soil, water and air to the contamination of entire territories, groundwater and even maritime areas, after inadvertently spreading through wind, rain and rivers (Eberle 1999). Depending on the components, the pollutants may not show their effects until several decades later. They can reinforce each other and interact cumulatively, and, in most cases, the environmental pollution lasts for several millennia. Chemicals and heavy metals contained in tailings are also able to enter plants and bodies, becoming part of food chains and entire ecosystems, causing diseases and even the extinction of species (Cortés, 2014; Vergara, 2011). For humans, a significant increase has been observed in respiratory, digestive and nervous system diseases, cancer and elevated mortality rates, while mothers and unborn children have fertility problems and other health issues during and after pregnancy (Cáceres, 2015; Cortés, 2014). The issue of mine tailings is not widely discussed or perceived in public opinion or in the media in Chile (Ureta, 2022), despite the risks, apart from a few cases of landslides or accidents. It is also not a frequent subject of social science research (Ojeda-Pereira & Campos-Medina 2021).

This article is based on the results of empirical research conducted between 2014 and 2022 on the social and ecological consequences of Chilean mining tailings, as well as on the management of these by the different actors involved, I reflect on the absence of slow violence phenomena in social research. This research focused on why tailings remain socially invisible (i.e. are not recognized as a problem by Chilean society) despite their enormous impact on people and the environment. The empirical study investigated the interaction between (non-)knowledge, the (in-)action of the actors involved and social (in)visibility (see Section 3). Furthermore, it examined under what circumstances they become visible. Socio-ecological conflicts surrounding tailings rarely arise and when they do, they often remain latent and socially invisible.[3]

We focus on the role of (non-)knowledge as one of several identified central factors that lead to the (in)visibility[4] of tailings as a socio-ecological problem and the (in)action of the actors involved – e.g. in the form of a manifest conflict. As the research shows, knowledge plays a particularly important role in slow violence, as a number of factors inherent to slow violence phenomena, such as the material invisibility of the source of the pollutant, the slow spread of its effects, the diffuse nature of the manifestation of its consequences, the blurred relationship between cause and effect etc., hinder the identification of the problem on the part of those affected (Nixon 2011). Knowledge about the existence of the cause of the problem and its possible consequences is therefore crucial to the possibility of problem identification (Roberts & Langston 2008; Frickel 2008; Allen 2008). Knowledge does not inevitably lead to action (Wehling 2006, Singer 2011), as is sometimes suggested in the literature. In the case of slow violence phenomena this is a prerequisite for the visibility of the problem and for the possibility of action. Political ecology has a strong focus on the identification of socio-ecological distribution inequalities through the actions (in the form of conflicts) of those affected, so (non-)knowledge is a central aspect of this research field.

After detailing the current state of research on the slow violence of mining tailings (Section 2) and making some conceptual clarifications (Section 3) the methodology is in Section 4. Sections 5 to 8 present the case studies, and some general findings on different (in)visibility levels. The conclusions are in Section 9, with implications for the visibility of slow violence in the social sciences.

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[3] The entire empirical study was published open access in 2024 under the title *Die unsichtbaren Folgen des Extraktivismus. Ein Blick hinter die slow violence der chilenischen Bergbauindustrie* (Landherr 2024). To avoid repeated citations from the German language study in this article, I recommend those interested consult the book where there are more details on the historical and sociopolitical context, methodology and findings.

[4] While ignorance and uncertainty are associated with the presence, absence or content of knowledge, visibility is understood here as a particular form of knowledge (Wehling, 2006; Croissant, 2014) that leads to an understanding of tailings as potentially hazardous, manifesting as the perception of risk or danger. This takes place at different scales (see the (in)visibility pyramid in Section 5).

2. Current state of research on the slow violence of mining tailings

Rob Nixon defines slow violence as phenomena that are usually not recognized as violence at all, often remaining invisible to the affected population until impacts become manifest and irreversible (Nixon, 2011, p. 2). Typically, the causes of environmental slow violence are elements or substances that are materially invisible and indistinguishable, such as toxic substances contained in pesticides or mining tailings, asbestos fibers, gases or radioactivity. Two other typical aspects of slow violence phenomena, which contribute to their invisibility, are the temporal delay between the causes and the appearance of their consequences, and the physical distance between those affected and the beneficiaries (Nixon, 2011, p. 41). Nixon builds on Johan Galtung's (1972) conception of structural violence, extending it towards a more dynamic and processual understanding (Nixon, 2011, p. 11). He incorporates Fanon's (2018 [1969]) temporal and time lag factor of the effects of violence on those affected, as well as its cumulative effects.

The concept of slow violence centers my research, operating both as a diagnosis of the phenomenon, ascertained in research in 2014 in Chile[5] and a theoretical starting point across disciplines and theoretical currents. Mine tailings are not only a national problem in extractivist countries like Chile, but are part of international value chains. They result from the international division of labor of the capitalist world-system (Wallerstein, 1986), with its inequalities and dependencies (Emmanuel, 1972; Marini, 1974) and its colonial continuities (Alimonda, 2011; Machado 2014; Quijano, 2000). Existing structures of power and domination at the global level help to maintain and deepen the tailings problem and its invisibility. Material flows are part of what Nixon (2011, p. 41) describes as "capitalism's innate tendency to abstract in order to extract." Mine tailings, are part of the global social metabolism (Fischer-Kowalski, 1997; Martínez Alier & Walter, 2015) based on an unequal distribution of resources and environmental costs (Martínez-Alier, 2002; Alimonda, 2011) and on ecologically unequal exchange (Hornborg & Martínez-Alier, 2016). They also result from the exclusivity of the Global North's mode of production and living (Brand & Wissen, 2017). The concept of slow violence allows us to dialogue with works on the epistemological consequences of a Western and dichotomous understanding of nature (Merchant, 1987; Escobar, 1996; Leff, 2001; Mies & Shiva, 2016), also present in the generation of (scientific) knowledge on the consequences of tailings and their components, contributing in part to the invisibility of the slow violence within them (de Sousa Santos 2010).

There is an extensive theoretical and empirical research tradition on ecological distributive inequalities (Martínez-Alier, 2002; Dietz, 2014; Gudynas, 2009; Pulido, 1996; Svampa, 2020; *et al*.), as well as those specifically related to the mining sector (Machado, 2011, 2014; Bebbington, 2007; Alimonda, 2011; Delgado Ramos 2010, *et al*.). These form a very rich basis for the study of slow violence phenomena, but at the same time there are important gaps[6], despite ecological distribution conflicts being an obvious target for political ecologists and studies of environmental justice (Nixon, 2011). Such issues disproportionally affect socially vulnerable communities and marginalized groups, causing the emergence of new, and the deepening of older, inequalities (Nixon, 2011; Ureta, 2020; Davis, 2006; Singer, 2011 Navas *et al.,* 2022; Heikkinen *et al.,* 2023, Vélez-Torres *et al.,* 2024, Lugo-Vivas, 2024). The double invisibility of the affected people themselves, as well as of the causes and consequences of their socio-environmental problems, is also reflected in the paucity of social research on mining tailings (Ojeda-Pereira & Campos-Medina, 2021).

A lack of studies on the phenomena of *slow violence* is due to:

1) the centrality of manifest, visible socio-environmental conflicts as the main focus of distributive inequality or environmental injustice (Martínez Alier, 2002; Alimonda 2011);

[5] During my participation in the research project "El Desecho de Chile: Un análisis sociotécnico de prácticas y políticas respecto del manejo de relaves mineros en las últimas dos décadas" conducted by Sebastián Ureta during 2014.

[6] I highlight the relevance of the Special Section "Toxic dispossession and environmental violence in Latin America" edited by Swistun, D., Lugo-Vivas, D. A. & Vélez-Torres, I. in the *Journal of Political Ecology* in 2024, which contributes to closing this gap in political ecology.

2) scientific ignorance about many of the effects of chemicals and heavy metals in general (Wehling, 2001, 2006; Roberts & Langston, 2008), which together with the material invisibility of these toxic substances hinders the perception of risk; and,
3) to the very condition of environmental injustice to which the affected communities are exposed, which contributes to their social and scholarly invisibility (Sousa Santos, 2010, Nixon 2011).

I considered the existing more general social research on slow violence (Ureta *et. al* 2018; Heikkinen *et. al* 2023; Lugo-Vivas 2024; Sandlos & Keeling 2016; Davies, 2022; Badidge, 2021; Lugo-Vivas, 2024; Carrasco, 2022; *et al*.), while working in the Latin American political ecology tradition (Alimonda, 2011; Delgado Ramos, 2010). The article spans wider than a political ecology frame, to better understand the research questions from related perspectives including environmental history and science and technology studies (STS) (Carson, 2000; Frickel, 2008; Latour, 2000; Nash, 2008; Roberts & Langston, 2008; Ureta, 2022; Vergara, 2011; Allen, 2008, among others), the anthropology and sociology of (non)knowledge or ignorance (Wehling, 2001, 2006; Alexander & O'Hare, 2020; Croissant, 2014), as well as work on environmental uncertainty and inaction or on mining tailings in Chile and Argentina (Auyero & Swistun, 2008; Singer, 2011; Ureta & Contreras, 2020; Ureta & Flores, 2022; Ureta *et al.,* 2018). Finally, there is literature on risk perception (Slovic, 1987), and the sociology of absences (Sousa Santos, 2010).

3. Research heuristic and conceptual clarifications

There is a lack of perception of the risks that tailings pose for Chilean society (Ureta *et al.* 2018; Ureta 2022, Landherr 2024). Previous research has identified this generalized ignorance about potential risks, as well as environmental inaction among all the actors involved. A heuristic was developed based on the interrelation of three pairs of categories: (in)visibility, (non)knowledge and (in)action. These categories are related, and influence the agency and action of the actors involved. There are mechanisms, structures, interests and power relations that contribute to the (in)visibility of tailings. My goal is to generate a global picture of the slow violence of mining tailings, including concrete local material and social circumstances, institutional and structural factors, and, most importantly the actors, their agency, and their interactions.

There is knowledge and "non-knowledge" or ignorance about phenomena such as environmental pollution caused by chemical substances (Wehling 2001, 2006). However, these are not used as two absolute opposites, but rather as a continuum of degrees of knowledge, and concepts such as uncertainty, indeterminacy or ignorance are located within this continuum (íbid.; Alexander & O'Hare, 2020; Croissant, 2014). Scientific knowledge is by no means perceived as the only form of knowledge and is not objective or neutral (Merchant 1987; Mies & Shiva 2016: Alexander & O'Hare, 2020; Leff, 1986; Escobar, 1996). Koselleck (1995) identifies (non)knowledge as measured by the "space of experience" and "horizon of expectation" among agents. Nevertheless, scientific knowledge has a special significance in this study, understood as the produced "truths" (Nash 2008) established by "truth producers" (Nash, 2008; Sousa Santos, 2006). These have legitimacy in negotiation processes about the reality of slow violence phenomena (see Section 5).

4. Methods

Exploratory qualitative research was conducted between 2014 and 2022 in the localities of Pabellón, Tierra Amarilla and Chañaral in the Atacama Region of Chile. All three are localities close to mining tailings with scientifically proven high concentrations of toxic substances[7] (Eberle, 1998; Cáceres Lillo, 2015; Cortés, 2014, Ministerio de Medio Ambiente 2012). They were chosen for their different mining histories and legal status (with the first abandoned, the second inactive and owned by a section of the big national company CODELCO, and the third in operation by a large company). Each had different public visibility and levels of

[7] Proven high toxicity, with socio-environmental problems, but no environmental conflict. Most Chilean tailings lack official scientific knowledge on toxicity or have not been studied, especially in abandoned and inactive tailings.

conflict. The goal was that these cases could be compared, but also complement each other with different social visibility and points in history.

In the three localities, as well as in the regional capital Copiapó, data were collected through participant observation and 164 in-depth interviews during five long research trips. These was accompanied by a detailed review of literature, documents and the local press, as well as drawing on existing research from various disciplines on Chilean tailings. The actors studied were the population affected by the tailings, public authorities, workers and officials of the mining companies, members of civil society and the press, and scientists, doctors and experts producing scientific knowledge on mine tailings. To protect respondents, pseudonyms are used.

This qualitative, flexible and situational method enabled the identification and the study of invisible events, effects and materials, non-knowledge, latent conflicts, inaction and the "inexistent" in general (Croissant, 2014), as well as the material circumstances, the interactions of the actors, and the power relations behind them. For this purpose, grounded theory (Strauss & Corbin, 1996) was chosen, enabling the discovery of new correlations and ongoing adaptive development of theory (Legewie & Schervier-Legewie, 1995). The heuristic (see Section 3) functioned as a framework but did not in any way define the course of the research, which was determined exclusively by the data collected.

5. Rendering mining tailings invisible

I present some of the most relevant research findings on the (in)visibility of slow violence caused by mining tailings in Chile. The main finding is that the public invisibility of the issue is the result of a multidimensional and multiscalar process, through which invisibility, and specifically non-knowing, is actively (re)produced or at least favored by rendering invisible the material or social circumstances, social mechanisms, and the (in)action of the actors involved. In the case of slow violence, this actively occurs through the production, management or retention of knowledge by the actors involved.

I chose to investigate a wide range of factors and generate an overall model that organizes them according to the level of visibility of tailings at the societal level (see Figure 1). These factors can be classified into three groups:

1) unintentional factors, mainly inherent to tailings as a source of slow violence;
2) intentional factors, composed of (in)actions of different actors, that contribute directly to (in)visibility, and
3) existing power and domination relations, as well as current institutional and structural frameworks at the national and international levels.

The (in)visibility pyramid (Figure 1) shows the degree of visibility and the perception of risk or hazard. The second pyramid (Figure 2) illustrates the related levels and forms of knowledge or ignorance at each step, from the generalized invisibility to the political or legal recognition of the environmental risk posed by tailings to the surrounding population and the natural environment.[8]

The first level of generalized invisibility, which defines the Pabellón case as well as most of Chile's mining tailings, is the only one that seems to represent a relatively stable and permanent state (Figure 1). At this level unintentional factors prevail, such as given material and social circumstances, as well as everyday scientific or state practices. At the higher levels of the pyramid there are more intentional actions to make tailings more visible, or invisible. As evidenced by the cases of Tierra Amarilla and Chañaral, the same case can move through different levels of (in)visibility over time, with full public recognition of toxicity (level 4) being almost impossible to reach. Tailings tend to appear to a wide section of society only at the third level, due to an event or a manifest conflict.

[8] For more on the pyramids that show the different levels of (in)action at each step, as well as the different actors and factors that contribute to each level of (in)visibility, see Landherr (2024), p. 435.

6. Generalized invisibility and uncertainty in Pabellón

Pabellón is an extremely poor locality, adjacent to and partly above an abandoned, highly toxic and largely forgotten historical tailing deposit (Ministerio de Medio Ambiente 2012; Sernageomin 2021) whose origins date back to the Chañarcillo silver and gold mine in the 19th century. The mercury content in Pabellón and Totoralillo alone has been estimated by scholars and government to be at least 185 tons (Eberle 1988; Ministerio de Medio Ambiente 2012). But still, Pabellón remains at the 1st level of generalized invisibility of its mine tailings. There is a material invisibility of the toxic substances contained in tailings (see Figure 4), and their impacts are not always visible, which makes it difficult for those affected to perceive the risk to themselves and others.

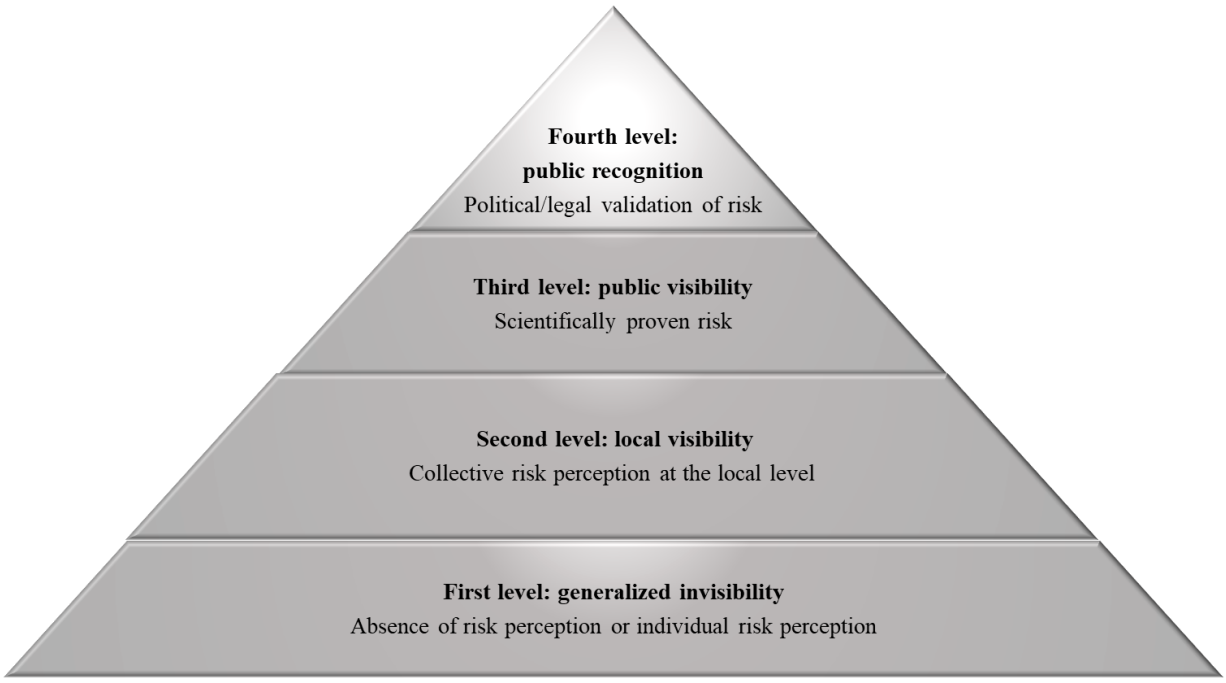

Figure 1: Pyramid of (in)visibility of mining tailings. Source: Author

In the case of Pabellón and other historical tailings, invisibility can occur though a collective forgetting, and therefore a loss of knowledge about the past (Frickel, 2008; Croissant, 2014). The mine was closed at the beginning of the 20th century but not marked or fenced off. Its industrial waste blends visually into the surroundings and residents who move there can no longer recognize it. They do not know why the land lies fallow. This collective forgetting goes hand in hand with a "loss of identity" of the materials, as they are no longer seen as a part of a production process and were never labeled as hazardous (Alexander & O'Hare, 2020). For example, the former flotation basins of the ore processing plant were converted into swimming pools for a campsite that existed until recently. Local historian Diego Castro (PE01) explained in an interview that "the pools were heavily contaminated, and people from Tierra Amarilla, Pabellón, and the surrounding area swam in them for years with the municipality's knowledge. The place was very popular here."

Knowledge about the existence of the tailings and the effect of their toxicity is necessary for people to generate an informed perception of risk. This applies especially to scientific knowledge, as the only publicly recognized "truth." In Pabellón, no one knows the details of extractive activities and exactly where the residues were originally deposited. Chemicals and heavy metals can only be detected through field and laboratory research, to become visible as a problem (Vogel 2008). On the other hand, investigations are only carried out

where pollutants are suspected. "In such situations, we're looking for a needle in a haystack. Classifying different tailings as hazardous or harmless cannot be done precisely under these conditions" explained chemist Cristobal Valenzuela (PW01) of the University of Atacama. "Each individual sample is too expensive [and so we cannot] make enough samples for a meaningful statement", he continued.[9] The original loss of knowledge and the difficulties producing it limit the possibility of social action to solve the problem (Frickel, 2008; Wehling, 2006). In Pabellón, the lack of access of the population to scientific knowledge and the absence of a collective risk perception were observed, resulting in a situation of generalized toxic uncertainty, as also diagnosed by Auyero and Swistun (2008) in their study of Flammable, a marginalized neighborhood surrounded by petrochemical plants and heavy industry in Buenos Aires, Argentina.[10]

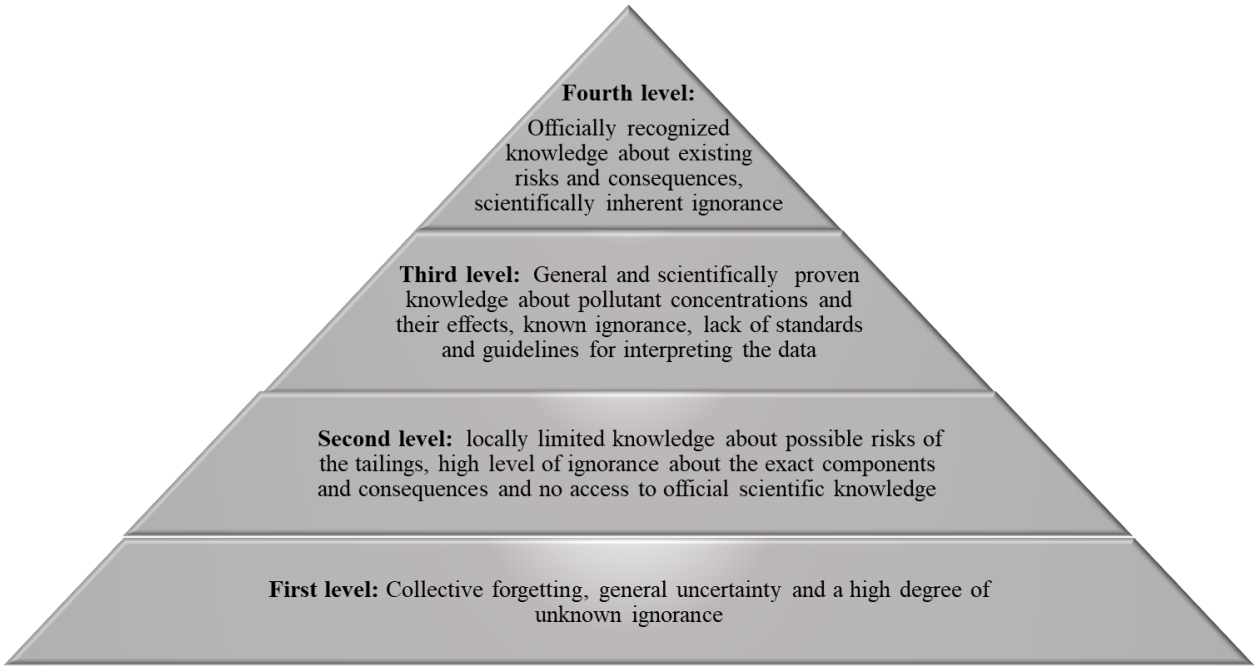

Figure 2: General tendencies of (non-)knowledge along the (in)visibility pyramid. Source: Author.

Those few residents with a clear (individual) perception of risk were found to have a strong sense of helplessness and powerlessness. "I feel powerless and also somehow angry (...) instead of helping us, they look down on our village as if it was garbage. Because we live like we must live, they think we are all criminals (...). The last thing they will do is to remove the tailings, they don't even provide us with electricity and water, why should they suddenly solve this problem now?" says Julian (PB22). Most feel abandoned by state institutions and society in general, showing a particular combination of a low perception of risk and perceived powerlessness that Singer (2011) called "toxic frustration." These factors generate collective environmental inaction, and little or no escalation of socio-environmental conflict.

[9] If independent scientists and government agencies then reach different conclusions, government agencies have greater legitimacy. They have a monopoly on official knowledge generation. This makes it difficult for those affected to independently prove contamination.

[10] Although some residents have a diffuse perception of the hazard posed by the tailings, no one has precise knowledge about their composition or possible consequences. A substantial number of residents had no perception at all, and some are not even aware of their existence. At the same time there has been almost no communication between residents. Overall, a very high level of ignorance of the threat, uncertainty, and contradictory statements was observed in Pabellón.

In addition, the affected population is often publicly invisible and exposed to the interplay of various social and ecological inequalities, within which tailings are usually not prioritized. In Pabellón there is no sewerage or potable water, no telephone service, internet or mobile phone signal, there is only one food store and there is no access to any basic services. The village is made up of illegal settlements, tolerated by the authorities over time, and a series of more recent land occupations (Figure 3). Many of the residents live or work illegally and are not very interested in engaging with the authorities. Most of those living in the occupied areas are forced to consume highly contaminated water, even drinking directly from the irrigation hoses of the neighboring agricultural company (the company claims they use fertilizers). Many residents live directly above the tailings deposit, with air polluted by pesticide application and the heavy air pollution from a nearby smelter run by ENAMI.[11] Referring to the tailings, a resident Tomás (PB23) stated: "With all the problems I have, the last thing that interests me are those hills", summarizing the lack of priority placed on slow violence in a situation of extreme environmental injustice. It is no coincidence that the poorest of the poor often end up living in highly polluted places, such as on or around tailings (Ureta, 2022; Davis, 2006; Alexander & O'Hare, 2020), since they are the only "free" spaces in which to settle. Environmental injustice is also perceived by the inhabitants themselves: "We are what nobody wants to see" says another interviewee, Julian (PB22). The Pabellón neighborhood committee, which seeks dialogue with the authorities to solve the community's problems, tells of the indifference and impotence generated by the complete absence of the state at the local level.

Environmental injustice, the lack of social and economic resources and personal and political impotence are, therefore, according to the affected people themselves, central factors for the lack of their perception of risks and their environmental inaction. Nixon would agree when he states that "unseen poverty is compounded by the invisibility of the slow violence that permeates so many of their lives" (Nixon, 2011, p. 4). Those affected, and their problems, lie outside the realm of the visible and the existing; what Boaventura de Sousa Santos (2010) calls "abyssal thinking." Due to the large number of factors – material and social circumstances, and mostly unintentional daily, state and scientific practices that hinder knowledge, risk perception and collective environmental action, the generalized invisibility found in Pabellón becomes insuperable.

7. Inefficient production of scientific knowledge and the toxic institutionality behind it

Unlike the vast majority of cases on the first level of the (in-)visibility pyramid, in Pabellón the 1998 study mentioned above (Eberle, 1998) found such high concentrations of toxic substances that it was given top priority in the government's list of toxic mining tailings (Sernageomin, 2020) as well as in a mitigation program initiated in 2012 (Ministerio de Medio Ambiente 2012).[12] Over the last two decades, several additional scientific studies about pollutant concentrations have been carried out in Pabellón. Nevertheless, three factors reduced their public visibility:

1) the general problems of knowledge production about tailings,
2) a 'toxic institutionality', and
3) an intentional withholding of knowledge.

These three aspects will be discussed below. Knowledge production usually only takes place at the higher levels shown on the pyramid, when a certain level of public visibility leads to increased research into cases (usually from level three onwards).

Thinking with environmental historians and from science and technology studies (STS) shows the generalized uncertainty and a lack of knowledge inherent to scientific knowledge production about toxic substances in Pabellón, as well their effects in general and, above all, their cumulative long-term effects. In

[11] ENAMI stands for Empresa Nacional de Minería (National Mining Company) and the smelter in Paipote, near Pabellón is one of the most polluting in Chile.

[12] Regardless, the mitigation program never completely materialized and its results have largely not been published.

addition, there are consequences from the interactions between different components (Roberts & Langston, 2008; Wehling, 2006; Vogel, 2008; Nash, 2008). We can also observe 'lost' knowledge (Frickel, 2008), and a focus on the dose of toxic pollutants instead of the histories of cumulative exposure (Vogel, 2008). A belief in a (socially imposed) boundary between the pure and the contaminated, is expressed in regulations about maximum allowed concentrations of toxic chemicals and minerals (Roberts & Langston, 2008; Wehling, 2001, 2006). This literature confirms that scientific practice must also be understood as a social practice (Latour, 2000), susceptible to the influence of self-interest, not only be scientists but also funders of science. In the Chilean case scholars also found that a lack of standards and guidelines regarding tailings not only complicates the interpretation of the data but also hinders its comparability.

Figure 3: Temporary houses that are part of the land occupation on the Pabellón tailings. Photo: Author

Despite the existing knowledge on tailings in the three cases presented here, with several studies per case conducted by different scientific actors, almost all of them were affected by a toxic institutionality that prevented the exchange and dissemination of knowledge and information among the various government and academic institutions involved, generating a (scientific) vagueness and a generalized inaction.[13] This toxic institutionality leads, among other things, to what Pollitt (2000) has described as institutional amnesia, where state institutions, through personnel changes and other factors, keep "asking the same questions" without making progress. Studies don't consider previous ones, leading to repetition and waste. The lack of exchange

[13] For a detailed explanation of the concept of toxic institutionality see: Landherr (2024), p. 296, 441.

and distribution of information reached such a point where, for example, the Ministry of Housing unknowingly authorized the construction of social housing on mine tailings in Tierra Amarilla that were listed as highly contaminated in the Sernageomin (2022) register. Another example is that in the first years of research no authority, apart from the Municipality of Tierra Amarilla, was aware of the existence of a settlement at Pabellón, not even the Ministry of the Environment, which at that time had just taken samples at the place. This same toxic institutionality is also evident in the fact that in no case were the affected people informed about the contamination to which they were exposed, not even those who had submitted samples of fingernails, hair or blood that indicated high concentrations in their bodies. And although the extremely high pollutant levels found in Pabellón in 1998 by the BGR[14] and state authorities have since been confirmed in numerous investigations and have generated a recommendation of immediate evacuation every time (Eberle, 1998, p. 17), evacuations have not happened to date.

Finally, it was also possible to determine "intentionally produced agnoses" (Croissant 2014) in Pabellón. Some of the studies not only remained unpublished but were also untraceable in the state register. Jens Müller (PW02), a former employee of the BGR, explains in an interview that "The report was never published because the topic was too hot." Müller mentions the economic interests behind a potential reprocessing of the tailings and the high costs of restoration as the main reasons for this. The material invisibility of the pollutants and the slowness with which their effects are manifested, generated doubt (Nixon 2011, 41), which is also generated through the strategic holding back of technical or scientific knowledge (Allen 2008).

8. Territorial power, latent conflicts and the active generation of uncertainty in Tierra Amarilla

The second level of local visibility (see Figure 1) is reached once material invisibility has been overcome and a collective perception of risk has emerged among the affected population. All other factors remain the same, including the lack of access to scientific knowledge described above, so the local population tends to rely on other kinds of knowledge for their diagnosis. In none of the cases studied did scientific knowledge play a relevant role in the perception of risk or environmental action; it was rather the knowledge of those affected through their daily lives which allowed them to draw conclusions. Tierra Amarilla has been a mining town and is still surrounded by several active mining companies (and tailing dumps), including Candelaria, which is one of the biggest mining companies operating in Chile and part of the *Gran Minería del Cobre* (companies with an annual production of over 75,000 metric tons of refined blister copper). As can be seen in satellite images, the Candelaria tailings deposit covers an area larger than the entire town of Tierra Amarilla and over time has formed an artificial hill so large that it has closed the entire valley to the west of the town, even reducing the hours of sunshine in the area.

The results of the few government investigations on the distribution of pollutants to the surrounding area and population have never been published. Epidemiologist Valentina Castillo (FS04) from the regional offices of the Ministry of Health confirmed in an interview that an unpublished study found elevated levels of lead, arsenic, and mercury in schoolchildren (other elements were not examined). However, funding for follow-up studies is missing, she said. Due to the lack of access to official knowledge about the tailings the residents have relied on other sources of knowledge related to their professional experience in mining or their own health, to identify the tailings as a source of hazard. "If you ask around, everyone here has cancer. I'm 67 years old and was born here; I have everything you can imagine, including cancer, of course", Ester explains (TB07). Daniela (TB06), another resident, says:

> It's terrible. Look, I have five daughters, two of whom have chronic illnesses. (...) I barely let my girls out anymore because the air is too heavy. This morning, you could hardly breathe; the toxic dust was particularly bad. (…) Anyone who says mining isn't harmful certainly isn't from around here. I sent my daughter, who has such serious health problems, to La Serena for a year,

[14] The German "Bundesanstalt für Geowissenschaften und Rohstoffe." This German state institution and the Chilean Sernageomin (Servicio de Geología y Minería) had a long-term technical cooperation.

> and she wasn't ill once during her time there. She came back and immediately it started again; now she only manages with medication.

Unlike Pabellón, the inhabitants of Tierra Amarilla almost without exception name long lists of diseases that they associate directly with the tailing dumps.

In Tierra Amarilla, with the emergence of collective risk perception, local visibility began to predominate (see Figure 1). With this emerged the possibility of socio-environmental conflict, leading on the other hand to the active and intentional generation of uncertainty on the part of the "doubt producers", for example by actively withholding existing knowledge (Nixon, 2011). This differs from cases of general invisibility where the observed ignorance und uncertainty about the tailings resulted primarily from unintentional factors, that are mostly inherent to phenomena of slow violence. As with most active mines, only the company owns the scientific knowledge about the exact composition of these tailings. Neither state institutions nor residents have access to these data. In other cases, such as the enormous tunnel system (of underground mining) existing under the inhabited area of Tierra Amarilla, which repeatedly leads to collapses, there was an active production of uncertainty through incomplete and untruthful scientific knowledge in a study commissioned by the company (in collaboration with state authorities) to discredit the concerns of the residents. Ureta and Contreras (2020) found that the public-private study disregarded the potential risk of collapse as a "myth," but only two years later images of a 36 meter diameter sinkhole in a residential area went around the world.

During the severe flooding in the Copiapó Valley in 2015, independent scientists and NGOs showed that several of the valley's tailings had overflowed and resulted in heavy metal pollution in the surrounding area (especially in El Salado, Diego de Almagro and Tierra Amarilla). State authorities confirmed these results with their own study but classified them as harmless, eliciting objections from the public and the President of the Environmental Department of the Chilean Medical Association, Dr. Andrei Tchernitchin. In an interview with CNN Chile[15], the doctor speculated that the high cost of a necessary clean-up probably led to this denial. Otherwise, he could not explain such a negligent assessment, as even the results collected by the state itself were very alarming. These practices of "testimony against testimony" are particularly effective in cases of slow violence, since the same conditions and factors that make it difficult to perceive risk also make it difficult to prove or refute the results of scientific studies about these risks. State institutions are usually seen as the legitimate producers of "truth" in these cases.

Even if the local perception of risk persists in Tierra Amarilla, the population is confronted by Candelaria, one of the largest and most powerful mining companies in Chile, which (re)acts at the local level in ways that are aimed at preventing conflict, through persuasion and other means. The effectiveness of these actions by the company are increased because the state is largely absent at the local level, and the company has territorial power (Landherr & Graf, 2021). Candelaria's actions go beyond corporate social responsibility (CSR) or "good neighbor" policies and are based on control of crucial natural resources (water, land and mineral rights), infrastructure (roads, schools, medical centers, sports and cultural centers, local media), and the labor market, which keeps residents in a position of strong economic dependence and provokes conflicts of interest among them. This situation worsens as mining destroys local markets, expels other productive sectors such as agriculture (to gain access to water rights), and makes subsistence agriculture difficult due to contamination and a scarcity of resources, exacerbating the described dependency. In this way the company manages to keep the conflict latent and at the local level, without it reaching public visibility.

When conflict, and the socio-environmental conditions that generate it, threaten to attain public visibility, the company intervenes directly. This was the case in Tierra Amarilla in 2013, when the municipality sued Candelaria before the Environmental Court, and the company responded with actions ranging from compensation and individual hiring of leaders to the threat and bribery of activists and public authorities. In the end Candelaria managed to reverse the lawsuit, acquire environmental permits for the extension of its activities and "solved" the conflict in the eyes of the public.[16] The combination of unintended factors of the first level

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[15] For the complete television interview, see: CCN Chile (2015, April 9): Andrei Tchernitchin por nivel de metales en Atacama: "La exposición de los niños sí es muy grave" [Video].
YouTube https://www.youtube.com/watch?v=b_BVjz0Gzms [5/06/25].

[16] For the full story and sequence of events, see Landherr (2024): 338ss.

with territorial power, as well as the direct interventions by the company, make the emergence of a publicly perceived open conflict very unlikely. Instead of really resolving the conflict, however, it is kept latent at local level and thus invisible to Chilean society and even to social researchers.

9. The neg(oti)ation of truth in Chañaral

Despite the set of factors that hinder collective environmental action in the face of phenomena of *slow violence*, in some isolated cases of conflict do become manifest, achieving a (temporary) public visibility of the socio-environmental problems behind the mining tailings. This situation corresponds to the 3rd level of the analytical pyramid (Figure 1), and the case of Chañaral illustrates this process. Chañaral is a coastal community, originally a fishing town, which at the beginning of the 20th century was home to the most important port in the region. Over almost half a century 350 million tons of tailings, mostly produced by the state-owned company CODELCO, accumulated in the form of an "artificial beach" (Figure 4) that irreversibly destroyed the port. The visibility of the toxic material in this case occurred because of the visible accumulation of materials on the coast, and the serious economic repercussions for the city. This triggered a conflict and a successful lawsuit against the company in the late 1980s.

Figure 4: The Chañaral "beach", the result of the accumulation of 350 million tons of tailings. Photo: Author.

In Chañaral, as was briefly the case in Tierra Amarilla, the ascent to the third level of public visibility marked the formation of alliances by the affected population and the mining company with other actors at regional and national level. The two sides had very different power positions and resources. While those affected usually receive their support from local or national NGOs, other resistance movements or independent media and academics, the companies could fall back on a powerful business association (Consejo Minero) and the

national ownership class and their power. This gave them a strong influence over the media, politics and even scientific production (Fischer, 2011; Landherr & Graf, 2017).

From one moment to the next, there was a massive increase in the production of scientific knowledge in the framework of a "truth negotiation process." A long list of studies of various kinds were carried out, mainly measurements of chemicals and heavy metal levels in the soil and in the bodies of those affected and their health effects, as well as some social science and historical studies (Cortés, 2014; Vergara, 2011; Gonzáles, 2021;).[17] While most studies showed extremely high levels of pollutants, it was difficult to prove the exact link to the tailings in a mining region where the pollutants could be of other origins (a defense the mining companies always use). However, a pioneering study by Dr. Dante Cáceres at the University of Chile was able to prove that severe respiratory diseases in schoolchildren were a direct consequence of the nearby tailings (Cáceres 2016). This prompted a strong reaction from the mining industry and their allies. Dr. Cuevas (CE02), one of the scientists involved studies on the tailings in Chañaral, commented that he went "deep into the lion's den (...) it has been very difficult for me to get funding since then." In this context the mining companies offer scholars unbeatable funding offers in return for working under strict confidentiality and only publishing the results if they are in their interests. Laughing, Cuevas told us that he has not yet succumbed to the temptation and can still look at himself in the mirror in the morning. The affected population depends on the often-voluntary work of independent scientists who work under precarious conditions, who have difficulties obtaining research funding (and therefore don't have the possibility of carrying out extensive and costly research). But large mining companies finance entire research centers and universities, hiring scientists with important reputations to refute the results of independent scientists.

Although studies by Dr. Cáceres' and Dr. Tchernitchin on Chañaral received considerable media attention, there was no direct response from the state authorities. When asked, the head of the regional office of the Ministry of Health said that there was no cause for concern among the population, as not a single government study had identified these risks to date (González 2021). What he did not mention is that there has been no comprehensive study in Chañaral in more than 20 years. By not generating "valid" knowledge, the authorities are actively creating a knowledge gap and fomenting doubt. The strong predominance of concealing actions is especially evident in the way the company, and in the case of Chañaral also the state institutions, actively produce uncertainty and symbolic concealment and invisibility, as I detail below.

10. The brief moment of public recognition of the environmental disaster in Chañaral

Public recognition (the 4th level in the pyramid) of the socio-environmental problems caused by mining tailings is achieved in the few cases where those who are affected manage to successfully negotiate the truth. This may happen, as in the case of Chañaral, through a legal trial, or in other isolated cases through official recognition of an environmental sacrifice zone. In these processes, the affected population and their alliances usually face an adverse institutional framework and structural conditions biased against them. In Chile, these are designed to maintain the current extractivist economic system, a cornerstone of the economy, and thus to ensure the unhindered operation of the mining industry. This industry wants to directly and indirectly maintain the slow violence of the continued invisibility of the outcomes of extractive activities. In Chañaral, the legal trial did not lead to resolution for the local population. A partly absent, partly incomplete regulation allowed a new process of negotiation of the truth and symbolic invisibility to begin, similar to the one described by Kirsch (2014) in the case of the highly polluting Ok Tedi copper and gold mine in Papua New Guinea. In Chañaral the creation of symbolic invisibility ranged from the establishment of the Pan de Azúcar national park and various tourism projects to "reforestation" projects with the aim of mitigation. These proved to be little more than cosmetic actions.

The best example of the process was probably when on December 31 in 2003, then-President Ricardo Lagos swam in Chañaral Bay in front of running cameras, residents and local politicians. The images were broadcast throughout Chile, while news anchors commented that the beach was open for swimming again following a successful decontamination plan. The fact was concealed that such a decontamination plan never

[17] For the entire list of studies, see Landherr (2024), p. 381.

took place and that the beach was still a highly toxic storage site for industrial waste. The viewers had no idea that the paradisiacal colorfulness of the landscape was because it was an artificial "beach." Nor could they have guessed that for the next two decades the pollutants would continue to spread unnoticed to the surrounding area and the bodies of Chañaralinos, driving a large proportion of fishermen and divers into unemployment. Nor could they imagine that fifteen years later it would become public knowledge that their children's bodies contained extremely high levels of toxic chemicals and heavy metals.

The controversial presidential swim has become a symbol of the concealment of one of the country's biggest environmental scandals. Not only was the President's reach used to improve the public image of the national company CODELCO, but also to send an implicit suggestion of harmlessness based on trust in state institutions and the state as a legitimate producer of knowledge. In all three cases discussed in this article state inaction was understood as proof of harmlessness. As Bruno told us, "If there was a danger, the state would have done something about it long ago" (PB13). In this way, with no measures taken to mitigate or solve the contamination, the problem was solved in the eyes of the Chilean people and even the Chañaralinos themselves. The situation returned for a decade to the level of generalized invisibility, until a group of activists raised the issue again, the series of scientific studies discussed above reaffirmed the permanence of the high levels of contamination, and the devastating floods of 2015 brought the issue back into the media (see Cáceres, 2016; Cortés. 2014). However, despite the public attention, the contamination has never been officially confirmed by legitimate "truth generators" such as, in this case, the Chilean state institutions.

11. Conclusions and implications for the visibility of slow violence in the social sciences

There are four main results from this study.[18] First, the research found that the emergence of a manifest socio-environmental conflict is the only way to raise the visibility of dangerous pollution from mine tailings for an affected population. But at the same time, a manifest conflict is extremely unlikely in cases of slow violence, due to the multiple factors that favor the concealment of the problem, preventing collective action or keeping an existing conflict latent. Therefore, manifest conflict, which is a privileged object of social science research and political ecology, does not seem to be a reliable indicator for the identification of environmental problems, inequalities and injustices caused by tailings and other sources of slow violence. The lack of a manifest conflict does not necessarily imply the absence of a *latent* conflict nor the lack of local perceptions of risk on the part of those affected. But does indicate the impossibility of generating collective action. Therefore, it is necessary to find alternatives to manifest conflict as the main indicator for the definition or diagnosis of socio-environmental inequalities and environmental injustices related to materially invisible socio-environmental problems (Ureta *et al.* 2018; Auyero & Swistun 2008). Furthermore, the level of public presence of an issue does not correspond to the dimensions and seriousness of its current and future consequences.

Secondly, the study showed a generalized uncertainty among all the actors involved. While knowledge about existing hazardous substances was indeed crucial for the emergence of risk perception, in none of the cases was it triggered by scientific knowledge. When it came to scientific knowledge production there was a widespread toxic institutionality and a high degree of scientific ignorance (Wehling, 2006) regarding the effects and interactions of the different toxic components of tailings, leading to a tendency to underestimate the possible cumulative effects. This was the case for the recommendations of scientific studies, and in existing regulations. The material invisibility of toxic substances and the generalized uncertainty make "the truth" negotiable and more prone to manipulation than in the case of more visible environmental disasters. In order for these specificities to be considered in political ecology research on socioecological inequalities, it is necessary to incorporate studies and literature from other schools and disciplines – such as environmental history, the sociology of (non)knowledge and ignorance, and STS – that have studied some of these factors in depth. However, I also showed that political ecology remains central to understanding slow violence phenomena. While the wider literature has in part studied the unintentional factors that are specific to slow violence phenomena and to the generation of scientific knowledge about them, most of those approaches do not analyze

[18] For a comprehensive presentation of the entire results of the study, again see Landherr (2024), which particularly addresses the interplay between ignorance, invisibility and inaction, as well as the relevance of the power relations between the actors.

the relevance of intentional factors, the agency or the power relations and asymmetries between actors which allow them to impose their interests in terms of management and visibility of tailings, nor the effects that socio-environmental inequalities have on the possibilities of action of the different actors. The latter were proven to be of great relevance, for example, during the process of negotiating "the truth." At the same time, a political ecology perspective should pay more attention to the repercussions of the unintentional factors on the intentional ones, and the possibilities of action and thus the possibilities for resistance by affected population.

Thirdly, the research showed that the three case studies are cases of (extreme) environmental injustice, and that the majority of those affected are socially invisible. They do not have the social, material and time resources to make their problems visible. These inequalities keep them (and their problems) invisible at the societal level, because their condition of environmental injustice is precisely the cause of their absence within social science and even within political ecology. Following an argument of Auyero and Swistun (2008), by focusing almost exclusively on cases of manifest conflicts and on the environmental action of those affected, we run the risk of leaving out those social groups that, due to their economic and social situation, are unable to achieve collective action or make their conflicts manifest.

Above all, research on cases of the 1st and 2nd level of invisibility of the pyramid (Figure 1) is very scarce, and thus most Chilean mining tailings are left unstudied. In cases of slow violence, the impossibility of overcoming material invisibility and the lack of access to existing scientific knowledge affects these groups in a special way. Generalized toxic uncertainty (Auyero & Swistun 2008) – and in cases of a clear perception of risk, the toxic frustration generated by the experience and the feeling of powerlessness of those affected (Singer 2011) – are determining factors to understand the tendency towards environmental inaction in these cases. Environmental disasters that do not present themselves as such, but occur gradually and slowly, also do not interrupt daily life, leading to the normalization of their consequences (Auyero & Swistun 2008). Once material invisibility is overcome, the most determining factor for effective collective environmental action seems to be an increase in the power of those affected and their allies, relative to the power of the responsible corporation, especially when it comes to knowledge production and the negotiation of the truth about the tailings and their effects.

Finally, it became evident that the (in)visibility of tailings is not a state, but the result of a process (Figure 1). Invisibility is not only perpetuated in its current manifestation but is also actively (re)produced by the (in)action of the actors involved through power struggles contested over the (in)visibility of the problem itself, making visibility/invisibility central to political ecology. Once again, knowledge production and management play a key role in the active production of (in)visibility. Only by considering unintentional and intentional factors, existing power relations and domination, as well as the institutional and structural framework at the national and international levels, can we truly understand the (in)visibility of mine tailings. In this respect, the (in)visibility pyramid can be understood as a tool – expandable as needed – for identifying the factors and actors involved in each level of (in)visibility. In the spirit of a sociology of emergence (de Sousa Santos 2010), tailings and other slow violence phenomena can therefore be identified as the cause of socio-ecological inequalities and latent conflicts that are often invisible to society and the social sciences. These can be made visible and operationalized as a research object, even if they have not yet resulted in a manifest conflict.

By creating this overall picture of the (in)visibility of tailings, the greater relevance of the lower two levels of the pyramid, which have barely been investigated to date, helps us to understand the complex interaction of (non-)knowledge and the (in)action of the actors involved within the individual levels of (in)visibility as well as their influence on the social invisibility of the problem. At the same time, the connecting points of theories and explanatory approaches that have so far been largely considered separately from each other are shown, thus allowing a better embedding of micro- and macro- sociological research on the topic and the merging of their results.

The relevance of the present research becomes clear if tailings are not understood as isolated environmental problems, but rather as an inherent part of the capitalist world system (Wallerstein 1986), the global social metabolism (Martinez-Alier & Walter 2015; Fischer-Kowalski 1997) and in their quantity. An estimated 282.5 billion tons of accumulated toxic material exists worldwide and around 12.3 km^3 of new

material is added annually.[19] This a global problem that is almost non-existent in hegemonic knowledge production and whose invisibility is currently also co-produced by the social sciences. By systematically studying the cases presented and the existing research on tailings in Chile, I have attempted to offer a heuristic draft and a conceptual model for overcoming this social and sociological invisibility. This requires not only more technical knowledge about tailings disposal sites and their composition, but also overcoming the abyssal thinking (de Sousa Santos 2010) in which political ecology is also partially trapped.

A social science committed to the visibility of socio-environmental inequalities and those affected by them must place special emphasis on making those cases visible which, due to material and social conditions, are particularly difficult for those affected to make visible themselves. This will assist those who are currently affected by multiple socio-ecological inequalities and who must assert themselves at the local level against powerful actors such as transnational corporations and their strategies for appeasing conflicts. As the article has shown, knowledge production, management and dissemination play a central role in this process and, especially in the case of materially invisible slow violence phenomena, are a central mechanism for asserting the interests of the respective parties. In the case of invisible environmental problems, knowledge becomes the central resource that enables or hinders resistance. Otherwise, the existing environmental injustice usually reinforces itself, as "the invisible" and is not investigated. Without this work, those affected cannot prove and render visible any negative impacts with socially legitimate sources of knowledge.

The lack of research on cases of slow violence means it is important in the current ecological crisis, and urges us to catch up. In the case of mine tailings in Chile, the growing demand for copper caused by energy transitions means that tailings are expected to increase significantly in the coming years. Taking the current ecological crisis seriously requires questioning the massive extraction of materials and substances with unpredictable consequences (Wehling, 2006). The latest environmental governance based on ignorance can be transformed into something like a "policy of weakness" (Ureta, 2022), which recognizes our dependence on multiple ecological processes that we fail to fully understand, requiring a preventive and respectful attitude very similar to what ecofeminists have proposed through a subsistence perspective (Mies & Shiva, 2016).

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