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Prince Claus Chair holder Professor Sebastián Ureta

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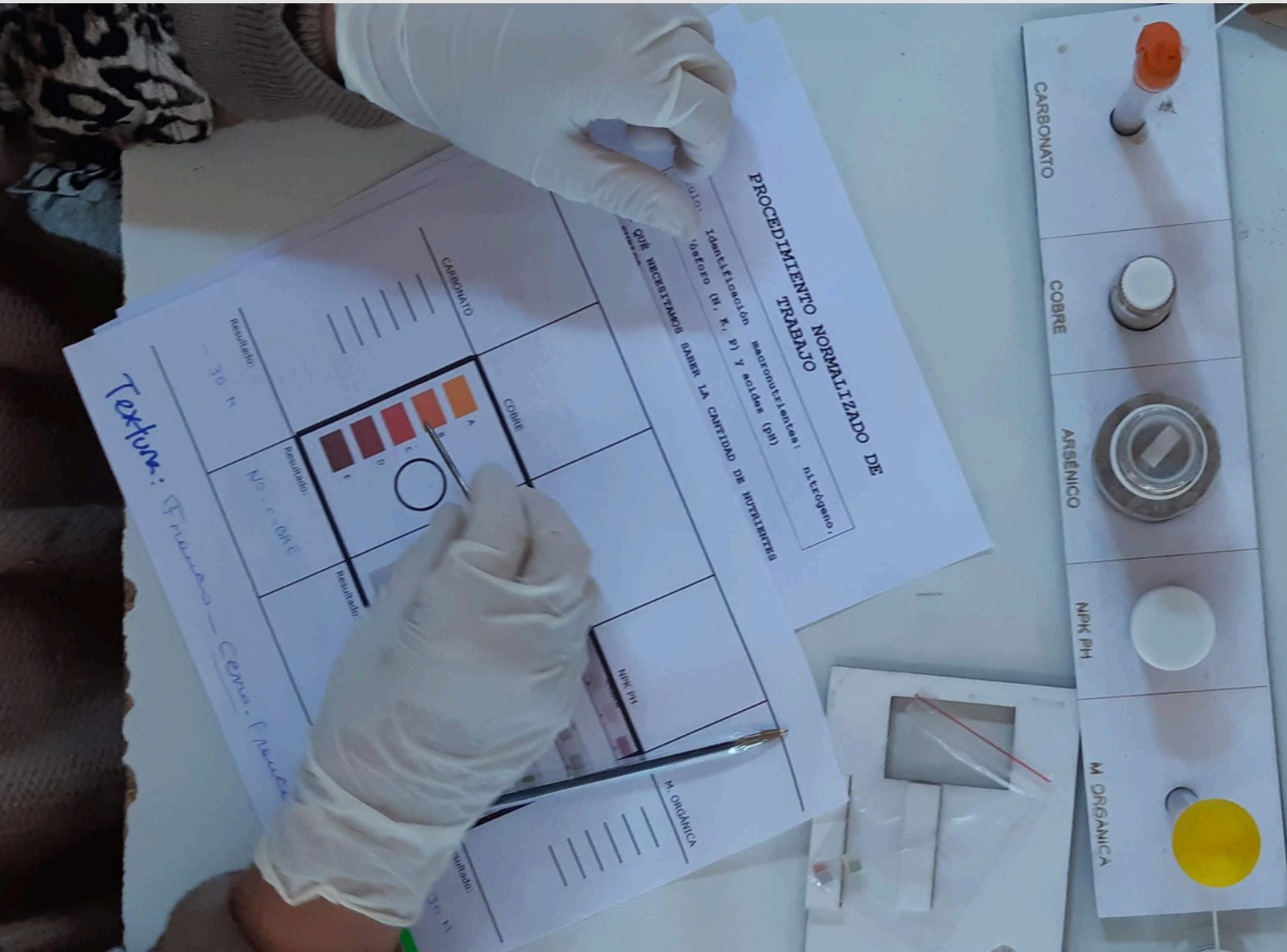
Beyond co-creation: Sketching a critical citizen science for a world on fire



Beyond Co-creation: Sketching a Critical Citizen Science for a World on Fire

Sebastián Ureta
College UC & Instituto para el Desarrollo Sustentable
Universidad Católica de Chile

Abstract

In recent years, citizen science (CS) has been widely recognized as a leading way to bring the production of scientific knowledge closer to citizens and communities, increasing social engagement with science while democratizing scientific practice. This positive assessment has led to the development of a wide range of CS initiatives worldwide, especially regarding environmental matters. This popularity, however, has not been without controversy. A growing number of researchers have argued that it is not uncommon for CS initiatives to end up generating effects directly contrary to those predicted. Instead of promoting a real rapprochement between scientists and the public, CS initiatives end up considering the citizenry mostly as cheap labor, refusing to acknowledge any epistemic value on them, and frequently indoctrinating them about the qualities of the status quo, both epistemic and socioenvironmental. Based on a CS project related to soil pollution carried out in Chile in the last decade, on this inaugural I will argue about the urgent need to develop a critical citizen science for engaging with a world in fire. Motivated by principles of social and epistemic justice, critical CS will start by acknowledging inequality and violence as framework components of any participative intervention in science. Discarding the usual aim of producing cheap data and social acceptance, these projects should aim at turning science and technology into powerful tools for ongoing struggles for socioenvironmental justice in fragmented worlds. Instead of naïvely celebrating the power of science, critical CS would be challenging and fractious, never shying away from controversy, but with higher chances of making real impacts in the lives of human and nonhuman populations in need.

Keywords: Citizen science, policy instruments, matters of concern, epistemic strategic actions, soil pollution regulation, Chile

Introduction

Smiling faces, lots of smiling faces. Smiling children, smiling senior citizens, smiling scientists, smiling public officials. Even cute smiling emojis of pipettes and other usually dour scientific equipment. This is what you get when you google images associated with the word “citizen science”. Lots and lots of smiling faces.

I loathe those smiling faces. Not only because I'm a grumpy middle-aged man (as my family here present could well testify). But also, because there is something slightly disconcerting about such open displays of joy associated with the practice of science. As probably many in the audience know, the practice of science is associated with many joys, for sure. And requires no little amount of humor, especially in these not-so-well-funded times. But joy and humor are not the same as smiling faces. Because the practice of science is also quite tough, demanding, frequently boring, and even depressing at times. You can characterize science using many images, but one with smiling faces would quite probably be not one of them.

Why has such an image become so popular when representing citizen science? Well maybe because practicing citizen science is fun. You are invited through colorful banners and flyers. The organizers are an enthusiastic bunch. Its methods and technologies are designed to be attractive and easy to use. You are asked to perform weird and entertaining tasks. The results are presented in joyful ceremonies. You just end up feeling so good about yourself and your fellow citizen scientists that smiling should not be such a strange reaction. After all, you are breaking the barriers separating scientists from citizens, "co-constructing" a science that is more democratic and open (Eckhardt et al. 2021), adopting the term in fashion to describe such encounters.

The problem is that beyond the practicalities of each project, there is very little to smile about, at least regarding projects centered on socioenvironmental issues. Despite decades of sustained action by scientific institutions, NGOs, local communities, and individuals throughout the world, most records show that environmental degradation is only getting worse, or not changing fast enough to avoid the worst scenarios of extensive damage and ultimately extinction. And the distribution of such degradation is highly unequal. While some groups still enjoy largely unchanged environments, even benefit from some little climate change, many others suffer its worst consequences, especially groups already affected by multiple forms of inequality and violence. As Greta Thunberg affirmed a few years back, our world is certainly "on fire".

How shall we read these smiling faces in this scenario? From a critical perspective, we could use them to simply dismiss citizen science as an irrelevant distraction. More than co-constructing a more democratic science, many authors argue that citizen science has mostly contributed to maintaining the status quo regarding the social standing of science. At best, citizen science has contributed to a Disneyfication of science – all fun, no effort – that masks a milder kind of scientific extractivism (Millar, Melles, and Rinner 2023) and public relations (Blacker, Kimura, and Kinchy 2021). At worst, citizen science can be seen as a tool for depolitization (Polleri 2019) and the stabilization of neoliberal regimes of knowledge governance (Vohland, Weißpflug, and Pettibone 2019). Against its stated aim of democratizing science, "citizen science can also be used to redirect attention away from actions that address inequalities and to reinforce modes of knowledge production that exclude alternative ways of knowing relevant to those without social power" (Lewenstein 2022, 183). Should these arguments lead us to conclude, as Philip Mirowski (2017) did a couple of years back, that citizen science "is little more than a cheap land-grab by big business"?

I don't think so. On the contrary, I am convinced that citizen science is critical to our troubling times. Behind its sunny, yet vacuous, current façade lies a massive potential to transform knowledge production into a force of socioenvironmental justice and planetary healing. To do so, though, we need to radically transform it. We need to leave aside simplistic notions of citizen science as a straightforward and well-willed process of co-constructing knowledge between experts and citizens. To leave aside the smiling faces for the nasty business of engaging with the violence of a world on fire.

To explore the contours that such an alternative conception of citizen science could take, on this inaugural, I will dwell on my own experiences when developing a citizen science project focused on creating a low-cost toolkit for assessing soil pollution in Chile. So far, this project has passed through three stages, each one of them associated with attempts at turning citizen science into a tool for environmental justice. As the next sections will exemplify, each stage faced different challenges and ended up producing contrasting results.

Citizen science as a policy instrument

Among the most harrowing situations emerging from the earthquake that affected central Chile in February 2010 was the story of the Galvez Chamorro family. Following most accounts, they lived a fairly pleasant life, taking care of housekeeping duties for the wealthy owners of a large farm some 300 kilometers south of Santiago. This situation changed radically on the night of February 27th, when a powerful earthquake struck the country. Unknown to the Galvez Chamorro —or the landowners—one hundred meters above their house lay an abandoned reservoir holding a large amount of waste from a closed-down gold mine. Given its lack of maintenance, the earthquake caused a massive spill of semi-liquid waste, that flowed down the hill at great speed and completely covered the Galvez Chamorro house in a matter of seconds, causing the death by drowning of the couple and their two young daughters (for a more detailed account see Ureta 2022).

The terrible fate of the Galvez Chamorro caused a public outcry, forcing the authorities to start dealing with the issue of abandoned mining waste after decades of inaction. Finally, in 2012 the Ministry for the Environment (MMA) published a guide establishing a procedure to identify and remediate soils polluted by industrial activity, following the risk assessment model established by the US Environmental Protection Agency (MMA, CORFO, and Fundación Chile 2012). This guide started to be applied for the very first time in 2013, focusing on the Atacama Region, an area in northern Chile with the highest national concentration of abandoned mining waste dumps. In charge of running this first implementation, the Ministry selected the Centro Nacional del Medio Ambiente (CENMA), an environmental science lab with extensive experience in running environmental assessment exercises.

At the time, I was starting a project focused on studying the governance of mining waste in Chile. In this capacity, I approached the head of the environmental chemistry lab at CENMA to explore the possibility of following ethnographically the implementation of the MMA guide. To

my utter surprise, she agreed to my request. Adopting a science and technology studies (STS) conceptual lens, I planned to identify and analyze the main barriers these scientists found in translating the mandates of the guide to the concrete regulation of soil pollution in Chilean locations. In doing so, I imagined occupying the usual position of a non-participant observer, a cordial but detached witness of technical work. Such an assumption was rapidly changed.

As I explore in my paper "Ruination Science" (Ureta 2021), CENMA was an institution that made detachment very difficult. Most of its technical personnel were extremely friendly and welcoming. Also, the lab has been experiencing important budget cuts for a while, facing many challenges in recruiting personnel or even running experiments. Consequently, my lukewarm offer to help with simple procedures was rapidly accepted. From the first field trip to collect samples to the Atacama Region in September 2013, I became a stable member of the research team, someone with whom to share a joke or, more importantly, to assign simple research tasks, from labeling soil samples to cleaning vials.

This unexpected closeness with the research process allowed me to obtain an intimate picture of the travails and barriers involved in applying the ministry's guide, knowledge that – later – I was able to translate onto several academic papers. In parallel, I developed no little degree of emotional and ethical attachment to the entities involved, from an admiration for the commitment CENMA personnel showed under important duress to a concern about the inhabitants of the areas we were evaluating, unknowingly living in proximity with highly toxic waste. Academic publications criticizing this situation were a way to respond to such concerns (for example Ureta, Mondaca, and Landherr 2018). But only one way, and possibly not the more effective one. Critique for critique's sake appeared to me as increasingly meaningless.

And then, again unexpectedly, I had the chance to explore an alternative way of affecting this issue. The third, and last, phase of the application of the MMA guide included carrying out a process of "risk communication" with the local population of the sites CENMA was studying. Given that CENMA was formed only by people with natural science backgrounds, this demand was somewhat mystifying for them. But they suddenly remember that this weirdo who has been helping them clean vials was a sociologist, hence supposedly an expert on all things related to society. So, the lab administrator asked me whether I would like to take charge of communicating the results of the assessment to local communities. At first, I was reluctant. I had some previous experience with community engagement, but I knew almost nothing about risk communication. But after agreeing with her that I could hire someone with expertise on these matters – and that I was free to register and write about the process – I became the "Coordinador social" (social coordinator) for the third phase of the project.

After setting up a small research team – comprised of a journalist with an MA in Risk Communication, a sociologist, and an anthropologist – we started to work on designing a risk communication strategy for the areas under study. Our first task was to review what the MMA guide said about the matter, rapidly agreeing that such a section was grossly undeveloped. On a document of more than 110 pages, the section on risk communication only occupied half a

page. Based on a single source – a working draft made by personnel of the Ministry for the Environment of Argentina – it states that,

> "The main objective of risk communication is generating a communication environment based on trust and credibility, which allows the community to have access to adequate information regarding the environmental situation in question, providing elements of judgment, so that those involved can take a reflective and collaborative position on the situation in question. Thus, at this stage, it is necessary to inform and clarify at least the dangers of the contamination situation, the probability of its occurrence, and the foreseeable consequences or damages, if such or such situations materialize." (p. 93).

In a document, I wrote analyzing this issue in June 2016 (Ureta 2016), and in line with most contemporary literature on risk communication (especially Lundgren and McMakin 2013), we argued that these objectives will be difficult to achieve if the risk communication model implemented is based solely on the unilateral communication of information by experts to the affected community, especially if this is done at the end of the research process. As we explained, since the mid-1990s, the concept of risk communication has been importantly reshuffled, giving space to more complex models of interaction between authorities, experts, and the public, especially in processes carried out in areas affected by environmental contamination. Leaving aside the traditional "deficit model" in science communication – the one that supposed that community members act irrationally because they lack relevant knowledge about the topic at hand – this interaction should aim at valuing and including multiple kinds of knowledge, especially the one carried by the community members, usually ignored in traditional processes of science communication. Such interaction, we affirmed, would be materialized through the inclusion of non-experts in all research stages.

Taking inspiration from STS literature on public engagement with science, we argued that worldwide citizen science has emerged as a central way for risk communication to move towards including local forms of knowledge. In doing so we simply adopted the definition from the Oxford English Dictionary (2016), affirming that citizen science can be understood as the "scientific work carried out by members of the general public, usually in collaboration with or under the direction of professional scientists and scientific institutions". We then claimed that the incorporation of citizen science into risk communication strategies had a series of advantages, such as allowing for better targeting of studies, generating stronger links between communities, experts, and authorities, increasing levels of social participation, allowing studies to continue over time and reducing costs, etc. To make our point more forcefully we even affirmed, without providing any reference, that "it is currently difficult to find any environmental regulatory body in developed countries that does not recognize (and incorporate) in risk communication … multiple variants of citizen science" (Ureta 2016, 3).

Inspired by the hype – even the romance - surrounding the term, we presented citizen science as an almost magical solution to the democratic deficits of risk communication and, more generally, of environmental risk assessment. In doing so we were conceiving citizen science mostly as what Lascoumes and Le Gales (2007) have called "policy instruments", or "a device that is both technical and social, that organizes specific social relations between the state and

those it is addressed to, according to the representations and meanings it carries" (p. 4). Citizen science was turned into a tool for government, hoping to reorganize the relationship between the regulatory techno-scientific apparatus and the citizenry towards more equality and democracy. Seduced by the ethos of equality and openness permeating most CS narratives, we were quite hopeful regarding its potential for reversing the top-down and technocratic approach of the MMA guide. In our naivete, we saw it as an instrument capable of rapidly democratizing pollution assessment, for good.

Following this, we proposed that,

> …risk communication … should not be reduced to a one-sided event for information distribution at the end of the study but should be transformed into a process that promotes continuous exchange between experts, authorities, and communities, with a strong emphasis on the active participation of the latter. We believe that successful risk communication should be based on a strategy that combines (1) the promotion of a culture of continuous information exchange between consultants, authorities, and local communities and (2) the application of some citizen science tools. This strategy will promote trust between the different stakeholders, and help to manage the expectations of participants and stakeholders, thus avoiding misinformation and speculation about the outcomes of the process, as well as increasing the impact of the project at the local community level (Ureta 2016, 4).

After some initial apprehensions, our partners at CENMA largely accepted this framing and we started sketching the actual procedures to be included in the risk communication strategy. Instead of a singular event presenting a summary of the results to the community, we proposed three different sets of activities, to be held in subsequent days.

The first one was a project launch, defined as seeking "to present the objectives of the study, its scope and limitations, with the ultimate objective of (1) managing expectations and (2) generating confidence among the different stakeholders" (Ureta et al., personal document, p.2). Although quite like a conventional project launch, the idea here was to also leave space for collecting the notions and apprehensions of the local community regarding soil pollution. The second, and by far the most innovative one, was an activity we called "collaborative sampling" whose explicit objective was to "incorporate a group of inhabitants in the process of knowledge production" (Ibid., p.2). With this aim in mind, we aimed to invite a limited group of residents from the three localities to accompany and collaborate with the recollection of samples of soil and dust. Following the principles of CS, this invitation had the triple aim of (1) "build trust and communication links between expert consultants and community members", (2) "making community members aware of the rationale behind the sampling" and (3) "to scientifically train community members" (Ibid., p.2). Finally, the initiative will include a presentation and analysis of the results, aimed at generating "a platform in which community members, authorities and experts can discuss on an equal footing the results of the study and its potential projections over time" (Ibid., p.2). From passive recipients of pre-packaged results, this framing aimed at transforming community members into active participants in the knowledge-production process.

Although it was a limited form of CS, as the local participants would be involved solely in one stage of the process (and not the more important), such change in their position could prove seismic regarding the modes of involving community members in environmental policy. More than local community members, its main public were our counterparts at the MMA and regulatory science in general. We expected to show them how things could be done differently regarding citizen engagement, hopefully kickstarting democratization through instruments such as the guide.

After some internal discussion, we agreed to carry out these activities for four days in early August 2016. With this aim in mind, preparations were carried out, including designing an invitation as could be seen in image 1.

Image 1. Invitation to the risk communication activities

Source: the author

This invitation, however, was the closest this activity was to being carried out.

On August 2, 2016, we received an email from Cecilia Aburto, our main counterpart at the MMA, reacting to the final proposal for the risk communication activities that we had sent her some days prior. Right after some cursory greetings, she stated "I would like to convey our apprehensions about the submitted documents. Unfortunately, we believe that you still do not fully understand what we want regarding risk communication". After this, she explained in more than three pages dozens of objections to our proposal, both in terms of structure and contents.

At the very center of her concerns was the matter of CS, especially regarding its possible impacts on their participants. As she explained,

> "…the central idea of risk communication should not be focused on "integrating their [neighbors] needs and concerns", it is designed in this study to disseminate and convey to the interested community the results of the study in a way that is accessible and understandable to the public. … The

> technical and administrative call for tenders of this study states [that] "…there is a need to reduce the existing information gaps associated with the risk to which this community is exposed, information that will also allow adequate decision making oriented to the management of soils with potential presence of contaminants".

Directly opposing our notions about the need to integrate locals into knowledge production, Aburto returns to an utterly traditional "deficit model" in which the local community has certain "information gaps" that are necessary to overcome by simply presenting them the results of the study in a way that is "accessible and understandable". After a further round of meetings, we gave in to her demands and dropped any element of CS from our risk communication strategy. In insight, it is easy to conclude that we were quite naïve, even deterministic, expecting that the sheer wonder of citizen science would automatically convince the technical actors demanding the study.

Finally, in December 2016 we presented a new strategy for risk communication stating that its objective was to "communicate to relevant audiences the results of the study … and promote a collaborative environment that would allow generating mutual bonds of trust, increasing the effectiveness and social relevance of the project". This plan identified three kinds of local public: authorities, community, and the media. To each one of them, a particular communications strategy was proposed, all of them based on making events in which a summary of the study's results would be conveyed in simplified form. All the elements of CS that we have been discussing so far were removed from the proposal.

Even this watered-down proposal of citizen engagement has proven to be too much. When late in December 2016, the head of the study at CENMA presented it to local authorities in the Atacama Region, things did not go as expected, as recalled by Solange Aguilera, the local representative of the MMA.

> "…we [MMA] went with CENMA to present it ... and it was the governor who said that "meanwhile no", because he had ... some apprehensions about the fact that he could be sued because the oldest population had lived for more than 20 years [near the waste and the government has done nothing] and [he feared] that they could sue the State, more than anything else, he was the one who said "no, for the moment let's leave it there" ... I remember that the governor was quite emphatic about this, "no way!" ... that's why we had to freeze that part".

The years before this project have witnessed an almost constant stream of social movements focused on environmental issues in Chile. Some of the more conflictive ones have been based on the Atacama Region, such as the opposition to the construction of a thermoelectric power station in Punta de Choros or the closure of a pork processing plant in Freirina. In both cases, local communities managed to cancel large private investments that were openly supported by regional authorities. Given these antecedents, the regional governor emphatically prohibited to implementation of any kind of citizen communication regarding the results of

the study, out of fear that it could kickstart a new protest cycle[1]. Our proposal for risk communication was shelved for good.

The final report on the application of the MMA guide in the Atacama region was delivered in February 2017 (CENMA 2017). It states that the population living near the three sites under study, especially children, were exposed the "unacceptable chronic risks" due to the high concentration of pollutants. Given such risks, the report states clearly that an action plan needed to be carried out urgently, including the removal of the waste and the remediation of its environs. To our current knowledge, no measure of this action plan has ever been implemented. The people living beside this toxic waste have not even heard about the study or its results[2].

Citizen science as a device for creating matters of concern

"*What more can I do?*" This was the question that rounded my mind in the months after delivering the final report of the CENMA consultancy. As time passed and no action whatsoever was implemented, it just grew louder and louder in my head. I just couldn't leave it like that, just another failure of regulatory science in a global south country to write nice papers about. I have been there. I have seen people living right above smelter waste, and children playing football on a field made of toxic mining waste. I felt that I had a moral duty to do something else, to try to shake things up a bit.

One possible path I considered would be to act as a whistleblower and send the final report undercover to someone in the local media. Or to pass it directly to the local neighbors' association, for them to start demanding a public intervention on the matter. That would have been quite simple to do, as simple as sending an email. But I just couldn't do it. For starters, I was afraid of the reaction that such an act could cause, how I could become involved in a public controversy, something completely at odds with my normal disposition to remain under the radar. I wasn't born an activist.

Besides, I believed that I had other paths to take and other ways to intervene. Paths that could be quite effective and would not force me to (completely) leave my academic comfort zone. This path was, you might have guessed by now, citizen science. I still believe that citizen science could make a difference regarding soil pollution and its regulation. This second time,

[1] The funny thing is that we have expected such a reaction. On the final proposal for the risk communication strategy, we acknowledged that due to "the notorious climate of social conflict in the country, especially in relation to environmental issues… [local authorities might fear that] the communication of the results of this study to the public could generate some form of social opposition movement". Despite these concerns, no specific strategy was designed to deal with such possible opposition. As usually happen to scientists when dealing with political powers (Ureta et al. 2023), we were in a weak bargaining position, but we were too naïve to realize it until it was too late.

[2] On this regard, and as a veiled protest, we stated that "the people in the community have no information about the study, nor do they have any degree of familiarity with the methodology and the concepts that allow them to understand the results of the study. So far, no risk communication actions have been carried out with them" (p. 34).

however, we should proceed differently, discarding the attempt at simply turning it into just another policy instrument. Instead, citizen science should be seen as a component of larger fights for environmental justice.

From Louisiana's "Bucket Brigades" (Ottinger 2010) to the "Ciencia digna" (Feeney-McCandless 2017) movement in Argentina, there were many examples of scientists and communities working for equality in producing scientific knowledge who were making a difference. Topically, the project "Gardenroots" led by Monica Ramirez-Andreotta (2015) since 2008 had been highly effective in turning soil pollution into a matter of concern and action by small landowners in Arizona and northern Mexico.

This potential of citizen science to empower communities in need has been heightened in the last decade by the emergence of multiple movements aiming at producing low-cost open-hardware environmental science methods and technologies. Usually aiming at operating on a do-it-yourself (DIY) format, these technologies greatly expand the affordability and complexity of citizen-led knowledge production. Citizen science and open-hardware technologies combined could truly create what Valerie Tousignant (2018) has called "scientific capacity", or the actual capacity of community members to produce and use scientific knowledge for their aims in a relatively autonomous way. Through them, the emphasis of these initiatives moves from the production of data to the creation of proper epistemic communities.

Following these examples, I started to conceive a new way to use citizen science regarding soil pollution in Chile. Adapting from Latour (2004), my new aim was to use citizen science as a tool for turning soil pollution from a "matter of fact" – a technical issue that solely expert entities such as the MMA or CENMA have to deal with – into a "matter of concern" – something that causes a personal experience, demanding communal forms of engagement. More than merely producing data, citizen science should aim at producing a particular way of representing soil pollution as a public issue.

After several months of considering different options, I finally knew how to proceed. As I wrote in a draft made in December 2017, my new aim would be to "hack" environmental regulation, "generating a new version" of the MMA guide. This alternative version of the guide will be created following several key principles:

- A change of users, from experts and public officials to the communities that live in the [polluted] sites.
- To incorporate citizen science principles to facilitate broad participation by people without advanced scientific training, who will have equal relevance to scientific participants.
- To give equal relevance to the diagnosis and remediation on the sites under analysis.
- To produce both results of (some) technical value as well as an informed and empowered public who understand and use them.
- To be conceived as an open instrument for public use, always perfectible and adaptable, without "final versions".

These principles were a reaction to the problems we had faced in the previous phase of the project. First, there was a focus on a new kind of user, from experts to the very communities living in potentially polluted sites. Then there was the explicit reference to citizen science, seeing it as a tool for public engagement. Thirdly, and probably more importantly, there was the dual focus on producing both data and an "empowered public" who can understand and use it, not only in making diagnoses but also in enacting or demanding remediation. The overall reasoning was that if the MMA guide could not be made more democratic, a new guide was needed.

Derived from such principles, early in 2018 the project "Nuestros Suelos" (NS) emerged. Its originally stated aims were "to generate an alternative way to assess and remediate soils polluted by mining activity, based on both citizen-led methodologies and open hardware technologies". A key principle behind it was "the belief that the lack of citizen-led methodologies and open hardware technologies for soil pollution assessment is not a matter of technical, social and/or financial impossibility, but is only derived that no one has thought about developing them so far". It was, hence, a rather idealistic argument about the political possibilities of imagination, of thinking things anew regarding soil pollution assessment.

As stated in the above principles, one key difference with the MMA guide was that NS was thought as not only centered on assessment but also on remediation. Assessment, on the one hand, was thought about as based on designing and implementing different methodologies and tools that would allow communities to establish the likelihood presence of several pollutants of concern (mainly lead, arsenic, and copper). Besides initial training, it was expected that in the long run, they were going to use these devices largely autonomously. Remediation, on the other hand, would be centered on the design of citizen-led methodologies and techniques for local soil remediation. These devices were not only focused on directly intervening local soils (such as, for example, by introducing new farming practices). In parallel remediation could involve "setting a strategy of political mobilization based on the data collected (to force the authorities to act on the matter)". Hence, remediation was thought of as both material and political, involving intervening polluted soils but also the sociopolitical arrangements that made possible the existence and maintenance of such pollution in the first place. More than offering a cheap methodology for assessing pollution, from the very beginning NS looked to enact a "critical citizen science which, motivated by principles of social justice, seeks to put science at the service of the citizenry to allow them to understand the importance of science as a tool for social justice", as explained in an abstract from mid-2018.

After putting together an interdisciplinary research team[3], in June 2018 the design phase started for good (for an extensive description of the process see Ureta et al. 2022). Despite initial intentions of working in an interconnected fashion, in practice, two work groups

[3] The main team of the first phase of Nuestros Suelos was Sebastián Ureta, Miriam Llona, Delia Rodríguez-Oroz, Daniel Valenzuela, Carolina Trujillo-Espinoza, Consuelo Guiñez, Alejandro Rebolledo, María José Maiza, and Camilo Rodríguez Beltrán.

emerged. The first one, composed of engineers, geologists, and designers, focused on developing kits based on chemical reactions for assessing three key heavy metals extensively present in Chilean soils: lead, mercury, and copper (image 2). The second, formed by sociologists and geographers, was mainly centered on designing two complementary sections of the methodology, a module for the systematization and analysis of the main territorial, historical, and practical dynamics of the soils under study and a final module for the compilation and evaluation of the information collected through the different steps of the initiative. It was going to be on these last two modules where the critical notions of our methodology would be concentrated. After several months of development and lab-based testing, by the end of the year, we had the prototypes of the whole methodology.

Image 2. The prototype of the NS toolkit

Source: the author

By mid 2019 we felt that it was time to do a proper test of the whole NS methodology. To do so we contacted a cooperative of small farmers based in the village of San Pedro, some 15 kilometers west of the city of Copiapó in the Atacama Region. After they agreed to participate, a training workshop was carried out for two days in June 2019. We had 9 participants, evenly paired between men and women, all with a history of intense relationships with soils through agriculture.

The workshop started with a session of participatory mapping, to locate the soil samples we were meant to analyze into a particular territory. During this activity, it was surprising to us how difficult was for the participants to talk about soil.

> In general, it is noticeable that it is quite difficult for people to talk directly about their practices with soil, including labor practices. They quickly move on to talk about their crops, little more than that. It is an extractivist relationship, clearly soil for them is not an object but only about their crops and cattle, they do not see it. For this reason, [when talking] they often leave soils aside, moving on to topics that are only partially relevant to our workshop … [nevertheless] participatory mapping went pretty well, people seem super enthusiastic about doing the mapping … Several interesting topics quickly emerge, which are marked on the map. People are very interested and active, so good for them (Field Diary, Sebastián Ureta).

As has been noted in the social literature on soils (Salazar et al. 2020), soils are difficult to think with. Given their underground existence for most people, they tend to remain opaque, just a background for other activities and effects. This is valid even for people, such as the participants in this workshop, whose livelihoods directly depend on them. When invited in the first module to describe the ways they relate to soils, they had difficulties in providing actual examples, opting instead for dwelling on matters related to crops and cattle. The soil was only visible through intermediaries.

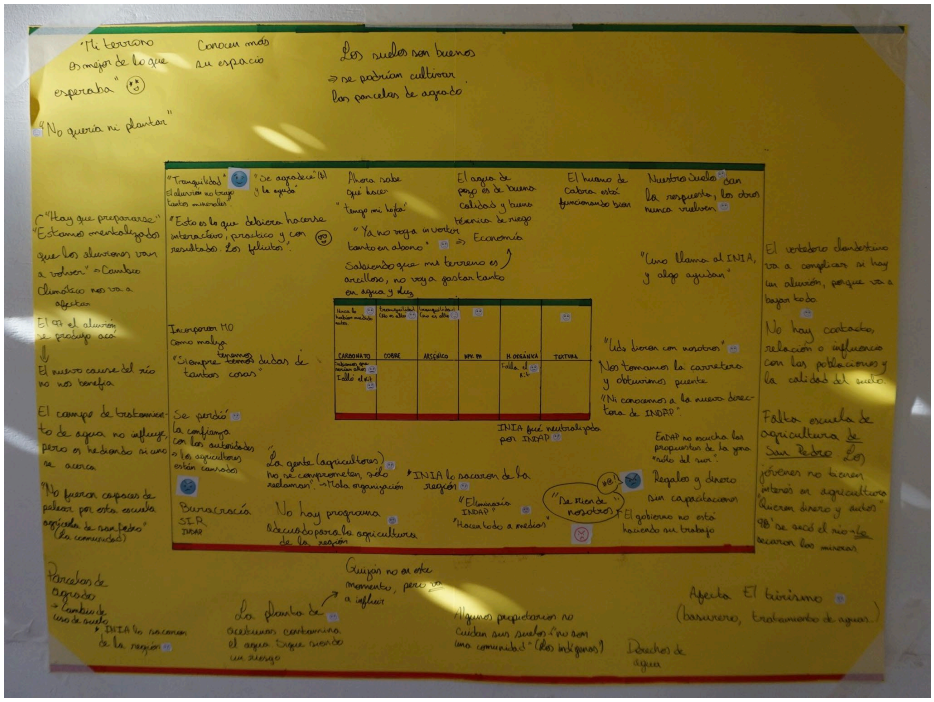
On the second day, we focused on training the participants on the use of the kits for assessing relative concentrations of lead, arsenic, and copper on the soil samples they brought. We advanced step by step, trying to be as didactic as possible in explaining each task, going from grinding the samples into fine dust to estimating the possible concentrations of each metal based on the reaction of the samples to a chemical reagent. Although several tasks appeared quite complex to accomplish for the participants, all of them managed to finish the exercise.

By early afternoon, we had produced different kinds of data, from maps of the area full of handwritten inscriptions to partially inflated balloons indicating possible concentrations of arsenic in soils. Then it was the time to put all this together and start sketching some general appraisals and possible paths of action. To do such synthesis we created a device called “el suelografo” (the soilgrapher). As can be seen in image 3 it consisted of a series of boxes drawn on a large sheet of paper. Each box was to be filled with the information collected during the two days of the workshop, starting from the assessment of possible concentrations of heavy metals (smaller box at the center) and going towards the larger territorial dynamics explored on the participatory mapping. If the information was deemed negative, it was put on the bottom of the device (underscored by red lines) while if it was positive, it must go to the top (underscored by green lines).

The process of putting together all this information went quite well, as revealed by my field diary of this day.

> In general, the suelografo works quite well, we quickly fill it with information, which is classified in terms of whether it is good or bad. We go through it point by point, from chemistry to geographical and social aspects. Even though we've been going for a long time, the participants look very enthusiastic and participate a lot. We are the ones who look spent... As we move from soil factors to more contextual ones, there are several situations of catharsis and criticism, especially of state actors (Field Diary, Sebastián Ureta).

Image 3. Completed suelografo



Source: the author

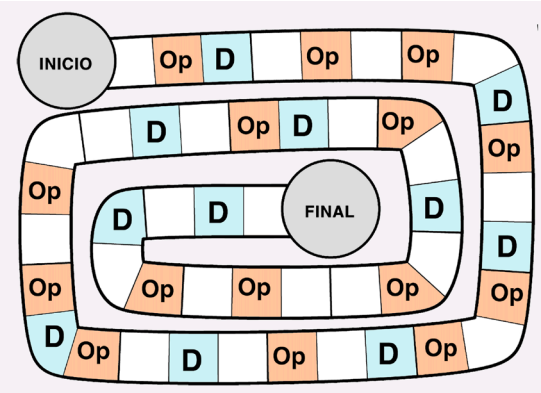
When in the closing session we asked the participants what they had learned, and most of the time they referred to the results of the kits for heavy metals. They especially highlighted, with relief, the fact that they have not shown any potentially worrisome concentration. All the other collected data, especially the multiple forms of quotidian violence and exclusion by local powers they have so graphically described, were rapidly forgotten. Concentration data was all that mattered.

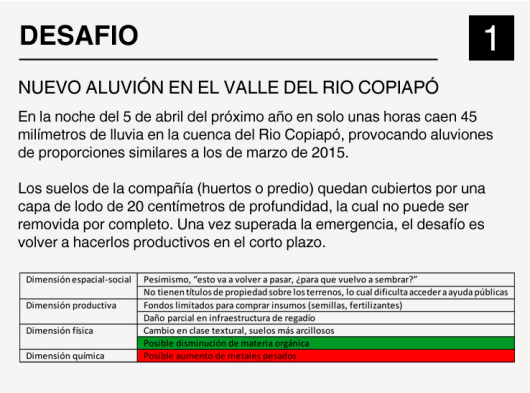
This troubling outcome, especially concerning the more critical inspiration of NS, led to some changes for the second test workshop, carried out in September 2019. First, this time we selected an urban community openly aware of being subjects of an environmental injustice. El Algarrobo was a neighbors' association formed by a group of 25 families living on the eastern outskirts of the city of Tierra Amarilla also in the Atacama Region. This area is located right below a massive waste depository from a local copper mine, a constant source of dust pollution and concerns for a possible collapse in the case of an earthquake. It was expected that this group, given their ongoing struggle against the mine, would be more able to take advantage of the political potential of NS.

In terms of design, also several changes were introduced in the methodology. Critically, and to enhance the chances of the device functioning as a catalyzer for further action, the suelografo was replaced by a board game. Adopting a "roll and move" structure, the game has the overall objective of enabling participants to work and integrate the heterogeneous information (social, chemical, productive, etc.) collected in previous stages. To do so, the game

asks them to confront imaginary challenges that local soils could face (such as a mining company polluting the river or an extreme rainfall event due to climate change) and outline a strategy to deal with them based on the collected data (for a more detailed description see Ureta et al. 2022).

Images 4 and 5: Components of Nuestros Suelos boardgame





Source: the author

This second workshop followed a path quite like the first one. The participants – this time a group of 16 people, mostly middle-aged women – seemed spooked at the beginning by our presence and the methodology, but rapidly gained confidence, being able to perform without major problems most tasks.

When invited to play the board game, the participants showed no problem in using the collected data to deal with the challenges posed by the cards. However, this critical engagement was somewhat too experimental, and theoretical. Somewhat there seemed to be a brake, a distance, between what we were doing at the workshop and the situation outside. For them, this was a ludic situation, an appreciated break from the troubles and boredom of their everyday lives, but little else. There seemed to be an invisible wall that impeded the participants to project what we were doing that day with concrete action, even at the quotidian level (and even more at an openly political level). As recalled in follow-up interviews conducted some weeks later, the Nuestros Suelos toolkit was very nice, but not something that they could use in their daily struggles for environmental justice.

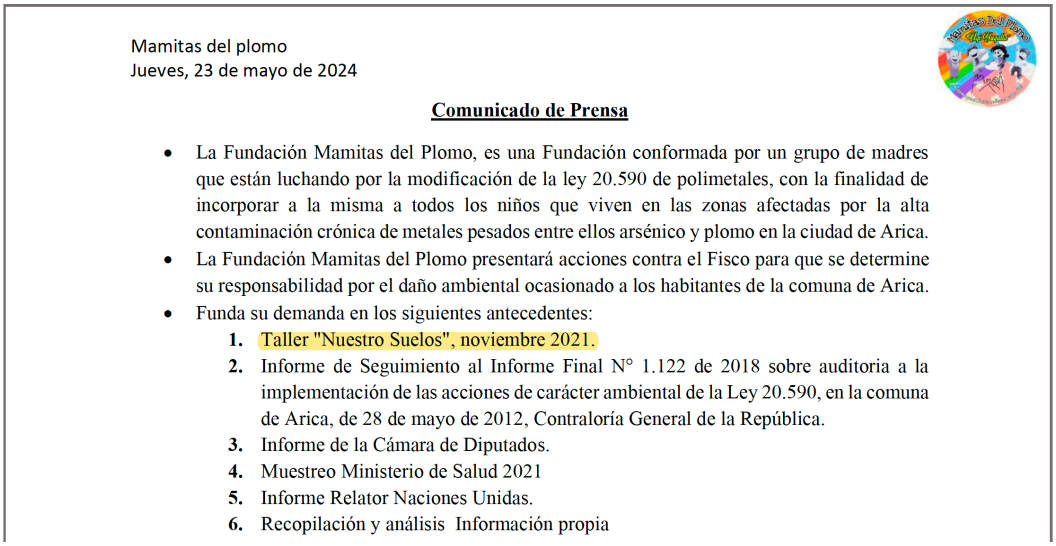
With this second workshop, the first phase of the project ended. There was a first draft of a handbook explaining the methodology made in early 2020 (but that was never published or distributed) and later an academic publication summarizing the experience (Ureta et al. 2022). Despite these advances, we felt that the transformative power of citizen science to polluted soils was still pending. We have succeeded in (at least temporarily) turning soil pollution into a *matter of concern* for the participants in our workshops. But we have largely failed in turning it into a *matter of care*. Following María Puig de la Bellacasa (2011, 89), going beyond a passive concern for an issue, caring "adds a strong sense of attachment commitment to something. … [it enacts] an ethically and politically charged *practice*". Someone who cares is someone to

acts, who moves trying to transform the issue at hand. The participants in our workshops ended up concerned about soil pollution, but *not concerned enough* to truly care. We ended up with a cool-looking toolkit and a new set of pictures full of smiling faces, but little else.

Citizen science as a tool for strategic epistemic actions

I was planning to finish my talk here. Adopting a sour tone, the conclusions were going to bemoan our lack of effectiveness and advise about concrete steps to increase the political capacities of citizen sciences. But on the very day on which I was planning to write this depressing conclusion, May 23rd, 2024, I received a copy of the press release that you can see in image 6.

Image 6. Press release regarding the Mamitas del Plomo lawsuit



Mamitas del plomo
Jueves, 23 de mayo de 2024

Comunicado de Prensa

- La Fundación Mamitas del Plomo, es una Fundación conformada por un grupo de madres que están luchando por la modificación de la ley 20.590 de polimetales, con la finalidad de incorporar a la misma a todos los niños que viven en las zonas afectadas por la alta contaminación crónica de metales pesados entre ellos arsénico y plomo en la ciudad de Arica.
- La Fundación Mamitas del Plomo presentará acciones contra el Fisco para que se determine su responsabilidad por el daño ambiental ocasionado a los habitantes de la comuna de Arica.
- Funda su demanda en los siguientes antecedentes:
  1. Taller "Nuestro Suelos", noviembre 2021.
  2. Informe de Seguimiento al Informe Final N° 1.122 de 2018 sobre auditoria a la implementación de las acciones de carácter ambiental de la Ley 20.590, en la comuna de Arica, de 28 de mayo de 2012, Contraloría General de la República.
  3. Informe de la Cámara de Diputados.
  4. Muestreo Ministerio de Salud 2021
  5. Informe Relator Naciones Unidas.
  6. Recopilación y análisis Información propia

Source: the author

This press release informs us that an NGO called “Mamitas del Plomo” (something that could be translated as “Lead mommies”) was presenting a lawsuit against the Chilean state for its potential responsibility for the environmental damage caused to inhabitants of the city of Arica, northern Chile. As revealed by the highlighted text, the first element supporting their claim was the “Nuestros Suelos” workshop in November 2021. Such a mention radically changed the conclusion of this talk, even my whole assessment of our project.

The story of Mamitas del Plomo and their lawsuit can be traced back to the mid-1980s, during the dictatorship of Augusto Pinochet. Between 1984 and 1985 more than 20.000 tons of highly polluted smelter waste were shipped by Boliden Minerals, one of Sweden’s largest mining corporations, to Arica, the northernmost city of Chile. The original aim was that a local company would remediate such waste, but such processing never happened, and the waste was simply dumped in a site located on the outskirts of the city. Over time, the site on which the waste was deposited became the location of several activities carried out by the

population living nearby, most notably an informal playground for children. This usage only intensified in mid mid-1990s when the Chilean government, unaware of the waste's presence, decided to construct social housing units in the surrounding areas. Since the late 1990s neighbors started to raise the alarm given a wave of several uncommon diseases among the local population, a situation that later medical studies linked to very high levels of toxic components (especially lead and arsenic) in the local population's bloodstream. After further tests indicated that the most probable source of such pollutants was Boliden's waste, the neighbors started a fight to make accountable the organizations responsible for their decade-long exposition.

Besides making frequent demonstrations claiming justice, in 1999 a group of neighbors presented a lawsuit against the Chilean state for negligence on the matter, an action that was won in 2007, resulting in a law identifying a series of measures that the state must implement to compensate the victims, from relocation to offering regular medical assistance. However, not everyone affected by the waste was identified as a beneficiary of the law. Critically, children born in the area after 2007 were excluded from any form of compensation. Such a situation motivated a group of local mothers to form Mamitas del Plomo in 2015, with the sole aim of pressuring the authorities to reform the law and include these children in the compensation package.

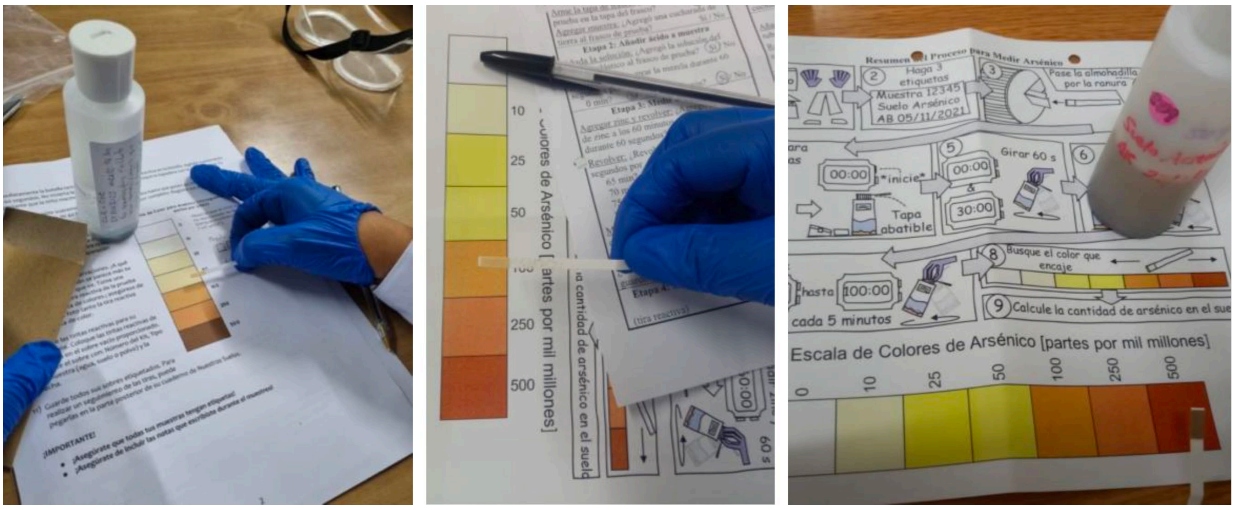
I first got to know members of Mamitas del Plomo during a research project in 2017 focused on analyzing another lawsuit presented by Arica neighbors against Boliden directly in Sweden (Ureta, Flores, and Soneryd 2020). Such a lawsuit was ultimately unsuccessful[4] but offered me the opportunity to engage with another entanglement of soil pollution. As happened in the Atacama Region, here there were soils heavily polluted by human action, pollution that was causing damage to an already vulnerable population. But there was also a key difference. This population was not only aware of such pollution but also has turned it into a political matter. Soil pollution in Arica was already a "matter of care" (Puig de la Bellacasa 2011), especially to NGOs such as Mamitas del Plomo, an object of constant action.

When a new phase of Nuestros Suelos started – this time under the leadership of Abby Kinchy from Rensselaer Polytechnic Institute and with funding from the National Science Foundation[5] - from the very beginning we knew that Arica could be a fruitful ground to deploy our tools. This phase started late in 2019 with the extensive redesign of the kits for measuring lead and arsenic (the one for copper was excluded). The whole process was made quite challenging given the COVID-19 pandemic, but we managed to have a working prototype of the whole methodology by mid-2021. After carrying out a first workshop in the US (Price et al. 2024), in November 2021 part of the team convened in Arica to carry out a first workshop in the area directly affected by the Swedish waste.

[4] As tellingly told in the wonderful 2020 documentary "Arica" by Lars Edman and William Johansson Kalén.
[5] The core research team was Abby Kinchy, Sebastián Ureta, Salvatore Engel-di Mauro, Dan Walls, Mónica Ramírez-Andreotta & Kathy High. For more information see https://oursoil.wp.rpi.edu/

Most of the participants in the workshop lived in the direct vicinity of Sitio F, the place in which the Swedish waste has been stored. Some of them had long trajectories of activism on the issue, even going back to the very start of the controversy in the 1990s, while others were only attracted by the possibility of learning more about the potential risks of the waste. In most aspects, this workshop was not different from the ones that we had carried out in Atacama and we obtained more or less the same results: people obtaining data through the usage of ingenious measuring devices. For the ones who had not been engaged on the issue, it was an opportunity to learn a bit more about soil pollution and its risks. For the ones who had a history of activism, the workshop largely served to confirm what they already knew. After all, the waste was already a central "matter of concern" in their everyday lives. As Maria – one of the founders of Mamitas del Plomo – said even more than the still ongoing COVID-19 crisis, "this is our pandemic. This is our little pandemic"

Images 7-9. Analyzing results from toolkits



Source: Caleb Yunis

However, things started to change in the final activity, in which we invited the participants to speculate about possible uses that our devices and the data produced could have regarding the issue. During this activity,

> …they talked about the challenge to improve existing public policies and for authorities to be more aware of the case. … It is striking to me that in general, the attendees are very clear-minded about what they want to achieve and how they can achieve it. They don't have a great interest in daydreaming or imagining a possible limitless future; … they always make their points from their particular realities and resources. For example, they highlight the need to generate networks with professionals and experts to validate their struggle and provide scientific evidence. … It also draws my attention that there is a great desire to maintain contact with the Nuestros Suelos Team and to participate in training about the methodology to other communities, aiming at the creation of a permanent community laboratory in the sector that will allow them to generate their data to continue the struggle for social justice (Author: Caleb Yunis)

This quote reveals a striking contrast with our previous experiences. When asked about possible future stages for the methodology, most participants in Atacama were prone to fantasize,

sketching highly speculative visions of citizen empowerment through science. The participants in the Arica workshop were different. Especially the seasoned activist among them, they were reluctant to let their imagination run wild. Instead, they talked about concrete measures such as strengthening the ties with experts such as our group and establishing a "community lab" on which to produce data that was relevant to their demands.

Instead of motivating grand gestures and wild dreams, the toolkit was turned into something humbler, but perhaps more effective: a vehicle to enact epistemic strategic actions. In a recent paper (Ureta et al. 2023), we define such actions as initiatives centered on "the strategic usage of environmental knowledge and knowledge infrastructures to reduce, neutralize, and/or redress the impact of the organizations and regulations blocking, diverting, or slowing down decisive action regarding the ecological crisis" (p. 5). Based on a guerilla frame– a form of action used for centuries by groups on the weaker side of power struggles – these actions are centered on the strategic usage of the tools of science and technology to start or reinvigorate struggles for environmental justice.

Reacting to such a demand in November 2022 we carried out a second workshop on Arica. This time the activity was not centered solely on training the participants on using our toolkit but also on locating it in a wider array of tools and methods for epistemic strategic actions. Consequently, its length was expanded importantly – from 2.5 days to a whole week – and its format transformed. The organizers were now a far larger group and brought with them a more complex array of devices, from alternative measuring technologies to multiple kinds of information and data. Besides including some former participants – such as members of Mamitas del Plomo – this time we invited local environmental activists, many of them quite young and already involved in global activist networks such as "Fridays for the future".

Images 10 and 11

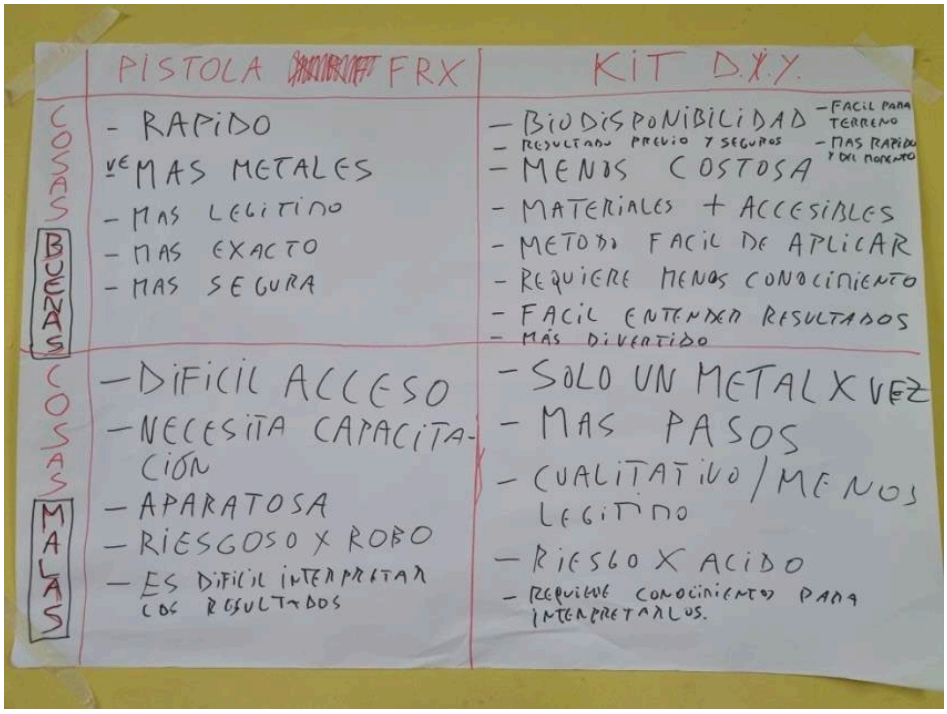
Source: Florencia Mondaca

Given such framing, the workshop was much more complex and comprehensive. Starting from an assessment of the participants' expectations about pollution, during a week of intense work

– including morning and evening sessions – we were not only able to train them about the usage of the toolkit. Besides this, we included modules with information about international pollution standards and what they mean, daily practices of care and how could be implemented, contrasting sampling methods, etc. Regarding the production of citizen data, we started by making a proper sampling plan for the affected area, to be able to better represent its different sectors. Besides, we asked them to collect three kinds of samples: soil, dust, and water. After reviewing all the necessary steps, we carried out a systematic sample recollection campaign, as can be seen in images 10 and 11.

Once the samples were collected, there came the time to analyze them. To be able to test the validity of our toolkit we used two other analytic methods. First, we were going to analyze them using a portable X-ray fluorescent (XRF) analyzer that we have brought from the US, allowing us to have right away quantitative concentration data on the samples. Second, the samples for soil and dust were going to be flown back to the US to carry out lab-based analyses on them. During all these steps we tried to develop in the participants a critical approach to each method, showing their capacities and limitations, as can be seen in picture 12, on which we were comparing the advantages and weaknesses of our DIY toolkit and the portable FRX.

Image 12. Contrasting the DIY toolkit and the portable FRX



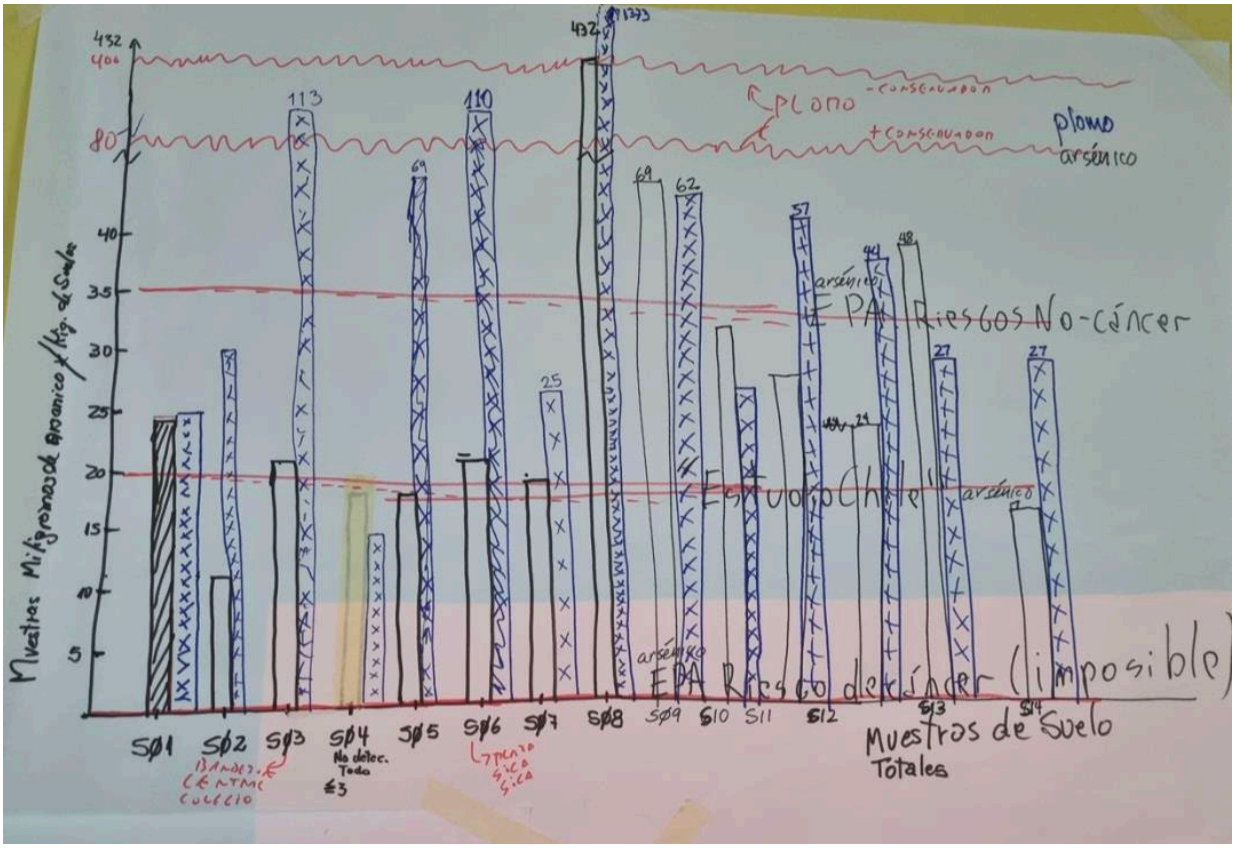
Source: Florencia Mondaca

After the samples were analyzed for lead and arsenic with the DIY toolkits and the portable FRX a whole session was devoted to the issue of data representation. The key question that we worked on with the participants was “What would we like to do with the data?”. Similarly in the previous workshop, this was not a moment for imagining ideal futures of perfect purity. As was

noted in the field diary, “We talked about the need to generate a strategy that is in line with the reality of the population to achieve an expected effect.” Hence, after some relevant discussions, it was decided to contrast the found concentrations of arsenic and lead with international health standards, especially the ones developed by the USEPA. Given the absence of Chilean standards, it was decided that this strategy would be effective in showing the real scale of the problem to external audiences.

As can be seen in image 13, visually this took the shape of a bar graph showing the found concentrations of arsenic and lead in each of the sampled sites, crossed by lines showing the maximum allowed concentrations from the USEPA standards. This way we were able to show, quite clearly, that although the found concentrations were not extremely high, in most cases surpassed the most widely accepted international standard. This result was not an idealistic discourse about the damage being done to them (although such discourses were also frequent during the work sessions), but a very concrete tool to keep up their fight for recognition and justice.

Image 13. Final graph with arsenic and lead concentrations



Source: Florencia Mondaca

In the final session, we discussed possible steps forward. Most of the participants wanted to keep working with these methods, maybe carrying out other sampling campaigns and setting

up a proper community lab. Regarding the collected data (and the one that was going to be produced later in the US lab), there was a clear intention to use it to strengthen their claims for justice, especially regarding the children who were not being considered on the law. As the head of Mamitas del Plomo claimed, for them the most critical issue was that “the children are being discriminated against for being outside the law, it is a growing problem that is not being repaired … These have been years of mistakes". When some months later we sent them back the results from the lab-based analyses of the soil samples – all showing concentrations above the maximum USEPA standards – they were rapidly translated into a key component of the lawsuit presented in May 2024. Citizen science was not merely cheap data or citizen training, not even a way to start caring about an issue, but it has become a strategic epistemic tool to move forward claims for justice.

Conclusions

On October 18, 2019, a massive social revolt started in Santiago, rapidly spreading throughout Chile. Claiming radical upheavals on our precarious social security system, millions of people took to the streets, paralyzing the country for weeks and forcing the government into unexpected concessions, such as starting the formal procedure to change our uttermost neoliberal constitution. Reacting to such events, many in the academia were drunk on social movements for months. Any other form of grassroots social organization – citizen science very much included – appears as a pathetic replacement for the direct power of the people. Why bother painstakingly producing scientific evidence if you can block streets and rapidly impose your terms?

Like any other drunken spree, this one came with a massive hangover. After putting together two constitutional drafts, the result of months of discussions at many levels, we ended up ratifying our good-old neoliberal constitution. Besides a few concessions here and there, popular demands for justice and equality were largely left unanswered, leaving Chilean society in a worse spot than the one it occupied before the revolt, facing the very same problems but now with the sadness of shattered dreams of transformation. The very same academics who were firm believers in the power of the people are now writing lucid analyses about why social movements are not the way to move forward projects for social transformation.

Chilean roller-coaster politics of the last few years, rapidly swinging from left to right, from hope to despair, have left many of us with a lot of unanswered questions. Personally, it has made me reconsider the value of citizen science as a way to engage with the challenges of a world on fire.

To become truly effective, citizen science should leave aside its predominant feel-good character, an excess of smiling faces that occludes the troubling political and ecological consequences of many implementations. However, it cannot be thought of as just another tool for popular mobilization, as other means are much more effective for this task. Both options miss what is, I think, the most important potential of citizen science regarding the

socioenvironmental crisis: its capacity to produce powerful epistemic devices from a position of weakness.

As stated above, the socioenvironmental crisis presents a highly uneven distribution, usually meaning that the worst consequences fall upon the ones least responsible for it. Conventional technoscience is one of the leading vehicles for the emergence and maintenance of such inequalities. The potential of citizen science projects to subvert – albeit temporarily – such orderings and provide epistemic tools to groups on the weaker end of power struggles should not be dismissed. Strategically associated with other forms of mobilization, citizen science can be at the forefront of successful attempts to redress violence.

To achieve such potential, however, citizen science projects must take a more reflexive and nuanced approach to power issues. Based on my own experience with polluted soils, I foresee (at least) three key elements that should be taken into consideration in this process[6]. First, and quite obviously, projects should always engage with issues of power and inequality. As seen in the first stage of my own story, they should avoid the usual mistake of thinking of citizen science solely as an innovative "instrument" for improving scientific governance, either within or beyond the state. Adopting a well-known phrase from Bruno Latour (1993), to practice citizen science is always to engage in a form of "politics by other means". There is always an inherent power in citizen science, a power that could be used to strengthen justice, democracy, and accountability. But such a usage is not automatic. If left unattended, such power could cause a counteraction on the part of powerful actors – as happened regarding CENMA's risk communication strategy – or even be used in an opposite direction, to strengthen existing regimes of exclusion and violence.

Second, it is not enough to merely celebrate citizen involvement. People and groups come with different kinds of baggage to citizen science projects: knowledge, expectations, experiences, effects, etc. This baggage greatly affects the outcome of any implementation; hence it should be taken into full consideration from the very beginning of any project. Especially relevant here is to consider previous relationships with technoscience and their practitioners. If people have no previous experience in dealing with scientists or scientific data – as happened in the first workshops in Atacama – it is quite expected that will face important barriers in turning science into a tool for concrete actions.

Finally, citizen science projects must rethink what consider as their products. An over-emphasis on the production of data tends to occlude the many other things that come into being through citizen science. The production of data is central, for sure. But it is not enough. To have a real impact, especially on controversial issues, data needs to be connected to multiple other entities and processes, from particular forms of visualization to human collectives able to mobilize it further. On the strength of this connection – as happened with

[6] A further point, not to be explored here, is the need challenge the usual anthropocentrism behind most citizen science projects (on this regard see Rautio et al. 2022; Dunkley 2023).

Mamitas del Plomo in the second NS workshop – is where much of the potential power of citizen science resides.

If rightfully deployed, citizen science can put environmental knowledge in the hands of those who need it most, the people and organizations on the frontlines of the battles against the worst effects of the socioenvironmental crisis. Leaving aside its joyful character, this citizen science will be nasty and troubling, uncomfortable and even depressing. But will provide these collectives with solid tools to continue their struggle for environmental justice in fractured worlds, it will help them resist and fight back, it will help them to mend and heal, to sketch a new, better, world for all of us, big and small, young and old, human and nonhuman.

Thank you.

References

Blacker, Sarah, Aya H Kimura, and Abby Kinchy. 2021. "When Citizen Science Is Public Relations." *Social Studies of Science* 51 (5): 780–96. https://doi.org/10.1177/03063127211027662.

CENMA. 2017. *Diagnóstico, Evaluación de Potenciales Riesgos y Plan de Gestión de Los Sistios Nantoco, Pabellón, y Totoralillo*. Santiago: Centro Nacional del Medio Ambiente - Universidad de Chile.

Dunkley, Ria. 2023. "Ecological Kin-Making in the Multispecies Muddle: An Analytical Framework for Understanding Embodied Environmental Citizen Science Experiences." *Transactions of the Institute of British Geographers* 48 (4): 781–96. https://doi.org/10.1111/tran.12613.

Eckhardt, Jennifer, Christoph Kaletka, Daniel Krüger, Karina Maldonado-Mariscal, and Ann Christin Schulz. 2021. "Ecosystems of Co-Creation." *Frontiers in Sociology* 6 (February). https://doi.org/10.3389/fsoc.2021.642289.

Feeney-McCandless, Ingrid Elísabet. 2017. "Por Una Vida Digna: Science as Technique of Power and Mode of Resistance in Argentina." *Alternautas* 4 (2). https://doi.org/10.31273/alternautas.v4i2.1062.

Lascoumes, P., and P Le Galès. 2007. "Introduction: Understanding Public Policy through Its Instruments—From the Nature of Instruments to the Sociology of Public Policy Instrumentation." *Governance: An International Journal of Policy, Administration, and Institutions* 20 (1): 1–21.

Latour, B. 2004. "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern." *Critical Inquiry* 30 (2): 225–48.

Latour, Bruno. 1993. *The Pasteurization of France*. Cambridge, MA: Harvard University Press.

Lewenstein, Bruce V. 2022. "Is Citizen Science a Remedy for Inequality?" *The ANNALS of the American Academy of Political and Social Science* 700 (1): 183–94. https://doi.org/10.1177/00027162221092697.

Lundgren, R., and A. McMakin. 2013. *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks*. London: John Wiley & Sons.

Millar, Edward, Stephanie Melles, and Claus Rinner. 2023. "Screens, Streams, and Flows:

Implications of Digital Platforms for Aquatic Citizen Science." *Geoforum* 146 (November):103864. https://doi.org/10.1016/j.geoforum.2023.103864.
Mirowski, P. 2017. "Against Citizen Science." *Aeon*, 2017. https://aeon.co/essays/is-grassroots-citizen-science-a-front-for-big-business.
MMA, CORFO, and Fundación Chile. 2012. *Guía Metodológica Para La Gestión de Suelos Con Potencial Presencia de Contaminantes*. Santiago de Chile: Ministerio de Medio Ambiente - Gobierno de Chile.
OED. 2016. "Citizen Science, n. Meanings, Etymology and More | Oxford English Dictionary." 2016. https://www.oed.com/dictionary/citizen-science_n?tab=factsheet&tl=true#99316619123.
Ottinger, Gwen. 2010. "Buckets of Resistance: Standards and the Effectiveness of Citizen Science." *Science, Technology, & Human Values* 35 (2): 244–70. https://doi.org/10.1177/0162243909337121.
Polleri, Maxime. 2019. "Conflictual Collaboration: Citizen Science and the Governance of Radioactive Contamination after the Fukushima Nuclear Disaster." *American Ethnologist* 46 (2): 214–26. https://doi.org/10.1111/amet.12763.
Price, Hannah L., Salvatore Engel-Di Mauro, Kathy High, Mónica D. Ramírez-Andreotta, Sebastián Ureta, Dan Walls, Chie Xu, and Abby Kinchy. 2024. "Soil Publics: Regenerating Relations with Urban Soils through Citizen Science." *Local Environment* 29 (4): 480–94. https://doi.org/10.1080/13549839.2023.2300977.
Puig de la Bellacasa, M. 2011. "Matters of Care in Technoscience: Assembling Neglected Things." *Social Studies of Science* 41 (1): 85–106.
Ramirez-Andreotta, Monica D, Mark L Brusseau, Janick Artiola, Raina M Maier, and A Jay Gandolfi. 2015. "Building a Co-Created Citizen Science Program with Gardeners Neighboring a Superfund Site: The Gardenroots Case Study." *International Public Health Journal* 7 (1).
Rautio, Pauliina, Tuure Tammi, Tuomas Aivelo, Riikka Hohti, Anttoni Kervinen, and Maria Saari. 2022. "'For Whom? By Whom?': Critical Perspectives of Participation in Ecological Citizen Science." *Cultural Studies of Science Education* 17 (3): 765–93. https://doi.org/10.1007/s11422-021-10099-9.
Salazar, Juan Francisco, Céline Granjou, Matthew Kearnes, Anna Krzywoszynska, and Manuel Tironi. 2020. *Thinking with Soils: Material Politics and Social Theory*. London: Bloomsbury Academic.
Tousignant, N. 2018. *Edges of Exposure: Toxicology and the Problem of Capacity in Postcolonial Senegal*. Durham & London: Duke University Press.
Ureta, S. 2016. *Minuta – Comentarios Respecto a La Sección Sobre "Comunicación Del Riesgo" de La "Guía Metodológica Para La Gestión de Suelos Con Potencial Presencia de Contaminantes."* Santiago: Centro Nacional del Medio Ambiente - Universidad de Chile.
———. 2021. "Ruination Science: Producing Knowledge from a Toxic World." *Science, Technology, & Human Values* 46 (1): 29–52. https://doi.org/10.1177/0162243919900957.
———. 2022. "Tailings and the Onset of a Chilean Anthropocene." In *Anthropogenic Markers: Stratigraphy and Context*, edited by C. Rosol and G. Rispoli. Berlin: Max Planck Institute for the History of Science. https://www.anthropocene-curriculum.org/anthropogenic-markers/critical-environments/contribution/tailings-and-the-onset-of-a-chilean-anthropocene.

Ureta, S., J. Barandiaran, M. Salazar, and C. Torralbo. 2023. “Strength out of Weakness: Rethinking Scientific Engagement with the Ecological Crisis as Strategic Action.” *Elementa: Science of the Anthropocene* 11 (1): 1–10. https://doi.org/10.1525/elementa.2023.00072.
Ureta, S., P. Flores, and L. Soneryd. 2020. “Victimization Devices: Exploring Challenges Facing Litigation-Based Transnational Environmental Justice.” *Social & Legal Studies* 29 (2): 161–82. https://doi.org/10.1177/0964663919841121.
Ureta, S., M. Llona, D. Rodríguez-Oroz, D. Valenzuela, C. Trujillo-Espinoza, C. Guiñez, A. Rebolledo, M. J. Maiza, and C. Rodríguez Beltrán. 2022. “Nuestros Suelos: Exploring New Forms of Public Engagement with Polluted Soils.” *Journal of Science Communication* 21 (1): N01. https://doi.org/10.22323/2.21010801.
Ureta, S., F. Mondaca, and A. Landherr. 2018. “Sujetos de Desecho: Violencia Lenta e Inacción Ambiental En Un Botadero Minero Abandonado de La Región de Atacama, Chile.” *Canadian Journal of Latin American and Caribbean Studies* 43 (3): 337–55.
Vohland, Katrin, Maike Weißpflug, and Lisa Pettibone. 2019. “Citizen Science and the Neoliberal Transformation of Science – an Ambivalent Relationship.” *Citizen Science: Theory and Practice* 4 (1). https://doi.org/10.5334/cstp.186.