Invisible contaminants and food security in former coal mining areas of Santa Catarina, southern Brazil

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Graziela Dias Blanco
Universidade Federal de Santa Catarina
graziblanco@gmail.com
ORCID: https://orcid.org/0000-0003-2458-957X

Rafael Barbizan Sühs
Universidade Federal de Santa Catarina

Escarlet Brizola
Universidade Federal de Santa Catarina

Patrícia Figueiredo Corrêa
Universidade do Extremo Sul Catarinense

Mari Lucia Campos
Universidade do Estado de Santa Catarina

Natalia Hanazaki
Universidade Federal de Santa Catarina

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Abstract
Background Mining activities have environmental impacts due to sediment movement and contamination of areas, and may also pose risks to people's food security. In Brazil, the majority of coal mining activities are in the south, in the Santa Catarina Carboniferous region. In this region, previously mined areas contaminated with heavy metals, frequently occur nearby inhabited zones. Heavy metals are contaminants that do not have odor, color, or taste, and are therefore difficult to detect. We aimed to verify whether people use plants from contaminated mine areas, and to understand which factors are related to plant use.

Methods We conducted semi-structured interviews with residents from 14 areas nearby abandoned mines in the main municipalities of the Santa Catarina Carboniferous region.

Results Out of the 196 interviewed residents, 127 (65%) reported collecting plants for medicinal and food use, directly from contaminated mine areas. Long-term residents, as well as those who noticed more environmental changes (positive and negative), cited more plants used, and had more detailed knowledge of plant use in their communities. When asked if they were aware of the possible contamination of mined areas, 85% said they knew about it. However, only 10% associated negative health effects with the use of plant species collected in contaminated mined areas.

Conclusions Our study demonstrates that people living nearby contaminated areas use and consume locally sourced plants, it also reveals a lack of information about contamination, as well as a lack of actions that include local communities in contaminated area restoration strategies. This situation poses a risk to the food security of the people living nearby former coal mining areas.

Background
Around the world, contaminated areas have endangered people's food security[1–3]. Among the sources of contamination, mining activities, such as coal mining, have caused public health concerns, due to the release of heavy metals in the mining process [1,2,4]. Although the impact level of metal toxicity depends on the concentration at which it is ingested, chronic exposure to relatively low levels of heavy metals may also cause adverse effects [5]. Heavy metals can bioaccumulate in the food chain, therefore metals in the soil can be accumulated by plants that are consumed by humans,
finally accumulating in humans [5,6]

Local communities are human groups, located in the same region and time period, that develop a cultural identity and a unique relationship with the environment [7–9]. The interaction of local communities with the environment is directly related to their culture, and to the experiences and perceptions of past and present generations [10], and is reflected in the use of local resources and dietary habits [10,11]. The study of heavy metal impacts on food security of local communities has gained prominence in regions such as China, related to urban growth in mined areas [1,12], and northern Europe, related to increased mining activities and insecticide use in agriculture [13]. In Canada there has been an increase in heavy metals in some foods used by indigenous communities [14]. In Latin America, studies with indigenous peoples and fishers have observed the presence of heavy metals in fish and vegetable resources consumed by local communities [15–18].

In Brazil, contamination of soil, plant, and fishery resources also pose a health risk to local communities [19,20]. Southern Brazil is where 99.98% of Brazil’s coal is mined [21,22]. The extraction of coal in the country began in the late nineteenth century, and continues to this day. It is estimated that in Santa Catarina state alone, there are more than 6,500 hectares of abandoned areas contaminated by heavy metals from coal mining activities [23]. Due to diminishing profitability in the late twentieth century, some mined areas were abandoned whilst local communities developed in these locations. Even after decades of inactivity, abandoned mine areas are still contaminated by heavy metals [24] and may pose a risk to the food security of these mining communities. Some abandoned open pit coal mines received restoration treatment, reconstructing the landscape and soil in order to create minimal conditions for vegetation development [25]. The restoration process consists basically of filling the pit with sterile pyrite and sandstone, covering this sterile layer with clayey regolith, and putting back previously stored soil; followed by planting species for soil fixation [26]. However, this restoration process is usually deficient, especially due to the different mining processes employed by mining companies and the lack of inspection of mined areas by responsible authorities, resulting in contamination of the surface layers of the constructed soil with coal residues [23,26]. Some plant species can survive and even thrive in these contaminated sites [27–30], and
may be bioindicators of contamination and useful for bioremediation, if they have bioaccumulation potential [27,29]. Some of these species, however, also have medicinal or food use, and therefore may pose a risk to human health [31]. Nevertheless, there are few studies investigating whether plant resources occurring in areas contaminated by heavy metals are being used by the local population [32].

People perceive and categorize changes in the landscape over time [33,34]. The perception of changes in the landscape by local inhabitants (e.g. changes in species diversity and richness, and air pollution) assists in understanding the environmental consequences of impacts such as urbanization, deforestation, and mineral extraction [35,36]. Generally, individuals living for longer, and closer to the resources, are those who have the greater knowledge and use of the plant resources [34]. Coupled with this, women tend to have a greater knowledge and use of medicinal plants, as they are usually responsible for early health care in several local communities [37–40]. Women are also more vulnerable to food security issues than men due to gender inequalities. Food security is the term used to define the right, that all people, at all times, should have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences for an active and healthy life [41]. Women often live in more unhealthy or contaminated areas than men, and, when they receive food from the government, it is of lower nutritional quality [41].

Methods

Study area

The study was conducted in the municipalities of Criciuma, Forquilhinha, Siderópolis, Treviso, Urussanga, and Lauro Müller, in the state of Santa Catarina (Fig. 1), in the main coal mining region in Southern Brazil. We selected 14 former coal mine areas, according to the following criteria: areas of at least 1 ha, which were abandoned for at least 30 years, with a history of heavy metals presence [24,26,44,45], and with inhabited zones located at a maximum distance of 300 m from the deactivated mine areas. Some of these abandoned mine areas underwent an initial restoration process, which consisted in filling the pit with pyrite and covering this layer with another layer of clay soil (30-50 cm) over the disturbed mine soil. The mining communities of Vila Funil, Rio Carvão, Barreiros, Guaitá, Cidade Alta, Vila Visconde, and São Sebastião Alto are settled nearby abandoned mine areas; and the mining communities of Vila Sao Jorge, Rio Fiorita, Volta Redonda, Campo Morozini, Santa Luzia, Santa Augusta, and São Sebastião are adjacent to partially restored mine
Data collection

We conducted semi-structured interviews with residents of the communities located in inhabited areas near the mined areas, individually, between February and March 2018 (Table 1). We visited every house in each community once, and interviewed those who were keen to participate in the research and who agreed with the free informed consent terms. One limitation of this method is that our sampling is possibly skewed for people who stay in their homes longer, but as we intended to cover all mining areas in the region, we had to choose between a broad sampling effort or an in-depth sampling effort.

Table 1 General information of localities, total rural population of each municipality, total number of families per community living nearby mining areas and number of interviews

| Municipality     | Total rural population of the municipality | Locality        | No. of families per mining community | No. Interviews |
|------------------|-------------------------------------------|-----------------|--------------------------------------|----------------|
| Siderópolis      | 2,944                                     | Vila Funil      | 35                                   | 16             |
|                  |                                           | Vila São Jorge  | 20                                   | 7              |
|                  |                                           | Rio Fiorita     | 36                                   | 20             |
| Lauro Muller     | 3,261                                     | Barreiros       | 27                                   | 16             |
|                  |                                           | Guaitá          | 21                                   | 19             |
| Criciúma         | 2,678                                     | Santa Luzia     | 37                                   | 8              |
|                  |                                           | Vila visconde   | 35                                   | 11             |
|                  |                                           | São Sebastião alto | 25                               | 8              |
|                  |                                           | Santa Augusta   | 14                                   | 10             |
|                  |                                           | São Sebastião   | 25                                   | 12             |
| Treviso          |                                           | Volta Redonda   | 24                                   | 11             |
|                  |                                           | Rio Morozini    | 26                                   | 16             |
| Urussanga        | 8,818                                     | Rio Carvão      | 32                                   | 25             |
| Forquilhinha     | 4,122                                     | Cidade Alta     | 23                                   | 16             |

Interview questions sought to understand: (1) whether plant species were collected or planted for consumption in areas contaminated by coal mining; (2) which were the main species collected and for
what purpose; and (3) the interviewee's perceptions of landscape changes and the impacts of mining. For each interviewee, the following variables were noted: residence time, age, gender, locality, and their work relationship with the mining companies. To be sure of where the plant resources were obtained, the interviewee was asked for each species cited: whether they were collected from contaminated areas, collected in other areas, or planted in home gardens or other cultivated areas.

To analyze the perception of landscape changes, the interviewee was asked if they had observed any changes at the site since they began living there, and the responses were categorized a posteriori by the authors as: (1) positive (i.e., positive changes have been observed over time in the landscape, e.g., an increase in the group of cited species); (2) neutral (i.e., no change was observed); (3) negative (i.e., negative changes have been observed over time, e.g., in the group of cited species). They were also asked if they knew what the landscape looked like before mining, whether mining impacts have or had a negative impact on the health of residents, and whether they had been informed (either by a public or private institution) of contamination of the mined areas (full questionnaire is accessible in Additional file 1). Whenever possible, we conducted guided tours to collect botanical samples of the cited species for identification (collector numbers GD Blanco 90-120, vouchers deposited at EAFM herbarium). This project was approved by the UFSC Human Research Ethics Committee (80660217.1.0000.0121) and registered at SisGen, the Brazilian System of Genetic Heritage and Associated Traditional Knowledge Management (AB9A76B). Prior to the interviews, the consent of each interviewee was obtained, and they signed a Free Informed Consent Form.

Data analysis

We built multivariate generalized linear models (GLMmv) to verify which variables could affect the group of cited species and generalized linear models (GLM) to verify which variables could affect the total number of citations. For both analyses we discarded information about plant species that were cited as cultivated only, and used data from the species cited as being collected from mined areas. The explanatory variables for both set of models were: residence time, gender, type of abandoned area (i.e., abandoned or partially restored) and the locality where the interviewee lives. However, locality and area type were never put together in the models, as both variables are related to geographic location, thus, highly correlated. For both models, the Poisson distribution family was used. Model selection was based on the Akaike Information Criterion (AIC) and validated using graphical residual analysis. For data visualization, a Principal Coordinate Analysis (PCoA) was performed. Analyses were performed in R environment with packages mvabund [46] for GLMmv, MASS [47] for GLM, and visreg [48] and vegan [49] for visualization of effects. The variables tested are listed in Additional file 2. For multivariate analysis, singletons (plants cited only once) and doubletons (plants cited twice) were removed.
To analyze the importance of the plants mentioned in the interviews we used their frequency of citations and the Smith salience index given by: \[ \Sigma(((L_i - R_j)/L_i)100)/N, \] where \( L_i \) is the size of the free listing; \( R_j \) is the position (order) of the item in a given free list \( L_i \); \( N \) = total number of free listings (or number of interviewees) [50]. We also considered that the first item of a given list has \( R_j = 0 \). This index ranges from 0 to 1, species with a value equal to or close to 1 are the species with the highest salience and species with values close to 0 are the least salient. After assessing Smith’s salience index, we calculated if the values differed by chance using a Monte Carlo analysis, following Chaves et al. (2019) [50].

Results

We interviewed 195 residents, with an average of 14 residents (± 5.4) per locality. The residents’ ages ranged from 15 to 86 years old, with an average age of 53 years (± 17.8). The majority of residents (115 or 59%) have lived in the community for more than 20 years (± 12.1), and 50 residents (26%) have always lived in the area, with the rest coming from other parts of the state. However, no respondents resided in the region prior to the coal mining. Among the residents, 130 were women (68%) and 66 were men (32%). All of the men, and none of the women, either work, or have worked, for the mining companies. Collecting or planting species for medicinal and/or food use was cited by 176 residents (90%), and 127 residents (65%) collected plants directly from areas contaminated by mining.

There were 176 species cited as planted and/or collected (Additional file 3), among which, 83 (47%) species were collected directly from areas contaminated by coal mining. From these, 18 (10%) species were obtained exclusively through collection in the mined areas (Table 2). The main species obtained exclusively by collecting from mined areas were *Psidium guajava*, *Plinia cauliflora* and *Eriobotrya japonica*. The main botanical families collected were Asteraceae and Lamiaceae, with 10 species (10%) each, and Myrtaceae and Fabaceae with 4 species (3.5%) each. For species collected in mined areas, 78% of residents cited medicinal uses, and 76% of residents cited food uses. The main use (54%) for medicinal species was for the treatment of digestive and infectious problems.

Smith's salience index for species collected directly from mined areas varied between 0.12 and 0.01. Species with the highest salience and with significant results after Monte Carlo analysis were *Psidin guajava*, *Plinia cauliflora*, *Psidium cattleianum*, *Morus* sp., *Foeniculum vulgare* var. *azoricum*, *Chelidonium majus*, *Bidens pilosa*, *Fragaria vesca*, *Justicia pectoralis*, *Aristolochia esperanzae*, *Achillea millefolium*, and *Eriobotrya japonica* (Table 2).

Table 2 Species cited only as collected by 195 interviewees, number of citations per species, uses, and salience (Smith’s index)
When questioned whether they were aware of the presence of contamination in abandoned mine areas, 166 residents (85%) said they were. However, when asked about harm to the environment or their lives, only 19 residents (10%) reported some type of physical discomfort (i.e., stomach ache and low blood pressure), when ingesting the species *Baccharis* spp., *Plectranthus barbatus*, *Solanum paniculatum*, *Arnica montana*, and *Achillea millefolium*. Regarding harm to the environment, the interviewees cited atmospheric pollution, due to the excessive dust released in the region from coal...
extraction. All residents moved to the area after the mining activity ended, and did not see what the landscape looked like prior to mining; however, 172 residents (88%) said they had observed changes, 113 residents (58%) reported negative changes, i.e., forest loss, less animals, fewer plants (this type of response was classified as negative, a posteriori, by the authors), and 58 residents (30%) reported landscape improvements, i.e. more trees, more plants, cleaner air (this type of response was classified as positive, a posteriori, by the authors). Another issue confirmed by 147 of the residents (75%), was the lack of information from public agencies and mining companies, about the environmental impacts that mining may cause, and possible contamination of plant resources. Duration of residence time, gender, perceived changes in landscape (i.e., positive, neutral, negative), location, and type of abandoned area (i.e. either abandoned or partially restored), did not affect the group of species cited by respondents (Additional file 4).

The same variables were analyzed in relation to the number of species cited. The locality, perception of changes in the landscape, and duration of residence time significantly affected the total number of cited species. The GLM model explained 27% of the variation in the total number of species used (Table 3, Fig. 2), of which locality explained 77%, perception of changes 15%, and residence time 8%. Longer-term residents and residents who cited negative or positive landscape changes, cited more species collected than residents who had not observed landscape change over time. Locality also had a significant effect on the number of citations.

Table 3 Summary of models and variables tested with GLM.
| Mod. | Int.  | Loc | Tip | Perc. | Gend. | Time   | df  | LogLik | AIC   | Delta | Weight |
|------|-------|-----|-----|-------|-------|--------|-----|--------|-------|-------|--------|
| 22   | 2.074 | +   | +   |       |       | 0.004711 | 17  | 677.842 | 1389.7 | 0     | 0.276  |
| 30   | 2.089 | +   | +   | +     |       | 0.004885 | 18  | 677.064 | 1390.1 | 0.44  | 0.221  |
| 6    | 2.231 | +   | +   |       |       | 0.004482 | 16  | 683.686 | 1399.4 | 9.69  | 0.002  |
| 14   | 2.245 | +   | +   | +     |       | 0.004885 | 17  | 683.281 | 1400.6 | 10.88 | 0.001  |
| 18   | 1.93  | +   |     |       |       | 0.006767 | 15  | 693.262 | 1416.5 | 26.84 | 0      |
| 26   | 1.941 | +   |     |       |       | 0.006944 | 16  | 692.789 | 1417.6 | 27.89 | 0      |
| 2    | 2.148 | +   |     |       |       | 0.004482 | 14  | 706.557 | 1441.1 | 51.43 | 0      |
| 10   | 2.152 | +   |     | +     |       | 0.004482 | 15  | 706.524 | 1443   | 53.36 | 0      |
| 31   | 2.206 | +   | +   | +     |       | 0.005626 | 6   | 769.991 | 1552   | 162.3 | 0      |
| 23   | 2.19  | +   |     | +     |       | 0.005439 | 5   | 771.065 | 1552.1 | 162.5 | 0      |
| 29   | 2.163 | +   |     | +     |       | 0.005814 | 5   | 771.186 | 1552.4 | 162.7 | 0      |
| 21   | 2.145 | +   |     |       |       | 0.005621 | 4   | 772.312 | 1552.6 | 162.9 | 0      |
| 17   | 2.016 | +   |     |       |       | 0.006696 | 2   | 781.196 | 1566.4 | 176.7 | 0      |
| 25   | 2.029 | +   |     |       |       | 0.006896 | 3   | 780.429 | 1566.9 | 177.2 | 0      |
| 19   | 2.045 | +   |     |       |       | 0.006546 | 3   | 780.473 | 1566.9 | 177.3 | 0      |
| 27   | 2.057 | +   |     |       |       | 0.006744 | 4   | 779.747 | 1567.5 | 177.8 | 0      |
| 7    | 2.366 | +   |     |       |       | 0.006744 | 4   | 779.804 | 1567.6 | 177.9 | 0      |
| 15   | 2.382 | +   |     |       |       | 0.006744 | 5   | 779.256 | 1568.5 | 178.8 | 0      |
| 5    | 2.318 | +   |     |       |       | 0.006744 | 3   | 781.676 | 1569.4 | 179.7 | 0      |
| 13   | 2.335 | +   |     |       |       | 0.006744 | 4   | 781.111 | 1570.2 | 180.5 | 0      |
| 3    | 2.264 | +   |     |       |       | 0.006744 | 2   | 794.521 | 1593   | 203.4 | 0      |
| 1    | 2.23  | +   |     |       |       | 0.006744 | 1   | 796.017 | 1594   | 204.4 | 0      |
| 11   | 2.271 | +   |     |       |       | 0.006744 | 3   | 794.403 | 1594.8 | 205.1 | 0      |
| 9    | 2.238 | +   |     |       |       | 0.006744 | 2   | 795.888 | 1595.8 | 206.1 | 0      |
Discussion
Residents living in mining communities nearby abandoned or partially restored coal mine areas are consuming plant species from these areas for food and medicinal purposes, which puts their food security at risk. The consumption of species that occur in mined areas was also reported in other regions of South America, as well as in the United States, Europe, India and China [1, 12, 13, 15, 18, 51]. Some of these species have been studied for their potential to bioaccumulate heavy metals, such as *Psidium guajava*, *Morus* sp., *Baccharis crispa*, *Baccharis sarothroides*, *Mentha arvensis*, and *Cymbopogon flexuosus* which bioaccumulate Al, Fe, Si, S, Ca, and Zn [28–30, 52–54]. Location, duration of residence time, and perception of changes in the landscape, were the main factors linked to citing more species obtained in contaminated areas.

Locality was the most important factor influencing the number of species cited (i.e., 77% of the 27% that explained the use of plant species from mined areas). Localities studied here are local communities settled originally to supply the coal mining economy with laborers to work in coal mines [21]. Over time, these mining communities developed bonds with their environment, learning about the plant resources available in each place, a behavior co-evolving with the available plant resources and influenced by expertise and direct and continuous observation of the environment [55, 56]. This behavior is also influenced by transformations in the social and cultural structures, policy systems, and spiritual beliefs [55, 56]. Even though these environments present a low plant diversity [57], the mining communities adapted to use the available resources for their medicine and food purposes.

Added to this, locality influenced species cited by the communities. This may be due to the high cultural diversity of peoples who colonized this region, including indigenous peoples such as Guarani and recent German, and Italian immigrants [58, 59]. Santa Catarina, and other areas in the South and Southeast of Brazil, is culturally heterogeneous, which may have an effect on plant knowledge and
use. The influence of different cultures and the mixture of knowledge is combined and integrated in the most recent generations [60]. This cultural influence may have a greater weight than, for example, the resource availability itself in the environment [60, 61]. The longer the time a person had resided in the area correlated with more species cited: older residents use a greater wealth of plant species, collected or planted, and they also perceive more changes in the landscape, both due to the length of time of living and learning in these environments [34, 56].

Residents who observed changes in the landscape, both positive and negative, cited more species than those who did not notice changes. Even when residents noted that there was a decrease in plant resources and negative landscape changes in areas contaminated by coal mining, they cited the use of plants collected in these areas for their food and medication. However, we emphasize that since the categorization as “positive”, “neutral”, or “negative” was made *a posteriori* by the authors, these results reveal a broad and simplified view of what is considered as a perception of improvement (i.e., positive) or loss (i.e., negative) in the environment. Similar observations are reported by Silvano and Begossi (2016) [20], who found that although fishermen knew about mercury contamination in fishery resources, they continued to consume this resource. As well as some residents noticing negative changes in the environment due to mining, 85% of residents said they know about the contamination of the mined areas; however, they still collect and use plant species from these areas. This may be due to contaminants such as heavy metals being invisible, or due to psychological barriers [62, 63]. Invisible contaminants are those that cannot be detected by human sensory abilities, i.e., cannot be seen, do not exude odor, taste or sound [62]. Since they are not perceived, these contaminants can be unwittingly consumed and, in the case of heavy metals for example, can impact human health causing neurological damages and metabolic disorders [31, 62, 64]. Psychological barriers, on the other hand, are when people are aware of environmental impacts, but do not act emphatically against them [63, 65]. People tend to think of environmental impacts as futuristic and distant from their reality, associated with governments failing to present more effective strategies involving local people, and within a framework of contemporary cultural and social issues [63, 66]. Social understanding of risk, such as food security risk, is built on views and beliefs associated with the
social and cultural forces of each society or community [67]. The construction of this perception goes through a comparison stage. For a mining community to perceive the risk to their own food security, it needs to see that a similar situation was identified as a risk, in another community that is culturally, socially, and historically similar to its own [67, 68].

No significant differences were observed in the group of species cited, and this can be due to the low diversity of plants available in mined areas. Few species can survive and develop in environments impacted by heavy metals [69]. The mining activity tends to result in more homogeneous environments, affecting the microbial and fungal diversity in the soil thereby affecting plant diversity [69, 70], revealing the threat to the biodiversity of these environments.

We did not find a difference between species cited by women and men. This homogeneous distribution of knowledge across genders was also observed in other studies [37, 39]. This may be related to the different social roles of each gender: men are the ones who work or worked in the mining areas, contributing to their knowledge of the plants that occur there. Even though women usually provide initial health care in communities and therefore have greater medicinal plant knowledge, in these localities men have a greater knowledge of the mined areas and of species found there, which seems to balance the knowledge of plant uses [39, 40].

The use of plant species from areas contaminated by coal mining, has also been observed in local communities in Europe; where these communities are among the most vulnerable to, and affected by, contamination of food resources [71]. Bolivia and other Latin American countries have warned of the risk to the food security of local communities near mined areas, primarily the consumption of fishery resources [17]. In China, foods that form the staple diet of local communities living near former coal mines (e.g., *Oryza* spp. and *Camellia sinensis*) are contaminated with heavy metals [72–75]. In Canada and the USA, rural and indigenous communities are twice as vulnerable to contamination of their food resources compared to the national average [76]. These communities have greater exposure to, and are in direct contact with, contaminating sources [11, 76], a situation similar to that faced by mining communities in southern Brazil.

Lack of food security due to consumption of contaminated fishing resources has been reported in
local fishing and river communities from the south, southeast, and northeast coasts of Brazil, as well as by indigenous Amazon communities [11, 20, 77]. In recent decades, the global return of incentives for coal extraction has raised concerns about the food security of local communities [24]. Coal is currently responsible for providing 29.6% of global energy needs and about 42% of all global electricity [24, 78]. Resurgence of coal mining may increase the contamination of areas previously mined for coal and add to the number of areas impacted by heavy metal contamination. In the far south of Brazil, children living in coal mined areas are at high risk of exposure leading to possible heavy metal poisoning [79]. For this reason, research that identifies whether there is use, and which species are being used for medicinal and food consumption in mined areas, is important to develop strategies aimed at guaranteeing the food security of mining communities.

Conclusion
Traditional knowledge is an important tool for identifying and locating areas and resources that can pose a risk to the food security of mining communities. Consumption of plant species collected from abandoned mine sites in southern Brazil, coupled with a lack of information, is a reality and a concern. Potential bioaccumulator species that occur in these areas are being used locally as food or therapeutic resources. This situation is aggravated by the fact that these contaminants are invisible, and because of psychological barriers to recognizing the risks related to the contamination of a living environment. In view of this scenario, it is necessary and urgent to inform the population about the risk of invisible contaminants in order to reduce their vulnerability to food insecurity, combined with studies that quantify the extent of heavy metal contamination in plant resources resulting from mining activity.

Declarations

Ethics approval and consent to participate
In order to carry out the present research, the necessary authorizations were obtained with CEPSH (Ethics Commitee on Research with Human Beings of Universidade Federal de Santa Catarina, processes number 80660217.1.0000.0121). All interviewees signed a free informed consent term.

Consent for publication
Not applicable.
Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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Authors' contributions
All authors contributed substantively to the research; GDB and NH designed the research project. GDB, RBS, EB and PFC collected the samples and performed sample analyses. Blanco, GDB, RBS, PFC, MLC and NH wrote the manuscript.

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Additional File Information

Additional file 1 .pdf. Model of the applied interview [interviewer’s orientations between brackets]

Additional file 2 .xls. Explanatory variables analyzed in lm and GLM

Additional file 3 .xls. List of species cited as used by residents. C: Collected, P: Planted.

Additional file 4 .tiff. PCoA showing that there was no difference in the set of species collected from mined areas between mining communities, perceptions of landscape changes (i.e. positive, neutral and negative), types of abandoned areas (i.e. either abandoned or partially restored) and gender (i.e. men and women)

Figures

![Study area](image_url)

Figure 1

Study area. Each number corresponds to a mining community: 1- Barreiros; 2-Guaitá; 3-Rio Carvão; 4-Volta Redonda; 5- Rio Morozini; 6- Vila Funil; 8-Vila São Jorge; 9-Rio Fiorita; 10-Santa Luzia; 11-São Sebastião Alto; 12-Santa Augusta; 13- São Sebastião; 14- Cidade Alta
Figure 2

Graphical representation of the explanatory variables of the selected GLM model in relation to the number of species citations according to locality (1 to 14), residence time and perception of landscape changes (i.e., 1-positive, 2-neutral and 3-negative)

Supplementary Files
This is a list of supplementary files associated with this preprint. Click to download.

Additionalfile2.csv
Additionalfile1.pdf
Additionalfile3.csv
Additionalfile4.pdf