

The environmental degradation process of the Vermelho River through the perception of Crixás's residents

O processo de degradação ambiental do Rio Vermelho na percepção dos moradores da cidade de Crixás - Goiás

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ABSTRACT

This study presents a discussion about the perception of the residents of Crixás, Brazil, regarding the degradation process of the Vermelho River. We examined the responses from 28 residents before and after they witnessed the induction of the mining company Serra Grande S/A. The research is qualitative and has an interpretative character. Further, we performed bibliographical and documentary research as well as fieldwork and had residents produce mental maps. The mental maps made it possible to apprehend, through written and pictorial language, their individual experiences and relationship with the river. The interpretation of the results indicated that for these participants, mining is one of the primary causes of the river degradation process; however, it also shows that other factors, such as sewage and garbage dumped into the river and removal of ciliary forest, contribute to the intensification of degradation, decline in biodiversity, and health problems in the population.

Keywords: Environmental perception. Experience. Mind mapping. Environmental degradation. Mining.

RESUMO

Este artigo apresenta discussão acerca da percepção dos moradores da cidade de Crixás sobre o processo de degradação do Rio Vermelho. Foram investigados 28 residentes que vivenciaram a condição do rio antes e depois da instalação da mineradora Serra Grande S/A. A pesquisa é qualitativa, tem caráter interpretativo e para realizá-la recorreu-se a levantamento bibliográfico e documental, trabalho de campo e aplicação de instrumento para produção de mapas mentais pelos participantes. Os mapas possibilitaram apreender, por meio da linguagem escrita e pictórica, as experiências dos indivíduos e sua relação com o rio. A interpretação dos resultados indicou que para os participantes a mineração é a principal causa do processo de degradação do rio e da retirada da mata ciliar, intensificando assim a degradação, causando diminuição da vazão, da biodiversidade e adoecimento da população.

Palavras-Chave: Percepção Ambiental. Experiência. Mapa Mental. Degradação Ambiental. Mineradora.

1 INTRODUCTION

The territorial formation of the city of Crixás is linked to the exploitation of its gold mines by various invaders; these include the bandeirantes in the eighteenth century and numerous mining companies as well as miners from different parts of the country in the early twentieth century. In 1989, the mining company Serra Grande S/A settled in Crixás and fostered the economic development and the extinction of illegal mines on the Vermelho River (Red River). Currently, the company has a joint venture with the African company AngloGold Ashanti and the Canadian group Kinross Gold Group.

In 1994, Serra Grande S/A faced its first civil inquiry initiated by the Public Prosecution Service (MP) due to environmental pollution caused by the discharge of effluents and solid tailings from the dam on the Vermelho River; further, in 2004, an environmental damage inquiry was also reported. In 2018, the MP commenced negotiations between Serra Grande S/A and the community regarding compensation for people affected by pollution caused by the mining company.

The tragedies that occurred in Mariana (2015) and Brumadinho (2019), due to the tailings produced by the rupture in the dam, led the National Mining Agency (ANM) to declare the “upstream” tailings containment structure adopted by Serra Grande S/A as defunct until 2021. This was because of the high rate of potential damage associated with its proximity to the urban perimeter.

The determination provoked a significant reaction from the mining company and the local community in Crixás. This gave rise to various questions, namely:

- I. What is the perception of the residents of Crixás about the exploitation of gold?
- II. How do residents perceive the environmental degradation processes caused by the mining company Serra Grande S/A?
- III. How do residents perceive the environmental degradation of the Vermelho River?

With regard to the questions given above, this article aims to discuss the environmental perception of Crixás's residents about the process of degradation of the Vermelho River caused by gold mining. It also seeks to collaborate and broaden discussions about the immediate realities of the combined relationship of humans with habitat and nature. To this end, it is also concerned with the historical process of the establishment of Crixia and the Vermelho River.

2 ENVIRONMENTAL PERCEPTION AND LIVING PLACE

This research is based on the understanding of environmental perception as a mental process for humans interacting with the environment. This implies that the meaning and importance attributed to observed events vary from person to person according to their experiences in a specific habitat or location (DEL RIO; OLIVEIRA, 2005; TUAN, 1980; MARIN, 2008).

Tuan (1980) says that environmental perception is expressed in two aspects: cognitive and affective. The cognitive expression encompasses intellectuality, motivation, moods, values, judgments, expectations, and prior knowledge. The intellect organizes and represents the reality, which is perceived through perceptual schemes and mental images. Conversely, the affective expression is associated with the feelings and bonds that the individual develops in relation to the environment in which they are located; this is because the affectivity drives the perception and unites people with their space. This implies that two people do not see the same reality and no two social groups establish exactly the same assessment of the environment (TUAN, 1980).

Perception develops as a response of the senses to external stimuli and provides the person with immediate knowledge about his surroundings. For the authors Tuan (1980) and Lima (1999), environmental perception comprises the environment in terms of physical, social, psychological, and imaginary dimensions. It is the expression of individual or collective experience in the place of habitat, whereas experience is a term that encompasses the different ways in which a person knows and constructs reality (MERLEAU-PONTY, 1999).

This study appealed to the concept of topophilia that, according to Tuan (1980, p. 107), is “all affective ties of human beings with the material environment”. These ties are built through experiences, which corresponds to the different ways in which an individual knows and builds reality. Thus, individuals use experiences and build thoughts based on their impressions of the place.

The place is expressed by the intellect received from the experience one has of it and/or in it (NOGUEIRA, 2001). This location may cease to exist in the future; however, it does not lose its meaning for the individual who has lived there. According to this concept, affective bonds are formed among human beings themselves and between human beings and places; these bonds are capable of expressing the perceptions and relationships amongst human beings as well as between humans and nature.

Thus, the “place keeps within itself, and not outside it; its meaning and the dimensions of the movement of history in constitution as a movement of life, which can be grasped by memory, through the senses and the body” (CARLOS, 1996, p. 14). Humans establish affective bonds with the places they inhabit. The place is perceived, felt, and represented because it is where they lived. The images that people build of the place are filled with memories, meanings, and experiences (KOZEL, 2007).

Experience can be constructed through more direct and passive senses, such as smell, taste, and touch, to activate visual perception and the indirect way of symbolism. It is a unique sensation, which inspires dreams and desires associated with ideas of an ideal place or its rejection (LIMA, 1999). The way the individual or group experiences or interacts with their place of livelihood can establish an affective bond or repudiation, or even a feeling of belonging or rejection.

Feeling and thinking about the place leads the person to add experiences in an intimate and conceptual way, because, according to Nogueira (2001, p. 43) “the place is given from each one’s experience, the place is presented as experienced by its population”. The author also says that the place is constituted based on the experience that the human being has, and it is through this experience that the relationship with the place is classified as affective, emotional, symbolic, and mythical.

That said, a place may cease to exist, but it does not lose its meaning for the person who has lived or lives there. According to this conception, affective bonds are formed between people and places where they have lived over time; this leads to the residents being so emotionally invested in their places that they are able to resist adversity in favor of living in these spaces. Individuals are able to accept the place and create a reality using their culture, knowledge, language, social standards, and five senses (touch, smell, taste, sight, and hearing). Perception develops as a response to human senses and external stimuli; it provides the individual with immediate knowledge about their surroundings (TUAN, 1980).

Perception can be seen as a sensation; it can be observed as something that affects the human being. It is triggered by experience; therefore, it is apprehended by the human senses and, through them, human beings are able to construct a mental map of the place where they have lived. This leads to them exposing their consciousness about the world.

The mind map is constructed through written or pictorial language, and is the expression of the human experience with the place of their livelihood. It makes thoughts, attitudes, and feelings visible, and can do so for perceived reality as well as their world of imagination. "It is a statement that comes from dialogic relations established between interlocutors in the socio-spatial context. Through language, the subject expresses himself and exposes his lived world" (KOZEL, 2009, p. 127).

The mind map is a type of language conceived by an individual to demonstrate their topophilic feelings. It can be made up of symbols and even written words that convey a personal perception of what is being represented.

In this study, the mental map was used from the perspective of apprehending, through language (written and pictorial), the perception of affective and cognitive memory of the research subject. The experiences of the places are stored in the affective memory, populated by symbols and icons, and are capable of reactivating memories and enabling the construction of mental maps.

3 MATERIALS AND METHODS

This research is qualitative and has an interpretative character. The research proposal was sent to the Research Ethics Committee of the Centro Universitário de Anápolis and was approved under number 2.22.016. The selection of research participants included individuals residing in the city of Crixás, specifically those residing on the banks of the Vermelho River; they were aged from 40 years, and included only those who had experienced the use of the river for leisure, food and income, and had also observed its contamination that was caused by clandestine mining and the accident (crack) at the Serra Grande mining dam.

Twenty-eight adults, men and women, participated in the research. To define the number of participants, the finite sampling was calculated using the software Excel. The number of 50 individuals was pre-established with a confidence level of 90% and a precision level of 10%, which was used to determine a calculated sample of 28 people.

The main instrument for data collection was the mind map. Its use was intended to apprehend, either through drawings or writing, the experiences of the research participants and their relationship with the place; this was because it understood that the mental map has the function of rendering thoughts, attitudes, and feelings visible.

The mind map was used as a data collection tool on participants' perceptions about the use of the Vermelho River and its degradation from 1990 to 2017. For its production, home visits were scheduled, respecting the time set by the participant. The research proposal was presented and, after the acceptance of participation, a request to sign the Informed Consent Form was made. Later, supplies were made

available, including an A4 sheet with the outline print symbolizing the Vermelho Riverbed in the localized stretch in Crixás, in addition to crayons (box with 12 colors), a black pencil, an eraser, and a sharpener.

In possession of the materials, the participant was asked to answer two questions: How did you perceive the river in your childhood or youth? How do you perceive the river today? From the questions he or she wrote or drew their perception. The composition of mind maps was free for the participant.

After data collection, for analysis of mental maps, we resorted to the methods employed by Kozel (2007) and Tuan (1983), and to interpret them we considered:

- IV. The representation of information, whether drawing, writing or use of colors;
- V. The specificity of the icons or symbols described therein (natural landscapes, constructed landscapes, movable and immovable elements, human elements);
- VI. The senses (sight, smell, taste, touch, and hearing) used to describe the landscape or place;
- VII. The participant's expressions of experiences with the place, namely: i) emotional (feeling of loss, longing, happiness, anger, and love); ii) attitudinal (feeling of acting or reacting), and iii) guilt (feeling of what is guilty or who is guilty).

The maps enabled the respondents to express themselves through the understanding of the relationship between human being and environment. Additionally, it is important to highlight that mental maps are related to the real world, because they are built by subjects who experienced the places produced and are materially constructed.

4 CONTEXTUALIZATION OF THE STUDY AREA

The city of Crixás is located in the São Luiz dos Montes Belos microregion in the state of Goiás (Figure 1). Its territorial formation was due to the exploitation of alluvial gold in the Vermelho River in the eighteenth century by the bandeirantes who installed the first mines. However, in the following century, gold exploitation stagnated, leading to population decline (OLIVEIRA, 2001).

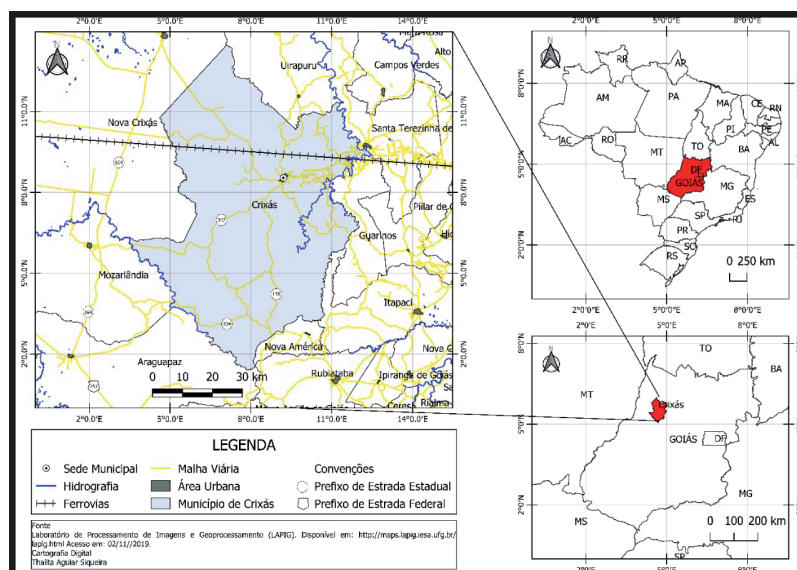


Figure 1 | Location of the municipality of Crixás, Goiás, Brazil

Source: Brazilian Institute of Geography and Statistics, 2019.

Geologist Albrecht Dietz, at the beginning of the twentieth century, identified gold ore in the lands called Chapéu de Sol and Venâncio in Crixás. The news spread and, with rapping on the riverbed, men and women ventured in search of Eldorado (OLIVEIRA, 2001). However, soon the English Company John Taylor & Sons bought the mining land, leading to its exploration until 1923. The intensity of ore mining diminished, but did not stop and, in 1980, Crixás had a population of 30,219 inhabitants; 75.66% were in the urban area. At that time, the practice of gold exploitation through alluvial and mechanical pumping water jets still prevailed (Figure 2,3).



Figure 2 | Gold miners searching for gold in Vermelho River, Crixás, Goiás, Brazil.
Source: Divino Rafael Ribeiro, 1987.



Figure 3 | Gold miners searching for gold in Vermelho River, Crixás, Goiás, Brazil.
Source: Divino Rafael Ribeiro, 1987

In the same decade, the Mineração Serra Grande S/A company started its operations in gold mining in Crixás. In 1990, the region's 5000 underground clandestine miners were banned from mining in the Vermelho River due to the embargo of the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) and from the Environment Police Station (AZEVEDO & DELGADO, 2002).

According to IBAMA, the ban occurred because the prospectors were contaminating the river with the use of mercury. The mining company had hired some of the local residents, who used illegal mining practices, to work in the ore extraction process.

The Serra Grande S/A mining dam is 1.5 kilometers from the municipality of Crixás and 80 meters high. Crixás is located topographically below the mining tailings dam, that is, it is below the containment dam (Figure 4).

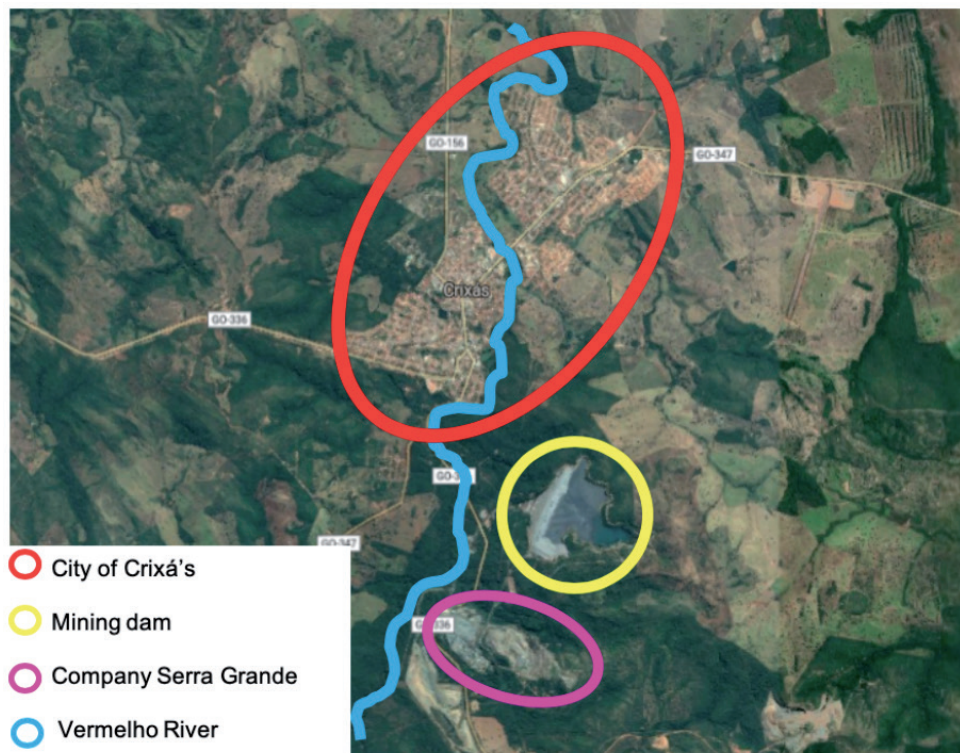


Figure 4 | Location of the city of Crixás's, dam of the mining company and headquarters of the mining company Serra Grande S/A.

Source: Google Maps

In the 1990s and 2000s, Serra Grande S/A exported its production to the United States and England. Additionally, in the 1990s, the company's tailings dam cracked, causing millions of cubic liters of contaminated water to be discharged into the Vermelho River. A civil public inquiry was instituted, with which the Public Prosecution Service took action against the mining company, based on the environmental aggression suffered by the river:

It is reported that in March 1994, the State Public Prosecution Service opened the Public Civil Inquiry No. 02/1994 to investigate, in summary, the profound aggressions to the environment caused by the discharge of effluents from the Serra Grande Mining Dam in the Vermelho River bed, municipality of Crixás (GOIÁS PUBLIC MINISTRY, ICP fls. 01/02).

The evidence of this accident is shown in the report of the Public Civil Inquiry No. 02/1,994, unequivocally accusing the mining company of the serious environmental pollution caused by the discharge of effluents and solid tailings from the Serra Grande S/A mining dam, which, by the way, presented high levels of arsenic and cyanide into the Vermelho River.

In 2004, the prosecutor again accused the company of water pollution and violation of Brazilian law. The document states:

“Positivized in various analyzes and reports attached to this (piece), it is clear, therefore, that the releases of the chemical waste mentioned mainly arsenic and cyanide - did not meet the recommended levels, which unequivocally demonstrates the existence of very serious water pollution and violation of current legislation” (GOIÁS PUBLIC MINISTRY, 2004).

In 2007, the Center for Mineral Technology (CETEM), a unit of the Ministry of Science, Technology, and Innovation, collected data on the existence of a high rate of mental retardation in the city, as well as cases of hydrocephalus, Down syndrome, and neurological problems, which may be correlated with mining contamination (FERNANDES; LIMA; TEIXEIRA, 2007). The research also points out that some of the residents of Crixás relate the diseases to the occurrence of cyanide, originating from the ore beneficiation process. The highly toxic substance would be mixed with the tailings of dams produced by the mining company.

In 2009, despite complaints of contamination and negative consequences in the lives of the local population, the company increased its area of operation, outsourced further underground, and expanded open-pit mines in the cities around Crixás. The exploration intensified. In 2015, due to the breach of the Fundão dam in the city of Mariana, MG, there was a national appeal about the situation of the dams in the country. Among the existing mining companies in Goiás, only Serra Grande S/A was classified as “high associated potential damage” by the National Department of Mineral Research (DNPM), currently the National Mining Agency.

Until 2016, the Serra Grande S/A dam had no Emergency Action Plan (PAE) and no sirens, light signals or direct warning to the population by radio, television or telephone (SOBREIRO, 2016), despite the elaborated PAE requirements made by the DNPM. In an interview with *Mineração e Sustentabilidade* magazine (2017), AngloGold Ashanti's CEO in Brazil, Camilo Farace, a group belonging to Serra Grande S/A, said that online monitoring systems were implemented in the rock massif.

To make it viable, a fiber optic network was installed, which allows the movements of the monitored highlight spans to be measured with millimeter precision. These activities, in addition to providing a quick removal of employees in cases of movement, generate numbers that enable the company to expand or reduce the exploitation of a certain area. The data will make it possible to identify whether a particular region still supports extraction activity or whether it is advisable to cease exploration (FARACE, 2017, p. 11).

It is important to highlight that Serra Grande S/A is responsible for extracting approximately 6000 kg of gold ore annually, according to Mauro Borges Institute (IMB, 2019); further, it is accountable for employing about 1243 people, corresponding to 33% of the population employed in Crixás, and generating an average salary income of R\$ 4431.07. These are the reasons given by the mining company to justify the exploitation of natural resources and the processes leading to degradation of the environment and human life.

5 RESULTS AND DISCUSSION

In the first group of maps (Figure 5), participants used only words around the figure to describe their perception and experience of the place. For them, the river is treated as a past, a dream of yore, with clean, flowing water used for drinking and playing. The emotional experience is exposed by the feeling of loss several times and the river is represented as a departed loved one and is “simply missed” by most.

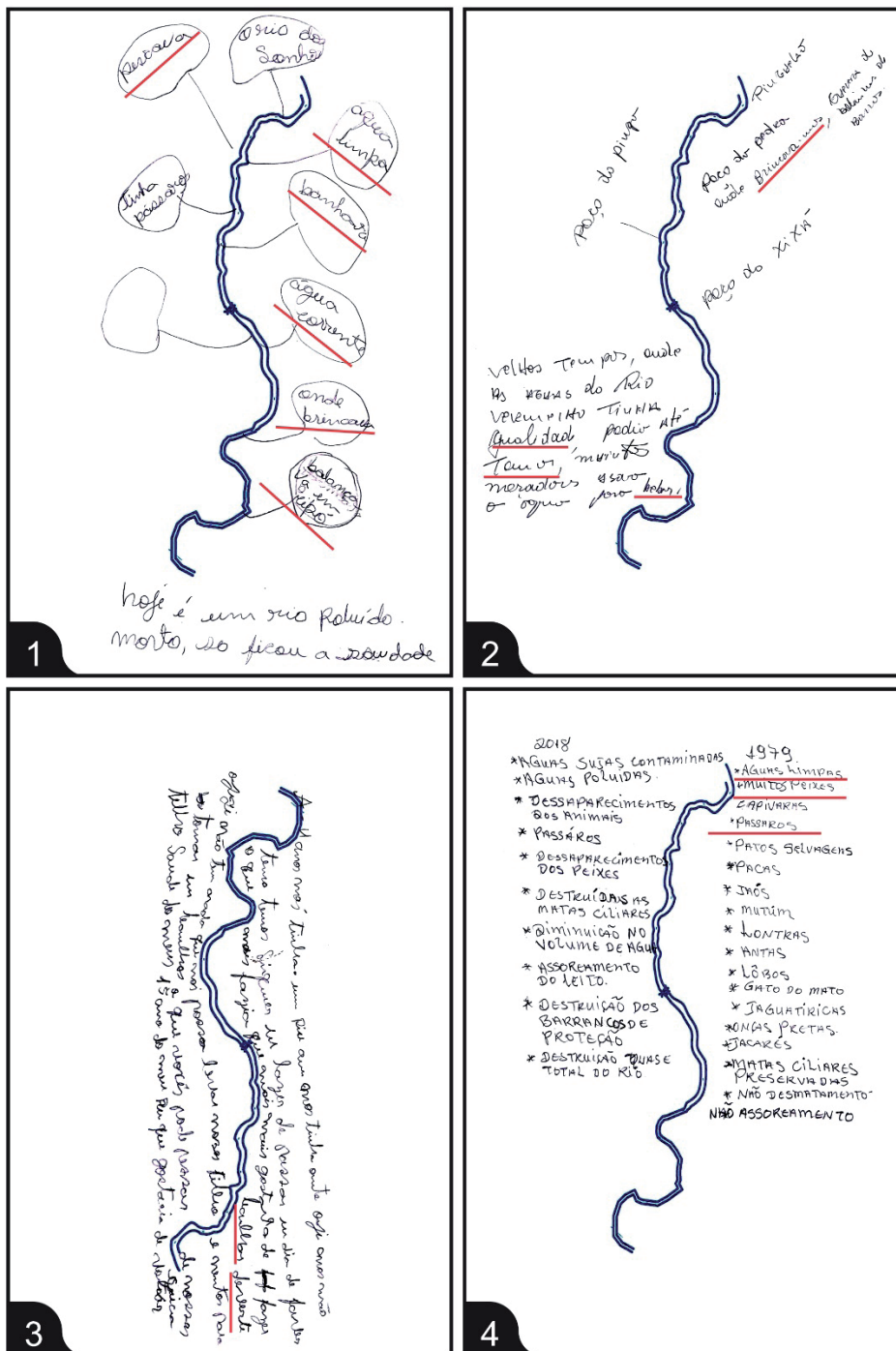


Figure 5 | Mental Maps – 1, 2, 3, 4, Vermelho River, Crixás, Goiás
Source: produced by survey participants, Crixás, Goiás, 2018.

In maps 1 and 2, the respondents refer to childhood games involving vines and wells, which were basically the surroundings where the games were played. Maps comprise memories and meanings of the living experiences, and they express a socio-spatial context of the process of degradation of the environment and human life. Maps 1, 2, 3, and 4 show the temporal relationship of man with the environment and the perception of environmental loss that degrades human life; this included the reduction in the supply of food and leisure. Environmental loss is felt through taste and touch by remembering the contact with water and observing the current description of the situation of the river.

In contrast to the previous one, in Figure 6 (maps 5 and 6), participants apprehend the need for river recovery; further, they direct this responsibility to the government and society. They also highlight the

sense of guilt of the prospectors and the mining companies, which were responsible for the degradation of the natural environment; they reiterated the fact that the river had turned into a source of diseases due to contamination and pollution of its waters caused by these companies, which is a disturbing factor for the lives of the people who reside there.

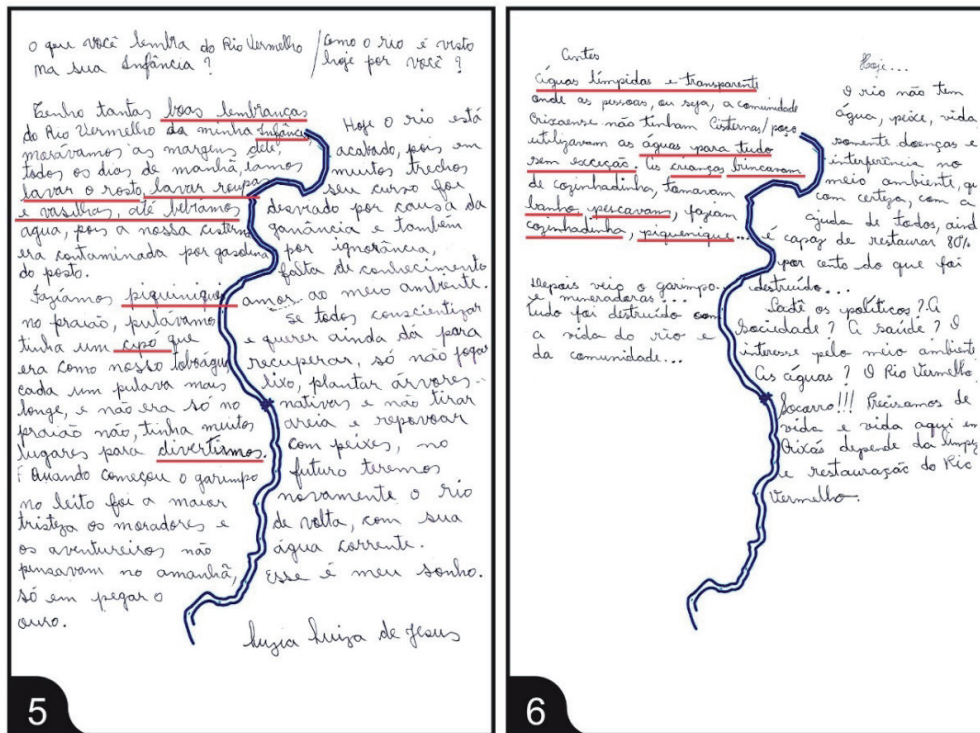


Figure 6 | Mental Maps 5 and 6, Vermelho River, Crixás's, Goiás.

Source: produced by survey participants, Crixás's, Goiás, 2018.

Maps 5 and 6 not only reflect the environmental degradation process caused by mining but also the sewage and garbage discharged into the river, removal of riparian forest, decreased flow, and decline in biodiversity; all these factors are seized by the conscience of individuals. The research participants comprehend degradation as a collective act, which is practiced by society and not just by an individual. There is a possibility of the existence of a sense of collective loss with due proportions; this is because the senses have been changed and replaced over time by the individual's experiences in and with the Vermelho River.

Figure 7, comprising maps 7, 8, 9, and 10, has mixed composition (drawing and writing), except for map 9, which shows only drawing. Human figures are present in all maps, along with fauna and flora. In map 8, the river is depicted as a precious belonging to the local population, expressing the feeling of loss: "Bathing in the Vermelho River today never again [...]". The participant illustrates people fishing, playing, doing what he calls "little cooking" by the river, washing clothes, and demonstrating the overall experience with the environment.

In map 9, the river cries, as the water reflects the present tense that resembles blood, but also the past through the memories of the jokes. The reflections of joy and pain of loss are mirrored on the map. Bachelard (1989, p. 49) tells us that "one can discover both waters, from joy and pain. But there is not just one memory. Never heavy water becomes light water, never dark water becomes clear. It is always the reverse." The two water bodies are also highlighted in map 10 through drawings and paintings of the sky, nature, death, and pollution. The participant recovers his experience and apprehends the place through the senses of sight, touch, and smell, which enables him to describe his transformative process.

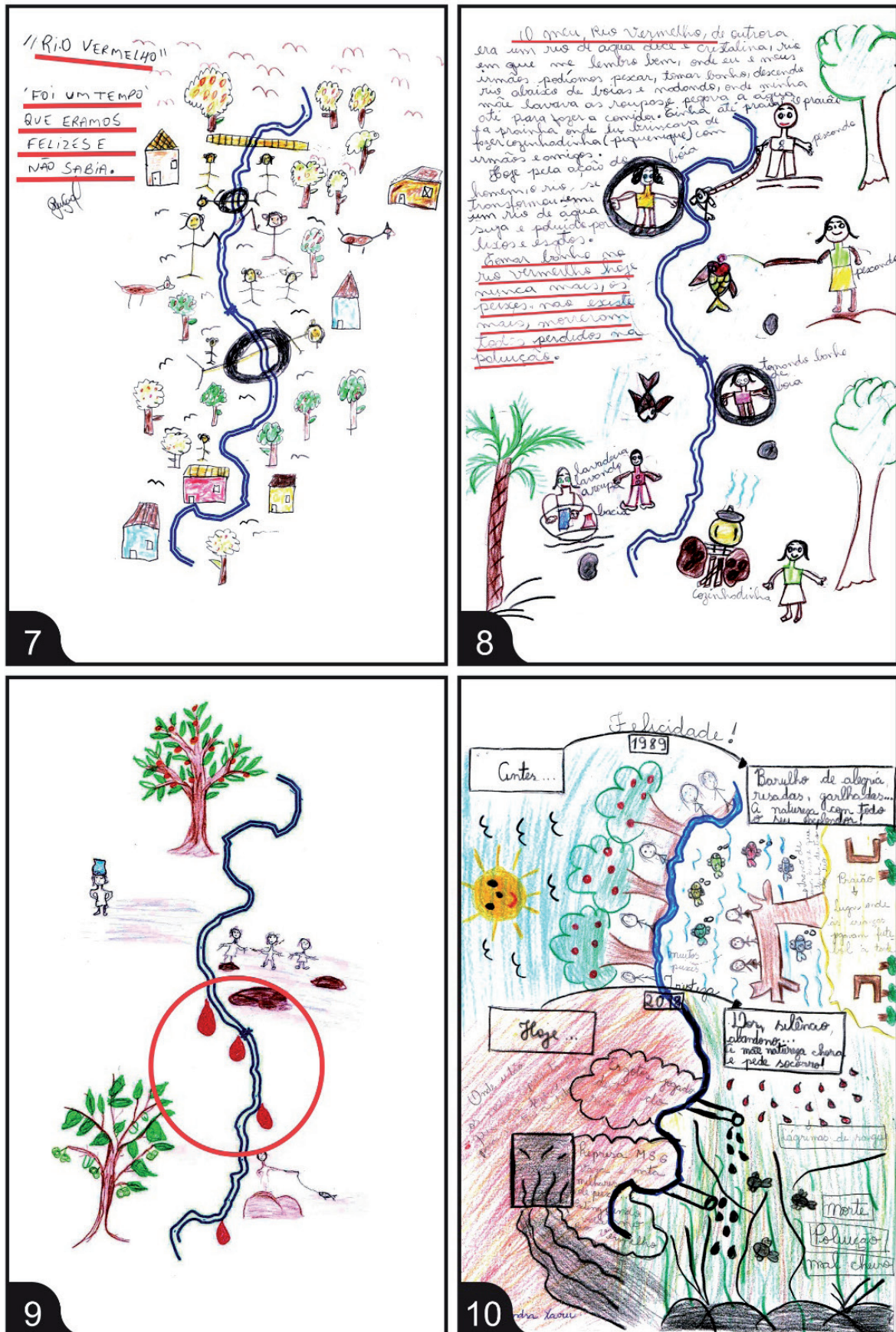


Figure 7 | Mental Maps 7, 8, 9 and 10, Vermelho River, Crixá's, Goiás
Source: produced by survey participants, Crixá's, Goiás, 2018.

In Figure 8, composed of mixed maps, map 11 details the experience of people by the Vermelho River, with citations of places where men bathed — “Baiãozinho”, and women — “Maria Broque”. Verbs used in the map are in the past as “they took, did, survived, took”, demonstrating the disintegration of the relationship with the environment, or even the expression of the anguish of loss.

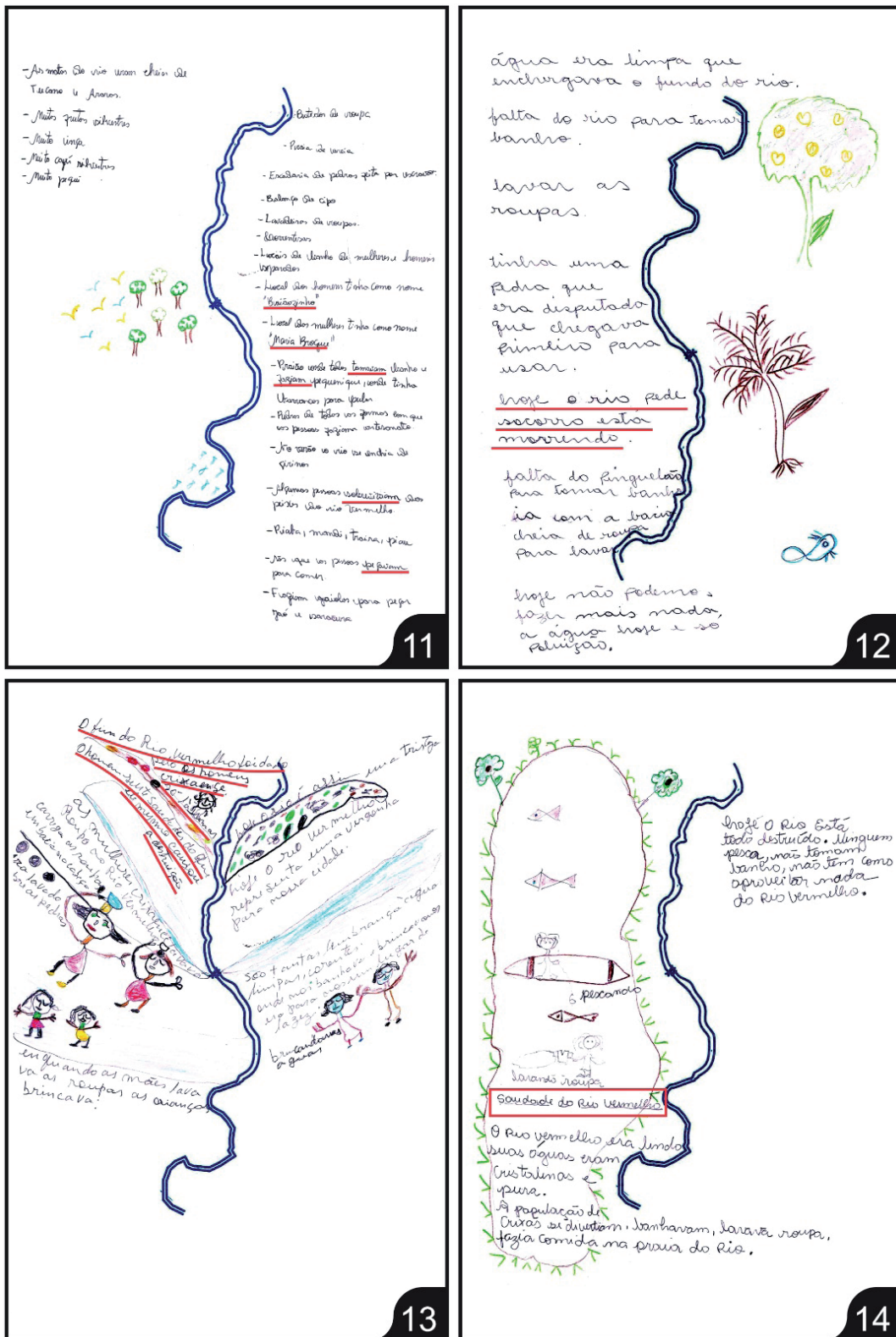


Figure 8 | Mental Maps: 11, 12, 13 and 14, Vermelho River, Crixás's, Goiás.

Source: produced by survey participants, Crixás's, Goiás, 2018.

In map 13, the respondent attributed the responsibility of degradation to society. He says: “The end of the Vermelho River was given by the crixáensi men, only tears.” The participant’s experience presents other authors of the river degradation process, not only attributing it to the mining company but also apprehends the ambivalence inherent in society’s relations with the environment, “Man misses what he himself caused, The destruction”. The Vermelho River is described in its tophophilic dimension as an active participant in people’s lives.

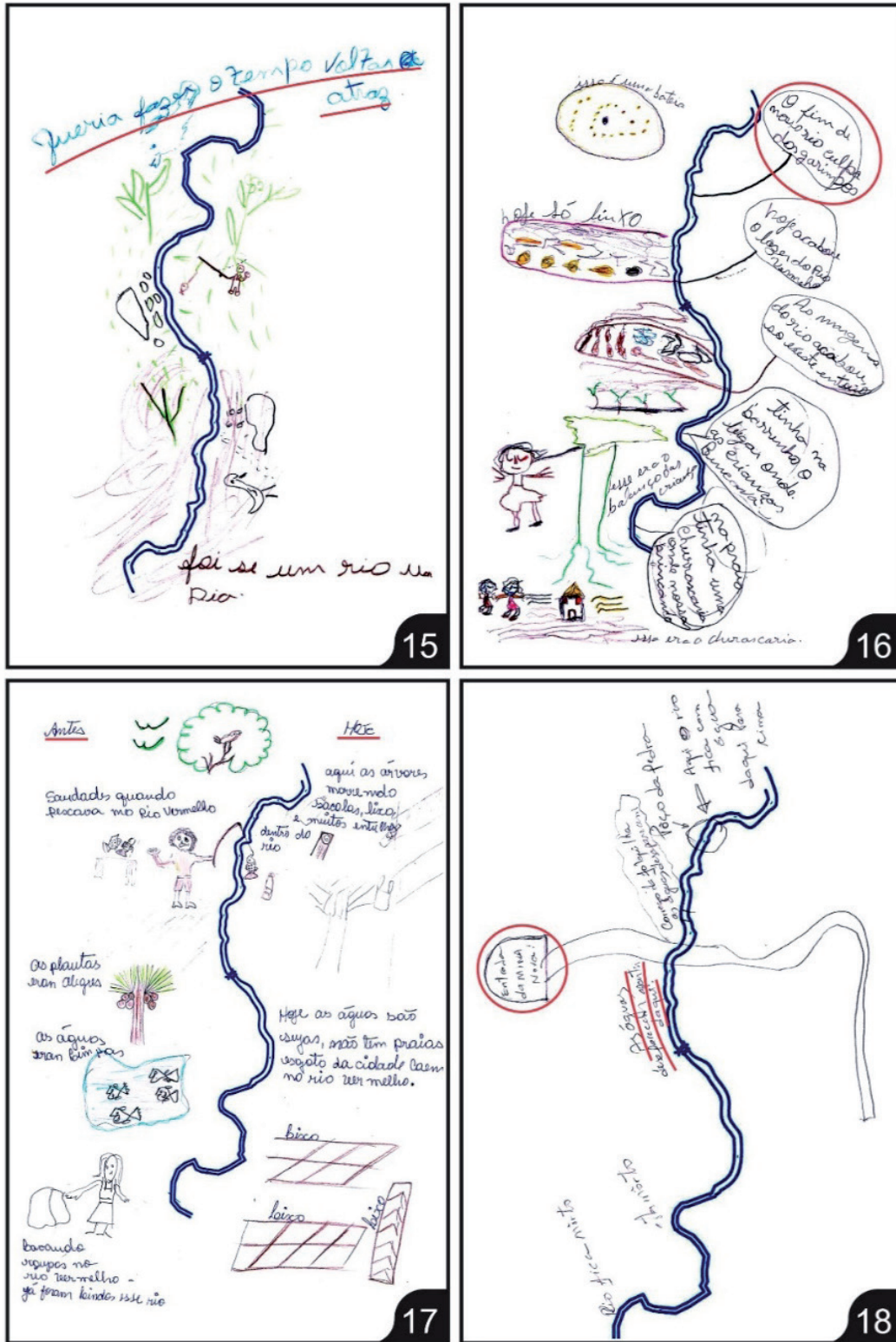


Figure 9 | Mental Maps 15, 16, 17 and 18 - Vermelho River, Crixá's, Goiás
Source: produced by survey participants, Crixá's, Goiás, 2018

In Figure 9, map 15 shows the phrase “I wanted to turn back in time” and in 16 the participant states “The end of our river is the fault of the miners”, as shown in 17. In maps, participants perceive the degradation of the environment, not only focusing on the mining company but also feeling responsible, as the river mining began before the company was set up. Map 18 shows where exactly the waters of the Vermelho River disappear, being swallowed up by the “new mine”, into one of the mining tunnels that pass just below the Vermelho River, “The waters disappear from here”.

Figures 7 and 8 show maps demonstrating culpability. The degradation of the river is seen as the responsibility of society, but mainly of the mining company that causes the flow reduction, water diversion, and contamination. Participants consider themselves responsible for the destruction of the river, especially those who were active in the mining area before the mining company was installed. However, they show dissatisfaction with the mining company's actions in the city.

Although it was not mentioned in the mind maps, it is important to point out that in 2015 the Goiás Public Prosecutor's Office (MP-GO) requested a survey on the quality of life of the Crixás population and, since then, the neighborhood association of Santo Reis has sought to negotiate with the mining company solutions for noise pollution that has caused disruption to residents.

In 2018, MP-GO reopened negotiations with the mining company to relocate 60 families to another location in the city and to transfer about 300 land to the company. Another note from the MP-GO refers to the diversion of “funds destined by the mining company to supply drinking water to residents of the [Santo Reis] neighborhood, who would have actually received water unfit for consumption” (GOIÁS PUBLIC MINISTRY, 2018, p. 1).

In light of the foregoing by the MP-GO, there is a need for further studies on the process of gold ore exploration and its consequences for the environment and the individual and collective lives of residents in the city of Crixás. New questions must be asked and investigated; for example: How the resource passed on by the mining company to municipal management is being used? In addition to the contamination of the waters of the Vermelho River, what other pollution or contamination is being caused by mineral exploration? What are the impacts on the lives of people being evacuated from their homes so that the mining company can expand its exploration of gold ore?

6 FINAL CONSIDERATIONS

The research presented in this article used mental maps to capture the experience that individuals had before and after the contamination of the Vermelho River. They recognize the river as their place and their home, perceiving the landscapes as representations of what symbolizes their history.

The representations of the experiences in the Vermelho River were presented. On one hand, these can be considered almost poetical. In mind maps you can find words and phrases like: “The river of dreams and the old days.” It is simple to create a nostalgic emotional picture, where the research participant presents his perception of loss. The river begins to populate the memory of those surveyed; the following phrases reiterate this: “Good memories”, “I just missed you”.

On the other hand, there are maps that indicate that the state, mining company, and society are responsible for the degradation of this river; further, those who worked as prospectors before the installation of Serra Grande S/A are also held accountable. The representations on the maps express emotions, especially longing and guilt; however, these are accompanied by an attitude that is directed toward the recovery or conservation of the waters. This implies that the research participants are emotionally linked to the Vermelho River and even blame themselves for the process of river degradation; however, they have not incorporated into their maps or indicated by their actions any blame toward the mining company for this situation. The maps show more homesickness and guilt rather than a political stance toward the facts.

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