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Risk, precautionary principle and environmental justice in mining conflicts

Risco, princípio da precaução e justiça ambiental em conflitos por mineração

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ABSTRACT: In the analysis of socioenvironmental conflicts by mining, several studies have pointed out the various causes that give rise to these tension scenarios, especially in local communities. However, one aspect that is not addressed is the perception of risks as a socio-environmental conflict cause. Based on this premise, this work discuss the theories that approach the risks and precautionary principle with the theory of environmental justice in order to identify the common elements between both and their implications in the context of conflicts that involve collectivities. We argue that the analytical link between the precautionary principle and the environmental justice theory allows us to note that in some conflicts regarding mining, in addition to the rejection of risks due to possible polluting effects, there are other interrelated issues of epistemological, social, cultural, economic and political content that influence in conflict scenarios. The work shows that these interrelations are expressed mainly in the intrinsic limitations of scientific knowledge for the evaluation of risks and uncertainties in complex mining projects, and in the political dispute surrounding the evaluation and decision on risks that could affect incommensurable goods such as the environment, human health and the forms of organization of various communities.

Keywords: Environmental Impact Study; post-normal science; resistance; epistemologies.

RESUMO: Na análise de conflitos socioambientais por mineração, vários trabalhos têm apontado as diversas causas que originam estes cenários de tensão sobretudo em comunidades locais. Contudo, um aspecto pouco abordado é a percepção dos riscos como causa de um conflito socioambiental. A partir dessa premissa, este trabalho discute teorias que abordam os riscos e o princípio da precaução com a teoria da justiça ambiental a fim de identificar os elementos comuns entre estas e suas implicações em conflitos que envolvem coletividades. A conexão analítica entre o princípio da precaução e a teoria da justiça ambiental permite advertir que, em alguns conflitos

por mineração, além da rejeição aos riscos por possíveis efeitos poluentes, existem outras questões inter-relacionadas de conteúdo epistemológico, social, cultural, econômico e político que influenciam nos cenários de conflito. O trabalho mostra que estas inter-relações se expressam principalmente nas limitações intrínsecas do conhecimento científico para a avaliação de riscos e incertezas em projetos de mineração complexos e na disputa política que envolve avaliação e decisão sobre riscos que poderiam afetar bens incomensuráveis como o ambiente, a saúde humana e as formas de organização de diversas comunidades.

Palavras-chave: Estudo de Impacto Ambiental; ciência pós-normal; resistência; epistemologias.

1. Introduction

Socio-environmental conflicts regarding mining are widely discussed in Political Ecology as a type of conflict within the so-called ecological distributive conflicts (Martínez-Alier, 2007). This ecological distribution originates in processes and patterns of meaning, valuation and appropriation of the natural resources and services provided by the environment as a system to support the various forms of life (Martínez-Alier, 2007). Nevertheless, these distribution relations (which are not solved by the economic valuation of nature) are determined not only by natural conditions but also by social, cultural, economic, political and technological conditions (Leff, 2003; Martínez-Alier, 2007) that generate impacts on society and nature. Thus, there would be a common link between distribution struggles and demands for the *repairing of ecological damages* (Martínez-Alier, 2007). These struggles are expressed in arenas of political dispute in which local communities and movements worldwide demand a fair distribution of environmental benefits and damages within their territories. This is the case of the Environmental Justice movement (e.g. Schlosberg, 2007; Acselrad, 2010; Ribeiro, 2017) and Ecologism of the Poor (Martínez-Alier, 2007).

The increase in socio-environmental conflicts due to extraction of mineral resources, particularly in the last two decades, has been widely discussed in a number of studies (e.g. Bebbington *et al*., 2008; Conde & Le Billon, 2017). The dynamics of these conflicts are expressed in a conflict of interests between different agents. On the one hand, there are companies dedicated to the extractive industry, often favored by a convenient institutional-normative structure of the receiving countries (Bebbington *et al*., 2008; Helwege, 2015; Guzmán Solano, 2016; Losekann, 2016; Walter & Urkidi, 2017); on the other, there are local and rural populations, environmental advocates and activists, indigenous communities, *quilombolas* (settlements established by descendants of African slaves), and non-governmental organizations (NGOs) that defend the environment and affected territories (Martínez-Alier, 2007; Bebbington *et al*., 2008; Zhouri, 2008; Souza & Milanez, 2016; Conde, 2017). Other studies also note that the incidence of mining conflicts occurs for different causes in different circumstances and with multiple pretensions (Conde & Le Billon, 2017). This makes socio-environmental conflicts due to mining processes with similar causes, but with different dynamics and results.

Among the causes of conflicts is the production of social and environmental impacts on the territories and water sources, as well as forms of social organization of the communities in dispute (Souza & Milanez, 2016; Conde, 2017). To this scenario

there shall be added the poor participation or exclusion of these communities in the decision-making process (Zhouri, 2008) and the lack of confidence in the companies due to previous experiences of poor compensation for mining losses (Martínez-Alier, 2007; Bebbington *et al*., 2008; Condes, 2017). Regarding the circumstances and pretensions in the conflicts, Conde (2017) mentions that the resistance exercised by the communities in dispute can be aimed at different political objectives that could be reached by performing different forms of opposition or mobilization. The author also notes that there are several factors in this process: the starting moment of the resistance, extra local alliances between local communities and NGOs, access to information on the enterprise, access to information networks that allow the exchange of experiences on the impacts caused by extractive activities in other territories, geographic area and type of resources to be extracted, degree of political marginalization, perception of the magnitude of the effects that the extractive activity can cause in the territories. and the organizational capacity of communities (Conde, 2017).

Most of the factors mentioned are elements that are common to mining conflicts, especially those developed in the last decades. Notwithstanding, the irruption of some of these factors is a consequence or manifestation of the confluence of more recent technological and social phenomena, such as free access to the Internet and social networks (Castells, 2013), which have enabled the enhancement and scope of socio-environmental struggles, as well as expanding its defense discourse and claiming in more complex current contexts, such as globalization, climate change and risks. It is in this last subject that our study is situated.

Based on a conceptual and theoretical review, through an analysis of the literature on the subject, this article is organized in the following topics: risks as the cause of mining conflicts, which analyzes the rejection to the risk assessment instruments by communities affected by enterprises; then, it is addressed the precautionary principle, its limitations and possibilities of application in the mining activity, whose analysis is supported by a comparative research of two cases of socio-environmental conflicts caused by mining (one in Brazil and another in Peru); and subsequently, environmental justice and its relation to the precautionary principle in mining are discussed. Finally, it is concluded that the combination of the precautionary principle with environmental justice strengthens an analysis of the risks inherent in intensive mineral exploration in favor of the interests of the affected communities.

2. Risks as a cause of mining conflicts

Conde & Le Billon (2017), after reading 224 studies published in a number of academic publications, state that there is an increase in interest and research on mining conflicts and cases of local communities in resistance. This may, in part, mean an increase in the number of socio-environmental mining conflicts. They also affirm that "[s]ocio-environmental impacts are clear drivers of resistance; many projects are been resisted before they start because communities have learned – through networks and alliances – of the impacts they cause to their livelihoods." (Conde & Le Billon, 2017, p. 13). Thus, there would be a trend of change in some causes and forms of development of the mining conflicts, determined to a large extent by the

technological and social transformations of the last decades. Nevertheless, we argue that this change would not be reduced solely to the mere rejection of the impacts of mining on the environment or human health, which are widely known and learned by local communities. It would also be a manifestation of a more complex analysis phenomenon, in which local communities in resistance are faced with uncertainties regarding the extent of impacts or irreversible damage that could be caused in their territories and which could endanger their sources of social reproduction.

According to the Atlas of Environmental Justice (EJAtlas)[1], 2408 cases were reported as ecological distributive conflicts and fight against environmental injustices worldwide. 517 of these cases (21%) are conflicts caused by the extraction of mineral resources and construction, while 126 of them are recorded as conflicts initiated in the preventive stage (resistance before the beginning of the activity), with questioning of Environmental Impact Assessments (EIA) or judicialization of cases. Of these 126 cases, 63 are reported as conflicts of medium intensity, while 44 are classified as high-intensity[2] (Temper *et al*., 2015). The purpose of this query was to observe the number of reported mining conflicts with characteristics that may help us identify conflicts whose cause (or one of its causes) is the perception of risk. The categories queried for this search were: moment of reaction to the enterprise, intensity of the conflict, and forms of mobilization of the local communities. The first delimitation sought to discriminate conflicts initiated by possible risks from those whose cause is the generation of environmental impacts. The second sought to identify conflicts that generated greater mobilization and articulation of the local communities with several other agents inside and outside their territories. This greater mobilization would indicate a greater controversy regarding the perception of risks of the enterprise questioned. Finally, the third one sought to observe the strategies used during the resistance by the communities.

In the latter category, a key element in the analysis is the *objection to the EIA*. The EIA is the most widely used environmental risk and impact assessment tool for most projects and ventures that affect the environment. It aims to identify, predict, assess and mitigate the biophysical, social, and other relevant effects of development proposals prior to the decision-making process (International Association for Impact Assessment, 1999). For this reason, local communities opposing a mining project object to the EIA as a resistance strategy (Conde & Le Billon, 2017), in order to anticipate the moment of environmental licensing or, in other cases, to interrupt the current licensing processes (Jaskoski, 2014; Helwege, 2015; Guzmán Solano, 2016).

[1] Available at: <http://ejatlas.org/>. Retrieved: Dec 9, 2017.

[2] The EJAtlas presents several search filters and uses logical boxes to accumulate or discriminate the desired categories. *Blue logical box:* ***and****; Green logical box: or; Red logical box:* ***not***. For the data presented, the following filters were used: 517 cases: Blue logical box: [(Category> Category> Mineral Ores and Building Materials Extraction)]. 126 cases: Blue logical box: [(Category>…), (Conflict> Reaction Stage> PREVENTIVE), Green logical box: {(Resistance> Mobilizing forms> Objections to the EIA), (Resistance> Mobilizing forms> Lawsuits, court cases, judicial activism)}]. 63 cases: Blue logical box: [(Category>…), (Conflict>…), Green logical box: {(Resistance> Mobilizing forms> Objection…), (Resistance> Mobilizing forms> Lawsuits…)}, (Conflict> Intensity> MEDIUM: street protests, visible mobilization)]. 44 cases: Blue logical box: [(Category>…), (Conflict>…), Green logical box: {(Resistance> Mobilizing forms> Objection…), (Resistance> Mobilizing forms> Lawsuits…)}, (Conflict> Intensity> HIGH: widespread, mass mobilization, violence, arrests, etc.)]. For more information about the methodology used in EJAtlas, please refer to: Temper *et al.*, 2015.

Because it is an official instrument used by government agencies, the questioning of the EIA must be formal and occur through institutional mechanisms. One of these mechanisms, which corresponds to the last category consulted, is the judicial questioning of the EIA, which also includes the objection to the mining project as a whole. Thus, some local communities achieve the suspension of the environmental licensing process, requiring clarification of the objections made. Notwithstanding, questioning the EIA may involve more complex issues that are not solved only by its clarification. These issues may relate, on the one hand, to the intrinsic limitations of instruments such as the EIA for risk assessment in complex projects, and on the other, to political disputes relating to the decision on the risks that could affect both the biophysical systems of the environment and forms of life of the communities in resistance.

3. Risk and precautionary principle in mining conflicts

The arguments presented in this article are based on a comparative study of two cases of socio-environmental mining conflicts that feature the warning of risks in large enterprises as one of their causes. Both cases are among the 126 cases raised in the EJAtlas.

The first concerns a conflict over a project to extract more than 1,8 million metric tons of phosphate per year, in the city of Anitápolis, state of Santa Catarina, Brazil. This project aimed at exploring a phosphate deposit located near the headwaters of the Pinheiros River, a tributary of the Braço do Norte river, which is part of the Tubarão river basin. Its deployment included the extraction of phosphate ore and manufacture of sulfuric acid, essential for the manufacture of simple superphosphate. To achieve this, the project had planned the construction of two dams of more than 50 meters in length. The first one would be built downstream in the Pinheiros River, to contain waste from the processing of the residual ore. Subsequently, another dam would be built upstream of that dam. Thus, during the 33-year period of the project, the dams involved a plan to contain approximately 34,000,000.00 m³ of tailings and sludge from the residual ore (Prominer Projetos & Caruso Jr Estudos Ambientais, 2006, pp. 103-104).

The lack of clarity relating to the magnitude and possible impacts of this project, as well as fears of a possible disruption of these dams, which are very close to the settlements (the axis of the downstream tailings dam is only about 500 m from the buildings closest to the location of São Paulo dos Pinheiros), led the populace of Anitápolis to question and mobilize against the project. Among the main motivations for resistance is the fact that Anitápolis is located in an area considered of great importance from the hydrographic standpoint, as it has the largest water source of Santa Catarina, with several river springs belonging to the basin of the Tubarão River and Lagunar Complex, which has an area of 5,816 km², encompassing 21 municipalities in southern Santa Catarina and a population of 360,556 inhabitants, constituting the South Santa Catarina Hydrographic Region – 9.

After a series of mobilizations, which began in 2005 and covered more than ten municipalities, in 2009, the Montanha Viva Association presented a Public Civic Action with a preliminary injunction request, filed against the environmental licensing carried out by FATMA (Foundation of the Envi-

ronment, a state licensing agency that was replaced by the Institute of Environment - IMA), before the Federal Environmental Court of Florianópolis, arguing, among other things, for the application of the precautionary principle. After deliberation, on September 28, 2009, the injunction was granted by Judge Marjôrie Cristina Freiberger Ribeiro da Silva, of the Federal Environmental Court of the Capital, in application, among other aspects, of the precautionary principle, ordering the suspension of environmental licensing and all activities by the enterprise. Finally, in June 2016, the enterprise informed the court the waiver of the environmental licensing, resulting in a declaration of extinction of the legal proceeding.

The other case concerns a conflict generated against the Conga gold mining project in the Department of Cajamarca, Peru. This project involves the exploration of copper, gold and silver in the Chailhuagón and Perol lagoons, allowing the processing of 3.1 billion pounds of copper and 11.6 million ounces of gold, which would soon be transported to the country's coastal region for its outflow to the international market.

The duration of the activities would be 19 years, covering an area of direct influence of 3,000 hectares and an indirect area of 16,000 hectares. Upon completion of the exploration, the cutting of the exploration wells would have an elliptical shape with a main axis approximately 1950 m long, and the maximum depth of the trench would be about 660 m (Knight Piésold Consulting, 2010; Moran, s.d.). Furthermore, two tailings deposits would be built in the Toromacho and Alto Jadibamba River basins. It is estimated that at the end of mining operations, the tailings deposit would occupy an area of approximately 700 ha. The associated infrastructure for this facility includes two main dams, one with heights of approximately 101.5 m at the highest point and another with a height of 66.5 (Knight Piésold Consulting, 2010; Moran, s.d.).

Although reports from the Yanacocha company did not expressly mention the destruction of lagoons in the affected area, it was evident to the communities that they should be dried for ore extraction and clearing. It was for this reason that in April 2005, representatives of the organizations of the provinces of Cajamarca and Celendin requested the Ministry of Energy and Mines (MEM) to declare that the Conga project was unfeasible for jeopardizing three river basins, which could cause the disappearance of more than eleven rivers and restrict access to water to more than 50 surrounding communities. Despite these observations, the communities' requests were not met.

In March 2010, a public hearing was held to present the EIA in the village of Chailhuagón. At the hearing, a complaint was made that the Conga project would affect four lagoons that supply the rivers, thereby requiring further hydrological studies. In October 2010, the company presented complementary information and a commitment to the realization of a new hydrological structure that updates the model of the affected aquifer. With this, on October 27, 2010, the MEM approved the EIA of the Conga project.

Given the irregularities of the project, social mistrust in the region increased. Thus, between September and October 2011, protests began in Cajamarca, with road blockades and burning of the company's machines. These demonstrations motivated the province's declaration of state of emergency, causing confrontations between communities and members of the police, which reached their peak

in July 2012, with strong protests that resulted in five casualties and dozens of wounded civilians. These episodes had a strong national and international repercussion, including a pronouncement by the Inter-American Commission on Human Rights.

Following these events, and as part of the resistance actions, in October 2012, a Constitutional Claim was filed, requesting the suspension of the project and invoking, among other grounds, the application of the precautionary principle. This demand has not yet been addressed by the Peruvian State. After these events, and with the continuation of community resistance actions, the Yanacocha company, in April 2016, declared the temporary suspension of the project[3].

It is not the purpose of this paper to address the details of conflicts or the technical issues of mining projects, but rather to analyze a particular element found in the study: the invocation of the precautionary principle in conflicts.

In both cases, one of the causes of the start of the conflicts was the fear of the local communities regarding the risks that could be caused by mining enterprises in their territories and the environment. The common element, little explored in this type of cases, was the invocation of the Precautionary Principle as an argument for the suspension of environmental licensing and, consequently, the mining projects. Considering the controversies surrounding the Precautionary Principle and the entrenched practice of mining as a productive activity for human development, two concerns arise: is it possible to apply the precautionary principle in mining activity? What are the implications of using the precautionary principle in the context of a socio-environmental conflict over mining? These two issues will be addressed throughout the text.

3.1. Limitations of risk assessment in mining

Productive activities such as mining are analyzed and evaluated through instruments such as the EIA. Based on standardized scientific procedures, this instrument contains the study, description, evaluation and estimation of results of a long-term enterprise, providing information on the technical, socioeconomic and environmental characteristics of an enterprise (Zhouri, 2008). Because of its content, the EIA aims to define programs and policy actions in relation to the future consequences reported (Youker, 2005). Based on this instrument, for many years, a number of mining ventures have been authorized and developed around the world, reporting various impacts and consequences in the territories where they were developed (Morodi & Mpofu, 2017). According to Zhouri (2008, p.120), a factor contributing to the generation of these harmful consequences is the standardization of this instrument, which can be followed by any work, thereby limiting its informative nature as regards to local ecological, social and cultural specificities. This makes mining an extractive activity of known negative impacts on the environment and on human health, on which compensatory and management measures are applied, but not always with the desired results. Thus, even with the knowledge and possibility of managing their impacts, many extraction projects fail to become completely relia-

[3] For a better analysis of the cases, please refer to: Lauda Rodriguez, Z L. *O princípio da precaução em conflitos socioambientais por recursos hídricos e mineração*. Estudo comparativo entre o Brasil e o Peru. São Paulo, Thesis (Doctorate in Environmental Science) – USP, 2018.

ble or controllable or to exempt them from possible situations of risk (foreseeable or otherwise) arising from the enterprise as a whole or, even, from external factors.

Brian Wynne (1992) notes that the risk assessment (EIA-based instrument) is a scientifically disciplined way to analyze possible risks, initially developed to address relatively well-engineered mechanical problems. The scientific support attributed to this form of analysis strengthened its construction as an instrument based on well-defined and determinist processes (Wynne 1992; 2002).

Changes in social, economic and cultural contexts, alongside the development of science and new technologies, have contributed to a better understanding of the causality system, giving rise to the emergence of complex systems that characterize today's societies. These complex systems are distinguished by the interaction of different phenomena, which simultaneously complement, compete and counteract one another, requiring a broader approach (Feil *et al*., 2015, p. 41) The complexity of these systems arises because their complete knowledge, which would allow a reliable calculation of probabilities of various outcomes, rarely exists, and the full range of potential outcomes is generally not known (WWAP, 2012, p. 240). Thus, these changes have also engendered new risks, whose limited knowledge makes them potentially more serious, as these systems cannot be designed, manipulated, and reduced within the bounds of existing analytical knowledge (Wynne 1992; Giddens, 1999; 2003; Beck, 2005; Veyret & Richemond, 2007; Duckett *et al*., 2015; Persson, 2016). As a society advances in technological terms, new risks are faced, affecting elements of the system in which it is developed (Veyret & Richemond, 2007). Therefore, the risks do not constitute specific circumstances, nor are they entirely foreseeable. They result from constant technological transformation.

Because they are part of the processes of social change, risks are not only based on science and technology, which seek to explain their causality, but also on how they are perceived and faced by society (Acselrad, 2002; Hermitte, 2005). Thus, risks are defined as a social perception (Slovic, 1987), mediated by the social group's capacity for support (Zanirato *et al*., 2008). The diversity of elements that influence the cultural aspects of communities, power disputes and economic interests establish different ways of characterizing risks and uncertainties, attributing different degrees of perception and importance to them (Wynne, 1992; Acselrad, 2002; Stirling & Gee, 2002). Therefore, the topic of risk is approached by several studies that propose various approaches for its analysis. All of them are derived from causal rationality as an analytical basis, differing in the characterization and manifestation of the degree of uncertainty throughout the process.

Funtowicz & Ravetz (2000, p. 25) address the risks stating that uncertainty is inherent in science and is not able to disappear from it. They then warn of the need for a new order of science, which is capable of facing these problems. They discuss three levels of problem solving: Applied Science, Professional Consultancy, and the Post-Normal Science. The first two levels contemplate traditional risk assessment strategies, while Post-Normal science comprises a new strategy for solving complex problems based on an "extended peer community" (Funtowicz & Ravetz, 2000, p. 25) that allows one to face the vacuums of normal science.

This strategy for confronting environmental and global problems are based on the interaction of

two axes: epistemic aspects (intensity of uncertainty) and axiological aspects (decisions at stake). The intensity of the two axes is what will determine the strategy to be used to solve problems. Thus, public agreements and participation will be decisive for the assessment of risks and possible solutions, which will mainly derive from the valuation commitments of the various parties involved in the issue in dispute (Aven, 2013).

According to Wynne (1992, p. 113-114), the distinction of the risk involves reflexive learning about the inherent nature and limitations of knowledge, even if it is produced with scientific competence. In this process, the *risk* itself is found, in which the behavior of the causality system is well known and the possibilities of several outcomes can be defined and quantified by probabilistic assessments. *Uncertainties* also exists, in which the system parameters are known, but the probability distribution is not, and the quantification of possible *outcomes* is limited. There is also *ignorance*, which applies when it is not possible to assign clear probabilities due to problems in defining a complete set of results (causality system) (Stirling & Gee, 2002). It is in these problems in the system definition that Wynne (2002) notes his main criticism. According to him, more than a characteristic of knowledge in itself, ignorance consists of a characteristic of connections and conventions based on a certain knowledge sets. The validity and growth of these conventions increases ignorance due to a false perception of completeness and to the negation and exclusion of the unknown outside of these conventions. Finally, there is *indeterminacy*, which would be an open and ambiguous condition, resulting from: "(…) whether knowledge is adapted to fit the mismatched realities of application situations, or whether those (technical and social) situations are reshaped to 'validate' the knowledge (Wynne, 1992, p. 115). In this sense, *indeterminacy* would not be a higher level on a scale of uncertainty, but would rather be in the entire process of producing scientific knowledge, even if the uncertainty is small, as it would be based on social conventions that validate scientific paradigms or technological systems.

Wynne (1992, p. 116) clams that uncertainty would not be expressed only on a scale of objective intensity, ranging from risk to ignorance. Risk, uncertainty, ignorance and indeterminacy would be overlapping one another, manifesting themselves according to the scale of the social commitments – referred to by Funtowicz & Ravetz (2000) as "decisions stakes" – which are based on the assertiveness of a given knowledge set. This distinction made by Wynne (1992) is important for understanding how conventional risk assessment methods are currently developed. These methods, including those used for EIA in mining, tend to treat all uncertainties as if they were only an objective incompleteness of the causality system (Wynne 1992, 2002), a manifestation of the absence of knowledge. In this sense, the improvement of the control system risk and the reduction of uncertainties would be determined by the intensification of the formal scientific knowledge that originates without any type of subjective interference (Wynne, 1992; Funtowicz & Ravetz, 2000; Stirling & Gee 2002; Duckett *et al*., 2015). This, on the one hand, removes and obscures the limitations of current risk assessment methods, not because of errors in the scientific procedures that underpin them, but rather because of the intrinsic limitations of scientific knowledge that are expressed in uncertainty and ignorance. Conversely, it also excludes the existence of social, political and

cultural contexts that give rise to interests, agreements, standards and social judgments that lay the foundations of Western scientific knowledge and condition social behavior in response to risks or uncertainties (Stirling & Gee, 2002; Duckett *et al*., 2015), thereby generating social commitments or "decisions stakes" (Funtowicz & Ravetz, 2000). This would show the complexity also present in social relations, particularly in the field of socio-environmental conflicts "(…) characterized by the diversity and heterogeneity of the stakeholders and their ways of thinking the world and in projecting the future" (Zhouri & Laschefski, 2010, p. 16, free translation).

Thus, authors such as Duckett *et al*. (2015, p. 381) have pointed to these limitations of the risk assessment system, stating that "(…) the application of quantitative risk analysis to matters of social concern as though it were a neutral, objective process is epistemologically misconceived, particularly in relation to technological fixed." Therefore, risk assessment would be in itself an undeniably political process not freer from value judgments than other overtly political processes. This does not disqualify or invalidate the quantitative methods of risk assessment that are extremely important when well targeted (Stirling, 2007; Todt & Luján, 2014). They are, however, inappropriate as a basis for complex decisions on the social, economic and political organization (Carolan, 2007; Stirling, 2007; Duckett *et al*., 2015).

In the context of mining activity, particularly in Latin America, conventional risk assessment procedures or instruments are developed, according to Funtowicz & Ravetz (2000), at the levels of Applied Science and Professional Consultancy. These instruments are part of the environmental licensing process, which sees the EIA as the main instrument that will serve as the basis for the decision-making process relating to the venture and risk management measures provided in it. In most cases, the EIA is prepared by a specialized consulting group hired by the company itself to approve the project (Zhouri, 2008). This is the first question relating to impartiality in the preparation of the EIA, due to the possibility that the assessments results presented by professional consultants reflect the interests of their clients, even if within the scientific parameters (Marshall & Picou, 2008, 244), without the possibility or ability of other interested parties to question its content during its development (Zhouri, 2008).

The process of environmental licensing and approval is usually a concentrated and restricted attribution for a specialized body for this task and linked to the public authority. Even with more participatory planning models, such as councils with civil society participation, this pattern is repeated because of the concentration of oligarchic power in democratic structures (Zhouri, 2008, p. 100). Thus, the social consensus on the form of risk assessment and management is implicit and delegated to the sovereign power of the state over the natural resources of a country. Nevertheless, the relative absence of the State as a representative of the communities affected by mining operations, its ineffective performance as an environmental custodian and its selective presence as a sovereign natural resource authority and public authority of corporate rights over these resources (Conde & Le Billon, 2017, p. 11) have been the drivers of multiple cases of socio-environmental conflicts. In these conflicts, not only the possible risks and uncertainties about biophysical systems are questioned, but also socio-environmental risks that cannot be estimated in probabilities

and that would affect immeasurable goods with notable difficulty in being expressed in monetary terms (Persson, 2016), such as life, human health and the social organization of these communities (Bebbington *et al*., 2008; Helwege, 2015; Conde & Le Billon, 2017; Morodi & Mpofu, 2017; Walter & Urkidi, 2017). This turns conflicts in opposition to mining projects in problems of complex systems in which conventional risk assessment procedures are not effective in reducing uncertainties nor are they appropriate to substantiate socioeconomic and sociopolitical decisions (Duckett *et al*., 2015), that will affect communities in conflict.

3.2. The precautionary principle in the mining activity

Stirling & Gee (2002) explain that, in risk assessment procedures, it is conventional to identify a single performance standard for the measurement of the various aspects of risk. The units of measurement frequently used for this purpose are mortality and human morbidity rates and, for some areas, cost-benefit techniques. The purpose of these techniques, particularly the last one, is to establish a broad monetary metric that allows comparisons between the multiplicity and magnitude of the risks with the benefits associated with the activity (Aldred, 2013; Persson, 2016), excluding and reducing consideration effects, as well as simplifying the evaluation process. Notwithstanding, both authors stated that, even hypothetically, it was possible to make a complete and comprehensive assessment of risks, there would still be the problem of how to prioritize these different aspects evaluated due to the diversity of preferences and interests of different individuals or groups (Stirling & Gee, 2002 , p. 522). In this scenario, several authors have proposed an approach based on the Precautionary Principle as an alternative to the risk assessment system (e.g. Stirling, 2007; Aldred, 2013; Morodi & Mpofu, 2017).

Discussions on the precautionary principle and its application are extensively covered in various academic studies and reports related to international environmental legislation. Despite being acknowledged in the Rio Declaration of 1992 as one of the basic principles of environmental policy (Derani, 1995; Stirling, 2007; Marshall & Picou, 2008), there are controversies about its applicability and its consideration as part of customary law (Garnett & Parsons, 2017) due to the diverse interpretations and controversies concerning this principle (Todt & Luján, 2014; Persson, 2016).

The main criticisms of the precautionary principle concern the ambiguity of its content (Morris, 2000) and the diversity of formulations necessary for its understanding and applicability (Sandin, 1999). This ambiguity would affect its reasonableness as a rule or parameter for making a rational decision (Sandin *et al*., 2002) for which the risk assessment system already contemplates reasonable cost-benefit parameters (Majone, 2002; Peterson, 2006). Another criticism made is its theoretical concentration on the unknown risks, remaining important to the benefits and advances brought by the development of science and technology. This would distort the priorities of innovation and hinder beneficial scientific and technological development, giving rise to harmful consequences (Marchant *et al*., 2013), in terms not only scientific, but also economic (Majone, 2002; Todt & Luján, 2014). It has also been argued that a precautionary

approach would repress the advancement of science and innovation by limiting scientific consensus and providing scenarios of rejection of well-established risk assessment techniques (Majone, 2002; Marchant *et al*., 2013; Todt & Luján, 2014). Others advocate the application of this principle only at the stage of risk management, and not at the stage of risk assessment (CEC, 2000).

In response, some authors (Stirling, 2007; Aldred, 2013) have argued that "[m]ost criticism of the precautionary principle is based on unfavorable comparisons with established 'sound scientific' methods in the governance of risk" (Stirling, 2007, p. 309). Nevertheless, as already discussed, the conventional risk assessment system also presents weaknesses in both its methodology, which depend on probabilities of what is reasonably safe (Carolan, 2007; Aldred, 2013), and on the process of producing its scientific basis. In this sense, the risk assessment system could not be considered a more scientifically rigorous methodology when compared to a precautionary approach that seeks "(…) a broader range of non-reductive methods, which avoid spurious promises to determine a 'science-based' policy" (Stirling, 2007, p. 312).

Other authors (Carolan, 2007; Aldred, 2013) advocate the need for an open definition of the precautionary principle as such – i.e., as a principle – thereby ensuring its variability and contingency, rather than an operational definition, mainly due to the indeterminate nature and complexity of ecological and social systems, among others, to be protected. In Stirling's words, "[t]he precautionary principle is not – and cannot properly claim to be – a complete decision rule at all. (…) [Since] it is, as its name suggests, more a general principle than a specific methodology" (Stirling, 2007, p. 312). This general nature requires, for its interpretation, additional value judgments that will depend on the context in which they are applied (Aldred, 2013). Therefore, it is not the purpose of the precautionary principle to provide a detailed and rigid protocol for understanding and making decisions about risks and uncertainties, but rather to be applied as a general guide for the preparation of precautionary policies aimed at granting the benefit of the doubt in favor of the protection of human health and the environment, as opposed to private or economic interests (Carolan, 2007; Stirling, 2007; Marshall & Picou, 2008). Consequently, authors such as Todt & Luján have argued that "(…) precaution may certainly affect particular technologies or scientific-technological fields in particular moments" (Todt & Luján, 2014, p. 2170), serving as a barrier to some sectors of production. Nevertheless, its application will not be a barrier when it is established in the interests of the public (Marshall & Picou, 2008). In general, the precautionary principle does not limit the innovation process, since the preventive element encourages the creation of new methodologies and specific technologies according to the uncertainties warned, and encourages the generation of new scientific and technological trajectories (Todt & Luján, 2014).

Despite these discussions, there is the settled understanding that the precautionary principle is applied in circumstances of lack of scientific certainty about actions or activities that may result in threats of serious or irreversible harm to the environment or to human health. Under this premise, this principle adopts as a characteristic an anticipatory approach to control possible damages, as opposed to a remedial or mitigating approach, to be triggered after the occurrence of damages (Wickson, 2005).

The idea of the primacy of human health and the environment as fundamental aspects to receive better protection is relative to the adoption of precaution as an alternative procedure to conventional methods that have proved insufficient to guarantee their protection (Persson, 2016). Another feature of this principle is the reversal of the burden of proof. Scientific uncertainty militates in favor of the environment and health (*in dubio pro natura*, *or health*), with interested parties being in charge demonstrating that the intended interventions will not have undesired consequences (Stirling & Gee, 2002; Milaré, 2005) or that the degree of environmental change associated with the activity or technology is within tolerable limits (Wickson, 2005). This reversal of proof involves an idea of "moral currency" (Carolan, 2007, p. 8) as an expression of what would be considered a fair way to regulate a technology, requiring its developers to demonstrate that their profits are not generated at the expense of beings human or the environment (Carolan, 2007; Marshall & Picou, 2008). This is especially important considering that "(…) if it is not possible to assess correctly the value of human health and the environment in monetary terms, cost-benefit assessments will be systematically misleading" (Persson, 2016, p. 136) which would justify the application of the precautionary principle. Notwithstanding, this principle is not a negotiating tool, nor an indicator of greater or lesser value of things or circumstances, or that certain values should prevail over others (Persson, 2016), hence the necessary ethical and deliberative element of this principle.

Thus, it should not be interpreted as an imminent veto principle, but rather as an indicator of a state of controversy in which incommensurable goods and interests from various parties are at stake. "(…) [T]he broader role of the precautionary approach, despite scientific and legal limitations, lies with its implicit connection to democratic interests and the public domain, serving as counterforce against private interests" (Marshall & Picou, 2008, p. 242) in contexts of distrust and loss of institutional legitimacy (Carolan, 2007). Thus, in scenarios of high uncertainty, the precautionary principle becomes an appropriate guide to operate within the participatory arena of post-normal science through the "extended peer community" (Funtowicz & Ravetz, 2000) to determine and prioritize the circumstances application of the precautionary approach (Marshall & Picou, 2008).

Stirling argues that the greatest potential of the precautionary principle, in addition to guiding to decision making, would be for "(…) highlighting more diverse ways to gather relevant knowledge" (Stirling, 2007, p. 313). On this subject, Wynne (1992, p. 127) has argued that, when scientific knowledge is brought into the public domain, social commitments that validate its construction must be deconstructed and renegotiated by embracing different epistemological commitments and expectations that will provide definitions that are also different from boundaries between the determinism (objective) of nature and culturally shaped human responsibility.

Considering the limitations of scientific knowledge and risk assessment methods based on it, the inclusion of different epistemologies for the complementation or construction of a new base for knowledge generation (Wynne, 1992; Carolan, 2007) from the initial evaluation stage can contribute to the search for solutions in cases of conflicts or complex systems in which the perception, valuation and assessment of risks and uncertainties are questioned. This new form of knowledge generation will serve as a basis for the formulation of evaluation methodologies that meet

not only the economic and political expectations, but also the cultural and epistemological expectations of all stakeholders.

The challenges faced in situations of risks and uncertainties require a democratic process for their evaluation, encouraging active and public involvement in a broad scrutiny in which "(…) scientific knowledge needs be 'negotiated' through deliberations including relevant stakeholders and the public" (Wickson, 2005, p. 119). In this negotiation, everyone should be able to participate and express the evaluation or perception of the seriousness of the issue at risk, as well as the assessment or severity of the decision that will justify the extra precautions (Persson, 2016). These negotiations should be based on rigorous analysis and constructive dialogue (Failing *et al*., 2007). For this process, Wickson (2005) notes that it is necessary to recognize the limitations of scientific knowledge and a reflexive willingness through an "extended peer review" (Funtowicz & Ravetz, 2000). Further, it will be necessary to establish the commitment of continuous and monitored research to reduce the uncertainties and advance of knowledge; and the "(…) transparent handling of (…) indeterminacy [(Wynne, 1992)] through reflection on scientific knowledge claims [in light of different epistemologies], broad based public participation and the consideration and implementation of a range of policy options" (Wickson, 2005, p. 125). Therefore, the purpose of this process will not be to produce irrefutable evidence, but rather to achieve a more inclusive and transparent consideration of the various options, leading to a better understanding of the issues in dispute and better informed choices (Failing *et al*., 2007).

Stirling (2007, p. 313) notes that the application of the precautionary principle from the risk assessment stage makes it possible to predict and identify a number of relevant issues during the process. The epistemological expansion in the construction of knowledge would encourage a reflexive contemplation of the life cycles and resource chains as present in the real world, considering indirect effects, synergy, and accumulation resulting from the interaction with the environment. This would make it possible to explore – besides the reductive schemes and procedures prepared in the laboratory and based on scientific knowledge – experiences generated outside the specialized disciplines.

This expanded knowledge base would enable the construction of public policies with genuine, extended and active public participation of all interested parties. This would generate a reciprocal engagement in the values and interests of the various groups and stakeholders, legitimizing the process through the recognition, acceptance and validation of risk and uncertainty assessment procedures, irrespective of the type of framework or methodologies used (Stirling, 2007). Thus, the application of the precautionary principle would provide openness and attention to the diversity of knowledge, providing several alternatives for addressing problems or conflicts. Thanks to this diversity, this knowledge base can be considered more scientifically robust than limited, strictly scientific approaches (Stirling & Gee, 2002; Stirling, 2007; Morodi & Mpofu, 2017).

Although the precautionary principle has emerged as an anticipatory measure for possible undesirable effects on the development of science and new technologies, it is possible to apply this principle in cases of high controversy generated in mining projects due to the risks and situations of uncertainty that may be caused in territories of local communities. In these cases, the issue of

risks and uncertainties would not lie in the use or impacts of the widely known technologies of the mining industry, but in the scope and magnitude of the mining projects (which result in the high complexity of the assessment), in addition to other social, political, economic, and cultural issues that turn these cases into complex systems problems. According to Morodi & Mpofu (2017, p. 11), the potential damage caused by mining does not consist solely of chemical contamination, but also structures of affected communities. This includes disfiguring the landscape, changing water sources and interfering with ecosystem services.

The complexity of these cases is manifested worldwide through innumerable social, political and legal struggles that, until a few decades ago, did not show up or were revealed only after the occurrence of a technological disaster or the generation of great impacts. Today, these struggles are manifested in advance by actions of resistance to location and undesirable land uses in the territory of several communities that are mainly opposed to the risks and uncertainties that permeate the development of these uses (Giddens, 1999; Beck, 2005; Martinez-Alier, 2007; Wynne, 2007; Marshall & Picou, 2008).

In this context, an alternative measure to solve these conflicts would be the adoption of the precautionary approach to the assessment of risks and uncertainties in mining. The application of this principle as a general guide would serve to identify highly complex mining projects and controversies that justify precautionary measures and procedures, guaranteeing the primacy of the protection of human health and the environment over mining interests. The precautionary approach would entail opening the risk and uncertainty assessment process to all interested parties and those potentially affected by the mining project. This would require, on the one hand, the strengthening of the public authority as a representative of communities in conflicts and a regulatory authority for corporate rights over natural resources, and on the other hand – and more importantly – the recognition and strengthening of communities that could be affected by the project, for an effective participation in the evaluation process. This would mean that, in addition to their recognition as legitimate stakeholders, they can effectively be heard and contribute with their knowledge, practices and experiences in the risk assessment process and deliberately make decisions with all other stakeholders (Stirling, 2007; Morodi & Mpofu, 2017).

Due to their open and flexible nature, precautionary principle designs can be applied to several cases of socio-environmental risk conflicts, including mining. Notwithstanding, it should be made clear that this application must be analyzed on a case-by-case basis, taking into account environmental and social concerns and risk *in context* and considering knowledge and experience within particular social and personal contexts (Fan, 2016, p. 426). From this perspective, several papers address the application of the precautionary principle and emphasize the consideration, incorporation, evaluation and dissemination of scientific and local knowledge to guide various development initiatives. Some studies address water management issues (Fan, 2016; Metz & Ingold, 2017), air management (Morello-Frosch *et al*., 2002) and the exploitation of marine resources (Vivero *et al*., 2008). An example of application of the precautionary approach, considering the risk perception of various stakeholders in a context of controversy, is the Water Use Planning in British Columbia, Canada, analyzed in

the work of Failing *et al*., (2007). In this project, after considering new information on the social and environmental impacts of dams, a decision was made to reexamine the water allocation of the main hydroelectric power stations of the province, with the participation of specialists, government auditors and authorities, and indigenous and local communities. The results of this study show that the treatment of the different knowledge sets in a structured process can help balancing the interests at stake of all parties (Failing *et al.,* 2007).

With respect to the mining industry, Morodi & Mpofu (2017) analyzes the environmental and social problems generated by acid mine drainage (AMD) in the political, economic, cultural and historical context of South Africa. In this study, the authors also propose the application of the precautionary principle as an alternative to conventional risk assessment systems in mining. They note that, in precautionary approaches, the limitations of science are acknowledged, allowing the recognition of a plurality of rationalities and values in the decision-making process. Nevertheless, they argue that the knowledge of indigenous populations – the most frequent social group in mining conflicts – is excluded or viewed with concern by the scientific community. Notwithstanding, even when not consisting of situations of risk, but rather effective damage caused by mining, indigenous and local communities are usually ignored, following the same pattern in the proposal of new mining enterprises (Morodi & Mpofu, 2017). The precautionary principle points to the marginalization of communities in the decision-making process, evidencing the submission of indigenous knowledge sets to the periphery, to the detriment of community interests (Morodi & Mpofu, 2017, p. 13).

Although this inequality in the treatment of diverse knowledge and experiences is clearly evidenced in the application of the precautionary approach, there is a direct relationship between these epistemological aspects and social, economic, political and cultural issues that are manifested in imbalances of power that generate socio-environmental conflicts. Several studies on the precautionary principle denounce these relationships, emphasizing the need to deepen assessments with the aid of other disciplines to ensure a better understanding of these issues. Herein lies the relation between the precautionary principle and other areas of study, such as environmental justice, political ecology, and postcolonialism/decoloniality (Lauda Rodriguez, 2018). Nevertheless, by extending the topic, we will focus the analysis on the elements of environmental justice, as we consider that there is identity and complementarity between some elements of the precautionary principle and environmental justice, which would serve as a basis for its integration both at the theoretical level and in the application of public policies.

4. Environmental justice and precautionary principle in mining

Wynne (2007) notes that, in the last decades, in different parts of the world, several participatory movements have begun to emerge with the involvement of diverse stakeholders in both urban and rural contexts. According to him, the claims of these movements, irrespective of context or specific issue, would represent not only a pattern of insurgency, but a systematic expression of power structures embedded in the culture of science, technology, and their

political circles, including habits of thought and academic practices and policies. This would have generated among citizens the need to create independent collective meanings, based on knowledge, visions and social needs different from the priorities of the elites sustained by science. In this way, there would be a moral and political contempt on the part of these independent movements as a result of the non-recognition by the scientific-technological elites of the public dimension of the commitments given in favor of society (Wynne, 2007, p. 101).

Examples of what Wynne argued are the environmental justice movements initiated in the United States and the so-called environmentalism of the poor, or popular ecologism, which emerged as part of the environmental justice movement in contexts of struggle of minority populations that have been articulated in different parts of the world, especially in the Global South, conquering spaces and overcoming "(…) the intellectual and social gap between North and South environmentalism" (Martínez-Alier, 2007, p. 351, free translation). In both movements, the interrelation of social, cultural, economic, technological and health factors contributed to its emergence, embracing the alliance between the claims for protection of human health and the environment, as well as the principle of social justice. The main claim of Environmental Justice focuses on the inequity of treatment of certain racial, ethnic or low-income groups or minorities that is expressed in two ways. On the one hand, the exposure of these groups to a series of social and environmental problems and risks, when compared to others with a higher socioeconomic profile. On the other hand, there is an uneven distribution of the benefits and positive implications that derive from the environmental policy and regulation implemented on these groups (Acselrad, 2002; 2010; Zhouri, 2008; Legarda & Buendia, 2011; Losekann, 2016; Souza & Milanez, 2016).

Regarding risk exposure, there is inequality not only by exposure but also by the possibility of addressing risks. Thus, those who find themselves in a typical position of power have the necessary resources to minimize their effects, as opposed to those who found in situations of greater vulnerability (social or economic) that are often not met (Acselrad, 2002; Souza & Milanez, 2016). In this context, the emergence of these movements constitutes a symptom, in the form of citizen contestation, of the nonconformity of these long-marginalized groups, against the inability of government bodies and technical and scientific elites to resolve conflicts generated by the implementation, in an excluding manner, of various industrial activities that affect them, causing damage and posing risks to the environment, human health (Marshall & Picou, 2008), and the forms of social organization of numerous social groups and communities.

In the Latin American context, the issue of environmental justice requires a necessary analysis of the heterogeneous social and cultural contexts. In this regard, Zhouri (2008, p. 104), when discussing the Brazilian context, comments that the analysis of the environmental issue in a such a diverse and unequal society imperatively demands the equalization of cultural diversity, democratization of access to natural resources, and distribution of industrial production risks. Furthermore, it would be necessary to consider the injustices of the distribution of the *environmental space* expressed in "(…) conflicts around territorial rights and cultural meanings that go beyond attempts at the monetary valuation of nature" (Zhouri 2008, p. 105, free translations).

Thus, the struggles for environmental justice in this region of the world combine a series of factors that contextualize their claims in defense of culturally specific rights and environments, fight against the socio-territorial segregation promoted by Western and market logic, and resistance against concentration of fertile land, water and soil in favor of economic groups and to the detriment of local forms of life (Acselrad, 2002; 2010). In this perspective, the environmental issue could not be separated from the logic of the (unequal) distribution of power over political, material and symbolic resources, since different forms of oppression (class, race, and gender, among others) contribute to the reproduction of environmental injustices (Acselrad, 2002, p. 51). This is where the strategic junction between environmental protection and social justice takes place (Acselrad, 2010).

The main element of the theory of environmental justice is the *distributive justice* that concerns the damages and benefits that derive from an enterprise or activity that generates environmental and social impacts. Discussions on environmental justice began on the basis of John Rawls' (2006) theory, which focuses on justice as the most basic structure of a society, defining the distribution of rights, goods and freedoms, the regulation of equality and economic and social equity (Schlosberg, 2007), as well as the appropriate distribution of benefits and burdens of social cooperation (Rawls, 2006). Based on this notion, several studies incorporated other elements in order to provide a better explanation of the nuances of distributive problems in the environmental issue.

One of the elements incorporated is *recognition*, whose absence in the fields of social and political conflict would constitute, according to some authors, the central point of an unequal distribution, to the detriment of certain individuals or social groups. This lack of recognition is due to the forms of degradation and devaluation that generate oppression and exclusion on individuals and communities in relation to their cultural values and political spaces (Schlosberg, 2007; Zhouri, 2008; Espejo, 2010). Another element is *participation*, which, as an essential principle of the democratic state, guarantees citizens the right to participate in the political organization of the sovereign power of the state as a form of defense against possible interference with their private autonomy (Nobre, 2004) and to ensure an adequate policy that is aimed at enabling their development and enjoyment of a dignified life (Coelho & Ferreira, 2009). In the political and democratic process, participation becomes effective through mechanisms and procedures that enable the establishment of institutional structures to achieve better recognition and distribution (Espejo, 2010). Another contribution in these discussions was the work of Amartya Sen and Martha Nussbaum, who introduced the approach of people's *capacities*, understood as the opportunities to do and be what they choose in the context of a certain society (Schlosberg, 2007), i.e., a person's possibility of realization within society (Espejo, 2010). The capacity approach is presented as a simultaneous approach aimed at connecting the problems of economic inequality (distribution) and cultural devaluation (recognition), including the right to participation and freedom as necessary capacities for the realization of people (Schlosberg, 2007).

Although these elements are part of the analysis of environmental justice, they are discussed as elements of the theory of justice in different areas of

social sciences. In the discussion of environmental issues, other elements that complement the proper debate on environmental justice were introduced. Some papers have pointed to the liberal bases of distributive justice theory that emphasize social distributions, burdens, duties, recognitions and privileges on the individual, taking it as a unit of reference. Nevertheless, processes of relationship and social interaction reinforce the creation of links between individuals and communities that influence cultural construction, economic transactions, power flows and positions of each collective in the global structure (Vivero *et al*., 2008). Many of the environmental injustices are denounced at the expense of more groups or communities than the individuals who conform it (Espejo, 2010). For this reason, the *collective* element is introduced in the analysis of environmental justice, proposing the expansion of the notion of *capacities* at the collective organizational level of groups or communities, considering this organization as the basis for the progress of individual capacities. Therefore, groups should also be considered in one category, making capacities integral to the development of any community (Schlosberg, 2007). Finally, there is the *ecological* element that forms the background for discussions on the other elements of the theory of justice. In it, the debate focuses, mainly, on how the environment should be considered in the relation of human beings to the natural world, starting with the anthropocentric or ecocentric[4] notion. Irrespective of the approach adopted, it is clear that the definition of environmental justice is still under discussion due to the complexity of concepts involved: justice and environment (Espejo, 2010). For this reason, there is no single definition of environmental justice, but rather elements and characteristics that conform it.

On this conceptual basis, numerous studies analyze a number of contexts of conflict in which the relationship between the exclusionary structures of power and the form of development and growth of the current capitalist system are questioned, generating scenarios of risks and serious damages to communities and the environment. In relation to the mining industry, many enterprises are questioned and analyzed under the elements of the theory of environmental justice. The main criticism is the way in which the most industrialized countries rely on the importation of ores from mainly Latin American and African countries to the growing demand of raw materials or consumer goods, with depreciation of negative social impacts and environmental degradation that this industry generates (Martínez-Alier, 2007). According to Zhouri (2008, p. 105), it is necessary to acknowledge that industrial projects such as mining and global policies based on abstract and distant formulations are generating environmental injustices, by causing risks and damages to the most vulnerable sections of society. The various socio-environmental conflicts in this region of the world reveal contradictions in which "(…) the victims of environmental injustices are not only excluded

[4] Liberal theories of justice, based on anthropocentrism, oppose the extension of the scope of justice out of the human domain and consider that there is a duty of compassion and humanity for the natural world, but not justice. Thus, even by carrying out actions that cause damage to nature, there would be no victims of injustice in it. Ecocentrism-based theorists, however, argue that the theorization of environmental justice must go beyond the distribution focus and rethink the elements of justice from an "ecological justice," broadening recognition to the natural world for both its value in itself and for its importance for the sustenance of the life of the human being and other species (Schlosberg, 2007). These debates also include studies on issues such as intergenerational, intergenerational and interspecies justice (Okereke, 2006; Espejo, 2010)

from the so-called development, but take on its full burden" (Zhouri 2008, p. 105, free translation).

The global expansion of environmental justice has embraced claims and complaints against multinational governments and corporations for their extractive excesses, characteristic of the capitalist neoliberal system, to the detriment of communities, groups and indigenous peoples in a historical context of poverty, exclusion and social injustice, especially in developing countries (e.g. Bebbington *et al*., 2008; Zhouri, 2008; Acselrad, 2010; Ribeiro, 2017).

Nevertheless, the emergence of mining conflicts that are based on risks and no longer solely on environmental damages, are signs of transformation in relations and disputes over power in matters involving the process of perception, evaluation and decision on risks. The rejection and resistance of communities against mining projects before the beginning of their activities, invoking principles such as precaution, gives us elements to warn that some of these disputes would not be limited to the decision on the risks by simple rejection of the known damages of mining; they would also involve the recognition and safeguarding of communities and populations, as well as their customs, practices, knowledge and worldviews, which influence the perception of risks. As Losekann (2016, p. 144, free translation) states, "[i]t is not simply nature and humans that are subject, but also a social / cultural / environmental position that is put at risk, being suppressed by such extractive endeavors if they thrive."

The theoretical framework on the precautionary principle addressed in this paper allows us to understand the complexity of risks and uncertainties due to the limitations of scientific knowledge in activities such as mining and the systematic exclusion of other knowledge and experiences that could contribute to overcoming these limitations. It also enables the consideration of a collective and democratic dimension of this principle, based on the collective nature of the social and epistemological claims of communities in conflict. A precautionary approach from the beginning of the risk assessment process will require recognition of the *collective* legitimacy of the communities that would be affected, as well as the *recognition* of their customs, experience and knowledge in evaluating a project. It will also require a broad and inclusive *participation* process that will make it possible to properly deliberate on and *distribute* the risks among all stakeholders involved in the evaluation process, thereby legitimizing the decision-making process. This would lead, in terms of social justice theory, to the development of the collective *capacities* of the communities in conflict. Thus, the precautionary approach in the whole process of assessing the risks and uncertainties of a mining project would allow the identification of elements that are claimed in the analysis of the theory of environmental justice.

The collective dimension of the society/nature relationship is expressed in various dynamics (social, economic, political, and cultural) of populations and communities within their territories, which includes the disposition of natural resources within them. In this context, *recognition* is an essential element both in the precautionary approach and in environmental justice for the identification of all stakeholders that have some interest in the mining project. *Participation* is another fundamental element in both approaches, which requires the implementation of mechanisms necessary to ensure its effectiveness during the process of evaluation,

decision and monitoring of risks and uncertainties. These last two moments would correspond to the last element of the theory of environmental justice, i.e., *distribution*, which would also involve the management of possible risks and uncertainties that would be caused by the mining project. Finally, applying a precautionary approach would contribute to strengthening the collective capacities of many rural populations and indigenous communities in conflict by being duly acknowledged (in their autonomy in the case of indigenous communities[5]), included and consulted on possible projects within their territories. This would favor more democratic processes in detrimental scenarios of exclusion, fostering the reestablishment of trust in the state (Morodi & Mpofu, 2017) and in mining activity.

5. Conclusions

Considering the emerging amount of socio-environmental conflicts initiated by the perception (Slovic, 1987; Zanirato *et al.*, 2008) and rejection of the risks of mining activity, which includes cases where the precautionary principle was invoked, this article proposed to explore and articulate the theoretical elements of this principle and the theory of environmental justice for the analysis of these conflicts. Two concerns arose based on the invocation or application of the precautionary principle in mining conflicts.

Is it possible to apply the precautionary principle in mining? The analytical link between the precautionary principle and environmental justice makes it possible to note that the incidence of these cases is not limited to controversies on the potential environmental impacts of mining on the territories of the communities in conflict. These are in fact complex systems scenarios, in which the controversies over possible risks and uncertainties of a mining project are determined not only by the activity itself but also by the context and conditions in which it is intended to be developed. The configuration of these conflicts, in which the application of the precautionary principle is relevant, is not determined by uncertainties in the technological innovation of mining, but rather by the scope and magnitude of certain projects, which would generate serious social and environmental risks and uncertainties, coupled with other social, political, economic and cultural factors that contextualize the conflict. Therefore, it is stated that it is possible to consider the precautionary principle in mining activity. Nevertheless, this should not be understood as a sign of imminent veto of complex mining projects, but rather as an indicator of a state of controversy in which the interests of various parties converge.

This leads us to the second concern: what are the implications of considering the precautionary principle in the context of a socio-environmental conflict over mining? An initial implication, derived from the dialogue between the two theories addressed, would be in the understanding of a collective and democratic dimension of the precautionary principle. This would be reflected in the emergence of movements and collectives that, through resistance in conflicts, claim their recognition, as well as their practices and epistemologies, contesting power

[5] The right to self-determination and autonomy of indigenous communities and peoples is acknowledged both in Convention 169 of the International Labor Organization and in the United Nations Declaration on the Rights of Indigenous Peoples.

structures supported by modern science. Considering that the precautionary principle is situated at the borders of the system of Western knowledge, this theoretical analysis on this principle would strengthen the socio-environmental struggles, exposing the limitations of scientific knowledge and the necessity of its complementarity, as well as the political nature of science, leaving aside the idea of a fully objective and neutral science.

The discussion about the risks brought by this principle would also contribute to the deconstruction of the hegemonic symbolic structures that restrict the debate of the risks to the *technical knowledge*, disqualifying other forms of knowledge and visions of the world (Acselrad, 2002; Zhouri, 2008). Thus, this principle highlights the need for institutional and democratic structures that allow the inclusion of the conflicting communities' claims and epistemologies, both in the process of assessing the risks of a mining project and in decision-making, thus providing a fairer distribution of social and environmental risks.

Simultaneously, as seen in the cases mentioned at the beginning of the text, the precautionary principle can also serve as a strategy of resistance and questioning of power structures, due to its instrumental and formal character recognized in institutions, especially in the judiciary. Thus, the articulation of this principle with the theory of environmental justice would serve not only as a theoretical framework for the analysis of socio-environmental conflicts, but also to strengthen the arguments of resistance in disputes before institutional instances in which environmental justice on risks is claimed.

Therefore, it is concluded that the irruption of the precautionary principle in the context of socio-environmental conflicts of collectivities must be assumed as a sign of the need for changes in the different structures of the current social system. We conclude, also, that a precautionary approach that considers the elements of environmental justice may be a more robust, inclusive and democratic alternative when compared to conventional risk assessment systems in activities such as mining. An integrated analysis of the precautionary principle with environmental justice would provide both scientific and political grounds for its implementation. This would support risk assessment processes with greater participation and legitimacy, preventing the occurrence of new socio-environmental conflicts and promoting greater social and environmental justice.

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