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GEOETHIC ISSUES INVOLVING TAILINGS DAM: VALUES AND CONFLICTS

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A B S T R A C T

From the conceptions of Geoethics, this work analyzed the perception of students, future science teachers, in Brazil and Portugal. The purpose of the study was to explore the issue from a Geoethics point of view, regarding the environmental and social impacts caused by mining activities. A survey was applied to the groups of students, considering the environmental impacts caused by tailings dams in areas of exploitation of metallic minerals. Two different cases from each country were focused: in Brazil, the breakdown of the tailings dam of SAMARCO Mining, in Mariana, MG, still in activity; and in Portugal, the case of the abandonment of the Terramonte mine, in Castelo de Paiva, deactivated. The applied survey was composed of open questions, and the analysis of the answers considered the Discursive Textual Analysis (ATD) to help understand the positioning of students from both countries. Considering the intrinsic value (value that a thing has in itself) and the instrumental value (means to obtain some purpose or objective), in both groups the students expressed that they considered that the environment has intrinsic value, but they pointed out the instrumental value of mineral resources in the daily life of society. In relation to the environmental impacts caused in both cases, the groups presented different perceptions, mainly due to the fact that Brazil is a recent occurrence and widely disseminated, in relation to the Portuguese case, which is not very widespread in the media.

Keywords: Geoethic, mining and environment, education for sustainable development, tailings dam.

THE RELATIONSHIP BETWEEN MAN AND NATURE IN NATURAL RESOURCES VALUATION

The epistemological challenges linked to environmental education are confronted by assumptions and utopias about the man-nature relationship. Santos and Imbernon (2014) discussed the relation between man and nature, whose shape has changed throughout mankind history. It started with the strong influence of Christian theology (Castelnou, 2006), passed Modern Science development and the Cartesian thinking consolidation, and got to a new perspective about nature.

This transition broke with the perception about an organic nature since back in the Middle Age people believed that nature behaved as a living organism, to perceive it as a machine-nature endowed with matter and movement (Braga *et al.*, 2004).

Thus, the mechanistic view about nature turns it into something that men can control since it is men's job to dominate nature (Fiugueiredo, 2008). Such mechanistic perspective about nature is a break with sacralized perceptions because it puts humans outside nature and no longer sees them as rational animals. When humans started perceiving the world around them as a world of technology, the explanations given by the sacred scriptures are no longer accepted, as replaced by purely physical causes. Nature became socially, culturally and economically meaningful, because the exploitation of natural resources mainly derived from the interest and expectations certain social classes had upon them.

The aforementioned perception of nature, which does not include mankind in nature itself, is addressed by Gonçalves (1998), who comes up with the concept of a "non-natural" man. His proposal, which was strengthened by the industrial civilization unveiled by capitalism, lies on the idea of an external and objective nature.

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The "social feelings" relationship described by Darwin spread through different societies, and members of these forming communities became more resilient; therefore, individuals' feeling of "belonging" to Earth got stronger (Grün, 2007). The feeling of belonging determines the way individuals "value" nature.

The intrinsic value of nature, which can be understood according to different concepts, is highlighted by the environmental ethics field (Routley, 2013; Rolston, 1996; Naess, 1995). However, the criticism to the instrumental value of nature connects all these concepts.

In fact, the boom in environmental issues in the 20th century led to a new perception of nature, since they started affecting the quality of life in urban centres. Moreover, at the same time, the issues let individuals question their consumption patterns, behaviours and values.

The different approaches adopted to plan and implement education reflect the different perspectives about man-nature relationship although conflicting points are also present (UNESCO, 2009; Santos and Imbernon, 2014). Some scholars have a restrictive understanding about the environment and introduce ecological education (which means environmental education in the narrow sense) to teaching processes; on the other hand, other researchers picture the environment in a broader sense by adding social aspects to such education processes. Moreover, there are groups that use a broader framework to include themes and approaches in the existing school curricula by focusing on sustainable development premises (UNESCO, 2009).

Based on the economic development premises, it is possible to state that the conventional economics science (the dominant Economics) does not understand the environment as a component to be evaluated (Mankiw, 2004). Mankind remains far from finding a balance between economic development and environmental preservation/conservation, although new terms such as ecodevelopment, green economy, eco-efficiency and sustainable development have been addressed by new models (Martínez-Alier, 2010).

According to the economic perspective of ecology, the inclusion of environment as a variable in economic models was possible due to the idea that ecosystems are "warehouses". Environmental economics depends on ecology since its main motivation lies on internalizing environmental costs in order to set prices that reflect the costs of complete marginal social opportunities (Cavalcanti, 2010). According to Morin *et al.* (2011) and Sachs (2007), the dominant economic model relies on a free externalization of socio-environmental costs, although it widens socioeconomic inequalities.

External factors, such as pollution, are adverse effects affecting decision makers. This model ignores these socioeconomic inequalities and, consequently, the willingness to pay the affected parties, which do not participate in the production and consumption of goods resulting from polluting activities.

Unlike environmental economics, the ecological economics emerges from the growing awareness of the threat faced by ecological systems, which enable life on planet Earth, the fact that shows a deeper understanding about the environment-society interactions (Cavalcanti, 2010).

However, contemporary society still supports the idea that growth and development are synonymous, since growth requires an assimilation or addition, whereas development is understood as expansion and evolution towards a better stage. However, such concept does not take into account the aspects concerning poverty and environmental degradation (Daly, 2004).

According to Daly (1989), "market prices are just relevant to local decisions taken under temporal and ecological perspectives, whose main consequences fall entirely on the human good-exchange economy and on the current generation"; therefore, such perspectives involve ecological and ethical decisions.

Ethical issues involving the exploitation of natural resources have been driving the political and scientific discourses since the late 20th century when "knowledge" and "values" became inseparable factors.

The relevance of ethical awareness by scientists of the implication of their work in and for society grows when their actions influence society. Actually, the media vehicles turn most of these implications into dissemination and criticism targets.

Scientific fields encompassed by Natural Sciences such as Biosciences and Geosciences coexist with topics related to the use and abuse of natural resources. It happens by a positive connotation associated with technological advances and with an implicit improvement in the quality of life, or by means of natural destruction and exploitation of some citizens'

lives. Geologists have made a significant contribution to this view because the majority of these professionals work in extractive industries (Almeida & Vasconcelos, 2014).

The ethical issues involving the use of natural resources, which are addressed on any environmental debate, refer to the real meaning of wrong or immoral, to whether the use of natural resources is legal or not (Light & Rolston III, 2003). Thus, individuals living in society often question such aspects; in fact, the perception by the society about the ethical relationship between use/exploitation of natural resources, and the "values" associated with impacts derived from this exploitation come to the mainstream when major environmental disasters caused by mining take place.

METHODOLOGICAL APPROACH AND DEVELOPMENT

The present study involved two cases of environmental impact directly associated with metallic mineral exploitation. Tailings from mineral exploitation retained in tailings ponds led to contamination in both cases and to issues that have directly and indirectly affected tailings ponds' neighbouring populations, as well as to impacts on physical (soil and water) and biotic environments (flora and fauna).

A survey was applied to 28 Brazilian undergraduate students in Natural Sciences (LCN – Licenciatura em Ciências da Natureza) after a 60-minute lecture about Environmental Ethics, Geoethics and Management. The students were enrolled in the School of Arts, Sciences and Humanities (EACH – Escola de Artes, Ciências e Humanidades) of São Paulo University (USP). The sample also included 7 (the universe of students) Master Degree students in Biology and Geology Teaching from Portugal, who were enrolled in the Faculty of Sciences of Porto University (FCUP – Faculdade de Ciências da Universidade do Porto). The Portuguese students aim at developing scientific literacy and promoting an environmental education focused on sustainable societies by formal education.

Cases involving the exploitation of metallic mineral resources that have led to environmental impacts of national repercussion in both countries were presented before the survey was applied.

The Brazilian case lied on the environmental disaster of great proportion that took place in Mariana County, MG (Figure 1), which had wide national and international repercussions. The catastrophic failure that happened on November 5th, 2015 in the tailings dam belonging to the mining company Samarco, located in Mariana County, Minas Gerais State, discharged 60 billion litres of iron ore tailings along more than 500 km in Doce River basin, which is the 5th largest river basin in Brazil.

Doce River Hydrographic Basin, which has 86,715 km^2 of drainage area, is 879 km long; its water springs are located in Minas Gerais State, more specifically, in Mantiqueira and Espinhaço Serra, and the basin flows all the way down to its mouth, in Espírito Santo State. The tailing slide generated by the failure caused immeasurable and irreversible environmental damages, which resulted in a complete devastation scenario that could be seen approximately 2 km away from the area where the failure actually occurred. Human lives and arable lands were lost, the ichthyofauna and tourism were strongly impacted by the accident, and the coastal ecosystems suffered countless direct and indirect impacts; in other words, it was a major environmental disaster. The impact mud had on fresh and sea waters have not yet been measured.

The Portuguese case focused on the abandonment of Terramonte mine, in Castelo de Paiva County (Figure 2). Terramonte mine was intensively exploited in the late 19th century, between the 1860s and 1890s; it was one of the most important European Pb, Zn and Ag extraction mines between 1966 and 1972. In the early 1990s, tailings deposition basins (dams) were constructed; however, they underwent erosive processes that led to environmental degradation issues in the surrounding areas and in Douro River as well, since the mining area was located in one of this river tributaries.

The Portuguese government assigned the concession for the environmental recovery of abandoned mining areas to the Mining Development Company (EDM – Empresa de Desenvolvimento Mineiro) from 2001 on. This company belongs to the Public business sector, the reason, why it was chosen to perform an action, understood as a Public Service.

Students and teachers discussed topics related to Environmental Ethics and Geoethics within the environmental education and management scope by exploring the issue from the geoethical viewpoint, as well as from the perspective of social impacts caused by mining activities in both countries, based on the Environmental and Ecological Economics.

Figure 1. Location map of Mariana, MG and mud route, Brazil.

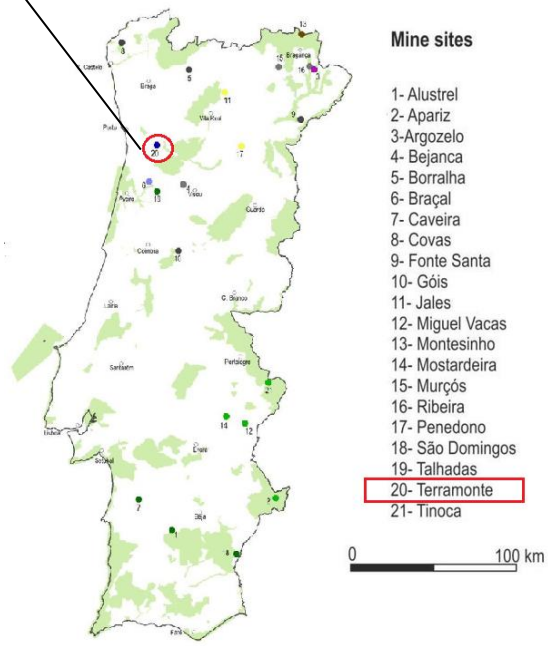

Figure 2. Location map of Terramonte mine, Portugal (adapted from Carvalho *et al.*, 2016).

Participants were asked to answer two open questions after the open-debates:

Question 1 – What do you think about the environmental impacts generated by mineral resource exploitation by

The aim of the first question was to assess "moral considerability" based on the anthropocentric culture perspective, according to which nature is treated as a good, as a resource and, therefore, it does not have intrinsic value.

The extensive idea that not only living beings but also ecosystems and inanimate natural beings hold inherent moral valuation (rights of nature) was presented by Leopold (1933) in his theoretical framework "The Land *Ethic*". The author points out that "the right to continued existence" applies to animals, plants and even to the soil.

Although Leopold was criticized for radicalism, some of the aspects pointed out by him, such as "there are obligations to land over and above those dictated by self-interest", involve elements directly associated with Geoethics. It is so because such obligations are based on acknowledging humans and Nature components as being ecologically equal (ecological egalitarianism).

Thus, the "value" given to these impacts reflects society's commitment to a sustainable development when it comes to metallic mineral resource exploitation and to the impacts derived from such processes. It is worth highlighting that these exploitation processes are directly linked to the manufacture of consumer goods that improve the quality of life, as well as essential to modern society.

Question 2) How can one "value" the environmental impact caused by the failure in Mariana County dam, which released Samarco mining tailings (Terramonte mine for Portuguese students), by taking into account "Biosphere" (in the broad sense), although without forgetting the obligation to not "jeopardize the well-being of objects or natural systems without a good reason to do so"? Remember that the biosphere encompasses inanimate things such as rivers (hydrographic basins), landscapes and ecosystems, as well as living things.

taking into consideration the intrinsic (value of something in itself) and instrumental values (means to fulfil some purpose or objective) of mineral resources?

The second question addressed the link between previous discussions held in class – when concepts such as environmental ethics, geoethics and environmental management were presented based on an economic bias – by taking into consideration the "value" of a natural good.

Thus, the conflicting situation presented to the respondents has required them to take a position to demonstrate their commitment to the construction of a sustainable society. They reasoned about their own performance as citizens in a context wherein "losses" are immeasurable, regardless of the economic or technological value given to the resource.

The positions taken by the students in the two countries were assessed using the Discursive Textual Analysis (DTA), which is a qualitative data analysis methodology proposed by Moraes and Garliazzi (2007). Apart from group studies and open-debates, DTA comprises stages that require dividing the texts produced by the actors involved in the research into units in order to perform a detailed analysis. Next, the relationship between each defined unit must be set in order to find the identity of each unit. Subsequently, the same procedure is performed to find the common elements emerging from the text as a whole. Such process leads to a new understanding of the meaning of this "whole".

> *More than divisions or clippings, the analysis units may be understood as elements highlighted in the texts, as important aspects that, according to the researcher, deserve emphasis, since they are pertinent to the investigated phenomena. When units are understood this way, they are necessarily linked to the whole.* Moraes and Galiazzi (2006, p.115).

Thus, DTA comprises three stages, namely: unitarization, categorization and communication. Unitarization lies on reassembling the texts within units able to show the meaning of these texts to the researcher. The so-called meaning-units derive from text disassembly.

The unitarization stage is, therefore, an essential step in DTA development, because most of the significant messages in the analyzed texts are found in the units;

however, new units may become important for defined goals throughout the research process. According to this perspective, the texts composing the corpus under analysis are constantly reassessed throughout the analysis process.

The categorization procedure lies in grouping similar meaning-units into categories that can be constantly regrouped. It is worth highlighting that the texts become less superficial and apparent at this analysis stage since details in each unit allow advancing to the total of units. Thus, it is possible to get access to the categories from the units, and it enables gathering information about them.

> *It corresponds to simplifying, reducing and synthesizing research information by comparing and differentiating unit elements that result in the formation of a set of elements, which have something in common.* (MORAES; GALIAZZI, 2006, p.75).

Finally, communication lies on discussing the results through descriptive and/or interpretative texts.

The DTA conclusion may generate metatexts that explore final research categories. Metatext elaboration is essential to the development of the methodological process since it allows researchers to improve their writing skills. According to Moraes and Garliazzi (2006), who developed the aforementioned information analysis methodology:

> *The Discursive Textual Analysis can be characterized as a metatext production exercise based on a set of texts. This process builds category structures and, once they are transformed into texts, they provide descriptions and interpretations able to present new ways of understanding the investigated phenomena.* (MORAES; GALIAZZI, 2006, p. 89).

The methodological design adapted to analyze the questionnaires is exclusively qualitative; thus, the current study does not intend to present statistically representative results, but to discuss the investigated concepts, as well as to investigate the relevance of scientific literature to the promotion of goals and targets outlined by the United Nations in Agenda 2030.

RESULTS AND DISCUSSION

The analysis process applied to the answers was based on the discursive textual analysis (DTA) of the questionnaires fulfilled by each group. The analysis was related to the main textual production ideas, which were directly referred to the proposed questions. The herein applied procedure allowed researchers to identify the concepts derived from the lectures, whose topics focused on aspects such as environmental management, environmental ethics and geoethics, as well as on the proposed questions; consequently, the procedure allowed writing more synthetic texts rather than prolix ones.

First, the main ideas from each respondent group (Brazil and Portugal) were separated into units. The analysis applied to question 1 (which involved the respondent's geoethical perception about the exploitation of mineral resources on the planet and their position on mineral exploitation versus generated environmental impacts) extracted repeated units in students' textual production, and it involved the unitarization stage, as shown in Table 1.

It was possible to see that students in both groups presented their concepts in two categories after unitarization: one category was associated with the "environmental impacts" generated by mineral resource exploitation, whereas the other one was linked to the use/need of "mineral resources" by society.

With respect to the categorization stage and according to the dominant economy perspective wherein the environment provides the material and energy necessary to produce consumer goods, the categories identified by both groups considered the environmental impacts as the consequence of the instrumental value attributed to the mineral resources. It is worth emphasizing the recurrence of citations pointing out that *the exploitation of these mineral resources is necessary to society's well-being*.

The groups set the differences between the instrumental value in the exploitation of resources (which was often referred to *as a cost to be paid for us to have the technology and other everyday requirements*) and the intrinsic value of nature. Thus, the citation "*intrinsic value is not always taken into consideration"* – either by societies that consume the produced goods or by the sectors that exploit the mineral resources – was also recurrent.

It is worth emphasizing that citations related to better and greater inspection and control by means of laws, public policies, among others, were observed in the group of Brazilian students. On the other hand, the same outcome did not appear in the group of Portuguese students.

Table 1. Unitarization of the most recurrent concepts among respondents.

Group of respondents	*Unitarization of concepts*
Portugal	Environmental impacts: instrumental value; harmful; Mineral resources: functional value; essential to well-being; weighing between the intrinsic and instrumental values of mineral resources; positive and negative aspects; essential to nowadays society.
Brazil	Environmental impacts: the value of the impacts cannot be paid; the impacts are not taken into consideration; process valuation, including impacts; the impacts affect the environment, which has intrinsic value; the impacts resulting from the economic perspective about resources; they result from human needs; mitigation; consumption-associated impacts; impending onus; inspection; laws; public policies; human well-being is a priority; instrumental value of resources and intrinsic value of the environment; anthropocentric nature; Mineral resources: companies only see the instrumental value; the exploitation of resources is necessary; consumer society's attitude; dominant economic system; the value of nature is instrumental; the exploitation is necessary but lacks environmental ethics; the well-being resulting from the use of resources has intrinsic value; resources have intrinsic value; nature is an externality within the economic context; dependence on nature; society does not perceive the intrinsic value, only the instrumental one; the economic value of resources; extraction of resources for financial gains; society mixes intrinsic value to the instrumental value of these resources.

The citations may be explained by the fact that the environmental disaster in the active Mariana County mine (MG – Brazil) is closer in time (it occurred on 11/5th/2015) to the lectures and the questionnaires, which were performed on 04/15th/2016, as well as because the disaster was massively broadcasted by the media. The students collected information about the Terramonte mine from the internet; it is noteworthy that the activities in this mine were interrupted before some of the students were born. In addition, the environmental damages, as well as the recovery process in the degraded area, were not widely broadcasted by the media, unlike the event in Mariana County.

Question 2 made respondents reason about environmental ethics and moral considerability concerning the biotic and physical environments. The initial approach focused on local issues generated by the exploitation of metallic mineral resources. It involved knowledge about and acknowledgement of existing environmental impacts according to each group, as well as the assessment of these impacts on each location.

The main units identified in the textual productions of the two groups were quite different: the Portuguese students referred to the generated impacts, to the remediation process, to the cost of technologies involved in this process (in some cases), and to the delay in remediating the impacts. As for this specific question, all the students in this group mentioned the lack of knowledge about the environmental disaster and their dependence on information exclusively from the internet. This information allowed inferring that the students' position was strongly related to the debates published on the internet, which mostly criticized the slowness in recovering the area and the environmental issues caused by Terramonte mine deactivation.

The group of Brazilian students kept on mentioning that *there is no way to value the loss of fauna and flora* or that *the loss of fauna and flora has no price*, among other citations. Thus, according to them, there is no way to value the environment. It is worth highlighting that this group mentioned the precaution and prevention principles, in the sense of avoiding damages, as well as the polluter-pays principle, as a way to indicate who should pay for the damages. The conflict between the instrumental and intrinsic values, which were mentioned by some respondents, indicates that students perceived that the dominant economy understands the environment according to the instrumental value perspective, only. One respondent who mentioned unsustainability consolidated this perception*;* he concluded that the environmental disaster cut away environmental quality *for future generations*.

Table 2. Unitarization of the most recurrent concepts among respondents.

Group of respondents	*Unitarization of concepts*
Portugal	Intrinsic value; technical aspects of contaminated area remediation; enormous and disastrous impact; the activities should be controlled to the maximum in order to avoid accidents; time factor and bioaccumulation; assessment of the instrumental value of the exploitation; risk analysis (avoid or reduce); assessing the intrinsic value in comparison to the instrumental value; taking into consideration the "cost" before the exploitation for recovery purposes.
Brazil	The environment was valued as instrumental; future precautions; there is no way to value the environmental impact; polluter-pays principle; prevention and precaution principles; there is no way to value the environment; moral and ethical responsibility; difficult valuation; unsustainable; impact is contrary to the sustainability principles; it is not possible set monetary value; treating it as an environmental crime; there is no way to value the social and cultural impacts; conflict of values (the instrumental value preponderates over the intrinsic one).

The groups showed quite different perceptions in question 2, probably because of the different ways information about the environmental disasters was distributed in each country. Terramonte mine (Portugal) had its activity interrupted in the early 1990s when many of the students were children and had no access to or interest in this type of information. In fact, all the respondents in the Portuguese group did not know about the Terramonte's case, so they got the information about it on the internet.

On the other hand, the environmental disaster in Brazil happened less than a year before the application of the questionnaire; in addition, it was widely broadcasted by the national and international media, which provided much information about the facts to the students.

It is worth pinpointing that the "biotic environment" (flora, fauna) was more cited than the "non-biotic environment" (rivers, river basins, etc.) by both groups. It showed that students valued life and did not take into consideration the environment in an integrated way. According to Němec (2012), the planet's inhabitants should understand that the "non-biotic environment" also presents some evolutionary dynamics, as well as that it is necessary improving predictions and mitigating disasters, since *no human effort is and will always be incapable of stopping any process involving the development of nature*, which, in fact, involves the Earth system dynamics.

CONCLUSIONS

The incorporation of geoethical principles to the conscience and daily life of society worldwide should be the goal not only of natural sciences scientists, ecologists and educators but also of managers, leaders, politicians and statesmen at all levels. In fact, the ones responsible for the fate of our planet and of all its inhabitants, including future generations, should take into consideration the planet's internal and external dynamics, which are often disregarded in mining activities.

Consequently, it is possible to identify social, cultural, economic and environmental impacts that take us away from the sustainability goals. However, although society repudiates behaviours related to the exploitation of mineral resources and the environmental damages they cause, it acknowledges the need to use these resources and accepts the negative externalities arising from this process.

The acceptance attitude of both groups is strongly associated with the need to use mineral resources, including the price to be paid for it, even for situations whose impacts are widely spread by the media, such as in Mariana County, Brazil.

The way of thinking about geoethics, when it comes to the "value" given to the environment, should be based on moral and ethical principles often accepted by mankind. Geological factors should be the object of reflexive thinking and respected in any environmental sustainability concept since society shows greater concern about the biotic environment than about the non-biotic environment (river basins, coastal plains, rock formations, etc.).

Overall, society does not realize that many natural phenomena, both in space and time, have periodic and hierarchical nature, and that these phenomena could be

predicted, as well. However, this knowledge, as the basis for a geoethical behaviour in the use of natural resources, goes against the environment valuation by society.

The externalities arising from the use of natural resources are only noticed when a polluting activity affects individuals who do not participate in the production or consumption markets; this causes conflicts that are often overcome by the instrumental value of the natural resource.

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