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The Transformative Power of Higher Education Institutions in Accelerating the Implementation of the UN SDGs

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Sustainable Development in Brazilian Geology and Geological Engineering Curricula: Perspectives for the Anthropocene

Rossana Vicente Goulart and Denise de La Corte Bacci

Abstract Sustainable development has been a global goal since the mid-twentieth century, attracting significant scientific efforts. To discuss the presence of environment, sustainability and sustainable development themes in Geology and Geological Engineering curricula in Brazil and also explore how geologists can play a more active role in social and political discussions about Anthropocene and contribute to the achievement of sustainable development objectives (SDOs), this chapter presents the findings of a content analysis of environment and sustainable development presence within 34 Brazilian Earth Sciences bachelor's degree programs. The study examined Geology and Geological Engineering bachelor's degree programs focusing on their course titles and the presence of sustainable development and/or sustainability terms within them. This analysis served as an indicator of the extent to which sustainable development is integrated into the professional training of geoscientists. The results reveal that out of thousands of courses, only twelve were dedicated specifically to sustainable development. These findings suggest that sustainable development remains a peripheral subject within Brazilian geological science and its professional training. We expect that this evidence contributes to the reflection about the need to improve the training of professionals and also to the discussion about Geology and Earth Sciences perspectives to and in the Anthropocene.

Keywords Earth sciences curricula · Sustainable development · Curricular greening · Epistemology · Anthropocene

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1 Introduction

The Anthropocene, suggested in the early 2000s by Crutzen and Stoermer (2000) in order to name a new period in which human activity began to interfere with surface geological processes, over the last two decades has surpassed the domains of geology and has become a concept discussed by anthropology (Latour 2020a, b a,b; Povinelli 2023), philosophy (Haraway 2016) and sociology (Moore 2022). The discussion around the term and theme is directly associated with climate change and remains an interdisciplinary controversy in which social and political aspects of the relationship between man and the planet (Acosta 2016; Krenak 2022) and models of socioeconomic development (Acosta 2016; Leff 2021) are related to geological aspects.

Even among geologists the formal designation of the Anthropocene is still not a consensus. The Anthropocene Work Group, part of the Subcommission on Quaternary Stratigraphy, in October 2023, formally proposed the varved succession of Lake Crowford as the global boundary stratotype for the Anthropocene, as an epoch, based on evidence presented by McCarthy et al. (2023). According to the authors, the start of this epoch is marked by records of nuclear residual dated 1952 and also by evidence of Earth system changes associated with The Great Acceleration (Steffen et al. 2015).

However, the International Commission on Stratigraphy (ICS), in March 2024, denied the Anthropocene as a formal unit arguing that it can be stated much earlier and be addressed e.g. to agriculture. ICS members also mentioned that, given the difficulty of defining a starting moment, the Anthropocene could be referred to as an event (TNYT 2024). This argument has been refuted (Chakrabarty 2024) and, concerning the impacts of human activities on the planet, ICS has already admitted that the Anthropocene "(…) will remain an invaluable descriptor of human impact on the Earth system." (ICS 2024).

Discussions about tackling the climate crisis (IPCC 2021) precede the formal discussion of the Anthropocene (Waters et al. 2023; McCarthy et al. 2023), and have been appearing on global agendas since the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 in Rio de Janeiro. In this context, the absence of effective policies to reduce global warming has been heavily criticized and associated with scientific negationism (Latour 2020b).

One hypothesis to these lack of effective actions is defended by Latour (2020b), who says that planetary economic elites, in the mid-1990s, in possession of already quite consistent data on the burning of fossil fuels and the various changes in natural processes caused by it, mainly climate change, decided, deliberately, to launch into the "unbridled extraction of everything that remains to be extracted (…). After that, let the flood come, we will be dead anyway" (Latour 2020b p.49). Based on this hypothesis, the author proposes that we stop moving along the Local–Global axis, where the Local attractor is understood as a backward, retrograde and refractory place for evolution, and the Global attractor is rich, full of infinite possibilities and often associated with the term "modern", and that we begin to consider a third attractor, outside this axis, the Terrestrial attractor. The Terrestrial suggested by Latour comprises a

political actor, who acts and participates in public life, and is not just the scenario in which political action takes place (Latour 2020b, p.52).

The need that Latour points out to rethink the relationship with the planet meets the invitation to "deterritorialize thought", remembering that there are other ways of thinking about the same object (Veiga Neto and Lopes 2010). Thus, considering that Earth Sciences, and Geology in particular, have as their object of study the processes responsible for changes within the planet and on its surface, it is worth questioning how these sciences have been developed and where they have been heading over the last decades already under the sign of climate change. Initiatives such as the ones comprised by Anthropocene Curriculum, promoted by Haus der Kulturen der Welt and the Max Planck Institute for the History of Science (Rosol 2021), are well succeeded examples of how to address the Anthropocene in curricular discussions, nevertheless, this is still a rare theme in geoscience literature.

Considering that sustainability and sustainable development are still the main alternatives for facing the climate emergency, in order to explore how the training of future geologists and geological engineers, who will face the problems of and in the Anthropocene, working on the planet that comprises an "agent that fully participates in public life" (Latour 2020b p.53), has taken place, the presence of sustainability and sustainable development themes in the curricula of undergraduate programs in Geology and Geological Engineering active in Brazil is a relevant indicator of the training. It also provides material for reflection regarding how prepared these professionals are and will be for the problems of the Anthropocene and if and how they can play a more active role in social and political discussions. Therefore, the aim of the research presented in this chapter is to discuss the presence of environment, sustainability and sustainable development themes in Geology and Geological Engineering Brazilian undergraduate programs curricula.

2 Anthropocene and Climate Change—A Brief History

Even though the Anthropocene has been discussed for more than two decades since it was coined by Crutzen and Stoermer (2000), planetary environmental changes have been discussed at least since the 1970s, initially reported as global warming (Broecker 1975), then as climate change and currently as climate emergency, climate hell and even global boiling (UN News 2023). From the United Nations Conference on the Human Environment, the first UN conference on the environment, held in 1972, the three dimensions relating the interaction between man and environment began to be discussed: social, environmental and economic. Sustainable development and sustainability began to be adopted by the UN as the development model to be followed in an attempt to balance these three dimensions. Since then, the relationship between economy, socioeconomic development and environment has been widely discussed, even when the term Anthropocene was not yet under discussion.

In 2023, with the announcement of the golden spike (McCarthy et al. 2023) it is recognized that climate change constitutes the backdrop of the Anthropocene (Steffen

et al. 2015; Waters et al. 2023). Since the evidence of changes in geological processes associated with climate change were found in the stratigraphic records attributed to the beginning of this epoch, in which the geological processes recorded, considered immutable until then, they were proved to be altered by human interference. The records of the Anthropocene give materiality to the suggestion of the planet as a mutable agent and no longer as a passive scenario that only provides resources, and provoke the need to rethink the way the object of geology is approached, since the geology of the Anthropocene is not the same as the Holocene, which was also not the same as the Pleistocene, Cretaceous and Proterozoic.

Therefore, environmental issues, still reserved for a small niche of professional activity and often addressed with shallow scientific depth by geology, predominantly in the exploration and exploitation of resources and the mitigation of impacts caused by these activities, as we will see in this chapter, become an inseparable part of all other issues. However, even though physical data has been the knowledge basis of climate and environmental changes discussions (IPCC 2021) used to explicit the need to change behaviors and policies in order to mitigate the causes and/or consequences of the problem, the discussions and new references proposed based on these data continue to be developed by economists, sociologists and anthropologists, but is still absent of geologists training.

3 The Need to Observe Others Perspectives

Considering that anthropology, sociology and even economics are ahead of geology in terms of discussion about the Anthropocene and its environmental and social consequences, it is relevant to observe contributions from authors of these areas to better understand what they are proposing. Also, as we are studying Brazilian universities and professional training, others perspectives should be observed, coming from Latin America and Brazil, considering that the early references, such as Crutzen and Stoermer (2000) and Gore Jr. (2006) came from the north.

Starting from the premise that "environmental processes and values are ontologically incommensurable; untranslatable and irreducible to market measures", the Mexican sociologist Enrique Leff, (Leff 2021, p. 47) proposes the adoption of an environmental rationality, which has "diversity and incommensurability as epistemological and political principles" for addressing current problems, as opposed to the current scientific and economic rationality (or Modernity, as he mentioned) which follows a homogenizing epistemological order.

> The deep meaning of the principle of incommensurability for sustainability emerges from the concept of the environment as a complex system, integrated by ecological, technological and cultural processes, in which the ideal and the material hybridize, in which different rationalities attribute different values to nature and different meanings to sustainability. (Leff 2021, p. 47)

Alberto Acosta, Ecuadorian economist, followed the same direction by questioning economic development, considered as the "global imperative" (Acosta 2016,

p. 56), and proposing the "Bem Viver" (well living in a free translation) as an alternative. Acosta understands that:

> The limits of lifestyles supported by this ideological vision of classical progress are increasingly notable and worrying. The exploitation of natural resources can no longer be seen as a condition for economic growth nor can it be a simple object of development policies. (Acosta 2016, p. 70)

"Bem Viver" is an adaptation of the kıkwa term beautiful life, originating from the Bolivian and Ecuadorian indigenous worlds, which comprises a way of life in community and in harmony with nature, that are understood as the fundamental bases for a dignified life (Acosta 2016). Thus, this way of living goes against development, which is based on a predatory relationship with nature. The author mentions that, when considering that the dominant thought associated with globalization does not understand the economy dissociated from economic growth, "a world without oil, mining or agribusiness" also becomes unthinkable (Acosta 2016, p. 243).

In Brazil, Ailton Krenak, one of the most influential and respected voices of indigenous nations, also addresses man's relationship with the planet from similar perspectives, pointing out the need to build a future along different paths than those built until then (Krenak 2021, 2022). The author points out that the perception that it is possible to build a form of life and existence separated from nature, and linked to it only through the consumption relations, is the mistaken idea behind the fear of "the end of the world". Although, about this end, Krenak says:

> The end of the world may be a brief interruption of a state of ecstatic pleasure that we don't want to lose. (...) When this is transferred to merchandise, to objects, to external things, it materializes in what the technique developed, in the entire apparatus that was superimposed on the body of mother Earth. (Krenak 2021, p. 60)

When talking about the Anthropocene, the author brings a similar idea, that the transformation of the "Earth configurations" maybe is only a transformation of the experience of humanity with the planet in this moment, which has been based on consumption:

> If there have been other configurations of the Earth, even without us here, why are we so attached to this portrait with us here? The Anthropocene has an incisive meaning about our existence, our common experience, the idea of what is human. Our attachment to a fixed idea of the Earth's landscape and humanity is the deepest mark of the Anthropocene. (Krenak 2021, p. 58)

These authors are essentially advocating the need for a change in rationality, in Enrique Leff's terms, and in the relationship with nature and the planet itself, in the ideas of Alberto Acosta and Ailton Krenak. In their works they explain the epistemological bases from which they propose these changes in perception and relationship between the human and the non-human.

However, the discussion on new socio-environmental paradigms considering climate change and the Anthropocene, even though intrinsically linked to geology, has, until now, been far from its formal scientific interests, considering the difficulty in consolidating the term itself in the scientific community. Other epistemological

perceptions of the relationship with the planet and of geology itself can greatly benefit from other reflective scientific approaches, such as anthropology, for example, in opposition to the strictly technological ones, such as those related to damage reduction and impact mitigation. In order to contribute to this epistemological discussion, we will begin by discussing education, more specifically what has been taught as geology.

4 Educational Institutions and Scientific Thinking

Educational institutions, specifically universities, as cultural institutions, considering that "every social practice has a cultural dimension" (Hall 1997, p. 33), when training future professionals in their undergraduate programs, including scientists, and developing their research and outreach activities, establish a way of thinking about and relating to different themes by attributing meaning to the objects of study. Therefore, it can be inferred that the university sustains and, perhaps, sometimes, creates a culture related to some theme through their practices of signification. Creating and establishing a culture can be done in different ways, objectively and subjectively (Hall 1997).

Objectively it is possible to analyze the ways of thinking and addressing environmental issues, sustainability, climate emergency and Anthropocene in the geology undergraduate programs by observing that, e.g., the renovation of Earth Sciences teaching in Brazil included foreign books and teaching material (Gonçalves et al. 2019), often in English. Although, subjectively, it is also possible to make this analysis by observing students, professors and coordinators current thoughts and talks about these same questions, out of the disciplinary programs.

Research regarding the historical evolution of geology undergraduate programs in Brazil, developed by geoscientists that have worked in these programs for decades, indicate that they are guided by serving a job market (Cordani et al. 2018; Ernesto et al. 2018). This market is mainly focused on mineral exploration, such as iron ores, oil and gas, sand, limestone, water, which often assumes the guise of goods essential to life and of public interest. However, these goods, also called resources, are, in its genesis, part of the predominant mercantile logic, which does not necessarily generate real achievement of well-being (Figueirôa 2022). In this way, the predominant professional training perpetuates a technicalist vision, based on positivist and classificatory, reductionist and resolute science (Morin 2015).

Although, there are other ways of addressing the education and research, i.e. epistemological views, about environmental questions, sustainability, climate emergency and Anthropocene. In order to provide a "rehabilitation" of geology reputation, which has been associated with "dirty industries", Stewart et al. (2023) propose three horizons to the paradigm change required for this rehab. Horizon 1, named Business as Usual, based on a traditional core curriculum would result in "Global prosperity (wealth creation)", Horizon 2—Entrepreneurial Transitions—based on "Geoscience for Society" curriculum can result in a "Low-Carbon (clean and green) Future",

while Horizon 3—Radical Visions—based on a "Planetary and human well-being" curriculum could result in a "Safe and just operating space for humanity" (Stewart et al. 2023).

This possibility of focusing efforts on education and research based on the relationship of human beings and the planet is also present in the argumentation of Heymann and Dalmedico (2019) when the authors mention the critics that have been made to the "neglect of the human dimension in climate research" and remember that "Earth system modeling, obviously, puts natural processes in the center, whereas human activities and affairs only represent a boundary condition (…). Though humans are a key factor in climate change (…), the IPCC never included expertise about the complexity of human action and behavior". The authors also remember a key aspect of the epistemological discussion and paradigm changing, as mentioned by Stewart et al. (2023), that is rarely discussed among geologists: the gradually lost (by the climate modelers, but not only by them) of the "ownership and control of the political use of their epistemic tools" (Heymann and Dalmedico 2019).

Professional training without a critical reflection of the historical, cultural and political context in which it takes place continues to meet the positivist ideals of construction and application of knowledge, ignoring the fact that there is no neutrality in the sciences, since paradigms are the result of their historical time and they also change with it (Kuhn 1962; Frodeman 2010). Therefore, considering that and also the Anthropocene geological discussion, it is opportune to bring Veiga Neto and Lopes (2010) reflections that it was in the rupture from the Middle Ages to Modernity, when man became the central element, that education became an imperative "as a path (…) sometimes towards humanization—as in Comenius, (…) sometimes towards awareness—as in Freire (…)". Then, when inviting us to "deterritorialize thought" and to think about pedagogical modernity in other ways, the authors also remind us that there are other ways of thinking about the same object.

5 Methodology—Indicators of Environmental Presence in Geology and Geological Engineering Undergraduate Programs in Brazil and Curricular Greening

Climate emergency and all environmental questions that come along with it, as well as the discussions about sustainability and other epistemological references, as mentioned in the previous sessions, are a fundamental subject to and in the Anthropocene, especially for Earth Sciences, so that it is wise to verify how much these themes constitute them. One way to do that is through the investigation of the curricula of undergraduate programs offered to future professionals and scientists. Regarding the evaluation of sustainability principles application to curriculum content, the concepts and tools of curricular greening are especially appropriate.

Curricular greening is the process of adopting actions based on the sustainability paradigm in all university's operational instances. It goes beyond the content that is

taught or a curricular change and aims for the construction of a sustainability culture in the universities based on actions that congregate teaching, research, community services and campus management (Carvalho et al. 2012). The curricular greening process is defined by the ACES Network (Network of Curriculum Greening of Higher Studies) as:

> (...) training of professionals committed to the permanent search for the best possible relationships between society and nature, taking into account the values of justice, solidarity and equity, applying universally recognized ethical principles and respect for diversity. (ACES Network, 2000 apud Silva et al. 2016, p. 211).

One of the indicators of curricular greening in universities was defined by Carvalho et al. (2012), for operational purposes, as the presence of environmentally oriented courses in university undergraduate programs. The authors define these courses as follows:

> (...) the course must have explained in its syllabus and in its teaching plan the intention of highlighting the socio-environmental dimension related to its specific contents. This dimension can come in the form of a discussion of socio-environmental problems, society and environment relations, the interfaces of that area of study with environmental policies or socio-environmental impacts, sustainability (...). (Carvalho et al. 2012, p. 138)

Silva et al. (2018) also add that in order to build a culture of sustainability, socio-environmental training must be present in all programs and not just those dedicated to specific training in the environment. However, research on curricular greening in Brazilian universities (Carvalho et al. 2012; Leme and Pavesi 2012) and also on the academic community's understanding of this topic (Silva et al. 2019) demonstrate that, although the process of making university a more sustainable environment is positively seen, it is still an incipient process.

Therefore, in order to start the investigation about the environmental presence, i.e. the occurrence of environmental themes, in the undergraduate Geology (G) and Geological Engineering (GE) programs offered in Brazil, we chose to firstly identify and quantify the courses with terms associated to the theme in their titles. The intention is to identify any environmental mention in the curricula, even if it is not an environmentally oriented course as defined by curricular greening. Then, among these courses, we identified and quantified the ones containing sustainability and/or sustainable development in their titles and, finally, by analyzing the syllabus contents, the environmentally oriented ones were identified considering the curricular greening criteria. In order to enrich the curricular greening analysis and also the geology epistemology discussion, we also identified and quantified the courses whose titles have terms associated with it.

A documentary analysis (Ludke and André 2022) of the materials available online in higher education institutions websites was carried out initially in the second half of 2020, and then it was updated and revised in 2024. The documents analyzed comprise undergraduate programs pedagogical political projects (PPPs), their curricula and courses syllabus. The analyses were carried out by compiling in two Google Sheets spreadsheets (one with G courses and another with GE courses) all the courses included in the curricula, their workloads and mandatory or optional character. The

environmental presence in the courses were identified by the recognition of the occurrence of environmental themes according to the terms of their titles, such as: Exploration, exploitation and management of underground water resources (title of the course)—water resources (term associated with an environmental theme)—water resources and environmental management (environmental theme). The environmentally oriented courses concerning curricular greening definitions were analyzed by reading all the syllabus of the courses in which an environmental presence was identified through an environmental theme.

The data presented comprises the curricula analysis of 31 undergraduate programs in Geology and 03 in Geological Engineering, in 34 different universities, which compose the total active programs offered in Brazil, according to the National Register of Higher Education Courses and Institutions official data provided by the Brazilian Ministry of Education.[1] In order to quantify the environmental presence in the curricula and which courses can be classified as environmentally oriented, we applied the following indicators:

1. Availability of curricula documentation on websites;
2. Number of courses with environmental themes in their titles;
3. Thematic category of the environmental courses identified;
4. Distribution of mandatory and optional courses;
5. Number of courses containing sustainability and/ or sustainable development in their titles;
6. Courses average workloads;
7. Number of environmentally oriented courses;

Additionally, it was added one last indicator related to the epistemology curricula content:

8. Number of courses with epistemology and associated themes in their titles.

6 Results—Numbers of Sustainable Development Presence in Brazilian Geology and Geological Engineering Curricula

The analysis of the curricular documentation and courses show that there is a high availability of curricula documentation on websites. Considering the 34 programs, 33 provide and one did not provide the curriculum (Indicator 1, Fig. 1), and, concerning the PPPs, 25 provide (73.5%) and nine do not (26.5%). Regarding the number of courses with environmental themes (ET) in their titles (Indicator 2, Fig. 1), from a total of **3363 courses cataloged** (3077 G; 286 GE), **328** (306 G; 22 GE)) **are entitled with an environmental theme**. The word "Anthropocene" is not mentioned in the title of any of the 3363 courses cataloged. The 328 courses were grouped in 16 thematic categories (Indicator 3) as presented in Table 1.

[1] Accessible at https://emec.mec.gov.br/emec/nova.

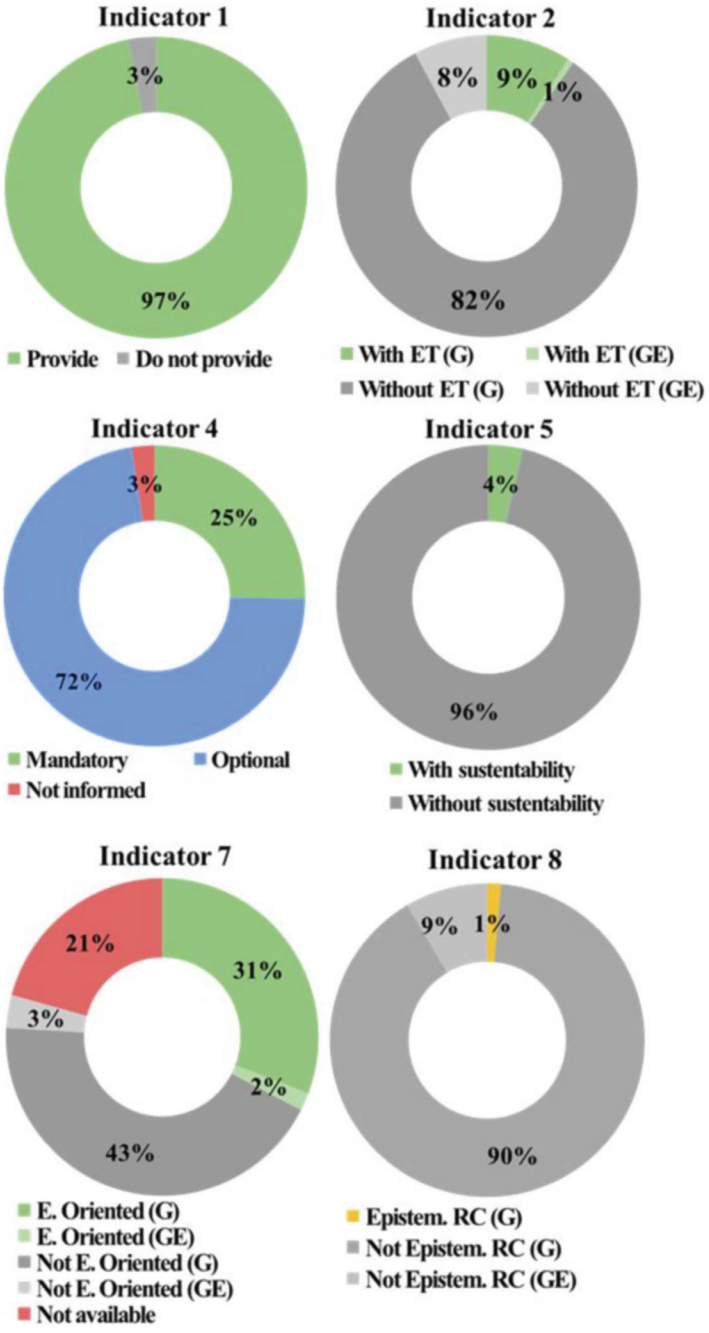

Fig. 1 Indicators of environmental presence in geology and geological engineering undergraduate programs

Table 1 Geology and geological engineering courses thematic categories

Category	Geology	Geological engineering	Total number of courses
Environmental geology	33	2	35
Geodiversity, geoconservation, geotourism and geoethics	17	4	21
Water resources and environmental management	35	0	35
Energy resources	26	2	28
Urban geology, environmental geotechnics and geological risk	24	4	28
Geochemistry, environmental chemistry and medical geology	22	2	24
Legislation and environmental law	10	1	11
Climatology, climate change, climate and atmosphere	24	1	25
Contamination, pollution, recovery of degraded areas	19	3	22
Geology and society	17	0	17
Mining and environment	4	1	5
Sustainability and sustainable development	12	0	12
Environmental politics and economics	7	0	7
Diagnosis, licensing, assessment of environmental impacts	13	1	14
Environmental education and scientific dissemination	15	0	15
Ecology	28	1	29
Totals	**306**	**22**	**328**

Regarding the distribution of mandatory and optional courses (Indicator 4, Fig. 1), from the 328 courses with environmental themes, **83 are mandatory**, **237 are optional** and eight are not informed. However, concerning the number of courses containing sustainability and/ or sustainable development in their titles (Indicator 5, Fig. 1), there are only **12 courses with sustainability and/ or sustainable development** in their titles, three are mandatory and nine are optional.

The average workloads (Indicator 6), considering the 328 courses environmentally related, are **56.6 h** (57G; 49.7GE). The average workload of the remaining courses

is 68.6 h (69.3 of 3077G; 60.9 of 286GE). The **12 courses related to sustainability and/ or sustainable development have an average workload of 52.7 h**.

Concerning the number of environmentally oriented (E. oriented) courses (Indicator 7, Fig. 1), among the 328 courses entitled with an environmental theme, 260 have their syllabus available for analysis and **107 of them** (107/328); (101G; 6GE)) were **identified as environmentally oriented**. From these 107, **33 are mandatory** (32G; 1GE), **74 are optional** (69G; 5GE) and they have **54 h of average workload**.

Finally, considering the number of courses with epistemology and associated themes in their titles (Indicator 8, Fig. 1), the epistemology related courses (Epistem. RC) comprise the ones with terms associated literally with epistemology (e.g. Epistemology of Geology and Science Methodology offered by UFRGS[2]) and those associated with anthropology, sociology, philosophy, history and sciences history. They comprise **48 courses** (47G; 01GE), **1.4% of the total cataloged**, eight are mandatory, 40 are optional, and they have **54.4 h of average workload**. Although these courses are out of the environmental themes described in the previous indicators, the themes which they are associated with are related to the curricular greening process definition. Nevertheless, even among them, the percentage of environmentally oriented is 22.9% (11/48 (11G).

7 Environment, Sustainability and Curricular Greening Evidence

Concerning PPPs and documentation availability—one in four PPPs are not available—and its content and effort taken to find it, it is possible to conclude that there is not an obligation to present it, nor a pattern to do it in an accessible form.

Concerning environmental presence through course titles analysis, only around 10% of all courses that compose geologists and geological engineers professional formation are lightly related to any environmental theme considering the broad spectrum of courses, from Environmental geology to Legislation and environmental law, grouped in 16 categories. This valuation pattern continues in the character of the courses—only one in four is mandatory even among this broad spectrum—and in their average workloads, that is 12 h lower than the more than 3000 non-environmentally related ones.

Concerning sustainability and sustainable development courses, through the same analysis, evidence shows an even narrower perspective, with only 12 courses among 34 programs. Only three of them are mandatory and their average workload is 16 h lower than the non-environmentally related.

Concerning curricular greening, the perspective is a bit wider, with around 33% of environmentally related courses identified also as environmentally oriented. One third of these are mandatory, but their average workload is 3 h lower than the environmentally related only. The courses average workloads show a valuation gradient

[2] Federal University of Rio Grande do Sul.

expressed by the dedicated time: non-environmentally related (69 h), environmentally related broad spectrum (57 h), environmentally oriented (54 h) and sustainability and sustainable development exclusively (53 h).

Considering all evidence above it is safe to say that sustainability and sustainable development, as paradigmatic concepts that are discussed and developed in a prioritized way, such as petroleum related themes in the current paradigm, still have very limited space in undergraduate Geology and Geological Engineering programs. However, when part of a broader discussion about the socio-environmental dimension of each specific theme, as proposed by curricular greening, sustainability and sustainable development have a more successful performance.

Finally, concerning the epistemology and associated themes courses, even though they occupy a very small part of the curricula, around 1%, their analysis is also relevant as they comprise a great part of the curricular greening which is its social dimension. So, even being small in the curricula, it is important to observe how many of these courses are environmentally oriented. The result is that only 23% of them can be identified this way. Even courses like Sociology (offered by Unicamp[3]) and Theories of Development (offered by UnB[4]) are not yet focusing directly on the social-environmental dimension of their themes, considering their syllabus content. Efforts are still necessary in order to establish an environmentally oriented approach to them.

8 Where is the Anthropocene in Brazilian Earth Sciences?

The evidence discussed above allows us to assume that the environmentally related courses lack the social dimension of the socio-environmental relations between man and the planet, while the epistemology related ones lack the environmental dimension of human existence on the planet. Therefore, considering that, in order to properly approach the Anthropocene, we are going to need social and environmental aspects to be worked together, which have not been, also given the absence of the term itself in the data cataloged, maybe it is more proper to question if there is place for the Anthropocene discussions in the Brazilian Earth Sciences, especially Geology undergraduate programs, considering the outline of this research.

If we consider the recognition of the Anthropocene as an earth science revolution, based on an epistemological change in social-environmental relations between humans and non-humans, from a Modern paradigm based on an attempt of their separation (Latour 2019), that brought us to the New Climatic Regime (Latour 2020a), to another for whose building other social-environmental relations references are needed, so we can also recognize climate emergency as a scientific crisis moment. According to Kuhn (1962), the crisis during a revolution indicates that the time has

[3] State University of Campinas;

[4] University of Brasília.

come to renew the instruments, since those provided by the current paradigm are no longer capable of solving the problems defined by it.

Even though, as Latour (2019 p. 88) defends, "the Modern constitution forces us to feel time itself as a revolution (…) because it suppresses the causes and implications of the objects of Nature, making their sudden emergence a miracle", perhaps the recognition of this non-separation and, therefore, of the non-existence of these miracles, is the scientific revolution itself since we still have the formal need to explain and require scientific changes through Modern concepts.

Therefore, if we consider exploitation of fossil fuels, consumption of non-humans, such as water and air, as resources, as well as the omnipotent anthropocentric position of humans in the Universe, as instruments of the Modern paradigm, which no longer cope with its problems, so these are the instruments that must be modified. At this point, the powerful lenses of Enrique Leff's environmental rationality, Alberto Acosta's Bem Viver and Ailton Krenak's solutions to the end of the world constitute accurate instruments to look through.

Still according to Kunh (1962 p. 120) "A new theory is always announced together with its applications to a certain concrete range of natural phenomena (…). Once accepted, these applications (…) will accompany the theory in the manuals where future scientists will learn their craft". Therefore, there is an urgent need, from the initial stages of training, to critically discuss the Anthropocene, its causes and models of possible human-non-human relations, in a multidisciplinary way, and with an expansion of the epistemological spectrum of Earth Sciences, especially of Geology. In order for it to happen, the themes that form the basis of this socio-environmental change demanded by the Anthropocene must be in the curricula as a priority, occupying the center of discussions.

9 Conclusions

Considering the aim of the research presented in this chapter, the evidence presented makes it clear that environment, sustainability, sustainable development and Anthropocene are themes under addressed or absent in Geology and Geological Engineering Brazilian undergraduate programs and also how narrow the space is for environmentally related themes in Earth Sciences curricula in view of the number of courses dedicated to them and their workloads. This scarcity was also observed in epistemology related courses. However, when checking the numbers relating to environmentally oriented disciplines, concerning greening curricula concept, a more promising perspective can be seen.

This perspective, when associated with the Latin American references mentioned, can indicate how Earth Sciences curricula can be rethought and updated. The change in perception of socio-environmental relations between man and the planet, or humans and non-humans, from the Latourian point of view, is fundamental to the change in scientific paradigm required by the Anthropocene. There is an urgent need

to question the systems of meaning of the objects of study in Geology. The perspective of Earth as a political actor is an objective, powerful and necessary perception for geoscientists to develop a critical vision regarding their object of study and their professional performance.

It is necessary to expand and improve the training of professionals committed to the permanent search for better socio-environmental relations, as well as values such as justice, solidarity and equality. Thus, the information about what has been taught constitutes a valuable tool for reflection regarding not only the quantitative aspects of the prescribed curricula, but how much what has been taught and learnt in the undergraduate programs reflect and promote the maintenance of the current paradigm. The limitations of this study could serve as a recommendation for expanding discussions about environment, sustainability and the Anthropocene in Brazil.

We suggest that geoscientists accept Veiga Neto and Lopes' invitation to deterritorialize the thought, considering what science has been done, and what science is required to do in the Anthropocene. Looking at Leff's, Acosta's and Krenak's perceptions it is possible to imagine an Earth Science where several epistemologies can coexist, so that we change the trajectory toward the flood.

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