Liability in Civil and Environmental Subjects for Carbon Capture and Storage (CCS) Activities in Brazil

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Abstract

This article intends to organize and understand the theories and norms related to civil and environmental liability in the Brazilian legal system and its relations with the potential implementation of CCS (Carbon Capture, Transport and Storage) projects in Brazil. Thus, in view of the protection of the environment, safeguarded as a Brazilian constitutional norm and related normative organization, the questions concerning civil and environmental liability are introduced. In addition, international guidelines on the subject in selected country standards are exposed through the composition criteria of the International Energy Agency (IEA) CCS normative repository. Then, notes are made on the fundamental importance of Civil and Environmental Liabilities in the prevention and control of environmental accidents, social risk management and safety in storage and carbon activities, as well as conclusions drawn from the current scenario of Brazilian Environmental Law.

Keywords: Environmental Liability; Environmental responsibility; Carbon Capture and Storage (CCS); Carbon Capture, Transport and Storage.

1. Introduction

As the complexity of legal relations in society increases, new rights and obligations emerge to be regulated and ensured by control mechanisms. The obligations arising from the legal system for their implementation require the imposition of responsibilities that generate patrimonial effects that incubate to recompose the states of legal fact to their parity with the rights and obligations. Thus, under the law, protected legal assets must be economically relevant to be considered as such, and non-compliance with

the protection of these assets generates patrimonial effects.

Anti-juridicity as an action contrary to the Law, carried out through the positivized norm and the principiologically protected values, does not find, according to Bezerra et al. (2005), embryonic difference between anti-juridicities and consequent sanctions, but they can be differentiated by reference to their guardianship objects, resulting in the existence of three types of sanctions: criminal, civil and administrative.

According to Bezerra et al. (2005), the criterion immediately used for the identification of these sanctions is the object protected by them, so that in offenses provided for by the Penal Code, the sanction to be applied will be of a criminal nature and will generally consist of a restriction on individual liberty. With regard to civil sanctions, the safeguarded interest will require the patrimonial reparation of individual, collective or both damages and the administrative sanctions have the purpose of defending, through repression and prevention, the collective interests.

The Federal Constitution, when dealing with the fundamental rights in article 5, inscribed the right to life, bringing as a reflection the right to an ecologically balanced environment, essential to the healthy quality of life, in view of paragraph 2 of the article that prescribes : "The rights and guarantees expressed in this constitution do not exclude others arising from the regime and the principles adopted by it". Article 225 of the Magna Carta, which in itself elevates the ecologically balanced environment to the category of fundamental right, from which its power / duty of protection derives.

This protection is closely related to the conception of "damage", which would be that of "injury to legally protected interests", environmental damage, in turn, would be the action or omission that undermines the various conditions, laws, influences and interactions of order. physics, chemistry and biology that allows, shelters and guides life in any form (SETTE, 2013).

Environmental damages are difficult to repair, especially due to their characteristics that are hardly found in non-ecological damages and, therefore, according to Colombo (2017), have the following specificities: they are irreversible; pollution has cumulative effects; the effects of ecological damage may manifest beyond neighboring surroundings; they are collective and diffuse damage in their manifestation and in establishing the causal link; have direct repercussions on collective rights and indirect on individual rights.

Several gases that exist naturally in the atmosphere when emitted in excess intensify the greenhouse effect: methane (CH4), nitrous oxide (N2O), ozone (O3), Hydrofluorocarbon (HFCs) and carbon dioxide (CO2) (NISHI at al, 2005). The study of carbon is of great importance because of its close relationship to the climate change of the earth (NOVAES FILHO et al, 2007). The large amount of gases emitted from human activities, mainly from the burning of fossil fuels and deforestation, has been causing greenhouse gases accumulation in the atmosphere and, consequently, the rise in global temperature (COTTA et al, 2006).

In the current context of climate change aggravated by the emission of anthropogenic greenhouse gases, new technologies for the decarbonization of production processes have been used as tools to mitigate carbon dioxide emissions.

Among the strategies for reducing the concentration of carbon dioxide in the atmosphere, the following stand out: a) the reduction of emissions from burning fossil fuels; b) reduction of burning of plant material;

and c) carbon sequestration through forest planting and management; and d) carbon capture and storage in geological formations (SOARES et al, 2002; COSTA et al, 2018b).

The so-called "carbon sequestration" occurs when conserving, preserving, restoring or planting forests due to the emergence of a carbon sink as forests remove part of the CO2 from the atmosphere through photosynthesis (SILVA et al. 2008) and so-called geological storage of carbon dioxide occurs when the gas is injected into a certain underground geological formation containing it.

Among these are the techniques of CCS (Carbon Capture, Transport and Storage), which, in the storage phase, despite its global importance for decarbonization, when performed in geological structures, cause changes in the environment that can result in possible environmental damage.

Carbon capture through CCS technologies can be stored in several ways, the most representative being hydrodynamic trapping, solubility trapping and mineral trapping. The choice of the most suitable stocking method should consider in its decision process several factors, among them the safety of the geological reservoir and its economic viability. Geological substrate storage is a storage mode that occurs by injecting CO2 into predetermined geological formations identified as specific target formations, including depleted oil and gas reservoirs, unexplored coal deposits and saline aquifers.

There are studies that point out the potential of the Brazilian territory for the geological storage of carbon dioxide in the Pre-salt region, in halite formation saline domes (KETZER, 2016; MAIA, 2018). Thus, the carbon dioxide emitted in hydrocarbon production and exploration in this region would be especially covered by geological storage, which means a considerable amount given the projections for production in the region for the next 20 years (SENADO, 2019).

Carbon dioxide storage is not provided for by current Brazilian regulation. Thus, it is necessary to study the current norms related to the subject, as well as studies that point out the best conducts performed internationally and those that can be applied in the country, since the conduct cannot be excluded from the legal appreciation on the grounds that there is no specific regulation (COSTA and MUSARRA, 2018).

Many of the technologies that are part of the CCS chain are well established and their practical application is well understood and based on practical experience gained in the context of various industries that deal similarly with underground geology (ROMEIRO-CONTURBIA, 2014). However, several risks associated with CCS have been identified at the local level, potentially affecting the environment, health and human property, and in relation to the global climate (ROMEIRO-CONTURBIA, 2014).

Geological storage risks carbon dioxide leakage and other substances related to the separation, transport and injection process, as well as the collapse of the storage structure and its consequences for biota, and in the pre-salt region there are still Consideration should be given to the effects of salt concentration (NACL) on the marine environment resulting from gas drilling / injection (BUI et al, 2018; COSTA et al, 2018).

In case of possible damage arising from the implementation of CCS techniques, the need to repair them occurs, this corresponds to the institute of liability, which concerns the duty not to injure anyone, providing compensation for any unfairly harmed interest by the causative agent. . Such legal institute requires civil reparation proportional to the damage on the part of the person who caused it, as a form of replacement or compensation.

Damages to civil liability are material or moral in nature. Those of a material nature reach an

identifiable economic value, characterized by the form of emerging damages or lost profits. The moral ones are characterized by non-transferability and subjectivity, such as the honor and dignity of the human person, and cause greater difficulty in their measurement (MUSARRA, 2009).

Thus, in order for reimbursement to occur, there must be, in addition to the damage, unlawful conduct that has generated it, would be the case of damage to property when caused by CCS activities. Already the environmental liability aims to set the parameters for the verification of the damage caused and the liability of the causative agent, whether individual or legal entity, public or private (MUSARRA, 2009) when reaching the environment, in case environmental damage.

The Federal Constitution of 1988 in the chapter devoted to the Environment establishes three types of liability as a form of reparation for environmental damage: civil, criminal and administrative, independent and autonomous. Thus, a single action or omission can give rise to three types of autonomous wrongdoing and receive the sanctions imposed. It is the result of an anti-juridical conduct, from which causes injury to be compensated. In addition, associated with objective responsibility is the polluter 's duty to fully repair the damaged environmental good, either through restoration or through ecological compensation (MUSARRA, 2019).

Therefore, it is intended to discuss, in this work, how the institute proceeds in terms of potential civil reparation of environmental damage in relation to CCS in geological structures in Brazil.

2. Liability in Brazilian Environmental Law

As pointed out, there are several forms of accountability, that is, manifestation of the obligation to answer for something, within the scope of the Brazilian Environmental Law. There are three types of "liability", ie three types of environmental liability: administrative liability, civil liability and criminal liability. They all derive from the constitutional provision (art. 225, par. 3) which states that "conduct and activities deemed harmful to the environment will subject offenders, individuals or legal entities, to criminal and administrative sanctions, regardless of the obligation to repair damages". , translation of the polluter pays principle. Liabilities can be divided into objective and subjective, civil liability falls under objective liability, and administrative and criminal liability fall under subjective liability (MORAES et al, 2018).

Civil redress for environmental damage is closely related to the polluter pays principle, which also achieves preventive and repressive measures and the costs associated with the use of natural resources (MORAES et al, 2018). Thus, administrative and criminal responsibilities are those classified as instruments of repression of conduct and activities considered harmful to the environment (MILARÉ, 2018).

2.1 General Liability

In general, liability expresses the obligation to answer for something, either by contractual obligation or by legal determination, in order to satisfy or execute a legal act arising from a legal obligation. Civil liability refers to the obligation to repair damage or to compensate it, being regulated in its general

principles and some special topics by the Civil Code, and may be covered in other legal acts in the face of the evolution of life, progress and forms. of new behaviors that arise over time (RIZZARDO, 2007).

The general civil liability is the obligation to repair damages caused not foreseen by a legal business, based on the fault (subjective liability, provided for in article 927 of the Brazilian Civil Code) and the risk (objective liability, provided for in paragraph 927 of the Civil Code). Thus, article 927 of the Civil Code states that "he who, by illicit act (arts. 186 and 187), causes harm to another, is obliged to repair it" and, in his sole paragraph, says that "there shall be an obligation to repair the damage, regardless of fault, in the cases specified by law, or when the activity normally performed by the perpetrator of the damage entails, by its nature, a risk to the rights of others ".

According to Dower (2007), liability arises when there is damage caused by someone, acting with intent or guilt, which is obliged to indemnify. The violation of one's subjective right is based on voluntary action or omission (intent), recklessness, malpractice and negligence (guilt), occurring an unlawful act and finding the guilt or intent of the cause of the damage. However, there is the incidence of exceptions, such as risky activities that cause serious damage, where there is presumption of guilt in the face of difficulty in proving guilt. Thus, in civil relations not caused by environmental damage, as a rule, guilt is the basis of liability.

According to Diniz (2012), civil liability is generated from the interest in restoring the legal balance altered or broken by the injury, recomposing the status quo or reimbursing the equivalent amount so that the victim may have repaired the damage caused. Such liability is defined in the application of measures to repair the moral or property damage caused to third parties by reason of their own act, considering the existence of illicit (subjective liability), and the risk, ie, liability without fault (liability objective). Merely civil liability is linked to CCS activities through individual or collective property damage, without any environmental consequences.

The exclusionary causes of liability are fulminating circumstances of the indemnity claim for attacking one of the general elements or assumptions of civil liability, which breaks the causal link (GAGLIANO and PAMPLONA FILHO, 2010). It can be said that they rule out the agent's responsibility for uncharacterizing the fault, breaking the causal link, excluding the authorship, ruling out the intent or rendering the damage unprovable, and there should be legal provision for such exclusion. They are classified into the state of necessity, self-defense, the regular exercise of law, act of God or force majeure, the sole fault of the victim or the fact of a third party.

As stated by Miranda (2012), the human being exposed to damage must be protected by material law in order to have right, claim and action tells the offender. The indemnity aims to render indemnity what was damaged, which could be damage to the body and psyche. In this sense, the human being who has inflicted harm on others must compensate.

According to the principle of civil liability, as a rule, situations are illiquid, where the reparation of the damage consists in the specific restoration of the injured legal property, that is, the in integrum recomposition, so that the victim will find himself in a situation as if the harmful event had not happened. When faced with the impossibility of returning to the original situation due to excessive burden or the impossibility of its excessive realization, it should be offered its pecuniary equivalent, adding the loss of profit limited to what was reasonably left to earn, and the interest (PEREIRA, 2011).

From this perspective, the calculation criterion is set by art. 402 of the Civil Code: “rt. 402. Except as expressly provided for by law, the loss and damage due to the creditor covers, in addition to what he effectively lost, which reasonably failed to profit ”(BRAZIL, 2002). Since the harmful event interrupts the normal succession of the facts, the new state of affairs must be as close as possible to the original situation, and the reparation must be supported because, according to human experience, in the abstract, the initial situation would be that existing had the damage not occurred. Therefore, the criterion of the extent of damage applies perfectly to the repair of material damage, as it has a reparatory character (MONTEIRO, 2010).

Therefore, the extent of the damage is the measure of compensation, which is the general criterion for setting the amount due in order to compensate the property damage, by quantifying the amount of the reduction experienced by the creditor's equity, in all its aspects. , and then sets the principal of the obligation of the debtor. It bears interest, monetary restatement and attorney's fees, under the conditions examined for general obligations (COELHO, 2012).

The property damage, for Maria Helena Diniz (2001, p.61), “becomes the concrete injury, which affects an interest related to the victim's property, consisting in the loss or deterioration, in whole or in part, of the material property that belongs to her. , being liable to pecuniary assessment and compensation by the person responsible ”. And the moral damage is for Sergio Cavalieri (2008) the injury to the integral good of the personality, such as honor, freedom, health, psychological integrity, causing pain, suffering, sadness, shame and humiliation to the victim, reveals, in essence, the offense to a personality right, without material prejudice.

Objective liability, again, that in which there is an obligation to repair the damage, regardless of fault, was specified by law as to the damage to the environment, the law in question is that by Law no. 6.938 / 81, National Environmental Policy Law, which states in its article 14, § 1: “Without prejudice to the application of the penalties provided for in this article, the polluter is required to indemnify or repair the damage caused to the environment and the third party affected by your activity (...) ”.

Even if there was no such provision, the same objective liability, provided for in the assumptions that “when the activity normally performed by the perpetrator entails, by its nature, a risk to the rights of others” is also related to CCS activities regarding damage. “by its very nature”, since it entails risks to the rights of others, especially the right to an ecologically balanced environment.

3. Liability for Environmental Damage

Environmental civil liability aims to set the parameters for the verification of the damage caused and the liability of the causative agent, whether individual or legal entity, public or private law. Thus, a single action or omission can give rise to three types of autonomous wrongdoing and receive the sanctions imposed. It is the result of an anti-juridical conduct, from which causes injury to be compensated. In addition, associated with objective responsibility is the polluter 's duty to fully repair the damaged environmental good, either through restoration or through ecological compensation (MUSARRA, 2019).

Everyone has the right to an Ecologically Balanced Environment, as stated in the caption article 225 of the Federal Constitution. Are they:

Article 225 - Everyone has the right to an ecologically balanced environment, a good for the common use of the people and essential to a healthy quality of life. The Government and the community are obliged to defend and preserve it for those present and future generations.

Having the concept of environment as a shelter of naturalistic aspects and factors that condition human life and its development in relation to the ecosystem to which it belongs. Thus, in addition to the well-known concept of Natural or Physical Environment, we currently find, as a way to identify this relationship at different levels of human activity, allusion to the Cultural Environment, Work and Artificial Environment (integrated by man, form of buildings and equipment).

Still in article 225, caput, of the CF, there is the concern of the legislator with the protection of the environment in an intergenerational way, which is extracted from the excerpt "imposing to the Public Power and the collectivity the duty to defend it and preserve it for present and future generations ", drawing attention to the need for joint protection in the search for the necessary balance (COSTA, 2018).

According to Dourado (2008), civil liability under environmental law is based on article 37 § 6 of the Federal Constitution and art. 14 Paragraph 1 of Law 6,938 / 81. Thus, according to the author, the objective nature of the civil liability imputed to the cause of environmental damage becomes unquestionable. It also notes that since 1969, when the International Convention on Civil Liability for Oil Pollution Damage was promulgated, and eight years later, when Law No. 6.453 / 77 on Nuclear Damage was issued, objective liability Insurged in our legal system, as a way to punish, and educate those responsible for the generation of energy and curb practices harmful to the environment.

Fiorillo (2017) asserts that in view of the difficulties present in the system in proving the guilt of the agent in the accomplishment of the damage, the subjective responsibility gradually ceases to be the rule, because the world tendency is to effectively seek justice. This would mean seeing the damage repaired "only through the eyes of the victim." This would be, for the author, a reason for attention of environmental law, considering the importance of the protected goods.

As stated, according to article 14, §1º, of the National Environmental Policy, Law nº 6.938 / 81, the civil liability is objective, that is, the polluter is liable regardless of the existence of guilt, and obliged to indemnify or repair the damage caused to the environment and third parties that have been affected by its activity (COSTA et al., 2017).

In addition, the Public Prosecution Service has the legitimacy to bring civil and criminal liability for environmental damage and that paragraph 5 of the same article states that the execution of the polluter 's required guarantees does not prevent the application of the obligations indemnity and compensation for damages provided for in § 1 of this article.

Federal Laws No. 4,717, 1965 and No. 7,347, 1985, which deal respectively with Popular Action and Public Civil Action, are also related to civil liability, including the possibility of signing a Conduct Adjustment Agreement, in an extrajudicial way, faster, which, if not fulfilled, can be executed in court by its legitimates, as established by art. 5, § 5, of Law 7347 of 1985. The term would act as a mechanism of procedural speed, especially with regard to situations that imply environmental civil liability (MUSARRA, 2009).

According to Leite (2004), environmental damage must be understood as any intolerable injury caused by any human action (guilty or not to the environment), directly as a macrobem of interest of the

community, in a totalizing conception, and indirectly to third parties in view of individualized self-interests that reflect the macro-good. The indivisibility of environmental damage, its transboundary character and the plurality of polluters contribute to the softening of the causal link according to Colombo (2017).

Thus, the criterion of certainty is replaced by the criterion of likelihood in examining the causal link between the cause and the effect of the damage (COLOMBO, 2017). Thus, civil liability for environmental damage has the following components: I- Activity; II- Damage; III- Authorship; and IV- Causality Nexus. The activity is that conduct that promotes environmental damage by action or omission, as well as by law or illicit. The nature of the damage: a) Individual; b) Collective; c) Economic; d) Non-economic. The authorship or imputation link is the attribution to a given person for the environmental responsibility for the damages occurred, it is a link between the harmful fact and the responsible, either by the risk or the fault. The Causality Nexus is the cause and effect indicative of the damage and the consequences of the fact or even the aggravation of its effects, observing, first, the causes of the damage, and then attribute the authorship.

According to Mirra (2019), the extension of the effects of civil liability includes the reparation of the damage to the environment itself and the suppression of the fact harmful to the environmental quality, whereby the definitive cessation of the activity that causes the degradation of the environment is obtained. environment**.**

3.2. Environmental Damage Repair

For Mirra (2019), the notion of reparation applicable to environmental damage always brings with it the idea of compensation because the degradation of the environment and environmental goods never allows the return of environmental quality to the state prior to the damage, and there is always something irreversible. environmental damage, which does not mean irreparable from a legal point of view. Thus, remediation of environmental damage should lead the environment to a situation equivalent (as is practically possible) to that which would have benefited if the damage had not been caused, and further compensates for environmental degradation that may prove irreversible. Hence the impact of the principle of full compensation of damage (MIRRA, 2019).

Comprehensive remediation of damage to the environment covers damage to the environmental good or resource immediately affected, and the full extent of damage produced as a result of damage to environmental quality, including: (a) the ecological and environmental effects of the initial assault on a certain environmental good that are in the same causal chain (such as the destruction of specimens, habitats and ecosystems interrelated with the immediately affected environment; the contribution of degradation caused to global warming); b) the environmental quality losses between the occurrence of damage and the effective restoration of the degraded environment; (c) future environmental damage that appears to be certain; d) irreversible damage to environmental quality, which must be compensated in some way; e) the collective moral damages resulting from the aggression to certain environmental good (MIRRA, 2019).

In accordance with the provisions of Articles 4, VII and 14, paragraph 1, both of Law no. 6,938 / 81, as well as paragraph 3 of article 225 of the Federal Constitution, it is up to the polluter / degrader to restore and / or indemnify the environmental damage caused.

Therefore, it is intended to recover the damage (reconstitution of the injured property) and, in its factual impossibility, the indemnity in cash. Natural restoration consists of the repair of the affected natural assets in order to restore the balance of the ecosystem. The Law no. 6.368 / 81 deals with the subject in the hypotheses of recovery of environmental quality (art. 2, caput) and in the principle of the recovery of degraded areas (art. 2, VIII). In dealing with the preservation and restoration of natural resources with a view to rational use and permanent availability (art. 4, VI). And when dealing with the imposition on the polluter and the predator, the obligation to recover and / or compensate the damage caused.

Environmental compensation is the adoption of a measure of equivalent importance within the same ecosystem in which damage has occurred or will occur, given the impossibility of specific remediation of environmental damage (TOZZI, 2019). Provided, for example, in Article 36 of Law no. 9.985 / 2000, in which ventures causing significant environmental impact, thus considered by the competent environmental agency, based on environmental impact study and its report - EIA / RIMA[1], the entrepreneur is required to support the implementation and maintenance of the conservation unit of the Integral Protection Group[2], in accordance with the provisions of this article and the regulation of this Law.

Machado (2010) understands that if the environmental impact study is not carried out (or has been incompletely prepared) and / or the environmental licensing does not happen (or happens irregularly), this does not eliminate the obligation of the entrepreneur to compensate the environment. harmed". Ecological compensation may be equivalent in situ; equivalent substituting for another location and monetary compensation, whose legal grounds are found in the Biodiversity Convention by Legislative Decree no. 2 of 1994 and in Law no. 7.347 / 85 (Public Civil Action Law) Article 3, enabling the condemnation in cash or condemnation of the obligation to do or not to do.

The equivalent substitution to be made at the place of damage will be partial regarding quality when only a few functions are replaced and quantitative for the impaired functions. The equivalent substitution in another place may occur when there is technical impossibility for expertise and other evidence admitted in law and the monetary compensation will be in the hypothesis of impracticability in the use of the other forms of reparation of the environmental damage, or of complementation of the reparation.

The sanction does not reach the major objective of recovering environmental damage, being a subsidiary form of reimbursing environmental damage. When the form of reparation is pecuniary in accordance with article 13 of the Public Civil Action Law (Law No. 7347/85), these resources are reverted to a fund managed by a Council (federal or state) in which they necessarily participate and the prosecutor and community representatives (TOZZI, 2019).

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[1] Environmental Impact Study and Environmental Impact Report.

[2] Conservation units (UCs) are territorial spaces, including their environmental resources, with relevant natural characteristics, which have the function of ensuring the representation of significant and ecologically viable samples of the different populations, habitats and ecosystems of the national territory and of the jurisdictional waters, preserving the existing biological heritage. Full Protection Units: the protection of nature is the main objective of these units, so the rules and regulations are more restrictive. In this group only the indirect use of natural resources is allowed; that is, one that does not involve consumption, collection or damage to natural resources. Examples of indirect use of natural resources activities are: recreation in contact with nature, ecological tourism, scientific research, environmental education and interpretation, among others. The strict protection categories are: Ecological Station, Biological Reserve, park, natural monument and wildlife refuge (MMA, 2019).

The criticism made for the Brazilian diffuse rights defense fund is that the sums received will not necessarily be applied to the area specifically affected in the specific case, which, for reasons of convenience and opportunity, may be used for the restoration of any other injured property (TOZZI, 2019).

According to Pereira (2019), the damage can reach microbens, which will be the individual damage that harms homogeneous individual interests and / or macrobens, which are collective in a broad sense. The latter are divided into: 1) Diffuse: when it reaches an undetermined number of people connected about the same fact; 2) Collective "in the strict sense": when it hurts interests belonging to a group of determinable persons, linked by the same legal relationship; 3) Homogeneous individual: These are environmental damages of common origin, which may or may not be cumulative, with several elements together (reaching, for example, fauna and flora and generating homogeneous individual damage.

For CCS activities, according to Romeiro-Conturbia (2014), understandably, the concern that most prominently appears in the minds of policy makers and the general public relates to the risk of CO2 escaping storage formation for the environment. surrounding (either the atmosphere or the water column) with the associated potential to undermine the very purpose of climate change mitigation. However, it is emphasized, as stated in an introductory way, that offshore geological storage has, as well as the leakage of carbon dioxide and other substances related to the separation, transport and injection process, the collapse of the storage structure and its consequences. depending on the geological structure to be used, its peculiarities, such as groundwater contamination, must be considered and, in the Prá-sal region, specifically, the effects of salt concentration must be considered. (NACL) in the marine environment due to gas drilling / injection (COSTA et al., 2018).

4. Relevant Aspects of Civil Liability in Carbon Storage Activities

According to Romeiro-Conturbia (2014), long-term liability for carbon capture and storage corresponds to the legal responsibility to compensate or repair any significant damage resulting from CO2 injection already ceased in a geological formation. The allocation of long-term liability requirements is a key issue for CCS's widespread deployment, as operators would be more likely to invest in technology in countries that have established clear rules on the extent of their liability (STRACO2, 2009). And, above all, for having implications on the cost of implementing the enterprise itself.

Among the various types of CCS, application to large point sources of emissions is considered the most promising for climate change mitigation purposes (ROMEIRO-CONTURBIA, 2014). The technological processes involved aim to ensure that CO2 resulting from power generation and other industrial activities, rather than being vented to the atmosphere, is stored underground within suitable geological formations for thousands of years.

As already said, the CCS chain can be broadly divided into three operations: CO2 capture, transport to storage, and underground sequestration. The storage phase is composed of three stages, namely CO2 injection, site closure and post closure. In the capture phase, substances from the gaseous mixture emitted by point sources are separated to obtain an almost pure flow of CO2, which is then transported to the storage location, which may be located on land or sea, by pipeline or ship (ROMEIRO-CONTURBIA, 2014).

As explained by Romeiro-Conturbia (2014), practical experience gained in the context of various industries that deal similarly with subsurface geology contributes to the expertise of CCS activities such as hydrocarbon exploration and production, mining, underground waste disposal. as well as underground storage of natural resources. However, according to the author, there is still limited commercial-scale operational experience of the CCS chain, which inevitably leads to a degree of uncertainty about its environmental integrity, and there are several potential risks associated with CCS locally. environment, health and human property and the global climate.

In the international context, the operational liability issues of CCS activities may be related to the capture, transport, injection or storage processes. Thus, Romeiro-Conturbia (2014) states that in order to define short, medium and long term liabilities, ie the legal liability to compensate or repair any damages during a CCS project, three phases are defined: (i) phase operating with CO2 injection and monitoring to track migration and behavior; (ii) structure closure phase and removal of removed infrastructure; and (iii) post closure with the demonstration that CO2 has been properly stored. For each phase, a responsible entity is allocated. According to the author, for the operation and closure phases, the storage operator is typically the entity responsible for correcting infiltration events.

Romeiro-Conturbia (2014) reports that many countries have been working to create and improve their own CCS legal and regulatory framework. Australia, for example, was the first country to establish a CCS legal and regulatory framework in 2006, and the European Union established a Directive in 2009 with post-closure cost financing mechanisms. Table 1 contains the implications for long-term post-closure responsibilities.

Table 1 - CCS legal and regulatory frameworks: implications for long-term liabilities

Country	**CCS legal and regulatory framework**	**Adoption**	**Minimum period for transfer of long-term liability**
Australia	Offshore Petroleum and GHG Storage Act	2006	At least 15 years after the issue of the site closing certificate.
United Kingdom	Energy Act 2008 and EU CCS Directive	2008	No shorter than 20 years
European Union	EU CCS Directive	2009	No shorter than 20 years
Norway	EU CCS Directive	2009	No shorter than 20 years
Canada, Alberta	CCS Statutes Amendments	2010	No shorter than 10 years

	Act		
United States	EPA UIC Class VI Regulation	2010	50 years following the cessation of injection
United Nations*	CDM Modalities and Procedures for CCS	2011	No shorter than 20 years or after ending the issuance of CERs

Source: Romeiro-Conturbia 2014,

Considering this regulatory scenario, item 5.1 describes the international experience, punctuating concepts and highlighting the normative evolution in selected countries. This exercise aims, mainly, to verify which lessons can be incorporated in Brazil, given the existing principles and the reality of the country.

4.1. The international experience

The Institute of Environmental Liability in other countries is based on Principle 13 of the Rio de Janeiro Declaration (1992), which states that "the State shall establish its national legislation regarding the liability and compensation of victims of pollution and other forms of aggression to the environment ". Each signatory state should therefore develop a system for the prevention and repair of environmental damage caused by activity within its jurisdiction, in order to prevent damage to the environment of other states (COLOMBO, 2017).

Machado (2010) reports that in France there is the understanding that the continuous transformations of the technique of the law of responsibility have the sole objective of greater assurance of the bodily safety of men living in society and that, thus, the notion of guilt was submerged from responsibility before industrial and mechanical accidents of the contemporary world. According to him, in Spain the constitution itself establishes the obligation to repair the damage caused. In Sweden, objective liability was introduced in the 1969 "Environmental Protection Act" (§ 30) when the nuisance is substantial and unreasonable to tolerate under the circumstances (MACHADO, 2010). In addition, in Germany special legislation provided for objective liability for water pollution and for the construction and operation of nuclear installations.

However, Romeiro-Conturbia (2014) points out that due to the uniqueness associated with the implementation of permanent CO2 storage, some aspects such as post-closure and long-term liability may require the creation of new structures for the liability institute.

According to Romeiro-Conturbia (2014), in many jurisdictions there is a transfer of responsibility from operators to the host country (a relevant authority) as it is shown that CO2 behaves as expected and must be effectively stored in a long-term stabilization. projection period (WARREN, 2011 apud ROMEIRO-CONTURBIA, 2014).

The Government of Australia established in 2008 an offshore regulation for CO2 storage based on existing petroleum legislation, through an amendment of the Offshore Petroleum Act 2006, now renamed

the Offshore Petroleum and GHG Storage Act, providing that the transfer of responsibility The long-term operator to Government will be made at the end of the post-closure period of storage.[3]

In Canada, in the face of solid regulatory experience of similar oil and gas activities in Alberta, including acid gas injection and use of carbon dioxide for advanced oil recovery and high pressure pipelines, the Provincial Government provides comprehensive legislative amendments to reduce CCS barriers and policy decisions to take long-term responsibility for stored CO2 (ROMEIRO-CONTURBIA, 2014). Depending on the regulation of the issue in Canada, the definition of liability may be attributed to "actions or omissions in relation to CO2 injection" (Alberta CCS Bylaws Amendments Act, 2010).

Ownership of stored CO2 is conferred on the government by issuing a certificate of injection closure issued by a Ministry. With this, the Government of Alberta assumes all responsibilities resulting from activities previously agreed with the CCS operator. Although the Alberta CCS Bylaws Amendments Act (2010) does not specify the minimum closing period (ROMEIRO-CONTURBIA, 2014).

The Alberta CCS Regulatory Framework Assessment (Alberta Energy, 2013) recommends long-term liability, including that a minimum closing period is required before accepting responsibility for the operator's website. The Government of Alberta should only grant a foreclosure certificate after a period of not less than 10 years after the start of the foreclosure period and when the lessee has demonstrated continued compliance with the required performance criteria for foreclosure (ROMEIRO-CONTURBIA, 2014).

Romeiro-Conturbia (2014) goes on to explain that this period is shorter compared to other countries and jurisdictions, but if there are any remaining issues regarding site performance and monitoring, a longer period may be imposed to demonstrate sufficient compliance if case (Alberta Energy, 2013). In addition, prior to issuing the closure certificate, the operator is required to contribute to a post-closure management fund to cover the responsibilities assumed by the government, as well as reservoir monitoring and management costs.

According to the Alberta CCS Bylaws Amendments Act (2010), the post-closure management fund is intended to cover the costs of monitoring stored CO2 related to the corresponding agreement between the operator and the Government of Alberta. It also has the purpose of satisfying the remaining responsibilities assumed by the government (ROMEIRO-CONTURBIA, 2014).

In Germany, Romeiro-Conturbia (2014) reports that the government attempted to pass CCS legislation in 2011 in which the operator would need to contribute post-closure costs to cover probable site monitoring costs for another 30 years after the transfer of the site. responsibility (apud Global CCS Institute, 2012). However, according to Romeiro-Conturbia (2014) Germany did not enact such a milestone in 2011, and

[3] In accordance with the Law, the Relevant Authority may declare the closing guarantee period for a CO2 sequestration project if: (a) the site closure certificate is in effect for an identified GHG storage formation; (c) on the day of the decision, which is at least 15 years after the site closure certificate is issued, the responsible Commonwealth Minister is convinced that: (i) the GHG injected into the training is behaving as provided for in Part A the approved local training plan; and (ii) there is no significant risk that a greenhouse gas substance injected into the formation will have a significant adverse impact on the geotechnical integrity of all or part of a geological formation or geological structure (...) (Australia, 2006). . In addition, section 391 of the Act requires a pre-certificate notice related to a site closure certificate to calculate the total costs and expenses of the long-term monitoring program and the value of the guarantee to be equal to these estimated costs (ROMEIRO-CONTURBIA, 2016).

only in 2012 was an agreement reached, with different conditions set and forcing CCS operators to retain responsibility for up to 40 years instead of the proposal and 30 years after the closing period.

According to POP (2018), the European Union (EU) did not seek to intrude on the choice of national legislation more than necessary to provide a general framework for CCS regulation, particularly as regards the liability regime. The challenge is to develop a set of reforms that carefully balances the achievement of three objectives: ensuring political acceptability, ensuring environmental sustainability and integrity of CCS projects (avoiding moral hazard) and encouraging rapid and commercial deployment.

The European Union CCS Directive provides for a division of responsibilities between the operator and the competent national authority[4]. According to POP (2010), the Directive's deadlines are extremely long and are foreseen for the management of CO2 storage sites with the idea that storage is intended to be permanent. The deadlines involved exceed the usual lifetime of the private entities managing the CCS storage sites (Article 18 (1)), whereby most of the responsibilities result from storage, so the location should be transferred to a competent authority after a sufficient period of time, indicating post-closure stability (POP 2018).

The site can be closed when the CO2 injection is permanently interrupted, with the operator being responsible for sealing the site and removing the injection facilities. In accordance with Article 17 of the Directive, the operator retains the responsibility to monitor, report and provide corrective action after closure.

The EU Directive also addresses the transfer of operator responsibility to the competent authority by proving that CO2 storage has been permanently contained and provided that a minimum period is determined by the competent authority.

In accordance with Article 18 of the Directive: This minimum period should not be less than 20 years unless the competent authority is satisfied that the criteria for evidence indicating that stored CO2 will be completely and permanently contained is met. before the end of this period (European Union, 2009). In addition, as a post-transfer obligation, the operator must provide a financial contribution to the competent authority before formalizing the transfer of responsibility as a way to cover projected monitoring costs for a period of 30 years.

The set of rules contained in the Environmental Liability Directive may perhaps be characterized as the only type of liability that is insufficiently stringent from the point of view of environmental protection, as in theory the defense of “authorization” and the defense of "State of the art". In theory, operators may use these defenses in cases of leakage where there is no fault or negligence on their part and where they were fully complying with the terms of their storage permit or the activity that caused the leak was not considered likely to be harmful in time. However, as some Member States may have chosen not to implement such defenses, they may not apply (POP 2018). This is the case of countries that opt for the theory of full responsibility, which is objective and does not discuss culpability.

[4] According to (POP, 2018), the leakage of CO2 from the storage site may have legal consequences such as administrative liability arising from the provisions of the Directive itself (transposed into national law); liability for environmental damage; the obligation to purchase allowances; liability under tort and other laws at national level.

4.2. Prevention and control of environmental damage

If the risk of leakage materializes, its consequences depend on the storage location and the way incidents are managed. In theory, leakage from onshore storage sites is likely to affect a much larger number of people than offshore areas, especially if they are located in valleys (ROMEIRO-CONTURBIA, 2014).

The effects of high levels of CO2 on human health and local fauna are well understood, depending on concentration, the effects range from rapid breathing, headache and tiredness to the most serious dangers of brain malfunction, loss of consciousness. and death by asphyxia (ROMEIRO-CONTURBIA, 2014). Lethal incidents involving the natural release of CO2 are often invoked to illustrate the dangers of potential leakage from storage sites, notably the 1986 Lake Nyos incident in Cameroon with 1700 human deaths (ROMEIRO-CONTURBIA, 2014).

However, there are theses portrayed by Romeiro-Conturbia (2014) who maintain that if a CO2 release occurs from a CCS site, it is more likely to take the form of gradual infiltration rather than sudden and rapid leakage, meaning that the amount of CO2 escaped would be at least initially much smaller. In addition to the unpredictable nature of such events, CO2 storage sites are subject to close monitoring by those who have a legal duty to remediate the leak immediately, so there would be an opportunity to restrict public access to the site in question. until it dissipated.

The main feared consequence of CO2 leakage from offshore storage sites is related to ocean acidification and its adverse effects on marine ecosystems and the livelihoods of populations that depend on them. Possible harmful consequences include: change in salinity index, disturbance in planktonic, benthic and ichthyofauna community due to sea leakage, disruption of ecosystems, change in ocean water quality from effluent disposal, change in air quality, contribution to greenhouse effect, accidental release of chemicals at sea (GOSAC, 2004).

There is also concern regarding water contamination, leading to adverse effects on the health of marine ecosystems. Regarding the impact on the global climate, the danger is that an extensive leak would render the climate change mitigation claim of CCS activities useless (ROMEIRO-CONTURBIA, 2014).

In case of storage in saline structures, as in the case of pre-salt, the concern with the elimination of brine should be mentioned. There are some salinity water quality guidelines for the protection of aquatic life in this regard in the jurisdictions of Canada (CCME, 1996). In US guidelines human activities should not cause salinity to fluctuate by more than 10% of the expected natural level and depth (EPA). In Australia, the rules require salinity to be within 1.2 ppt (parts per tonne) of usual environmental levels within 50 m of the discharge point and within 0.8 ppt of depth levels within 1000 m of the point. of salt discharge.

There is also concern about the temperature of the fluids during injection. For example, the Canadian Water Quality Guidelines (CWQG) for the protection of marine life limit the maximum temperature range to 1% of the ambient water temperature for any human activity (CCME, 2008).

Moreover, while CCS is only one of the greenhouse gas reduction strategies, several authors emphasize that it is the only option that can help achieve the required scale of emission reductions within the relevant timeframe (ROMEIRO-CONTURBIA, 2014).

But, according to Nardelli e Griffith (2003) environmental transformation is not simply structural, it also involves a change of values, which will guide future strategies. For them, the concept of "sustainability" seeks an alternative vision of the future to effectively respond to the environmental crisis.

4.3. Safety in Carbon Storage Activity and Social Risk Management

The consolidated environmental jurisprudence of the Brazilian Superior Court of Justice already guides some theses about environmental law, those that point to the social management of risks include the non-existence of acquired right to pollution or degradation of the environment, solidarity co-obligation in relation to degradation. environmental, the obligation to recover for the owner of the property even if it has not contributed to the damage outbreak and the already discussed objective liability for full risk.[5]

For CCS activities it should be borne in mind that there will be no exhaustion of the duty of non-degradation even in the event of compensation. As for the obligation to recover for the property owner, it must be considered that the geological storage may occur in cases where the property owner is the State, and, by its nature, proposes the damage (ie accompanying the thing) , may appear in the liability pole in liability actions, jointly or severally with the operator of the activities.

Another institute that deserves to be mentioned is the environmental insurance, the theme is provided for in Laws 6,938 / 81, 11,284 / 2006 and 12,305 / 2010. Thus, coverage for environmental risks aimed at the full remediation of environmental damage, provided for in the Brazilian legal system, may, according to (COSTA, 2011) exceed the economic and financial capacity of the person responsible, which does not relieve him / her from doing so. assumed the risk of its activity / undertaking and the resulting encumbrances, becoming, according to the author, relevant the adoption of financial guarantees that help and complement this repair, as insurance.

According to (COSTA, 2011), in 1991, the Brazilian model of the Environmental Pollution policy was elaborated, which was changed in 1997, remaining until the present day, which, however, was not successful, the author notes that, although it is Standardized, including as an economic instrument of PNMA, environmental insurance needs regulation, which is the primary condition to enable its adoption as a guarantee of resources to repair damage caused by activities / enterprises potentially degrading the environment. This results in the lack of technical and legal definitions, which implies a broad and deep debate between the Government, the insurance market and other representatives of civil society interested in the issue (academy, environmentalists) and makes the implementation of environmental insurance unfeasible.

Thus, it is necessary to regulate based on the best technical-legal solution for the elaboration of a coverage modality that can meet both the normative requirements (prevention / precautionary duty and reparation of environmental damage) as well as the insurance market reality (COSTA, 2011).[6]

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[5] Theses STJ in environmental scope: Thesis 3: There is no acquired right to pollute or degrade the environment, and there is no permission to the owner or squatter to continue practices prohibited by the legislature. Thesis 7: Those responsible for environmental degradation are jointly and severally liable, forming, as a rule, in public or collective civil actions. Thesis 9: The obligation to recover environmental degradation rests with the property owner, even if it has not contributed to the outbreak of the damage, given its propter rem nature. Thesis 10: Responsibility for environmental damage is objective, informed by the theory of integral risk, with causation being the binding factor that allows the risk to be integrated into the unit of the act, and the invocation by the company responsible for environmental damage is inappropriate. of liability excluders to depart from their obligation to indemnify.

[6] Insurance to cover environmental risks is already included in PNMA, Law no. 11,284 / 2006 and Law no. 12.305 / 2010, in this case, in the civil liability group, and the matter still needs regulation and not other rules that establish practically the same

For CCS could be provided financial guarantees permitted by law to cover environmental risks on a mandatory basis, including the contraction of insurance. That could be required of the entrepreneur when licensing (bidding in some cases, such as in the forest concession) of his activity / enterprise, to cover any damage caused to the environment, the purse and third parties, understanding set out in articles 20 and 21 of Law no. 11,284 / 2006 (COSTA, 2011). The insurance market, as a rule, requires a supplementary questionnaire to the insurance proposal and risk inspection, which provide information on compliance with environmental and related standards and companies' initiatives regarding their prevention, thus contributing to the management of the risks.

In addition, the internationalization of environmental quality standards, especially in relation to specific CCS standards, such as those cataloged by the International Energy Agency (IEA)[7], can contribute to safety and thus to risk management and its consequent liability in all spheres, including civil.

Regarding activities with potential implementation in the Pre-salt region, it is necessary to take into account already established environmental standards for the oil and gas industry that may be related to the injection and storage of carbon dioxide, namely, as provided by Law 9,966 / 00 for the prevention, control and supervision of pollution on offshore platforms, requiring Emergency Plan and independent biennial audits by operators (in the case of the CCS of those who build and / or make use of facilities), and the provisions of Normative Instruction IN 01/2018, ie the Fluid and Gravel Monitoring Project.

As for eventual leaks, the current regulation in terms of analogy can be considered, as regards the storage of natural gas (CH4, methane), which already has rules in force in Brazil from the production and exploration of Oil and Natural Gas, as ANP Resolution No. 52/2015, as well as its transportation, through ANP Resolution No. 6/2011, and the incident reporting procedure, ANP[8] Resolution No. 44/2009, all of which are superseded by the Gas Law (Law 11909/2009).

5. Conclusion

Among the CCS activities, the greatest concern in terms of environmental risks is the safety of CO2 storage in a geological reservoir, which must be stable in its structure and consider geological containment parameters predetermined by experts. In addition to being environmentally acceptable, this storage does not harm the environment or society by ensuring that no fluid leaks into the atmosphere and therefore has the least possible impact. It should also be noted, as pointed out by Ravagnani and Suslick (2008), that CO2 storage is necessarily less harmful to the environment than the continuous emission of uncaptured gas and must be subject to all national and international laws and regulations. international as the social comes to predominate over the individual, increasing the sense of collectivization and the affirmation of the dignity of the human person and their security and social justice.

object, requiring regulation themselves (COSTA, 2011). There is Bill 10494/2018 that aims at the requirement of environmental insurance when the preparation of EIA / Rhyme is necessary, however, still in process.

[7] Following the example of IEA Greenhouse R&D Programme (IEA GHG) "Remediation of Leakage from CO2 Storage Reservoirs, 007/2011, September 2007", Orchard Business Centre. Stoke Orchard, CCheltenham Glos. GL52 7RZ. UK, 2007.

[8] ANP - National Agency of Petroleum, Natural Gas and Biofuels.

Since, as a result, civil liability is the one that aims to repair the damage, whether property or off-balance sheet, and the Federal Constitution of 1988 welcomed article 14, § 1 of Law No. 6.938 / 81, which already dealt with objective liability by damage to the environment, where the conduct of the agent causing the damage has nothing to do with its legality and is obliged to repair it.

Even with regard to long-term rules, which, as seen at international level, follow at least reasonable deadlines for the transfer of responsibilities and certificates with studies proving their stability, the claim of non-compliance could not be accepted in the current Brazilian legal system. responsibility. Moreover, even if some countries, such as those mentioned in the European Union, which adopt the theory of objective liability and may serve as a comparison, there has not yet been sufficient time for administrative and judicial discussion to conclude how any post-transfer liability demands of traders would be resolved.

This corroborates Romeiro-Conturbia's (2014) observation about long-term liability rules for a CO2 that says the storage site and any associated responsibilities (including measures to remedy damage) is one of the most challenging issues when designing a CCS legal and regulatory framework therefore, such as carbon capture and storage are relatively recent mitigation technologies.

There are currently no real cases of real conflicts with long-term liability, and therefore policy makers and scientists are challenged to anticipate questions about the extent of the possible damages and the type of liability that the parties will have to include and fulfill. Lack of definition of long-term liabilities and associated implications can increase the risks and costs for a CCS project.

But again, it is the environmental liability in Brazilian law that results from its own autonomous system in the context of liability, with special rules that apply to the matter, to the detriment of the general rules of the Civil Code that are not compatible with them and that is subject to a specific legal regime, established from the Federal Constitution and the National Environmental Policy Law, which does not include any mitigation rule for the full compensation of damage, being derogatory from the general regime of the Civil Code (MIRRA, 2019).

Thus, at the present stage of Brazilian Environmental Law, no limitation to the full reparability of environmental damage is accepted, as the right to the environment is unavailable, which means that no legislative provision, litigation agreement or court decision that has as its purpose or the effect of limiting the extent of compensation for environmental damage may be considered legitimate (MIRRA, 2019).

This means that the instruments analyzed here, such as environmental compensation and, eventually, the provision of financial guarantees and environmental quality standards, must be perfectly aligned with the interest in maintaining a balanced ecosystem. Therefore, it is possible to create legal instruments in Brazilian law that provide a balance between objective environmental liability and common time constraints in international law, through the establishment of funds, insurance or other forms of securitization. In addition, the reflections of CCS activities on property rights must be clear enough that social risk management can be raised for accountability in the event of a long-term transfer of rights and obligations.

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7. References

[1] ANP, Agência Nacional de Petróleo, Gás Natural e Biocombustíveis. Resolução ANP nº 46 de 01 de novembro de 2016. Aprova o Regime de Segurança Operacional para Integridade de Poços de Petróleo e Gás Natural. Disponível em: <http://nxt.anp.gov.br/NXT/gateway.dll/leg/resolucoes_anp/2016/novembro/ranp%2046%20-%202016.xml?f=templates&fn=document-frameset.htm>. Acesso em 10 dez. de 2017.

[2]_____. Glossário do Anuário Estatístico Brasileiro do Petróleo, Gás Natural e Biocombustíveis. Rio de janeiro: ANP, 1997. Disponível em: <www.anp.gov.br/wwwanp/?dw=82255>. Acesso em 10 dez. 2017.

[3]_____. Resolução ANP nº 27 de 18 de outubro de 2006. Aprova o Regulamento Técnico de Desativação de Instalações e especifica condições para devolução de áreas de concessão na fase de produção. Disponível em: <http://nxt.anp.gov.br/NXT/gateway.dll/leg/resolucoes_anp/2006/outubro/ranp%2027%20-%202006.xml?f=templates$fn=document-frame.htm$3.0$q=$x=$nc=7537>. Acesso em 10 dez. de 2017.

[4] BENSON, S.M. Lessons Learned from Natural and Industrial Analogues: Carbon Dioxide Capture for Storage in Deep Geologic Formations—Results from the CO2 Capture Project, Vol. 2. London: Elsevier Publishing, 2005. p. 1133-1141.

[5] BEZERRA, Fabiano César Petrovich; Cabral, Indhira; Evaristo, Michelle. Tipos de Sanções – Efetividade das Sanções Patrimoniais e Administrativas ao Dano Ambiental – Concomitância de Punições Aplicação à Indústria de Petróleo e Gás. In: Direito Ambiental aplicado à indústria do Petróleo e Gás Natural, Nobre Júnior, Edilson et al, Fundação Konrad Adenauer, 2005.

[6] BRASIL. Constituição Federal da República do Brasil, 1988. Available in:: http://www.planalto.gov.br/ccivil_03/constituicao/ConstituicaoCompilado.htm. Access in: 12 sep. 2018.

[7] BRASIL. Lei da Política Nacional do Meio Ambiente de 1981. Available in:: http://www.planalto.gov.br/ccivil_03/Leis/L6938.htm, 1981. Access in: 12 sep. 2018.

[8] BRASIL. Lei de Introdução às normas do Direito Brasileiro, 2012. Available in:: http://www.planalto.gov.br/ccivil_03/Decreto-Lei/Del4657compilado.htm. Access in: aug. 2018.

[9] BRASIL. Lei Federal n. º 10.406, de 10 de janeiro de 2002. Institui o Código Civil. Brasília: Casa Civil, 2002. Disponível em: <http://www.planalto.gov.br/ccivil_03/leis/2002/L10406.htm>.

[10] BUI, Mai et al, 2018. Carbon capture and storage (CCS): the way forward. In. Energy Environ. Sci., 2018, 11, 1062.

[11] CAVALIERI FILHO, Sergio. Programa de Responsabilidade Civil. 8. ed. rev. e ampl. São Paulo: Atlas, 2008.

[12] CCME, Canadian Water Quality Guidelines for the Protection of Aquatic Life SALINITY (Marine) https://www.ccme.ca/files/ceqg/en/backup/209.pdf.

[13] COELHO, F. U.. Curso de Direito Civil: Obrigações e Responsabilidade Civil. 5ª edição, São Paulo: Saraiva, 2012.

[14] COLOMBO, S.. O princípio da precaução no Direito ambiental. REMEA - Revista Eletrônica do Mestrado em Educação Ambiental, [S.l.], v. 14, set. 2012. ISSN 1517-1256. Disponível em: <https://www.seer.furg.br/remea/article/view/2889>. Acesso em: 10 dez. 2017.

[15] COSTA, Hirdan Katarina de Medeiros; SANTOS, M. M. ; MATAI, P. H. L. S. . Questões ambientais e Licenciamento ambiental - Cap. 17. In: José R. Simões Moreira. (Org.). Energias Renováveis, Geração Distribuída e Eficiência Energética.. 1ed.Rio de Janeiro: LTC editorial - Grupo GEN, 2017, v. 1, p. 354-367.

[16] COSTA, Hirdan Katarina de Medeiros. Princípio da Justiça Intra e Intergeracional e o Art. 225 da Constituição Federal de 1988. In: Hirdan Katarina de Medeiros Costa; Mariana Fernandes Miranda. (Org.). Temas de Direito Ambiental: 30 anos da Constituição. 1ed.Rio de Janeiro: Lumen Juris, 2018, v. 1, p. 151-172.

[17] COSTA, Hirdan K. de M.; MIRANDA, Mariana F.; MUSARRA, Raíssa M. L. M. M.; SANTOS, Edmilson M. dos. Environmental License for Carbon Capture and Storage (CCS) Projects in Brazil. Macrothink Institute, Journal of Public Administration and Governance ISSN 2161-7104 2018b, Vol. 8, No. 3.

[18] COSTA, Hirdan K. de M.; MUSARRA, Raíssa M. L. M. Salt Cave and Experimental Activity of CCS (Carbon Capture and Storage) in Brazil (mimeo), 2018.

[19] COSTA, Hirdan K. de M.; MUSARRA, Raíssa M. L. M; MIRANDA, Mariana F. The main environmental licensing requirements on CCS activities in Brazil. Sustainability & Development Conference, SDC 2018 Annual Meeting, University of Michigan, EUA, 2018c.

[20] COSTA, Sildaléia Silva. Seguro Ambiental: garantia de recursos para reparação de danos causados ao meio ambiente. Orientador: Prof. Dr. José Aroudo Mota Tese de Doutorado Brasília-DF, UNIVERSIDADE DE BRASÍLIA CENTRO DE DESENVOLVIMENTO SUSTENTÁVEL outubro/2011.

[21] COTTA, Michele Karina et al. Análise econômica do consórcio seringueira-cacau para geração de certificados de emissões reduzidas. Rev. Árvore [online]. 2006, vol.30, n.6 [cited 2019-10-08],pp.969-979. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-76220060006000012&lng=en&nrm=iso>. ISSN 0100-6762. http://dx.doi.org/10.1590/S0100-67622006000600012.

[22] COUTO E SILVA, C.. Principes fundamentaux de la responsabilité civile en droit brésilien et comparé, p. 9. s.d.

[23] DINIZ, M. H.. Curso de Direito Civil Brasileiro: Responsabilidade Civil. Volume 7. 26ª edição. São Paulo: Editora Saraiva, 2012.

[24] DOURADO, Maria de Fátima Abreu Marques. Responsabilidade civil ambiental. Disponível em:https://jus.com.br/artigos/7689/responsabilidade-civil-ambiental.

[25] DOWER, N. G. B.. Curso Moderno de Direito Civil. 3ª edição. Editora Nelpa; São Paulo, 2007.

[26] EPA, United States Environmental Protection Agency. Carbon Dioxide Capture and Sequestration. Washington: EPA, 2016. Disponível em: <https://www.epa.gov>. Acesso em 03 dez. de 2017.

[27] FIORILLO, C. A. P.. Curso de Direito Ambiental. 17ª edição. São Paulo: Editora Saraiva, 2017.

[28] GAGLIANO, P. S.; PAMPLONA FILHO, R. Novo Curso de Direito Civil: Responsabilidade Civil – Volume III. 8ª edição. São Paulo: Saraiva, 2010.

[29] GOSAC, Relatório PH4 / 37, Agência Internacional de Energia, Programa de Pesquisa e Desenvolvimento de Gases de Efeito Estufa, Cheltenham, Reino Unido, 2004; 96 pp.

[30] IEA, International Energy Agency. Carbon Capture and Storage. Available at: https://www.iea.org/topics/carbon-capture-and-storage/. Accessed on: 07 Sep. 2018.

[31] IPCC, 2018. Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Summary for Policymakers.

[32] INTERNATIONAL ENERGY AGENCY, IEA. Agência Internacional De Energia. Captura e Estocagem de Carbono. Available in: https://www.iea.org/topics/carbon-capture-and-storage/. Acesso em: 07 set. 2018.

[33] KETZER, J. M. Medina et al. Atlas brasileiro de captura e armazenamento geológico de CO2 = Brazilian atlas of CO2 capture and geological storage – Porto Alegre: EDIPUCRS, 2016.

[34] LEITE, Jose Rubens Moratto. Aspectos Processuais do Direito Ambiental. Rio de Janeiro: forense Universitária, 2004.

[35] MACHADO, Paulo Affonso Leme. Direito ambiental brasileiro. 18º ed. São Paulo: Malheiros Editores, 2010.

[36] MAIA, Álvaro. Central Co2 Disposal Station of Santos Basin, mimeo. Set. 2018.

[37] MILARÉ, Edis. Direito do Ambiente: a gestão ambiental em foco: doutrina, jurisprudência, glossário. 6. ed. São Paulo: Ed. Revista dos Tribunais, 2009.

[38] MIRANDA, P. de. Direito das obrigações: direito de obrigações, fatos ilícitos absolutos. Atualizado por Rui Stoco – São Paulo: Editora Revista dos Tribunais, 2012. p. 93.

[39] MIRRA, Álvaro Luiz Valery. Responsabilidade civil ambiental e a reparação integral do dano, Conjur, 2016. Disponível em: https://www.conjur.com.br/2016-out-29/ambiente-juridico-responsabilidade-civil-ambiental-reparacao-integral-dano.

[40] MMA, Ministério do Meio Ambiente. Efeito estufa e aquecimento global. Available in: http://www.mma.gov.br/clima/energia/item/195-efeito-estufa-e-quequecimento-global. Access in jun de 2019.

[41] MONTEIRO, W. B. Curso de Direito Civil: Direito das Obrigações. 37ª edição. São Paulo: Saraiva, 2010. p. 603.

[42] MORAIS, R. F. V.; REIS, D. F.; PEDROZA, D. C. Auditoria de Conformidade Legal: Compliance Ambiental na prática. 1. ed. RIO DE JANEIRO: LUMEN JURIS, 2018. v. 300. 252p.

[43] MUSARRA, Raíssa Moreira Lima Mendes. Termo de Ajustamento de Conduta e Ação Civil Pública. Trabalho de Conclusão de Curso, Especialização em Direito Público, Universidade Gama Filho, Rio de Janeiro, 2009.

[44] NARDELLI, Aurea Maria Brandi e GRIFFITH, James Jackson. Mapeamento conceitual da visão de sustentabilidade de diferentes atores do setor florestal brasileiro. Rev. Árvore [online]. 2003, vol.27, n.2 [citado 2019-10-08], pp.241-256. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-67622003000200013&lng=pt&nrm=iso>. ISSN 0100-6762. http://dx.doi.org/10.1590/S0100-67622003000200013.

[45] NISHI, Marcos Hiroshi et al. Influência dos créditos de carbono na viabilidade financeira de três projetos florestais. Rev. Árvore [online]. 2005, vol.29, n.2 [citado 2019-10-08], pp.263-270. Disponível em:<http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-67622005000200009&lng=pt&nrmiso>. ISSN 0100-6762. http://dx.doi.org/10.1590/S0100-67622005000200009.

[46] NOVAES FILHO, João Paulo et al. Distribuição espacial de carbono em solo sob floresta primária na Amazônia meridional. Rev. Árvore [online]. 2007, vol.31, n.1 [cited 2019-10-08], pp.83-92. Available from:<http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-67622007000100010&lng=en&nrm=iso>. ISSN 0100-6762. http://dx.doi.org/10.1590/S0100-67622007000100010.

[47] PEREIRA, C. M. S.. Instituições de Direito Civil: Volume III – Contratos. 15ª edição. Rio de Janeiro: Forense, 2011. p. 529.

[48] PEREIRA, C. M. S.. Instituições de Direito Civil: Volume III – Contratos. 15ª edição. Rio de Janeiro: Forense, 2011.

[49] POP, Anda. The EU Legal Liability Framework for Carbon Capture and Storage: Managing the Risk of Leakage While Encouraging Investment, 2018. Disponível em https://www.abdn.ac.uk/law/documents/ASLR_Vol6_Dec15_32-56_Pop.pdf

[50] REZENDE, D. Sequestro de carbono: uma experiência concreta. 2ª edição. Palmas: Instituto Ecológico, 2002.

[51] RIZZARDO, A. Responsabilidade Civil. 3ª Edição. Rio de Janeiro: Forense, 2007.

[52] ROMEIRO-CONTURBIA, V. R. D. S. Carbon Capture and Storage Legal and Regulatory Framework in Developing Countries: Proposals for Brazil. (2014) PhD Dissertation, Institute of Energy and Environment, University of São Paulo.

[53]SENADO FEDERAL. Entenda o PreSal. Disponível em https://www12.senado.leg.br/noticias/entenda-o-re/pre-sal. Acesso em junho de 2019.

[54] SETTE, Marli Teresinha Deon, Manual de Direito Ambiental. Curitiba: Juruá, 2013.

[55] SILVA, Rodrigo Firmino da et al. Projeção do estoque de carbono e análise da geração de créditos em povoamentos de eucalipto. Rev. Árvore [online]. 2008, vol.32, n.6 [cited 2019-10-08], pp.979-992. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-67622008000600003&lng=en&nrm=iso>. ISSN 0100-6762. http://dx.doi.org/10.1590/S0100-67622008000600003.

[56] SOARES, Carlos Pedro Boechat and OLIVEIRA, Marcio Leles Romarco de. Equações para estimar a quantidade de carbono na parte aérea de árvores de eucalipto em Viçosa, Minas Gerais. Rev. Árvore [online]. 2002, vol.26, n.5 [cited 2019-10-08], pp.533-539. Available from:<http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-67622002000500002&lng=en&nrm=iso>. ISSN 0100-6762. http://dx.doi.org/10.1590/S0100-67622002000500002.

[57] TOZZI, Rodrigo Henrique Branquinho Barboza. As Teorias do Risco na Responsabilidade Civil Ambiental. Disponível em http://www.lex.com.br/doutrina_24857023_AS_TEORIAS_DO_RISCO_NA_RESPONSABILIDADE_CIVIL_AMBIENTAL.aspx

[58] UNFCCC - United Nations Framework Convention on Climate Change. Modalities and Procedures for Carbon Dioxide Capture and Storage in Geological Formations as Clean Development Mechanism Project Activities. http://unfccc.int/files/meetings/durban_nov_2011/decisions/application/pdf/cmp7_carbo n_storage_.pdf Last accessed in February, 2014.

[59] UNITED NATIONS ORGANIZATION, UN. ORGANIZAÇÃO DAS NAÇÕES UNIDAS. Conferência das Nações Unidas sobre Meio Ambiente e Desenvolvimento (Agenda 21), adotada de 3 a 14 de junho de 1992. Available: http://onu.org.br/rio20/img/2012/01/rio92.pdf.

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