detritus | Multidisciplinary Journal for Circular Economy and Sustainable Management of Residues

WASTE-TO-ENERGY: REUSE OF OIL SPILLED ON THE BRAZILIAN COAST IN 2019 THROUGH CO-PROCESSING

Érica Machado da Silva Guerreiro * and Elisabete de Santis Braga

Oceanographic Institute of the University of São Paulo, IO/USP, Praça do Oceanográfico, 191, Cidade Universitária, Butantã, 05508-120, São Paulo, Brazil

Article Info:
Received:
25 November 2025
Revised:
2 March 2026
Accepted:
6 March 2026
Available online:
31 March 2026

Keywords:
Oil spill
Co-processing
Cement industry
Reuse
Alternative fuel

ABSTRACT

In August 2019, one of Brazil's largest environmental disasters occurred as a result of a crude oil spill from an oil tanker between August 2019 and March 2020, reaching the northeastern and southeastern coastal regions of the country, known as the Blue Amazon. Eleven states, 130 municipalities, and 1,009 localities were affected, in addition to 10 ecosystems, more than 57 protected areas, and 34 animal species. Despite the extreme circumstances, the disaster did not receive a timely response from the federal government, and this inaction led to more significant long-term consequences, such as the compromise of preservation areas and the temporary suspension of artisanal fishing, damaging the livelihoods of thousands of residents in the affected localities. The waste was mostly collected by volunteer citizens and reused for energy recovery in co-processing as an alternative fuel in cement kilns. Around 5,379.76 tons of waste were collected, most of which were sent to cement industries. It was found that a large amount of the collected oil was reused energetically as fuel in co-processing industries. The present article is a descriptive case report and aims to analyze and offer an overview of the energy reuse of oil collected after spills in co-processing activities. Primary data were obtained from official reports, while secondary data were acquired through a literature review. The results showed that reusing oil collected from spills in the cement industry was considered alternative for waste destination instead of disposal in landfills, and new destinations could be implemented by the official environmental organisms.

1. INTRODUCTION

In August 2019, the largest oil spill in Brazilian coastal history occurred. From August 2019 to March 2020, 11 states, 130 municipalities, and 1,009 localities were affected by the oil spill (IBAMA, 2020a). The disaster caused extensive damage to marine biodiversity, affecting 10 ecosystems, more than 57 protected areas, and 34 species (Soares et al., 2020). At the time, many artisanal fishermen suffered the impacts of crude oil contamination, in particular due to the suspension of fish and shellfish consumption in the Northeast region of Brazil (Pena et al., 2020). There was an immediate reduction in the sale and consumption of fish, severely affecting the main source of income and food for thousands of families, especially female shellfish gatherers (Silva et al., 2021). Furthermore, there was significant damage to tourism activities, a major source of income for the affected coastal areas.

Figure 1 shows the extent (700 km) of the Brazilian coastal area affected by the oil spill, reaching the northern and northeastern areas, above and below the Equator due to the bifurcation of the Brazilian Current. This region is an oceanic frontier of the continent, belonging to an area known for its natural riches as the Blue Amazon.

According to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA, 2020b), the oil that reached the Brazilian coast in 2019 (Figure 2) presented high viscosity, high density, and low concentrations of volatile compounds due to the oil quality and weathering. Because of its characteristics, manual removal techniques (using shovels) were used. Visible monitoring sensors did not detect oil slicks, indicating that the oil was not drifting on the sea surface but below the surface, and for this reason it was undetectable by remote observation systems (IBAMA, 2022a).

After the spill, much attention was dedicated to discovering the source of the oil, which was later confirmed by Brazilian authorities to be of Venezuelan origin. Initially, most of the oil residue was collected by volunteer citizens without personal protective equipment (PPE) or any type of training. However, as the oil spill spread, there was greater

* Corresponding author:
Érica Guerreiro
email: ericaguerreiro@usp.br

https://doi.org/10.31025/2611-4135/2026.19574

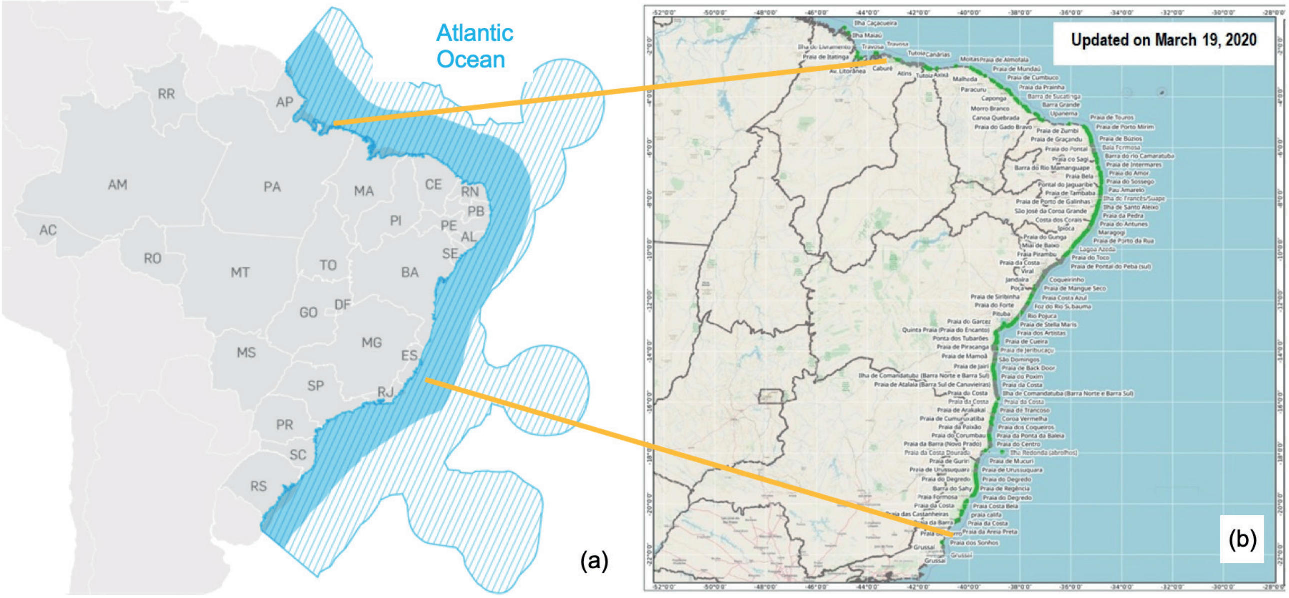

FIGURE 1: (a) Blue Amazon (blue area). Source: IBGE/Estadão; (b) Extent of the oil spill on the Brazilian coast (green area). Source: IBAMA, 2020a.

FIGURE 2: (a) Oil spill in Pau Lagoon, in Coruripe (located at Alagoas State), in 2019. Source: MPF, 2025b; (b) Volunteers attempt to rescue young man trapped in the thick layer of oil at Itapuama Beach (located at Pernambuco State). Source: Leo Malafaia/Folha PE, 2019.

mobilization of state environmental agencies, city governments, and the Brazilian Navy.

According to Tassigny et al. (2024), risk communication in disasters involving marine pollution is essential to prevent further damage and reduce uncertainty – particularly standardized disclosure directed at communities surrounding the disaster, in addition to wide communication by the press directed at society. The people most exposed to the oil were those who worked on coast cleanup activities and workers involved in artisanal fishing (Carmo and Teixeira, 2020). This accident stands out among other oil spills in Brazil due to its extent (over 700 km), and despite its proportions and environmental damage, there have been no measures of compensation for the damage caused by the pollution (Lawand et al., 2021).

A guidebook (IBAMA, 2022b) was published under the guidance of International Tanker Owners Pollution Federation with recommendations to the population regarding personal protective equipment use and with instructions for manual cleaning — which was the most appropriate method for collecting the oil in order to reduce environmental damage.

At the beginning, the Brazilian Navy (2020) indicated that the incident occurred gradually, with the first signs of oil not suggesting a situation of national significance, and in the absence of identification of the polluter, the Brazilian Petroleum Company (Petrobras) was asked to clean up the beaches due to its quantity of equipment and greater presence along the coast.

In this scenario, one of the biggest challenges was managing the large amount of waste generated by the spill. The solution found by the authorities was to send most of the oily waste for co-processing, where it would be reused as fuel in clinker-production kilns. The accident's scale increased and 5,379.76 tons of waste were collected, raising concerns about its destination. Most of it was sent to cement industries, while a smaller amount was sent to other final destinations, such as Class I landfills. The oil sent to cement factories was reused as an alternative fuel in co-processing activities.

Considering the oil spill reached the Brazilian coast in 2019–2020, this study aims to verify the destination of oil spilled in different Brazilian coastal regions, observing the energetically feasible use as a contribution to the improvement of environmental protective action in the future. This work contributes to the dissemination of data on the energy recovery of oily waste in co-processing, as an alternative for waste disposal after the spill that occurred in Brazil in 2019.

One of the biggest challenges during the elaboration of the study was obtaining data related to the destination of oil collected on the coast after the accident, because there was not wide dissemination at the time and most of the information was obtained through the Access to Information Act (legislation for open information). Therefore, this study is highly relevant, since it aims, in the context of this accident, to reveal information regarding the amount and application of the oil collected on the coast, contributing to the improvement of the most effective actions in similar future situations. Among the main limitations found during the study, the following stand out: reliance on official data, the absence of independent environmental performance metrics, the lack of emission measurements, and the constraints of a short communication format.

2. METHOD

This study a short communication presenting a descriptive case report and is based mainly on official reports regarding the energy reuse of oil collected after spills in co-processing activities. The research is performed using scientific bibliographic sources and documents available related to the oil destination from the spill of 2019–2020 that reached the Brazilian coast.

First, a survey was conducted on primary data with public information obtained directly from the authorities involved in the oil spill that occurred in Brazil in 2019 — such as the amount and destination of the oil collected. The work proceeded with consultation of documents under the Access to Information Act (Brasil, 2011) and official websites. Subsequently, secondary data relevant to the object of study were added based on the selection of scientific papers from bibliographic searches. Also, some complementary data were carefully added from news published in the more formal press.

3. RESULTS AND DISCUSSION

According to the Federal Public Prosecutor's Office (MPF, 2025a), based on data from Chico Mendes Institute for Biodiversity Conservation, shown in Table 1, a total of 13 federal conservation units, among others, were affected by the oil spill in 2019. Some of these reserves are extractive, meaning they are home to native communities that depend primarily on the ecosystem services provided by the environment.

TABLE 1: Conservation units affected by the oil spill on the Brazilian coast in 2019. Source: based on data from MPF (2025a).

Location (State)	Conservation Unit
Maranhão (MA)	Cururupu Extractive Reserve
	Lençóis Maranhenses National Park
Piauí (PI)	Delta do Parnaíba Environmental Protection Area
Ceará (CE)	Jericoacoara National Park
	Batoque Extractive Reserve
	Prainha do Canto Verde Extractive Reserve
Paraíba (PB)	Barra do Rio Mamanguape Environmental Protection Area
	Manguezais da Foz do Mamanguape Area of Ecological Interest
	Acaú-Goiana Extractive Reserve
Pernambuco (PE)	Costa dos Corais Environmental Protection Area
Alagoas (AL)	Lagoa do Jequiá Extractive Reserve
	Piaçabuçu Environmental Protection Area
Sergipe (SE)	Santa Isabel Biological Reserve
Bahia (BA)	Cassurubá Extractive Reserve Corumbau Marine Extractive Reserve

IBAMA (2016) presents a National Emergency Action Plan for Wildlife Affected by Oil, which is responsible for assigning the members of a wildlife team to the spill site, with the objective of protecting and developing an appropriate response to wildlife affected by oil. Meanwhile, the National Contingency Plan sets out the responsibilities and guidelines whose competences and actions are assigned to each agency linked to the organizational structure in order to deal with oil accidents in waters under national jurisdiction. Such plans were used in dealing with the accident, the extent of which required a widely coordinated action.

Around 5,379.76 tons of waste were collected, 30% of which was oil. In accordance with technical guidelines for waste management (IBAMA, 2020c), the oil collected along the coastline was stored in big bags. Table 2 shows the reported amount of waste collected by state in the areas affected by the oil spill. The states of Alagoas (2,564.58 tons) and Pernambuco (1,676.26 tons) had the highest amounts of waste collected.

Furthermore, based on external access to IBAMA public data, most of this waste was sent to licensed cement kilns for co-processing, as shown in Table 3, at the Votorantim Cimentos facilities in Laranjeiras (located in Sergipe State) and Sobral (located in Ceará State), Mizu Cimentos (located in Baraúna, Rio Grande do Norte State), InterCement (located in Bahia State), and Cimenteira APODI (located in Ceará State) for energy generation in their respective industries.

In some states, waste transportation and disposal were carried out by the state itself (through the state environmental agency or city halls), while in other locations PETROBRAS was responsible for transporting the waste to cement industries (Brazilian Navy, 2020). In 2019, Mizu Cimentos received approximately 60.3 tons of contaminated material collected from the beaches of Northeast Brazil (Mizu, 2025).

TABLE 2: Amount of waste collected by state after the oil spill on the Brazilian coast in 2019. Source: based on data from IBAMA (2022).

State	Waste Collected by Petrobras (tons)	Waste Collected by Local Authorities (tons)	Total Amount Collected (tons)
Alagoas (AL)	16.09	2548.49	2,564.58
Bahia (BA)	95.03	364.46	459.49
Ceará (CE)	0.00	39.76	39.76
Espírito Santo (ES)	0.00	6.26	6.26
Maranhão (MA)	0.01	13.68	13.69
Paraíba (PB)	0.00	0.85	0.85
Pernambuco (PE)	29.84	1,646.42	1,676.26
Piauí (PI)	0.00	10.46	10.46
Rio de Janeiro (RJ)	0.00	0.00	0.00
Rio Grande do Norte (RN)	12.16	33.83	35.18
Sergipe (SE)	356.19	213.16	569.35
Offshore	1.00	2.88	3.88
TOTAL	510.32	4,880.25	5,379.76

It is possible to verify that, even after all the challenges related to storage and logistics costs, most of the oil collected (as shown in Figure 3) on beaches in Northeastern Brazil was reused energetically as an alternative fuel in co-processing industries, instead of being disposed of in landfills without any prior treatment.

The growth in waste generation and its final disposal are major challenges for Brazilian cities. According to estimates, more than 81.6 million tons of municipal solid waste (MSW) were generated in 2024 (ABREMA, 2025). In a scenario of significant final disposal rates, energy recovery methods have emerged as an important and appropriate environmental solution for final disposal. Federal Law No. 12,305 (BRASIL, 2010), established the National Solid Waste Policy, which implemented energy recovery from solid waste in the country; according to its legal criteria, disposal should be considered only after all possibilities for use, reuse, and treatment of waste have been exhausted.

Since then, waste has been considered material with potential for recovery and/or reuse. Although there are legal instruments aimed at waste recovery and reuse activities, little progress has been made in the country. As a result, the reuse of oily waste collected after the 2019 spill in co-processing activities in cement industries has proven to be highly relevant, as it reuses a large amount of waste instead of simply disposing of it in landfills.

Although it is still unclear from an environmental perspective to quantify emissions, changes in carbon footprint, and the possible effects of replacing petroleum coke with pre-processed waste in co-processing, the technolo-

TABLE 3: Quantity and destination of oil collected on beaches in Northeast Brazil after the 2019 environmental disaster. Source: based on data from IBAMA (2022).

State	Estimated Oil Collected by Petrobras (tons)	Estimated Oil Collected by Local Agencies (tons)	Total Amount of Oil Collected (tons)	Temporary Storage	Transportation	Destination
Alagoas	16.09	2,548.49	2,564.58	Petrobras Waste Management Center in Carmópolis (SE)	Petrobras	Votorantim Laranjeiras (SE) and Mizu Cimentos in Baraúna (RN)
Bahia	95.03	364.46	459.49	Petrobras Waste Management Center in Carmópolis (SE); CETREL (in Camaçari)	State	Cimenteira InterCement and CTR-Bahia
Ceará	0.00	39.76	39.76	-	State	Cimenteira APODI (CE)
Espírito Santo	0.00	6.26	6.26	São Luiz da Barra, Linhares and São Mateus - ES	State	Class I Landfill Site operated by Vitória Ambiental
Maranhão	0.01	13.68	13.69	IBAMA (MA), Tutóia, Port Authority in São Luiz, and Waste Management Center in Parnaíba (PI)	State and Petrobras	Class I Waste Management Center of Tiara and Votorantim Cimentos in Sobral (CE)
Paraíba	0.00	0.85	0.85	Cabedelo	State	Class I Metropolitan Landfill in João Pessoa

FIGURE 3: Cleanup carried out by volunteers: (a) Paiva Beach (located in the city of Recife). Source: Oton Veiga/TV Globo, 2019; (b) Itapuama Beach (located at Pernambuco State). Source: Sidney Vieira/Araújo et al, 2020.

gy for reusing oil waste to produce energy in cement industries was applied as an alternative final destination for waste after the oil spill.

Co-processing is an activity that reuses waste of high calorific value and biomass as alternative fuel in cement kilns. The process proposes the replacement, although partial, of fossil fuels (such as coal and petroleum coke) in clinker production kilns – the main raw material and responsible for CO_2 emissions in cement production.

Co-processing is licensed in Brazil by the National Environment Council under Resolution No. 499 (BRAZIL, 2020), with the following definition: "Co-processing of waste in clinker production kilns: environmentally appropriate final destination involving the processing of solid waste as a partial substitute for raw materials and/or fuel in the clinker production kiln system in cement manufacturing".

The waste mixture is uniform in size and has a high calorific value — generally 18 megajoules per kilogram — recovered after collection, sorting, and treatment (BNDES, 2014). It is estimated that in Brazil, alternative fuels account for 32% of thermal substitution in relation to traditional fossil fuels (such as coal and petroleum coke) in co-processing, with an annual processing of 3,258 million tons of waste in the country (ABCP, 2024).

A simple order-of-magnitude estimate of the potential energy recovery from the oily waste was performed using typical calorific values reported in the literature. Since, approximately 5,379.76 tons of waste were collected after the spill, of which about 30% corresponded to oil-contaminated material, it results in an estimated 1,614 tons of oily waste.

$$M_{oil} = 0.30 \times 5379.76\,t \approx 1{,}614\,t \approx 1.6 \times 106\,kg$$

where: M_{oil} = mass of oily waste; 1t = 1000 kg

Also, assuming a typical lower heating value of 18 MJ kg^{-1} for waste used in cement kiln co-processing, the theoretical energy recovery potential is approximately 2.9×10^7 MJ, equivalent to about 29,000 GJ (≈ 8,05 GWh) of thermal energy. This simplified estimate illustrates the significant energetic potential of the recovered oily waste when used as an alternative fuel.

$$E = M_{oil} \times LHV = 1.6 \times 106\,[kg] \times 18\,[MJ]\,[kg^{-1}] \approx 2.9 \times 107\,MJ$$
$$E \approx 2.9 \times 107\,MJ \approx 29{,}000\,GJ \approx 8{,}05\,GWh$$

where: E = thermal energy; LHV = lower heating value

High calorific value waste can be used for co-processing purposes due to the absence of harmful effects on emissions in an industrial facility, the clinker production process, and the final product quality (FRICKE et al., 2015). The residence time in the kilns is usually from 2 to 4 seconds, during which the waste is completely destroyed. One of the biggest problems faced by the cement industry is the large amount of CO_2 emissions related to the calcination of raw materials for clinker production, and therefore co-processing has shown to be an alternative technological strategy to reduce such emissions.

In this way, the reuse of oil collected on the Brazilian coast after the accident in co-processing activities, when possible, was a final destination solution found by the authorities at the time, instead of disposal in landfills. Based on available official data, co-processing was the main destination; however, a more in-depth assessment of environmental performance is needed.

Smoldering (slow combustion) is a flameless combustion process that has been used to treat oily waste, which is used as fuel and has a heat source used to initiate the reaction, since the combustion is sustained by an air distribution (Sabadell et al., 2018). However, it should be noted that the application of smoldering combustion is a relatively recent technology for waste treatment (Yermán, 2016).

Regarding the political implications related to the 2019 oil spill on the Brazilian coast, we can highlight that: emergency waste management protocols should include predefined industrial reuse pathways; transparency of waste destination data must be institutionalized; and co-processing can function as a contingency waste management mechanism in large-scale spills.

4. CONCLUSIONS

The oil spill on the coast of Northeast Brazil in 2019, known as the largest in the country's history and one of the world's biggest environmental disasters, had several impacts on the local population and damaged biodiversity, affecting protected and sensitive environmental areas, as well as damaging artisanal fishing and the livelihoods of thousands of families.

A total of 5,379.76 tons of waste were collected, mainly by volunteer citizens, most of which were sent to cement industries, where they were reused as an alternative fuel for energy generation in clinker production kilns in co-processing activity.

In a scenario of significant waste disposal rates in Brazil, energy recovery methods have emerged as an important and appropriate environmental solution. In this way, co-processing was the alternative found by the authorities at the time, instead of the large amount of oily waste disposed of in landfills.

However, other strategies for collecting and utilizing oily waste (such as smoldering) resulting from environmental accidents should be identified and included in government protocols so that other alternatives can be adopted, especially those that involve a reduction in CO_2 emissions and do not compromise ecosystem services, the maintenance of life, and health.

ACKNOWLEDGEMENTS

This study was financed, in part, by the São Paulo Research Foundation (FAPESP), Brasil. Process Number 2024/11097-0.

The authors are grateful for the financial support provided by the National Council for Scientific and Technological Development (CNPq) (Project REDE OLEOMAR CNPq 440893/2020-8 and Process CNPq 308916/2022-0) and the infrastructure of the LABNUT laboratory of Oceanographic Institute of the University of São Paulo, Brazil.

REFERENCES

ABCP – Brazilian Portland Cement Association. Associação Brasileira de Cimento Portland. Panorama do Coprocessamento – Brasil 2024 (Ano base 2023). São Paulo, 2024. ABCP, 2024.

ABREMA - Associação Brasileira de Resíduos e Meio Ambiente. Panorama dos Resíduos Sólidos no Brasil 2025. São Paulo, 2025.

ARAÚJO, M. E.; RAMALHO, C. W. N.; MELO, P. W. Pescadores artesanais, consumidores e meio ambiente: consequências imediatas do vazamento de petróleo no Estado de Pernambuco, Nordeste do Brasil. Cadernos de Saúde Pública, 36(1), 230319. 2020. https://doi.org/10.1590/0102-311X00230319

BNDES Brazilian Development Bank. Banco Nacional de Desenvolvimento Econômico e Social. Análise das Diversas Tecnologias de Tratamento e Disposição Final de Resíduos Sólidos Urbanos no Brasil, Europa, Estados Unidos e Japão. Fundação de Apoio ao Desenvolvimento da Universidade Federal de Pernambuco (FADE/UFPE). BNDES, 2014.

BRASIL. Ministry of Environment. Ministério do Meio Ambiente. CONAMA – Conselho Nacional do Meio Ambiente. Resolução CONAMA/MMA Nº499, de 06 de outubro de 2020. Dispõe sobre o licenciamento da atividade de coprocessamento de resíduos em fornos rotativos de produção de clínquer. Diário Oficial da União. Brasília, 2020. BRASIL, 2020.

BRASIL. Access to Information Act. Lei de Acesso à Informação. Lei no 12.527, de 18 de novembro de 2011. Regula o acesso a informações prevista na Constituição Federal; e dá outras providências. Diário Oficial da União. Brasília, 2011. BRASIL, 2011.

BRASIL. Brazilian National Solid Waste Policy Plano Nacional de Resíduos Sólidos (PNRS). Lei nº 12.305 de 02 de agosto de 2010; altera a lei no 9.605, de 12 de fevereiro de 1998; e dá outras providências. Diário Oficial da União. Brasília, 2010. BRASIL, 2010.

Carmo, E. H., Teixeira, M. G. (2020). Desastres tecnológicos e emergências de saúde pública: o caso do derramamento de óleo no litoral do Brasil. Cadernos de Saúde Pública, 36(2). https://doi.org/10.1590/0102-311X00234419

Estadão. (2024). Estadão. https://www.estadao.com.br/sustentabilidade/amazonia-azul-marinha-mar-brasil-ibge/?srsltid=AfmBOopMQueaOaGH3Z4O-pZl6OyhmauvXIXr0FVqzYrVat_hrEiUQ7p4

FRICKE, K.; PEREIRA, C.; LEITE, A.; BAGNATI, M. Gestão Sustentável de Resíduos Sólidos Urbanos: Transferência de Experiência Entre a Alemanha e o Brasil. Braunschweig: Technische Universität Braunschweig, 2015. TU Braunschweig, Germany, 2015.

G1, Globo. Protocolo internacional para limpeza de óleo nas praias traz alertas para 4 situações enfrentadas no Nordeste. (2019, October 29). G1. https://g1.globo.com/natureza/desastre-ambiental-petroleo-praias/noticia/2019/10/29/protocolo-internacional-para-limpeza-de-oleo-nas-praias-traz-alertas-para-4-situacoes-enfrentadas-no-nordeste.ghtml

IBAMA – Brazilian Institute of Environment and Renewable Natural Resources. Instituto Brasileiro do Meio Ambiente e dos Recursos. DIRETORIA DE PROTEÇÃO AMBIENTAL COORDENAÇÃO-GERAL DE EMERGÊNCIAS AMBIENTAIS. Ibama. 2022a. Available on: https://www.gov.br/ibama/pt-br/assuntos/fiscalizacao-e-protecao-ambiental/emergencias-ambientais/manchasdeoleo/arquivos/2022/2022-12-16_sei_ibama_6898984_relatorio_tecnico_ibama.pdf .Accessed on: 17 november 2025.

IBAMA – Brazilian Institute of Environment and Renewable Natural Resources. Instituto Brasileiro do Meio Ambiente e dos Recursos. Orientações. Ibama. 2022b. Available on: https://www.gov.br/ibama/pt-br/assuntos/fiscalizacao-e-protecao-ambiental/emergencias-ambientais/manchasdeoleo/orientacoes - uso-epi .Accessed on: 17 november 2025.

IBAMA – Brazilian Institute of Environment and Renewable Natural Resources. Instituto Brasileiro do Meio Ambiente e dos Recursos. Localidades afetadas. Brasília. IBAMA, 2020a. Available on:https://www.ibama.gov.br/phocadownload/emergenciasambientais/2020/manchasdeoleo/2020-03-19_LOCALIDADES_AFETADAS.pdf . Accessed on: 11 august 2025.

IBAMA – Brazilian Institute of Environment and Renewable Natural Resources. Manchas de óleo. Litoral Brasileiro. Brasília. IBAMA. 2020b. Available on:https://www.gov.br/ibama/pt-br/assuntos/fiscalizacao-e-protecao-ambiental/emergencias-ambientais/manchasdeoleo/arquivos/ibama-manchasdeoleo-desmobilizacao-cartilha_v2.pdf . Brasília, 2020. Accessed on: 11 august 2025.

IBAMA – Brazilian Institute of Environment and Renewable Natural Resources. Orientação técnica: gestão de resíduos. Brasília. IBAMA. 2020c. Available on:https://www.gov.br/ibama/pt-br/assuntos/fiscalizacao-e-protecao-ambiental/emergencias-ambientais/manchasdeoleo/arquivos/2022/20221216_OT_gestao_residuos_oleo.pdf . Brasília, 2020. Accessed on: 11 august 2025.

IBAMA – Brazilian Institute of Environment and Renewable Natural Resources. Plano Nacional de Ação de Emergência para Fauna Impactada por Óleo. IBAMA. 2016. Available on:https://www.ibama.gov.br/phocadownload/emergenciasambientais/paefauna2016_plano.pdf . Brasília, 2016. Accessed on: 25 june 2025

Laward, A., Dutra de Almeida Silva, C., & Ferreira de Oliveira, L. P. (2021). Derramamento de óleo no nordeste brasileiro: Responsabilização e desdobramentos. Revista De Direito E Negócios Internacionais Da Maritime Law Academy - International Law and Business Review , 1(1), 84-113. Available on: https://mlawreview.emnuvens.com.br/mlaw/article/view/8 . Accessed on: 25 november 2025.

MPF - Federal Public Ministry. Ministério Público Federal. Dúvidas frequentes - Derramamento de óleo na costa brasileira. Available on: <https://www.mpf.mp.br/grandes-casos/casos-historicos/oleo-na-costa-brasileira/duvidas-frequentes>. Accessed on: 10 april 2025. Brasília, 2025. MPF, 2025a.

MPF - Federal Public Ministry. Procuradoria da República no Estado de Sergipe. ACP - Ação Civil Pública nº 0805679-16.2019.4.05.8500 -assinada por procuradores dos nove estados do Nordeste. Available on: https://www.gov.br/ibama/pt-br/assuntos/fiscalizacao-e-protecao-ambiental/emergencias-ambientais/manchasdeoleo/arquivos/2023/20230118_Of_Ext_30_279_2020_CM_MMA_An_Incidente_Poluicao_Oleo_Relatorio_final.pdf. Accessed on: 10 april 2025. Sergipe, 2025. MPF, 2025b.

Marinha do Brasil - Brazilian Navy. Coordenação Operacional. Incidente de Poluição por Óleo na Costa Brasileira. Relatório Final. Rio de Janeiro, 2020. Available on: https://www.gov.br/ibama/pt-br/assuntos/fiscalizacao-e-protecao-ambiental/emergencias-ambientais/manchasdeoleo/arquivos/2023/20230118_Of_Ext_30_279_2020_CM_MMA_An_Incidente_Poluicao_Oleo_Relatorio_final.pdf . Accessed on: 11 august 2025.

Mizu. Socio & Environmental - Mizu. (2025, February 24). Available on:https://mizu.com.br/en/socio-environmental/ . Accessed on: 22 november 2025.

Pena, P. G. L., Northcross, A. L., Lima, M. A. G. de, & Rêgo, R. de C. F. (2020). Derramamento de óleo bruto na costa brasileira em 2019: emergência em saúde pública em questão. Cadernos de Saúde Pública, 36(2). https://www.scielo.br/j/csp/a/RdpV54PDWjxktvSjhJRCvTP/?lang=pt

Sabadell, G., Scholes, G., Thomas, D., Murray, C., Bireta, P., Grant, G., & Major, D. (2018). Ex Situ Treatment Of Organic Wastes Or Oil-Impacted Soil Using A Smoldering Process. WIT Transactions on Ecology and the Environment. https://doi.org/10.2495/wm180341

Silva, L. R. C. da, Pessoa, V. M., Carneiro, F. F., Andrade, N. S. M., & Meireles, A. J. de A. (2021). Derramamento de petróleo no litoral brasileiro: (in)visibilidade de saberes e descaso com a vida de marisqueiras. Ciência & Saúde Coletiva, 26(12), 6027-6036. Available on: https://www.scielo.br/j/csc/a/hKJZft8YxVVw4yhGYK4kyLD/?lang=pt. Accessed on: 28 August 2025.

Soares, M. de O., Teixeira, C. E. P., Bezerra, L. E. A., Paiva, S. V., Tavares, T. C. L., Garcia, T. M., Carneiro, P. B. de M. (2020). Oil spill in South Atlantic (Brazil): Environmental and governmental disaster. Marine Policy, 115, 103879. https://www.sciencedirect.com/science/article/abs/pii/S0308597X19308346

TASSIGNY , Mônica; ROCHA, Ronald; BEZERRA DE MELO GIRÃO MOTA, Andrea. Poluição Marinha E Direito Dos Desastres: Análise Do Incidente De Derramamento De Óleo No Litoral Do Nordeste Brasileiro Sob A Perspectiva Da Comunicação De Risco. Novos Estudos Jurídicos, Itajaí (SC), v. 29, n. 3, p. 591-616, 2024. DOI: 10.14210/nej.v29n3.p591-616. Available on:https://doi.org/10.14210/nej.v29n3.p591-616 . Accessed on: 2 september 2025.

Yermán, L. (2016). Self-sustaining Smouldering Combustion as a Waste Treatment Process. InTech EBooks. https://doi.org/10.5772/64451