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Technical Paper

Mysterious oil spill in Brazil (2019-2020): what lessons can we learn from previous events?

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Abstract

Oil spills cause great concern regarding environmental and human health. Different places around the world have suffered and still suffer the consequences of these spill, facing issues and challenges, which are, in general quite similar. The present work aims to revise critically on the main effects and characteristics of oil spills that happened during the past 20 years. For that, nine big oil spills that happened in between 2000 and 2020 were selected, allocated in the five continents, in seven different countries: Galapagos, Spain, United States, Australia, South Korea, Nigeria and Brazil. To analyse the spills, the following criteria was adopted: impacts on biota; impacts on human health; socioeconomic impacts; if containment measures were applied and in which were they; and if short, medium and long term monitoring happened. The results shown in this study are an important step to help in the comprehension of the main struggles and impacts related to this type of incident at global level, in addition to identify possible guidelines that may contribute to fight and manage future spills.

Keywords: oil spills. environmental accidents. polycyclic aromatic hydrocarbons

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1. Introdução

Fossil fuels are essential for societies to function, due to the large use of petroleum and gas as sources of energy. However, this broad use of petroleum and its derivatives have generated a global reliance on fossil fuels for energy production, which have been increasing with population growth and economic development around the world. During the extraction and transport processes, oil leaks and acute accidents with petroleum are frequent and can cause negative effects to the environment and humans (Câmara et al., 2021; García-Mira et al., 2006). Throughout the years these impacts have been observed in different accidents around the world, such as in 2002 in Spain (Garza-Gil et al., 2006; Morales-Caselles et al., 2008) and 2010 in the Gulf of Mexico (Krishnamurthy et al., 2019; Liu et al., 2016; Rohal et al., 2020).

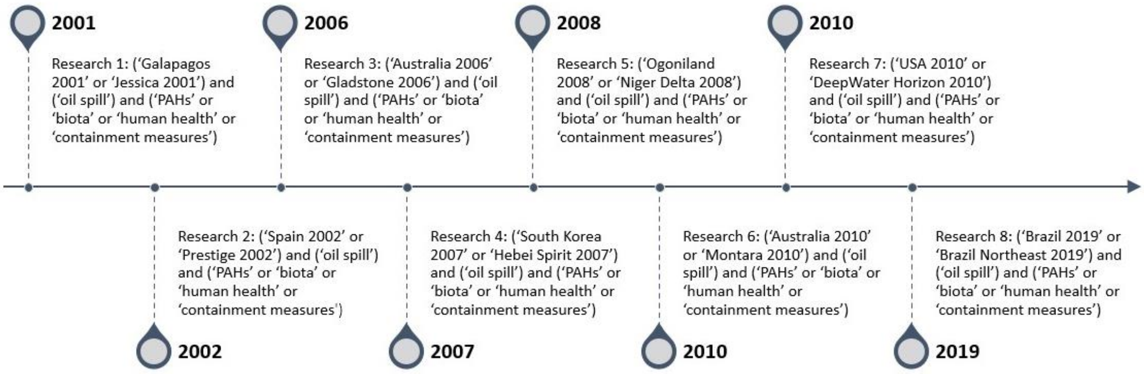
In 2019, the most extensive oil spill recorded in tropical oceans was registered: enormous amounts of petroleum spread over more than 3000 km of Brazilian NE and SE coast, impacting environmental and human health (Almeida & Giarrizzo, 2020; Câmara et al., 2021). Over a thousand localities registered the presence of oil patches and tars (INSTITUTO BRASILEIRO DO MEIO AMBIENTE E DOS RECURSOS NATURAIS RENOVÁVEIS-IBAMA, 2020) affecting animals, local communities, and the economy . The oil spill and its impacts were initially neglected by government agencies, forcing the communities to work on the removal of the oil without appropriate equipment, exposing themselves to several risks (Oliveira et al., 2020). Fisherman and traditional communities were especially affected economically because their main source of income and food, fish, and seafood, suffered oil contamination which caused harm and deaths to the biota (Almeida & Giarrizzo, 2020; Câmara et al., 2021).

This paper aims to review oil accidents that occurred over the past two decades (2000-2020) to identify the main hits and errors in monitoring and mitigation efforts during these accidents.

2. Metodologia

We selected 8 major oil spills (Figure 1) that happened between 2000 and 2020 considering different places in the five continents to visualize the similarities and differences in the measures and actions each country had. The spills were chosen according to their sizes (i.e., tons of leaked oil) and to their impacts – on the environment, on the population and on the economy. The analysis of the accidents research covers six different topics: (i) impacts on the physical environment, (ii) impacts on biota, (iii) impacts on human health, (iv) socioeconomical impacts, (v) which containment measures were applied, and (vi) if the spill was monitored throughout the years (short term < 1 year, medium term 1-5 years, long term > 5 years). To do the research, a combination of words/terms were chosen, present below on Figure 1:

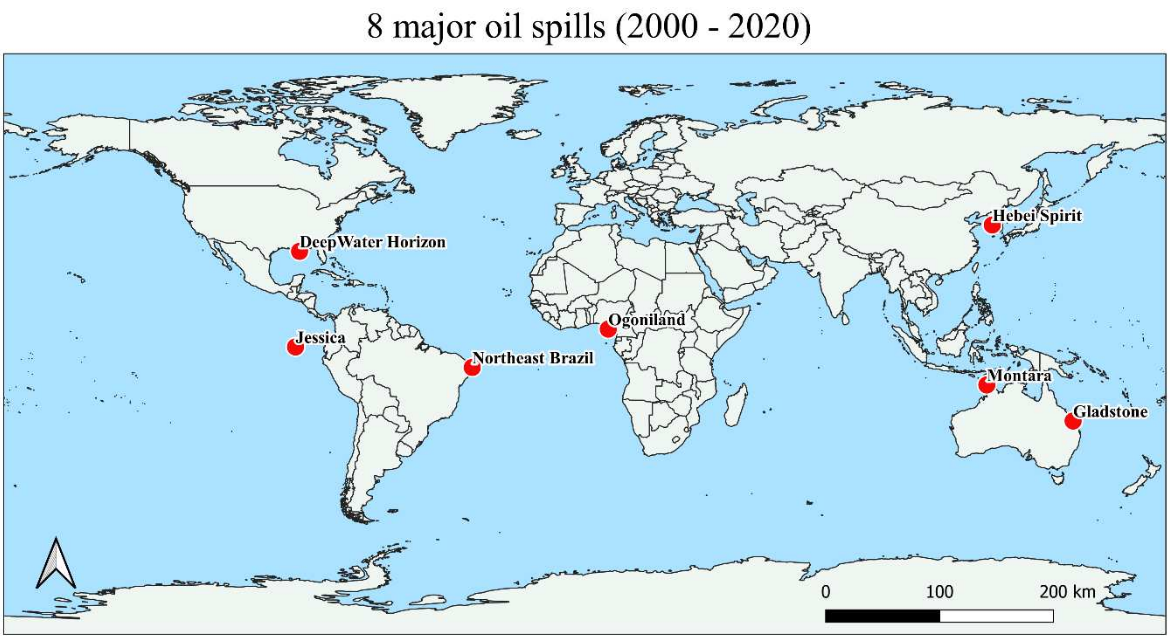
Figure 1 – The combination of words used for the research of the papers in each category.



Fonte: produced by the authors.

The selected oil-related accidents were Jessica (2001), Prestige (2002), Gladstone (2006), Hebei Spirit (2007), Ogoniland (2008), Montara (2010), Deepwater Horizon (2010) and Brazil Northeast oil Spill (2019). These environmental disasters can be observed spatially in Figure 2.

Figure 2 - Map of the locations of each oil spill selected for this study.



Fonte: produced by the authors.

3. Resultados

Chart 1 shows how many papers were selected for each oil spill in each category. In total, 107 papers were used to compose this study. 28,04% of the studies were related to the Prestige oil spill and 23,36% were related to the DeepWater Horizon oil spill. The 2008 Nigeria oil leak represents 17,76%, the 2019 Brazil oil spill represents 10,28%, and the 2007 South Korea accident represents 9,35% of the studies. The Jessica, Gladstone and Montara oil spills represents 6.54%, 2.8% and 1.87%, respectively.

Some of the papers covered more than one topic. 46.73% of the studies were related to the biotic environment and 28.97% covered the physical environment. Studies related to human health represent 17.76% and the ones related to the socioeconomic impacts represent 18.69%. Containment measures were not widely studied, only being present in 11.21% of the papers. Short-term, medium-term, and long-term monitoring the oil spills represent 34.57%, 22.43% and 21.5%, respectively with the Prestige oil spill being the most monitored of all.

Chart 1 – Data found for each oil spill.

	Year	2019	2010	2010	2008	2007	2006	2002	2001
General Information	Country	Brazil	USA	Australia	Nigeria	South Korea	Australia	Spain	Galapagos
	Name	Northeast Brazil	Deepwater Horizon	Montara	Ogoniland	Hebei Spirit	Gladstone	Prestige	Jessica
	Oil tons	5,000	560,000	Unknown	Unknown	10,900	25	70,000	900
	Containment measures	2	1	1	2	2	1	2	1
	Total	9	25	3	19	11	3	30	7
Number of Papers	Biotic environment	4	9	1	6	7	3	16	4
	Physical environment	2	9	2	8	4	2	3	1
	Socio-economic	3	4	-	4	2	-	6	1
	Human health	1	5	-	6	2	-	5	-
Monitoring strategies	Short term (<1 year)	9	4	1	4	1	3	8	7
	Medium term (1-5 years)	1	6	1	2	3	-	11	-
	Long term (>5 years)	-	4	-	4	5	-	10	-

Fonte: produced by the authors.

General data: When and where each happened, the name of each spill and how many oil tons were spilled and the total number of papers used to analyze and compare the spills. It also shows how many papers were selected to each category (with some fitting into more than one) and how many papers studied and collected data for each spill in shot, medium- or long-term time span.

4. Discussão

From the data evaluated, it is noticeable that oil spills cause damage to the environment, to the economy and to human (physical and mental) health; and that such harm is seen throughout the years and in different parts of the world. These incidents have even more in common: a general lack of governmental plans and actions to mitigate the impacts of the incidents, as seen in Nigeria (Albert et al., 2018; Obida et al., 2018) and Brazil (Oliveira et al., 2020). Even in the cases where there was a contingency plan, such as in the 2007 Hebei Spirit spill with the Northwest Pacific Action Plan (NOWPAP), the elaborated plan was not sufficient to contain the damage. In Hebei Spirit spill case, participation of leaders to actively combat the spill was lower than expected in terms of financial support and policy decisions, causing the contingency plan to malfunction (Chung & Lee, 2016).

One important question that emerged after most of these oil spills is "why do governments not act and follow the contingency plans?" While this question still does not have a proper answer, humans and biota continue to suffer with the impacts of oil spills. To measure these impacts, most of the studies quantify and compare values of compounds present in petroleum such as polycyclic aromatic hydrocarbons (PAHs) and heavy metals to the ones presented before the accidents (Moreno et al., 2011; Pérez-López et al., 2006; Seo et al., 2014; Soares et al., 2021). In addition, to measure the damage to human and environmental health, some papers focused on showing the biochemical responses to the pollutants – as well as mental health and economical responses for humans (Câmara et al., 2021; Kwok et al., 2017; Laffon et al., 2013). All the spills selected for this paper presented short-term monitoring, which shows the worry with acute impacts in the areas where they happened. Research focused on chronical impacts was less present: of the eight spills, four presented medium-term monitoring and three long-term monitoring.

Sediments were analyzed in all the articles assessed in this work, especially because PAHs are hydrophobic compounds and tend to accumulate in sediments (Table 1). Sedimentary PAHs concentrations usually decreased with time even in short time spans. For instance, initial PAHs concentrations of 4547 ng g^{-1} decreased until 163 ng g^{-1} six months after the Gladstone accident (Melville et al., 2009); and from a peak as high as 17,033 ng g^{-1} (Pérez-Cadahía et al., 2004) to values between 66.9 ng g^{-1} and 329.5 ng g^{-1} (Izagirre et al., 2014) in a mussels (*Mytilus galloprovincialis)* 5 years after the Prestige oil spill. Bivalves and fish were present in most of the papers (Table 1) since they're already known as good for evaluating ecotoxicological impacts and some species are highly consumed by people and impact directly on the economy (Câmara et al., 2021; de Oliveira Estevo et al., 2021; Obida et al., 2018) and human health (Krishnamurthy et al., 2019; Kwok et al., 2017; Laffon et al., 2013; Nriagu, 2019). Right after the Prestige spill, the consumption of mussels was risky due to its high toxicity levels, which reached up to 17,003 µg kg^{-1} (Pérez-Cadahía et al., 2004); four years later the PAHs values decreased to a range of 66.9 - 329.5 µg kg^{-1} (Izagirre et al., 2014). Ecological assembles and interactions were impacted by the leaks with changes in the presence of animals, for example: minor changes in the sea lion population after the 2001 oil spill in Galapagos (Salazar, 2003) and species immigrating from the oiled areas after the DWH spill which caused disturbance in the nekton communities (Martin et al., 2020).

Table 1 – Data found for Total Hydrocarbons (THC) in sediments, polycyclic aromatic hydrocarbons (PAHs) in sediment, water, and biota samples for each of the 8 selected oil spills.

Oil spill	Year	THC sediment (ng/g)	PAHs sediment (ng/g)	PAHs water (ng/L)	PAHs biota (ng/g)	Orgasnism	Reference
Jessica	2003	400 - 48,900					Kingston et al., 2003
Prestige	2004			4 - 55,142	5,978.8 - 17,033.0	*Mytilus galloprovincialis*	Pérez-Cadahía et al., 2004
	2007				101 - 190.63	*Larusmichahellis*	(Alonso-Alvarez et al., 2007)
	2008		n.d. - 323		27,000 - 39,000	*Arenicola marina*	(Morales-Caselles et al., 2008)
	2014				66.9 - 329.5	*Mytilus galloprovincialis*	(Izagirre et al., 2014)
Gladstone	2008		<105 – 9,805				(Andersen et al., 2008)
	2008		<105 - 658				(Melville et al., 2009)
Hebei Spirit	2013		1,200 - 530,000				(Lee et al., 2013)
	2014		0.9 - 116				(Seo et al., 2014)
Ogoniland	2016				3.67 - 105 7.5 - 35.8 45.9 - 171.9	*Crassostrea virginica* *Littorina littorea* *Periophthalmus koeleuteri*	(Nwaichi & Ntorgbo, 2016)
Montara	2016	300 - 2,600	1.8 - 11.2				(Burns & Jones, 2016)

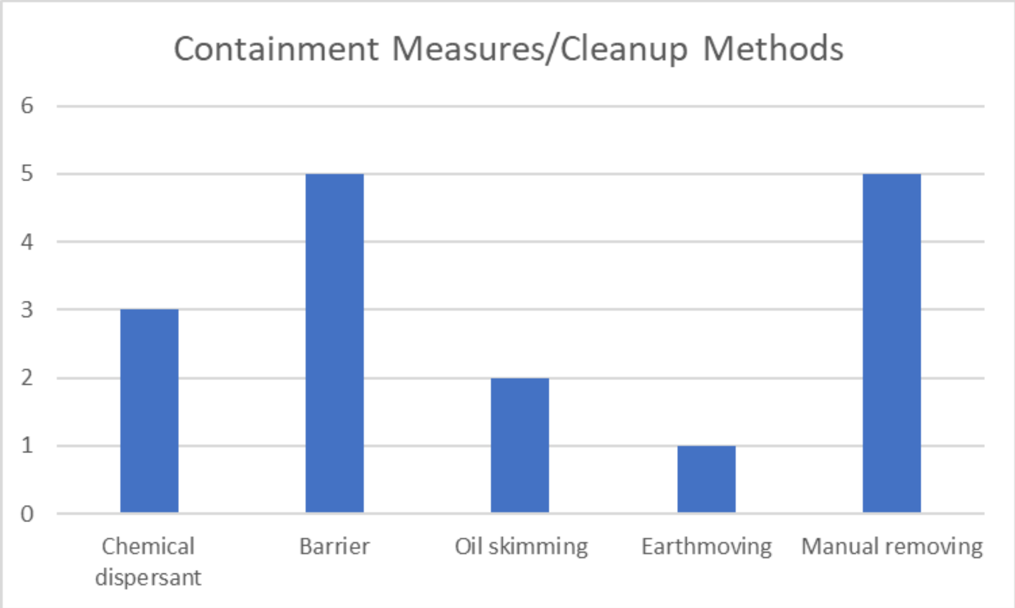
DeepWatcer Horizon	2016	7.2 - 252			(Liu et al., 2016)
Brazil	2021	<0.01 - 275.49	14.28 - 32.06	*Diapterus rhombeus*	(Soares et al., 2021)
			29.88 - 114.63	*Anomalocardia brasiliana*	

Fonte: produced by the authors.

During the first year after the Prestige oil spill the economic losses were estimated to be sixty-five million Euros (Garza-Gil et al., 2006), the same happened after the 2010 spill in the Gulf of Mexico with the stone crab (*Menippe mercenaria*) industry losing fifteen million dollars (Rohal et al., 2020). Along with the economic issues, humans also faced health issues; some short-term, such as back pain, headache, nausea, and respiratory tract irritation (Krishnamurthy et al., 2019; Na et al., 2012; Pérez-Cadahía et al., 2007); and other issues lasted more than five years, with people who participated in the cleanup of the shore after the DeepWater Horizon oil spill reporting heart disease and fatal coronary health issues (Strelitz et al., 2019) or changes in hormonal patterns (Laffon et al., 2013), since PAHs have endocrine disrupting effects. In Nigeria, the 2008 Ogoniland and later oil spills generated public health issues for thousands of people (Obida et al., 2021), including miscarriages and increase of sexually transmitted infections due to prostitution related to the influx of male workers to the region (Nriagu, 2019), and these consequences are still present to this day.

To mitigate the impacts, containment measures were applied: barrier, chemical dispersants, and oil skimming (and it is possible to observe in Figure 3 which were applied in the discussed spills). A combination of methods was used in 4 spills, with barrier method + chemical dispersants being the most common, as seen in the DWH and the Hebei Spirit spills. Oil skimming was used on both spills on the Australian coast (Andersen et al., 2008; Burns and Jones, 2016). As the oil got closer to the shore and/or as tars appeared on the beaches the cleanup was done by manual removing, especially by volunteers and fishermen; only the Prestige oil spill used earthmoving as a cleanup method at some beaches (Fernández-Álvarez et al., 2006).

Figure 3 - Containment measures and clean up methods used and their frequency.



Fonte: produced by the authors.

Barrier method was used on the Jessica, Hebei Spirit, Montara, DeepWater Horizon and Brazil oil spills. Chemical dispersants were used to contain three spills: Hebei Spirit, DeepWater Horizon and Brazil. For the cleanup all spills, except the ones on Nigeria and Australia, had people manually removing the oil and tars from the sea and the beaches.

Unfortunately, no data was found on the Ogoniland oil spill, but the United Nations Environment Programme (UNEP) published a study in 2011 evaluating the local impacts (Unep, 2011). This and other studies (Adesipo et al., 2020; Sam et al., 2017a, 2017b; Zabbey et al., 2017) presented plans and techniques that can be applied to clean up the area, and since Ogoniland has been suffering with oil leaks for over 20 years, as the ones occurred in 2008 and 2009, it can take decades for the environment to be healthy again.

5. Considerações finais

The data presented on this work shows that the lack of planning for mitigating oil spills is a common factor around the world, and throughout the years this has been harming the environment and human lives causing similar damages. It also shows the importance of long-term monitoring to understand how the pollution affects biota and to verify the contamination levels to guarantee they are safe for human consumption. Since coastal cities tend to depend on the ocean for food supply, humans who consume oil contaminated seafood and/or fish can develop hormonal, neurological and other health issues which are also important to consider for long-term monitoring.

Collect, compare, and spread information on past oil spills is important to find a pattern in its consequences and on how we deal with them. Understanding the mistakes on decision making and the fails on contingency plans can north governments and scientists to better plan containment measures and cleanup methods. These can help with mitigation factors for the 2019 Brazilian oil spill, for other recent spills and for future ones.

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