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Reuse of the crude oil spilled on the Brazilian Coast in 2019 as an alternative fuel in the cement industry

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ABSTRACT

In 2019, a crude oil spill disaster on the Brazilian Coast, known as the most extensive environmental disaster in the country's history, reached 1,000 km of Northeast and Southeast regions and affected 11 states, 130 municipalities, 1,009 locations, and also, compromised protected areas and the subsistence of thousands artisanal fishers. This unprecedented environmental catastrophe started to be observed in August 2019 and lasted until March 2020, and despite the extreme circumstances it did not receive the required attention in a short period of time from the Brazilian Federal government, whose inaction led to greater long-term consequences. After chromatography analysis, it was proven that the crude source was from an oil tanker on the way from Venezuela to South Africa. In accordance with Brazilian Navy reports, it was collected 5,379.76 tons of waste which was reused as an alternative fuel in cement industries - in order to substitute, even partially, fossil fuels (such as coke and coal) - instead of being disposed of in landfill, since of the seven cement factories in the Northeast region, five received the amount of oil waste collected on the coast. In such context, this article, analyzing the mentioned oil spill disaster as a case study, aims to present the official data related to the amount of oil recovered, as well as its respective destination, since there has been no wide dissemination of such information even in light of the seriousness of this tragedy. Therefore, it was made an assessment about the reuse of crude oil from Brazilian waters' spill as an alternative fuel in cement kilns. The methodology is predominantly theoretical and bibliographical, since it is based on systematic bibliographic review focused on official reports and secondary data. The first stage of this study involved the identification of the primary data related to crude oil information of the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) that was accessed based on the Information Act (Law No.12527). In addition, a secondary data was obtained from external access to scientific papers from Science Direct database. In this case study, it was observed that the reuse of the crude from the oil spill as a fuel shows to be a promising application of waste recovery technology for energy purposes in cement industries due to its ability to reuse the amount of oil that would previously be disposed of in landfill, very probably without recycling and treatment.

Keywords: oil spill, Brazilian coast, cement industry, energy recovery, alternative fuel.

1 INTRODUCTION

In 2019, a crude oil spill disaster on the Brazilian Coast, known as the most extensive environmental disaster in the country's history, reached 1,000 km of Northeast and Southeast regions from Maranhão to Rio de Janeiro state and affected 11 states, 130 municipalities, 1,009 locations, and also, compromised protected areas and the subsistence of thousands artisanal fishers. This unprecedented environmental catastrophe, illustrated in Figure 1, started to be observed in August 2019 and lasted until March 2020. Despite the extreme circumstances, it did not receive the required attention in a short period of time from the Brazilian Federal government, whose inaction led to more significant long-term consequences.



Figure 1. *Oil spill at Carneiros Beach (located in Pernambuco State) in 2019. Photo: Bruno Campos/JC Imagem/Folhapress (Thomas, 2019)*

The specifications that make this environmental disaster so particular are the characteristics of the oil spill, mainly because the crude oil could not be seen from the surface and also, the number of ecosystems and protected areas (over 55) affected, and the lack of measures taken by the government as well (Soares et al., 2020).

This oil spill is considered the most extensive (2,890 km) recorded in tropical waters, as shown in Figure 2, causing long-term negative impacts (such as chemical contamination) to marine biodiversity including ten ecosystems, affecting over 57 protected areas and 34 species (Soares et al., 2022). In accordance with the Brazilian Federal Police, it was proven after chromatography analysis that the crude source was from oil tanker on the way from Venezuela to South Africa (Brasil, 2022).



Figure 2. *Locations affected by the oil spill on the Brazilian Coast from August 30 2019 to March 19 2020 (IBAMA, 2023)*

Energy recovery from waste has gained more visibility in Brazil after the oil spill on the Coast in 2019 was reused as a fuel in co-processing industries, and in this way, the application of high calorific residues for energy purposes has shown to be possible, besides avoiding its final disposal in landfills. In Brazil,

co-processing has shown itself as the most promising way to use energy from waste compared to other waste-to-energy technologies due to the annual processing of 2.5 million tons of waste in the country (ABCP, 2022) and a thermal substitution rate of 35% concerning petroleum coke.

The article aims to present an analysis of the co-processing of waste material in cement kilns from the oil spill in 2019 on the Brazilian Coast based on official reports and secondary data, since no relevant information has been released regarding the crude oil collected in this environmental disaster.

2 METHODOLOGY

The methodology is predominantly theoretical and bibliographical, since it is based on a systematic bibliographic review focused on official reports and secondary data. The first stage of this study involved identifying the primary data related to crude oil information from the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) that was accessed based on the Information Act Law No.12527 (Brasil, 2011). In addition, secondary data was obtained from external access to scientific papers from Science Direct database.

3 DISCUSSION AND ANALYSIS

Burning alternative fuel (AF) from waste contains about three times less ash than burning coal (Mlonka-Medrala et al., 2021). The transforming process from solid waste into alternative fuel demands the control of some parameters to maintain a high calorific value and better fuel performance, such as chlorine, fluorine, sulfides and moisture content. Particle size is also a limiting factor in some processes because if the particles remain suspended, they can be deposited inside certain equipment. According to Sampaio (2014), the main production stages of this treatment process are 1) the sorting process, 2) drying, 3) initial grinding, 4) magnetic separation, and 5) final grinding. Figure 3 shows a superior view from an alternative fuel pre-processing plant.



Figure 3. *Alternative Fuel (AF) Pre-Processing Plant in Brazil. Photo: Érica Guerreiro*

It is very important that waste treatment is separated by the material types, in particular, segregation by shape and size, such as 2-D (two dimensional) and 3-D (three dimensional), since cubic particles have different combustion behaviour compared to flat ones (Sarc & Lorber, 2013).

The cement industry corresponds to the most prominent application of alternative fuels – in which they are responsible for more than 70% of the total energy use - and also is justified by the high temperature over 2000ºC during the combustion conditions (Galko et al., 2023). Energy recovery from waste has significantly contributed to the circular economy as an alternative fuel production over the last few years

(Sehata et al., 2022) due to the use of combustible materials such as plastics, paper, cardboard, wood and textiles (Huang et al., 2022).

The majority amount of oil collected from the Brazilian Coast was mixed with other types of waste, as shown in Figure 4, to be transformed into a high calorific energy blend, which was burned as fuel in the cement kilns.



Figure 4. *Oil collected from the oil spill in Recife State. Waste transformation into alternative fuel. Photos: Bobby Fabisak/JC Imagem (Vieira, 2019)*

According to the Brazilian Navy, responsible for the investigation, it was collected 5,379.76 tons of waste - 30% of which was oil equivalent. Table 1 shows the reported amount of waste collected per state in the areas affected by the oil spill.

Table 1. *Amount of waste collected per state after the environmental disaster in 2019*

State	Waste Collected by Petrobras[a] (tons)	Waste Collected by Local Organizations[a] (tons)	Total Amount of Waste Collected[a] (tons)
Alagoas	16.09	2,548.49	2,564.58
Bahia	95.03	364.46	459.49
Ceará	0.00	39.76	39.76
Espírito Santo	0.00	6.26	6.26
Maranhão	0.01	13.68	13.69
Paraíba	0.00	0.85	0.85
Pernambuco	29.84	1,646.42	1,676.26
Piauí	0.00	10.46	10.46
Rio de Janeiro	0.00	0.00	0.00
Rio Grande do Norte	12.16	33.83	35.18
Sergipe	356.19	213.16	569.35
Offshore	1.00	2.88	3.88
TOTAL	**510.32**	**4,880.25**	**5,379.76**

[a] Public data provided by IBAMA from Access to Information Law (Brasil, 2011). Accessed on May 16th, 2022.

In addition, based on external access to public data from the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), part of the oil was disposed of in Class I landfills (for hazardous waste) while the other amount of oil was mostly destined to cement kilns with license for co-processing for energy generation purposes (as shown in Table 2), such as the facilities of Votorantim Cimentos in Laranjeiras (located in Sergipe State) and Sobral (located in Ceará State), Mizu Cimentos (located in the city of Baraúna, Rio Grande do Norte State), InterCement (located in Bahia State) and Cimenteira APODI (located in Ceará State).

Table 2. *Quantity and destination of oil collected from the Brazilian Coast*

State	Total Amount of Oil Collected[a] (tons)	Temporary Storage[a]	Transportation[a]	Destination[a]
Alagoas	2,564.58	Petrobras Waste Management Center in Carmópolis (located in Sergipe)	Petrobras	Votorantim Laranjeiras (located in Sergipe) and Mizu Cimentos in Baraúna (located in Rio Grande do Norte)
Bahia	459.49	Petrobras' Waste Management Center in Carmópolis (located in Sergipe) and CETREL (located in Camaçari)	State	InterCement and Waste Treatment Center CTR-Bahia
Ceará	39.76	-	State	APODI Cement (located in Ceará)
Espírito Santo	6.26	São Luiz da Barra and São Mateus	State	Class I Landfill of Vitória Ambiental
Maranhão	13.69	IBAMA, Tutóia, Port Authority of São Luiz and Waste Center in Parnaíba (located in Piauí)	State and Petrobras	Class I Waste Management Center of Tiara and Votorantim Cimentos in Sobral (located in Ceará)
Paraíba	0.85	Cabedelo	State	Class I Metropolitan Landfill of João Pessoa

[a] Public data provided by IBAMA from Access to Information Law (Brasil, 2011). Accessed on May 16th, 2022.

Thus, according to Ecoparque Pernambuco's, an amount of 1,562 tons of crude oil were collected only from the coast of Pernambuco State, which were destined to LafargeHolcim cement facility in the form of energy blend after treatment.

It is possible to verify that a part of the oil collected from the beaches of the North-eastern Coast was reused energetically as alternative fuel in co-processing industries instead of being disposed of in landfills, confirming the feasibility of energy recovery from waste.

4 CONCLUSIONS

The present study aimed to bring to light the main information related to the oil spill on the Brazilian coast in 2019, whose large amount has been successfully co-processed. It showed that most part of the oil waste was transformed into alternative fuel in the cement industries. Therefore, co-processing from crude oil spills showed to be a promising application of waste recovery technology for energy purposes due to the ability to reuse the amount of oil that would previously be disposed of in Class I landfills, very probably without recycling and treatment.

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For those who believe in science.

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