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Monitoring and Control of Hydrocarbon Contributions in Coastal Waters: Importance and Methods.

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ABSTRACT

Despite the increasing focus on environmental protection, particularly of the marine environment, the extent of pollution caused by human activities remains unclear. The discharge of pollutants into the ocean continues to be a major issue, and the true magnitude of the damage caused is still unknown. The purpose of this study is to shed light on this problem by examining the collective consciousness of society and the role of the media in bringing attention to the issue of hydrocarbon contamination of the marine environment.

The study seeks to determine if all sources of hydrocarbons reaching the ocean receive equal attention in the media, and whether there is a lack of pressure from society and the media on the adoption and enforcement of legislation to address this issue. Regardless of the origin of these hydrocarbons, it is crucial that the issue receives the necessary attention and resources to effectively combat its effects on the marine environment.

In order to obtain this information, the most popular methodologies for studying and detecting contaminants are reviewed. A comprehensive analysis of these pollutants and their detection models is essential for obtaining a better understanding of their impact on the marine environment. Only by quantifying the extent of the problem can we begin to implement effective solutions to protect our oceans and ensure their health for future generations.

1. Introduction.

The presence of hydrocarbons in the marine environment can have various sources, both natural and anthropogenic. Natural sources of hydrocarbons include percolation from the earth's crust, release from vegetable waxes, and input from marine organisms (Guadalupe Meniconi et al., 2002). However, it is estimated that natural sources account for only about 6% of the total hydrocarbon concentration in the ocean, with the remaining 94% being attributed to human activities such as industrial and domestic practices (The National Academies of Sciences Engineering and Medicine, 2022).

2. Collective Awareness of Marine Pollution from ships.

Marine pollution generated by ships is a widely discussed topic in the media, opinion articles, and on social networks. We often come across references to the devastating consequences of oil spills caused by ship accidents and the illegal dumping of oily water by ships during nighttime. "Ship pollution" has become a well-known issue due to its prominence in the media. It can be argued that there exists a collective awareness of the problem among the general public.

If we scan through these types of posts, we can find comments such as:

The 16 largest ships in the world pollute more than all the cars circulating around the world combined. Several of those ships are actually tankers that transport oil or crude from one place to another. (Arcos, 2022)

Maritime transport contaminates thousands of times more than land transport. It is an indisputable fact that, despite its

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growing role in the economy, the shipping industry lags significantly behind other sectors in its efforts to reduce the air pollution it produces. (Bravo & Buschell, 2019)

The disinformation to which citizens are exposed regarding the pollution produced by ships is favored by the complexity of the maritime sector in general and the operation of ships in particular. In certain texts that refers the discharge of sewage[2], it is common to find images of crude oil spills and articles about bilge dumping[3] are accompanied by images of fauna soaked in crude oil (Deutsche Welle, 2022), which could facilitate the misinterpretation. Obviously, the damage that hydrocarbons from ships can caused to marine environment should not be ignored or underestimated, but for the same reason, the silent chronic pollution of the sea that is generated from land should not be neglected either.

International maritime regulations, driven by the significant impact that oil spills have on society, the environment, and the economy, have been increasingly stringent in their requirements for ships to reduce their harmful emissions. Initially, the focus was mainly on hydrocarbons, but regulations have been developing and expanding objectives such as microplastics, which have received a lot of media attention, and sulfur emissions. The aim of these regulations is not only to prevent these substances from reaching the ocean, but also to protect the atmosphere. In addition to having increasingly sophisticated waste management equipment, vessels are frequently evaluated to ensure that their waste is properly managed (International Convention for the Prevention of Pollution from Ships (MARPOL), 1973; Directive (EU) 2019/883 of the European Parliament and of the Council of 17 April 2019 on Port Reception Facilities for the Delivery of Waste from Ships., 2019).

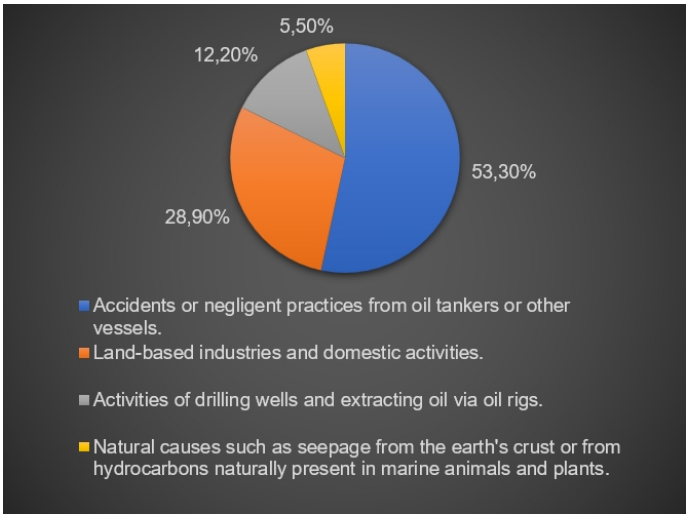
In regards to waste discharged into the sea from land, it is not only due to accidents or negligence like what ships can cause, but also from a continuous flow of effluents containing unknown substances. Examples of pollutants from land that reach the marine environment include urban wastewater discharge, direct emissions from industries, runoff from gullies, roads, and other land-based infrastructure, the contribution from rivers, and the arrival of fertilizers from farm fields through river drainage systems. (The National Academies of Sciences Engineering and Medicine, 2022).

To gain a brief insight into the views of the general public, a survey consisting of a single question was conducted. A random sampling was carried out, choosing the respondents at random, which guarantees that any member of the population has the same probability of taking part, since the information on age, profession, or academic or cultural level was not relevant. It was just randomly distributed like one of those oil slick reports on TV. It was made clear that it was an opinion question and that there was no correct or incorrect answer to prevent respondents from wanting to get it right. To the question: *In your opinion, what do you think is the main source of hydrocarbons into the ocean?* Four options were offered. The choices were the following:

- Accidents or negligent practices from oil tankers or other vessels.
- Natural causes such as seepage from the earth's crust or from hydrocarbons naturally present in marine animals and plants.
- Activities of drilling wells and extracting oil via oil rigs.
- Land-based industries and domestic activities

The results obtained from the survey are shown in *Graph 1*. A total of 200 people of different ages and cultural levels participated in the survey, ranging from young people in secondary education to senior citizens. The results showed that over 50% of those surveyed believe that ships are the main cause of hydrocarbon spills in the ocean. The remaining 50% of the participants were divided among other sources, with a clear predominance towards land-based industrial and domestic activities. It is worth noting that the survey provides valuable insights into public perception on this issue, which can inform and guide efforts towards addressing the problem of hydrocarbon releases in the marine environment.

Figure 1: Opinion poll results.



Source: Author.

3. Marine pollution by hydrocarbons.

Trying to determine the percentages of contribution of hydrocarbons to the marine environment according to their origin is currently impossible (Ministerio para la Transición Ecológica y el Reto Demográfico, 2019). Although crews in vessels know the quantities of all their oily products on board, the same cannot be said for oily mixtures that reach the ocean from land. Even in the hypothetical case in which all the urban wastewater treatment plants and drainage pipes, as well as industrial emissions were controlled, the arrival of hydrocarbons from rivers

[2] Annex IV of the MARPOL Convention defines sewage as drainage from toilets, urinals, medical premises spaces containing living animals.

[3] The bilge waters are mixtures of water and different residues from the ship´s engines.

or runoff waters caused by rains could only be determined with frequent sampling at the release point.

Focusing on hydrocarbons, the enormous variety of types of these compounds together with their water-repellent characteristics make them a great challenge when it comes to managing them to avoid environmental damage (Farrington & Takada, 2014). The hydrocarbons that reach the sea will evolve according to a series of processes that will depend on their properties, environmental conditions, and state of aging, thus making them difficult to control. The situation is further compounded by the toxic, mutagenic, and carcinogenic characteristics of aromatic hydrocarbons (Kuppusamy et al., 2020), as well as their persistence in the marine environment (Wattayakorn, 2012). For this reason, their introduction into the marine environment, making them available to biota, is a matter of great concern from the environmental and safety point of view for our own specie. There are many studies that confirm the potentially lethal and sublethal effects of different species after their contact with hydrocarbons, not only in the striking oil slicks, but also in concentrations that are imperceptible to the human eye (Hook et al., 2016; Perliński et al., 2021). In addition, these hydrocarbons can accumulate in the fatty tissues of individuals that will incorporate them into the trophic chain (Ministerio de Sanidad, 2017).

4. Record of the release of hydrocarbons into the marine environment.

Given the aforementioned information, the importance of thoroughly controlling the release of hydrocarbons into the marine environment becomes clear. One effective way to monitor and record these contributions is through continuous surveillance using seawater, sediment, or biota sampling at pre-selected coastal points. The information obtained from these samples will provide more than just knowledge about the water quality conditions, it will serve as a valuable tool for making comparisons in case of acute spills or to track changes over time. It is important to note that the monitoring model must be constantly updated to adapt to changes in the study areas, as a rigid, unchanging model would quickly become obsolete. As a result, ongoing monitoring of activities such as population density, river contributions, maritime traffic, tourist pressures, etc., is essential to effectively regulate pollutants in coastal waters.

The choice of the method of analysis is also presented as a point of vital importance, since not all methods are suitable for all hydrocarbons (Yang, 2011). Regarding the available methods, the most widely used are gas chromatography, infrared spectroscopy and high-performance liquid chromatography (HPLC). However, it will also be necessary to decide whether to analyze total hydrocarbons, aromatic hydrocarbons or aliphatic hydrocarbons. Prior to the analysis, regardless of the method, the extraction of the sample is required, whose procedure will depend on the selected analytical method. Total hydrocarbons can be measured using infrared spectroscopy or ultraviolet fluorescence spectroscopy techniques, which are very useful methods in the environmental and food sector (de Fuentes Navarta et al., 2008), but do not reach the sensitivity of chromatography of gases and cannot determine the fractions separately (American Society for Testing and Materials, 2003). To obtain the separated aliphatic and aromatic fractions, a gas chromatograph or HPLC will be necessary, in addition, in the measurement of the aliphatic hydrocarbons, the concentration of the unresolved hydrocarbon mixture (UCM) will be detected. UCM concentration consists of hydrocarbons combination that are extremely difficult to separate and analyze. For example, some lubricating oils contain a percentage of 96% of UCM, so the identifiable fraction is a minimal portion (Fingas, 2016).

Conclusions.

The perception that maritime transport is solely responsible for releasing hydrocarbons into the marine environment is not only unfair but also hazardous, as it prevents the attention of society and governments from focusing on the whole problem. Regardless of the source of hydrocarbon discharge into the ocean, careful control of referred contribution is essential to avoid ignorance and the risk of an uncontrolled and continuous discharge. A comprehensive monitoring model that characterizes the location and potential sources of hydrocarbon releases, as well as regularly updates information, is presented as the most appropriate option to obtain a continuous record of the contribution of hydrocarbons to coastal waters. A suitable detection model will offer valuable information to know the quality of the water and the evolution of the pressures it supports, as well as the possibility of comparing different areas and different moments.

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