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REVIEW

Review of the implications of oil dispersants on the environment, aquatic and human health

Revisión de las implicaciones en el ambiente, salud acuática y humana de los dispersantes del petróleo

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ABSTRACT

Introduction: oil spills pose a significant threat to ecosystems and human health. In Ecuador, multiple incidents have demonstrated the environmental and social consequences of these events, such as the recent spill in the Esmeraldas River in 2025, where chemical dispersants were used to contain the pollution. This study aimed to critically review the recent scientific literature on the types of dispersants used in oil spills, their mechanisms of action, and environmental and health effects.
Method: a qualitative methodology was applied through a bibliographic review of scientific and technical sources (2010-2025), prioritizing studies in tropical contexts or similar to Ecuador's. Research on the toxicity of dispersants, effects on aquatic organisms and humans, and their practical application in spills is included.
Results: seven dispersants were identified: Corexit 9500, Finasol OSR 52, Superdispersant-25, Dasic Slickgone NS, F-50, SEACARE CITRUS, and HD 865 Plus. While some, such as SEACARE CITRUS and HD 865 Plus, are biodegradable and exhibit lower toxicity, others, such as Corexit 9500, have raised concerns about their adverse effects on marine fauna and exposed workers. Overall, the evidence shows that, although these compounds facilitate crude oil biodegradation, they can also affect the resilience of aquatic ecosystems and pose subclinical risks to humans.
Conclusions: it is urgent to conduct more research in Latin American contexts to assess the long-term risks of chemical dispersants. This information is key to guiding responsible decisions in environmental management and public health in the event of future spills.

Keywords: Oil Spill; Chemical Dispersants; Environmental Impact; Human Health; Aquatic Ecosystems.

RESUMEN

Introducción: los derrames de petróleo representan una amenaza significativa para los ecosistemas y la salud humana. En Ecuador, múltiples incidentes han demostrado las consecuencias ambientales y sociales de estos eventos, como el reciente derrame en el río Esmeraldas en 2025, donde se usaron dispersantes químicos para contener la contaminación. Este estudio tuvo como objetivo revisar críticamente la literatura científica reciente sobre los tipos de dispersantes utilizados en derrames petroleros, sus mecanismos de acción y efectos ambientales y sanitarios.
Método: se aplicó una metodología cualitativa mediante revisión bibliográfica de fuentes científicas y técnicas (2010-2025), priorizando estudios en contextos tropicales o similares al ecuatoriano. Se incluyen investigaciones sobre la toxicidad de dispersantes, efectos en organismos acuáticos y humanos, y su aplicación

práctica en derrames.
Resultados: se identifican siete dispersantes: Corexit 9500, Finasol OSR 52, Superdispersante-25, Dasic Slickgone NS, F-50, SEACARE CITRUS y HD 865 Plus. Si bien algunos como SEACARE CITRUS y HD 865 Plus son biodegradables y presentan menor toxicidad, otros como Corexit 9500 han generado preocupación por sus efectos adversos en fauna marina y trabajadores expuestos. En general, la evidencia muestra que, aunque estos compuestos facilitan la biodegradación del crudo, también pueden afectar la resiliencia de ecosistemas acuáticos y representan riesgos subclínicos en humanos.
Conclusiones: se concluye que es urgente generar más investigación en contextos latinoamericanos para evaluar los riesgos a largo plazo de los dispersantes químicos. Esta información es clave para orientar las decisiones responsables en la gestión ambiental y la salud pública ante futuros derrames.

Palabras clave: Derrame de Petróleo; Dispersantes Químicos; Impacto Ambiental; Salud Humana; Ecosistemas Acuáticos.

INTRODUCTION

An oil spill is caused by the failure of oil pipes or conduits due to natural disasters or human actions. These types of incidents cause the pipes to rupture, resulting in an oil spill, which causes significant and, in many cases, irreparable damage to the environment. In these cases, the oil companies responsible for the extraction, production, or distribution of oil and its derivatives must bear the costs associated with repairing the affected pipelines, taking into account the technical evaluation of the damage, the necessary labor, and the clean-up work to mitigate the environmental impact, as well as the latent danger to the people living within their area of influence, as it impacts on their health, production systems and lifestyles.[1,2]

In Ecuador, throughout history, there have been several cases of environmental disasters related to the oil industry, especially oil spills, which have seriously affected the environment and local communities, the most significant being:

- 1972-1992: During Texaco's operations in the Ecuadorian Amazon, multiple oil spills were recorded, including the spill of 16,2 million barrels of crude oil due to accidents in the Trans-Ecuadorian Pipeline.[3,4]
- 1987: An earthquake caused the rupture of the Trans-Ecuadorian Pipeline, spilling several million gallons of oil that contaminated the Napo River and reached Peru.[3]
- 1989: A landslide caused the spill of 210 000 gallons of oil into the Napo River.[3]
- 2000-2008: 1,415 oil spills were recorded in Ecuador, according to data compiled by Acción Ecológica.[3]
- February 27, 2017: The rupture of a valve operated by the state oil company Petroecuador caused the spill of 20 barrels of oil at the Balao Maritime Terminal, forming a slick in the sea of approximately 3 km at Las Palmas beach.[5]
- April 7, 2020: The rupture of two oil pipelines and a polyduct in San Rafael, between Sucumbíos and Orellana, caused the spill of 15,800 barrels of oil and fuel, contaminating 360 km of the Coca and Napo rivers.[3]
- July 19, 2023: Due to a failure in the relief system during the process of light crude oil reversion and line packaging from ships through the Esmeraldas terminal, a spill of around 1200 barrels of oil occurred from Balao, contaminating the waters of the Las Palmas tourist resort.[5,6]
- June 27, 2024: A pipe burst in block 16 in Orellana, which, after rainfall in the area, advanced as far as the Napo River.[7]
- March 13, 2025: A landslide in Quinindé, Esmeraldas, caused the rupture of the Trans-Ecuadorian Pipeline System (SOTE), spilling 25,116 barrels of oil that affected rivers, mangroves and beaches. In the latter, as a measure to contain the oil spill, when it reached the mouth of the Esmeraldas River, the surface slick was treated by applying chemical dispersants sprayed by 21 vessels. These vessels also used the action of their propellers to generate turbulent currents, promoting the dispersion of the oil throughout the water column.[8,9]

Oil dispersants are chemical substances that break down crude oil spilled in tiny droplets in water columns and can be applied to surface or subsurface oil in a situation close to an uncontrolled oil spill.[10,11] There are three main types:

1. First-generation dispersants: Introduced in the 1960s, these products were similar to industrial cleaners and degreasers, with high aquatic toxicity. Due to their negative environmental impacts, their use has been discontinued. They are hydrocarbon solvents that break oil into droplets but are highly toxic

and no longer widely used.[12]

2. Second-generation dispersants (Type I): designed to treat oil spills at sea by spraying from boats and containing hydrocarbon solvents with low or no aromatic content and between 15 % and 25 % surfactants, they are applied undiluted and require a high proportion of dosage (between 1:1 and 1:3 dispersant to oil). Although less toxic than first-generation dispersants, they are less effective and can be more toxic than third-generation dispersants, which is why their use has declined in many countries.[13]

3. Third-generation dispersants: These are the most advanced, with formulations designed to be more effective and less harmful to the ecosystem because they are composed of mixtures of two or more surfactants combined with glycol and light petroleum distillate cartridges. The concentration of surfactants varies between 25 % and 65 %, which is higher than in the products.[13]

Using chemical dispersants to mitigate oil spills is a common practice aimed at minimizing the impact of crude oil on aquatic surfaces by promoting its dispersion in the water column. However, this strategy has raised significant concerns about its effects on the environment, aquatic health, biodiversity and the functionality of the ecosystem as a whole, because they are highly sensitive to changes in their physical, chemical and biological conditions, and oil spills significantly alter these factors, reducing habitat quality, the reproduction and survival of species and deteriorating essential ecological functions such as water purification and primary production[14,15] and in human health, due to the fact that exposure to polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) obtained from crude oil and the influence of temperature and meteorological conditions, through inhalation and skin contact, has been shown to be associated with an increased likelihood of headache, dizziness, difficulty concentrating, numbness/tingling sensations, blurred vision, memory loss/confusion and neurological alterations[16,17,18] and that, in the long term, they generate cardiovascular, respiratory, renal, hepatic and blood-borne conditions for cleaning workers and in local communities.[19,20,21,22]

In this sense, given the lack of clear consensus and the limited availability of research in Latin American or tropical contexts, such as the recent case of the spill in the Esmeraldas River, it is essential to carry out a critical review of the literature published in recent years to identify the main types of dispersants used, their mechanisms of action, documented effects and identify knowledge gaps, providing a solid basis to guide future research about environmental management and public health decisions due to the exposure of components and the alteration of the intestinal microbiota, which raise relevant questions about the possible systemic and subclinical effects of prolonged or repeated exposure to these compounds.[23,24,25]

METHOD

This study was developed using a qualitative approach through a bibliographic review of the scientific and technical information literature in March and April 2025 in scientific databases such as Scopus, ScienceDirect, PubMed, and Google Scholar, as well as in technical documents from Ecuadorian government agencies such as the Ministry of the Environment, Water and Ecological Transition; Petroamazonas; Petroecuador. The search terms used were: “oil dispersants,” “environmental impact of dispersants,” “toxicity of dispersants,” “human health and oil dispersants,” “Ecuador and chemical dispersants,” among others, combined with Boolean operators (AND, OR), including scientific articles, theses, technical reports and regulatory documents published between 2010 and 2025 with information on dispersants used in oil spills in locations similar to Ecuador and excluding those articles that did not present scientific evidence of the impact of dispersants or focused exclusively on land spills.

The information was analyzed qualitatively in a database and was grouped into three main categories: environmental impact, aquatic health, and human health.

RESULTS AND DISCUSSION

Chemical dispersants have become essential for responding to oil spills, particularly in aquatic environments. Their primary function is to break up oil slicks into smaller droplets, thus increasing the contact surface and facilitating biodegradation by native microorganisms. However, this apparent solution has significant ecological and health implications that must be rigorously evaluated due to the substantial toxic effects on marine organisms such as oysters, copepods, and fish.[26,27,28,29,30] Furthermore, studies on exposed workers revealed respiratory, skin, and eye irritation symptoms, pointing to possible occupational risks.[31,32] Combined exposure to oil and Corexit increased toxicity in fish up to 52 times compared to exposure to oil alone.[33]

For their part, Finasol OSR 52 and Superdispersante-25, authorized in Europe, have shown similar effectiveness in dispersing hydrocarbons but present lower toxicity compared to Corexit, particularly towards crustaceans.[34,35] However, there is no significant evidence regarding their chronic impact on marine and coastal ecosystems, which highlights the need for longitudinal studies.

Dasic Slickgone NS, another internationally approved dispersant, has been evaluated with mixed results.

Although it is considered less toxic than more aggressive alternatives, specific data on its long-term action in coastal environments such as Esmeraldas are scarce. In vitro studies suggest some cytotoxicity in fish cell lines, although at non-lethal levels.[33]

In Latin America, products such as F-50 and SEACARE CITRUS have gained notoriety due to their more environmentally friendly profile. F-50, based on surfactants, acts by reducing the viscosity of crude oil and favoring its dispersion without significantly affecting the immediate environment.[22] SEACARE CITRUS, formulated with biodegradable citrus extracts, represents a more ecological alternative. Its mechanical mode of action and low toxicity make it a candidate for sensitive ecosystems, although rigorous ecotoxicological studies that fully support its environmental safety are lacking.[23]

Finally, HD 865 Plus incorporates petrolyllic bacteria together with natural surfactants, which represents an evolution towards bio-enzymatic technologies and a bioremediation approach that aims to reduce adverse impacts on human health and marine biodiversity.[36] Although promising, this approach requires scientific validation under real spill conditions, particularly in tropical areas such as the Ecuadorian Pacific

Table 1. Oil dispersants and their impact on the environment, aquatic life and human health

Dispersant	Description	Environmental impact	Impact on Aquatic Health	Impact on Human Health
Corexit 9500 [29,30,31]	Chemical dispersant widely used in oil spills, especially during the Deepwater Horizon incident in 2010.	It can reduce the amount of oil on the surface of the water, but its use has raised concerns due to possible toxic effects on the environment.	Studies indicate toxicity in aquatic organisms, including invertebrates and fish. For example, it has been observed to inactivate certain aquatic viruses and negatively affect oysters and other shellfish.	Associated with respiratory, dermal and ocular irritation symptoms in workers exposed during clean-up operations.
Finasol OSR 52 [35,37]	Dispersant used in response to oil spills, approved for use in several European countries.	Evaluations indicate effectiveness in dispersing oil in marine environments; however, more research is needed on its long-term effects on the ecosystem.	Limited data available; some studies suggest that its toxicity is comparable to other dispersants, but more specific research is needed.	No significant adverse effects on human health have been reported, although information is limited.
Superdispersante-25 [34]	Chemical dispersant used in oil spill response operations.	Comparative studies indicate that it is less toxic than other dispersants such as Corexit 9527, but it may still present environmental risks.	It has been observed to have toxic effects on crustaceans and other marine organisms, although to a lesser extent than some other dispersants.	Limited information available; no significant adverse effects on humans have been documented to date.
Dasic Slickgone NS [33,34]	Dispersant used in the oil industry to control spills in marine environments.	Evaluations indicate that it is effective in dispersing oil, but more research is needed on its long-term ecological impacts.	Specific data on aquatic toxicity are limited; further studies are needed to determine its effects on marine biota.	Detailed information on human health effects is not available; caution is advised during handling.
F-50 [38]	Hydrocarbon dispersant that can be diluted in fresh or salt water.	It is made up of a mixture of surfactants that allow 15 % spilled crude oil to be quickly reduced without affecting the environment and is used in environmental remediation treatments.	No data have been found to indicate its use or effect on aquatic organisms related to oil dispersion.	No toxicity effects have been reported through inhalation, although it can cause gastric damage if ingested orally, it irritates the eyes and does not irritate the skin, although prolonged contact is not recommended.
SEACARE CITRUS [39]	Biodegradable and non-toxic dispersant based on water and citrus extracts, designed to disperse hydrocarbons spilled in bodies of water such as streams, rivers and lakes. It is applied directly to the spill with agitation of the area.	Due to its biodegradable and non-toxic composition, it is expected to have a reduced environmental impact compared to chemical solvent-based dispersants. However, specific information on long-term effects is limited.	There are no specific data available on its toxicity to aquatic organisms. It is assumed that its impact is less due to its non-toxic and biodegradable nature, but detailed studies are required to confirm this.	No significant adverse effects on human health related to the use of SEACARE CITRUS have been reported. However, as with any chemical agent, the use of personal protective equipment is recommended during handling to avoid possible irritation.

HD 865 Plus [36]	Concentrated dispersant used in hydrocarbon spills in water. Formulated with a mixture of petrolytic bacteria and natural biodegradable and non-toxic surfactants.	Designed to be biodegradable and non-toxic, suggesting a reduced environmental impact. However, it is recommended to evaluate on a case-by-case basis and consider the specific conditions of the affected environment.	The combination of petrolyllic bacteria and natural surfactants indicates an intention to minimize adverse effects on aquatic biota by promoting the biodegradation of hydrocarbons.	No significant adverse effects on human health related to its use have been reported. It is recommended to follow standard precautions when handling chemicals.

CONCLUSIONS

The evidence suggests that, although dispersants are helpful in emergencies, their application should be evaluated in terms of the type of ecosystem affected, the toxicity of the product, the environmental conditions, and the possibility of using complementary strategies such as physical barriers or bioremediation. However, their use is not without consequences. Dispersants such as Corexit 9500 have proven highly effective. They are also significantly toxic for aquatic organisms and potentially hazardous to human health, especially when adequate safety protocols do not accompany their use. More recent alternatives, such as Finasol OSR 52, Superdispersant-25, and Dasic Slickgone NS, have relatively lower toxicity profiles, although there is still no conclusive evidence on their long-term effects. In the Latin American context, products such as F-50, SEACARE CITRUS, and HD 865 Plus offer more sustainable approaches, especially because they are based on biodegradable components and petrologic bacteria. However, the lack of ecotoxicological field studies limits the generalization of their benefits and calls for long-term studies.

Given the variety of products available and the heterogeneity of the ecosystems affected, it is necessary to adopt a precautionary approach based on verifiable scientific evidence when choosing a dispersant, considering its immediate chemical effectiveness and collateral effects on biodiversity and human health. It is also recommended to complement its use with integrated response strategies such as physical barriers, biological remediation, and post-event environmental surveillance, as a key opportunity to strengthen environmental and health monitoring systems in spill emergencies, which in turn drives national research into safer and more sustainable dispersion technologies, tailored to the ecological characteristics of Ecuadorian rivers and coasts that can minimize the short-term impact on aquatic and human health.

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