

## Article

# Recovery Strategies of Contaminated Marine Sediments: A Life Cycle Assessment

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**Abstract:** This study performed a Life Cycle Assessment (LCA) on recovery strategies of dredged contaminated marine sediments in a large Mediterranean port located in central Italy (Tuscany) in order to find the most environmentally sound solution. The study considered marine sediments polluted by potentially toxic elements (PTEs) and/or organic compounds, two different sediment particle sizes and the combined use of three soil remediation technologies: soil washing, electrokinetic treatment and enhanced landfarming. The analyzed scenarios depended on the sediment properties and characteristics of the treatment technologies investigated, and were compared with the corresponding reference scenarios, consisting of the landfilling of dredged contaminated sediments. The LCA results show that scenarios associated with sediment recovery generated potential environmental impacts lower than the corresponding reference scenarios. Almost all the impact categories considered in the CML-IA baseline method showed an environmental convenience in the recovery of contaminated sediments, especially for abiotic depletion and global warming. Future studies should focus on optimizing the combined use of multiple technologies and reducing the resource consumptions related to their implementation in order to achieve both environmental and economic benefits.

**Keywords:** LCA; marine sediments; contamination; recovery; remediation; soil washing; electrokinetic; enhanced landfarming; PTEs; hydrocarbons



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## 1. Introduction

Nowadays, resource scarcity and climate changes are growing issues all around the world that researchers and practitioners will have to address in the near future [1]. Adopting “zero waste” thinking seems to be the right way for sustainable development [2]. These matters are part of the objectives of the circular economy, which calls for the resource recovery by considering waste as a product to be reused in order to achieve environmental and economic benefits without compromising the next generations [3,4].

In view of this, the recovery of dredged contaminated marine sediments represents a viable way to contribute to the ongoing paradigm shift. Indeed, marine sediments are often affected by pollution due to industrial, civil and port activities, and their removal is strictly necessary, involving very expensive operations in several aspects [5].

This study compared the potential environmental impacts due to the recovery or landfilling of contaminated marine sediments located in a large port of central Italy (Tuscany). Generally, management of marine sediments is governed by Italian Legislative Decree 152/2006, which provides guidelines for dredging activities, aimed at the maintenance of river and coastal areas, and for the reuse of decontaminated fractions after appropriate treatments. Until the recent past, the most common management strategy of contaminated marine sediments was landfill disposal; however, this option is considered a potential risk

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**Sediments** United States. Congress. House. Committee on Transportation and Infrastructure. Subcommittee on Water Resources and Environment,2001 *Strategies to Address Contaminated Sediments* United States. Congress. House. Committee on Transportation and Infrastructure. Subcommittee on Water Resources and Environment,2001 *House Report* , **Contaminated Sediments in Our Nation's Rivers and Harbors, Particularly in the Great Lakes** United States. Congress. House. Committee on Public Works and Transportation. Subcommittee on Water Resources,1990

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The year 2023 has witnessed a remarkable surge in literary brilliance, with numerous compelling novels enthralling the hearts of readers worldwide. Lets delve into the realm of popular books, exploring the engaging narratives that have enthralled audiences this year.

**The Must-Read :** Colleen Hoover's "It Ends with Us" This heartfelt tale of love, loss, and resilience has captivated readers with its raw and emotional exploration of domestic abuse. Hoover skillfully weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can succeed.

**Uncover the Best :** Taylor Jenkins Reid's "The Seven Husbands of Evelyn Hugo" This captivating historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reid's compelling storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery.

**Discover the Magic :** Delia Owens' "Where the Crawdads Sing" This captivating coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens spins a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting.

These popular novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of engaging stories waiting to be discovered.

The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts.

The Secret History is a masterful and gripping novel that will keep you speculating until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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