Circular management of beach litter: densimetric separation of natural and anthropic fractions

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Introduction

Accumulation of waste on coastlines is a common problem in the Mediterranean Sea with significant environmental and economic consequences. These accumulations, mostly consisting of biomass (e.g., *Posidonia oceanica*) and anthropogenic debris (e.g., plastics, wood, metals), are classified as urban waste (Legislative Decree 152/2006) and are not serviced by waste management consortia, leading to disposal primarily in authorized landfills. Although it is clear that maintaining the natural material is essential for preserving the coastal ecosystem, local authorities frequently face pressure to remove these deposits to improve beach aesthetics. Moreover, biomass accumulations are notably rich in anthropogenic materials. The collection and treatment of beach litter is crucial in safeguarding marine-coastal environments and recovering Secondary Raw Materials (SRM). This article presents the first results of an experimental study aimed at densimetric separation of natural inorganic fractions (i.e., sand) from organic fractions (i.e., *Posidonia oceanica*) or plastic anthropogenic wastes.

Materials and methods

The research activities involved sampling waste from the beaches of Mola of Bari and Fasano (Apulia, Italy). Samples were analyzed to determine the composition of organic natural fractions, mineral natural fractions, and anthropogenic waste. Each fraction was then chemically and physically characterized (e.g., granulometric analysis, ecological classification of plant species, sink-float for microplastic selection). Moreover, densimetric separation tests were conducted to separate *Oceanic Posidonia* from sand or plastic waste. These tests were performed by varying the three parameters of the densimetric table: air flow rate (V), vibration frequency, and inclination angle.

Results

The waste samples were separated into three fractions: natural organic, natural mineral, and anthropogenic. The natural organic fraction in both samples was the most prevalent, comprising approximately 80% of the total; the anthropogenic fraction was minimal (accounting for around 5%).

In beach waste collected from Fasano's, the plastic fraction was predominantly made up of PET (65%). This was followed by PS (23%), POM (8%) and other plastics (e.g., PE and PVC). This data shows a potential risk of lightweight plastic pollution.

The plastic composition in beach waste from Mola di Bari showed a significant difference from that of Fasano: PP constituted 43% of the total plastic, PET made up 25%, and POM accounted for 14%. Other plastics were present in smaller quantities (e.g., PVC represents just 0.2%).

With reference to the densimetric separation of beach waste, the best separation efficiency (exceeding 85%) was achieved with an inclination of 2°, a vibration frequency of 45 Hz, and an air flow rate of 60 Hz.

Conclusions

The densimetric separation tests demonstrated that optimal separation efficiency for mixtures of Posidonia and sand, as well as plastic and sand, can be achieved under specific operational parameters. The results indicate that densimetric separation may be an effective technique for efficiently sorting different beach waste fractions. This approach can contribute to reducing pollution and recovering secondary raw materials. However, further studies are needed to refine these methods and evaluate their scalability and economic feasibility for large-scale waste management applications. Additionally, investigating the environmental implications of recycling beach waste, particularly in coastal ecosystems, could provide valuable insights into sustainable waste management practices in the Mediterranean region.