Prediction of ocean debris drift trajectory and recovery range using a coupled numerical model

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ABSTRACT

Marine waste is now a global problem, especially for plastic bottles and plastic waste that are hard to decompose. These wastes not only put marine life at risk, but also damage the health of marine ecosystems. In order to understand the immediate drift and distribution of marine garbage so as to better manage marine garbage, the numerical study on the ocean debris drift in the western part of the Bohai sea is conducted in this paper. The influence of prominent factors, such as wind speed, wind direction, and garbage source, on the drift trajectory and range has been examined and discussed in detail. Furthermore, the marine garbage treatment program is analyzed. It is found that the topographical features of the location of the ocean waste source affect not only the length of the particle's final drift trajectory but also the particle's diffusion. The increase of wind speed will cause the accumulation of the marine debris, and the change of wind direction will periodically affect the drift distance and diffusion area of particles. The findings drawn from this study are instructive in the marine waste management in the western part of the Bohai sea.

KEY WORDS: marine debris, plastic bottles, plastic waste recycle, Bohai sea, drift trajectory.

INTRODUCTION

With the rapid development of coastal industry and agriculture and the rise of coastal tourism, more and more debris, especially plastic bottles and plastic waste, in the marine environment has caused serious pollution to the marine landscape, which will affect the health of the marine ecosystem and may threaten the safety of navigation, thus producing negative effects on the marine economy (Ordóñez, and Arenas, 2019). To better manage ocean debris including plastic bottles and plastic waste, which is an extremely important part of marine debris, it is necessary to understand the immediate drift and distribution of the marine debris.

The drift of marine debris is very complex and is influenced by external factors such as wind, ocean currents, and waves. To point out the mechanism and characteristics of marine debris drift, several related researches, and measurement tools have emerged in recent years (Purba and Faizal, 2019; Carlson, Suaria, Aliani, Fredj, Fortibuoni, Griffa, Russo and Melli, 2017; Handyman, Purba, Pranowo, Harahap, Faizal and Yuliadi, 2019). Moy, Neilson, Chung, Meadows, Castrence, Ambagis and Davidson (2017) conducted aerial surveys of the waters around each island of the Hawaiian Islands, collected high-resolution photos and processed them into orthophoto images, and conducted the visual analysis in GIS. Their study determined the amount, location, type and size of debris in the sea around the Hawaiian Islands at a macro level. Gutow, Ricker, Holstein, Dannheim, Stanev, and Wolff (2018) has conducted a multi-year survey of the distribution and composition of marine debris on the sea surface and seabed in the southeastern part of the North Sea over a considerable spatial coverage. Furthermore, they established an extensive database on the temporal and spatial distribution of marine debris.

However, methods such as aerial surveys or dragnet sampling surveys require a lot of time and cost and sometimes are not accurate or comprehensive. With the development of the computer, the numerical simulation method has been applied to the management of marine garbage. Politikos, Christos, George, and Kostas (2017) combined the circulation model with the Lagrange particle tracking model to simulate the migration of floating garbage in the Aegean Sea (eastern Mediterranean) of Greece. Numerical simulations of ocean debris drift span large scales of region and time, such as from Jakarta bay in Indonesian waters to the Pacific and Atlantic oceans, and from days to centuries. (Jasmin, Purba, Harahap, Pranowo, Syamsudin and Faizala, 2019; Van, England, and Froyland, 2012; Purba, Harahap, Prihadi, Faizal, Mulyani, Fitriadi, Pangestu, Atmoko, Alfatih and Sito, 2017)

However, most of the researches is based on fixed wind and flow conditions and there are few studies on the effects of changes in these parameters. Based on the preview research about the marine garbage problem, the wind and the flow situation of the Bohai sea is adopted to investigate the ocean debris drift trajectory and recovery range. In the present study, a numerical study will be made to examine the drift of marine debris under the action of wind and current. The influence of primary factors including wind speed, wind direction, and garbage source on the drift trajectory and range has been discussed. Section 2 presents the governing equations and corresponding numerical methods. Model validation is described in Section 3. Section 4 presents