Chapter 5
Examining the Effects of Mucilage in the Marmara Sea on Fisheries, Tourism, and Maritime Transportation via the System Dynamics Approach

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ABSTRACT

The Marmara Sea, which is of great importance for Turkey, has been facing a serious mucilage problem since the last quarter of 2020 due to various natural and human-induced factors. In addition to the negative effects of the observed mucilage explosion on the marine ecosystem and human health, studies in the literature emphasize the inevitability of critical negative economic consequences of mucilage, especially on the fishing, tourism, and maritime transport sectors. However, there is no study in the literature to analyze the effects of policies aimed at eliminating mucilage or preventing its re-emergence with a mathematical method. Therefore, in this chapter, a dynamic model is proposed to analyze the effects of the mucilage in the Marmara Sea on fisheries, tourism, and maritime transport. Here, the proposed conceptual and stock-flow models reflect the complex relationships among causes of mucilage, mucilage level, fisheries, tourism, and maritime transport sectors, and preventive actions.

INTRODUCTION

Covering an 11352 km^2 area in between the Mediterranean Sea and the Black Sea, the Marmara Sea is of great importance for Turkey since it has direct and indirect effects on many eco-systems, and vital economic potential for the region as a result of its geopolitical location. (Doğan, 2013). Based on 2020 population statistics more than 23.7 million people reside in the provinces of İstanbul, Kocaeli, Yalova, Bursa, Balıkesir, Çanakkale and Tekirdağ which are on the shore of the Marmara Sea; and this number constitutes approximately 28.35% of the whole population in Turkey (TURKSTAT, 2021). Among these provinces, especially İstanbul plays a critical role in the industry, finance, service, trade, transportation, logistics, and tourism sectors of Turkey. The basin of the Marmara Sea is displayed in Figure 1.

It is known that in the above-mentioned provinces, where population and industrialization along the shores are dense, industry-based pollution and pollution due to discharge of domestic wastewater have negative impacts on the Marmara Sea and the water sources that disembogue into there (Doğan, 2013). In addition, pollution as a result of maritime transportation is another factor that deteriorates the ecosystem in the Marmara Sea. (Taşdemir, 2002). Öztürk et al. (2021) list the causes that lead to pollution in the basin of the Marmara Sea as pollution that is carried with the upper layer of water from the Black Sea through the Bosphorus, nitrogen loads due to domestic wastewaters, and pollution as a result of industry-based wastewaters. These sources of pollution have led to a major problem in the Marmara Sea recently, which is known as "mucilage" in marine pollution literature. In fact, the mucilage issue is believed to have crucial negative impacts on especially fisheries, tourism, and marine transportation. Therefore, in this chapter, considering the complex nature of mucilage formation and the dynamic relationships between the causes and impacts of mucilage, the effects of mucilage in the Marmara Sea on fisheries, tourism and maritime transportation are examined by utilizing the system dynamics (SD) approach. The proposed conceptual model and the stock-flow model represent the complex mechanisms that lead to mucilage formation (i), the impacts of mucilage on the fisheries, tourism, and maritime transportation sectors (ii), and the consequences of several preventive actions that can be taken against existing mucilage or its re-occurrence (iii).

The rest of the paper is designed as follows: The definition of mucilage and the related studies in literature are given in the next section. That section also includes the mucilage problem in the Marmara Sea and the importance of the Marmara Sea in terms of fisheries, tourism, and maritime transportation. Next, brief information about the system dynamics approach is provided in the methodology section. Following that, the proposed conceptual model and the stock-flow model are given. The study is concluded with a brief discussion and further implications.

MUCILAGE AND RELATED STUDIES

According to the Mucilage Assessment Report prepared by the Turkish Academy of Sciences (2021), mucilage is a phenomenon that negatively affects fisheries and species diversity and causes serious problems on the ecosystem in the areas where it is observed. Danovaro et al. define (2009) mucilage as "small-sized lumps coming together with the effect of factors such as heating of the water surface and stratification in the water column". According to their definition, these lumps turn into formations that can reach hundreds of kilometers in size and distribution. Mucilage can cover the sea surface on the coastline; or can be observed as long filamentous and network structures spreading in the upper water

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