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OUTBREAK OF MARINE MUCILAGE IN THE SEA OF MARMARA IN 2021

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An outbreak of marine mucilage in the Sea of Marmara in the spring and summer of 2021 is described. Based on satellite data, an analysis of similar outbreaks in the previous decade was carried out. As shown, the current situation is unique both in terms of the water area coverage and phenomenon duration. The need for comprehensive research is emphasized in order to understand the causes of the occurrence of the marine mucilage and the consequences of its effect on the marine ecosystem and economic activities in coastal waters.

Keywords: marine mucilage, Sea of Marmara, marine ecosystem, satellite data, outbreak

Since the spring of 2021, extremely high agglomerations of marine mucilage were observed in the Sea of Marmara waters: on the sea surface, according to data from optical sensors, those reached areas of tens of square kilometers. The substance was previously recorded both in the Sea of Marmara basin (Aktan et al., 2008) and in other water areas (McKenzie et al., 2002 ; Precali et al., 2005), but the current situation indicated several new risks for the natural balance of marine ecosystems.

The marine mucilage is a colloidal substance that forms conglomerates ranging millimeters to dozens of centimeters long and becomes a substrate for microorganisms of various taxonomic ranks (bacteria, viruses, *etc.*) (Xu et al., 2013). This phenomenon has not been sufficiently studied. It seems to be associated with vital activity of some phytoplankton species (Lancelot, 1995). As considered, the occurrence of the marine mucilage is related to an increase in phytoplankton biomass or its response to stressors, with the last ones being not reliably identified (Balkıs et al., 2001 ; Danovaro et al., 2009).

With optical satellite sensors of medium and high resolution, the marine mucilage is recorded both as a suspension in the sea surface layer and as a floating substance. On RGB composites (from MSI Sentinel-2, OLI Landsat-8, MODIS Aqua sensors, *etc.*), the marine mucilage is usually seen as white to yellow long filamentary formations with increased brightness in convergence zones.

The authors of this work analyzed probable presence of the marine mucilage in satellite imagery since 2010. In addition to daily observations based on medium-resolution data, 440 high-resolution scenes and sets were analyzed (240 items from Landsat satellites, 187 items from Sentinel-2, and 13 items from Gaofen) on clear-sky days or days when the Sea of Marmara water area was recorded fragmentarily. To isolate areas with the marine mucilage, both RGB composites creating and multichannel approach with the elimination of the reflected radiation were applied.

It turned out that the marine mucilage occurs on the Sea of Marmara surface almost every year (except for 2014), mainly in March or April. Its outbreaks can be single or of a long-term nature. Until 2020, those were recorded by optical sensors for 1–9 days. Typically, areas with the marine mucilage were of several square kilometers.

In 2021, a different situation was observed. During March and almost all of April, the outbreak of the marine mucilage differed from that in previous years by a longer interval of presence on the sea surface and a larger volume in the water column. Since 29 April, an intensive increase in the floating marine mucilage was registered: first, in the Gulf of Gemlik and adjacent areas; then, in coastal zones in the western and eastern sea areas; and later (by 3 May), in nearly all water area. From 29 April to 26 June, the marine mucilage was almost constantly visible in optical images.

In 2021, the transfer of the marine mucilage through the Dardanelles into the Aegean Sea was observed for the first time as well. Since the late March, the transfer was repeatedly detected both on RGB composites and in images with the reflected radiation eliminated. On 9 June, the greatest transfer was recorded: the distance between the Dardanelles outlet and the Thassos island exceeded 150 km.

The outbreaks, such as in 2021, reveal several mechanisms of effect on the environment, due to which representatives of almost all levels of the trophic chains are subjected to negative impact. Specifically, an increase in the areas of the floating marine mucilage accumulation is accompanied by the effects of overheating: the temperature in a marine mucilage zone exceeds the surface temperature of the surrounding waters by 5–6 °C. Moreover, shading areas are formed limiting the intake of solar radiation into the subsurface water layers, and this affects phytoplankton vital activity. Furthermore, the marine mucilage is characterized by a decrease in surface tension and a wraparound effect resulting in the death of benthos (Özalp, 2021) and possibly fish and waterfowl. The question of the development of pathogenic microorganisms remains unclear; its probability is high, given the biological basis of marine mucilage.

The occurrence of the marine mucilage in extreme quantities can probably be analyzed from the point of view of a potential ecological disaster. Therefore, its further comprehensive study is urgent – by biological, chemical, satellite, and other methods.

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ЭКСТРЕМАЛЬНОЕ ПРОЯВЛЕНИЕ МОРСКОЙ СЛИЗИ В МРАМОРНОМ МОРЕ В 2021 ГОДУ

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Описано экстремальное проявление морской слизи в Мраморном море весной — летом 2021 г. На основе спутниковых данных проведён анализ подобных проявлений в предыдущее десятилетие. Показано, что текущая ситуация уникальна как по охвату акватории, так и по продолжительности явления. Отмечена необходимость проведения комплексных исследований для понимания причин возникновения морской слизи и последствий её воздействия на морскую экосистему и хозяйственную деятельность в прибрежных водах.

Ключевые слова: морская слизь, Мраморное море, морская экосистема, спутниковые данные, экстремальное проявление