ISSN: 2148-9173 **Vol: 9 Issue:3 September 2022**

International Journal of Environment and Geoinformatics (IJEGEO) is an international, multidisciplinary, peer reviewed, open access journal.

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Hasan Bora USLUER

Abstracting and Indexing: TR DIZIN, DOAJ, Index Copernicus, OAJI, Scientific Indexing Services, International Scientific Indexing, Journal Factor, Google Scholar, Ulrich's Periodicals Directory, WorldCat, DRJI, ResearchBib, SOBIAD

International Journal of Environment and Geoinformatics 9(3):084-090 (2022)

Research Article

Effects of Mucilage on Safety Navigation in the Turkish Straits

Hasan Bora Usluer

Galatasaray University, Maritime Vocational School, Çırağan Cad.,Nu.36,34349 Ortaköy-Beşiktaş/İstanbul

E-mail: hbusluer@gsu.edu.tr

Received: 13.11.2021
Accepted 25.01.2022

How to cite: Usluer, H., ,(2021). Musilage Effects on Ships at The Turkish Straits. *International Journal of Environment and Geoinformatics (IJEGEO)*, 9(3): 084-090. doi. 10.30897/ijegeo.1057466

Abstract

Mucilage, which has surrounded the Marmara Sea and the Turkish Straits in particular for the last few months, is a gel-like and slippery mass of microorganisms that are mostly clumped together and cover large areas, consisting of proteins, carbohydrates, and fatty acids released out of the body by single-celled organisms under stressful environmental conditions. Although the Turkish Straits sea area is the waterway connecting the Caspian Sea and the Mediterranean Sea, it is essential to transition for marine species. The mucilage effect on the filtration of the ship systems is caused by the seawater used by the ship's cooling systems during the passage through the straits. Due to the protection of local and global sea areas, a high level of attention is needed, especially on significant waterways located on the transit route of ships moving to many ports of the world serving global transportation such as the Turkish Straits. The study is trying to describe Mucilage's effects on ships during sailing at the Turkish Straits.

Keywords: Mucilage, Turkish Straits, Maritime Transportation, Navigation Safety, BWMS

Introduction

Mucilage has a different structure in marine habitats. It has known as foam or snow. Also known as aggregated mass, kind of flocs, cloud, or mucilaginous (Suzuki and Kato, 1953; Riley, 1963; Lancelot, 1995; Rinaldi et al., 1995; Piazzi et al., 2018; Özalp, 2021; Aksu et al., 2021; Savun-Hekimoğlu et al., 2021; Öztürk et al., 2021; Karadurmuş and Sarı, 2022; Gazioğlu et al., 2022).

According to a survey from Okyar et al., Some zooplanktonic taxa were identified in April–December 2008 in the Sea of Marmara. This survey showed that the Mucilage caused significant shifts in the Sea of Marmara of zooplankton abundance and community structure (İşinibilir, et al., 2015). According to Innamorati et al., Mucilage could damage fisheries, marine tourism industries, and marine ecosystems (Innamorati et al., 2001). Deterioration as a result of anthropogenic effects in the marine ecosystem directly affects the biological structures of the seas and changes their demographic characteristics. Some studies show remarkable evidence that this situation causes environmental changes.

The authorities of the Republic of Turkey immediately took action regarding the mucilage effect, which is frequently seen in the Sea of Marmara in the middle of 2021 and causes pollution in the sea. Not only have many studies been carried out after the mucilage epidemic in the Sea of Marmara in 2021, but a project call was made only for Mucilage within the body of TUBITAK works were started quickly. One of the studies focused on mucilage problems in closed seas and such as Sea of Marmara (Gazioğlu and Savun Hekimoğlu, 2021). The study examined the impact of mucilage on specific sectors such as ecology, fisheries, and tourism. Intense mucilage formation in the Sea of Marmara is being investigated by other studies (Balkis et al., 2021; Acar et al., 2021; Kavzoğlu et a., 2021; Hu et al., 2022). The authors imply that due to the excellent mucilage event, the habitat of the sea changed, and unobserved species became dominant. According to the findings of mucilage outbreaks in the Strait of Canakkale affect the surface creatures and threaten the coral habitat at 39-51 m depth of the sea. (Özalp, 2021).

Mucilage has been a problem since the beginning of 2000, which has increased dramatically in the Sea of Marmara. A study about mucilage investigations was showed potentially toxic species in the Sea of Marmara (Taş et al., 2020). Especially in May 2021, many scientific studies were made about mucilage effects in the Sea of Marmara. These effects are ecological effects, tourism, fishing, and maritime transportation. However, there is a vast gap in the effect of mucilage on shipping. In this paper, a short review of the impact of mucilage on pumps, filters, and heat exchangers is examined and its effects on navigational safety (Öztürk et al., 2021; Uflaz, et al., 2021). Furthermore, the ship's main engine and auxiliary systems malfunction due to lack of cooling is investigated. So, it would affect navigational safety both the Sea of Marmara and the Turkish Straits during navigation.

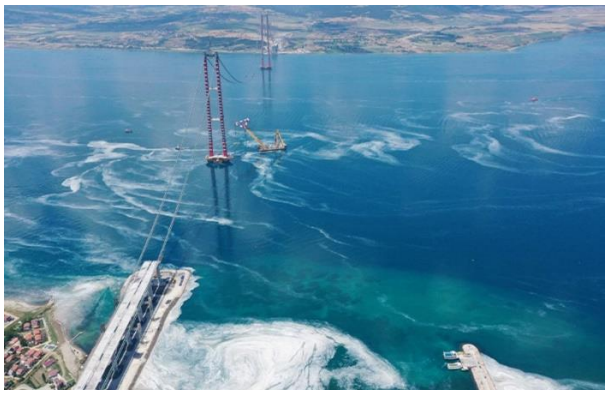

Fig. 1. Mucilage effects on the Strait of Canakkale (AA, 2021)

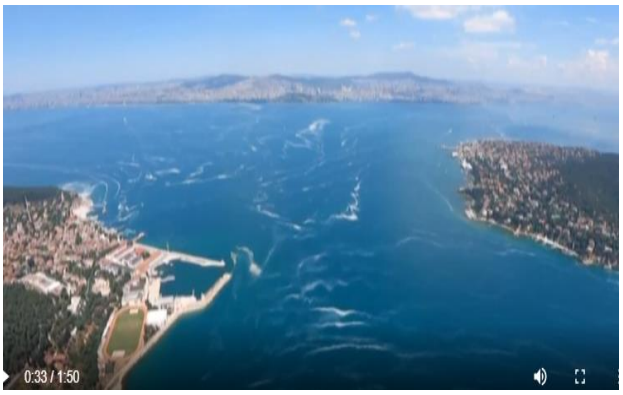

Fig. 2. Mucilage effects on the Strait of Istanbul. (AA, 2021)

Materials and Methods

As known from the available machine working principles, the machine needs cooling during its operation. Large-scale machinery systems such as ships require cooling to reduce the heat generated. In ships, the sea is an indispensable source of cooling water. The part where seawater is used in cooling water systems is defined as sea chests. These sea chests used on ships are designed as high and low. The reason is that one chest is kept open and the other clean, ready for use in the engine room, according to the water level, in order for the ship to sail safely. Thus, when the filters in the sea chests are contaminated by marine pollution or living organisms, the cooling process is continued using spare parts. Conventional or central cooling systems are widely used in the maritime industry.

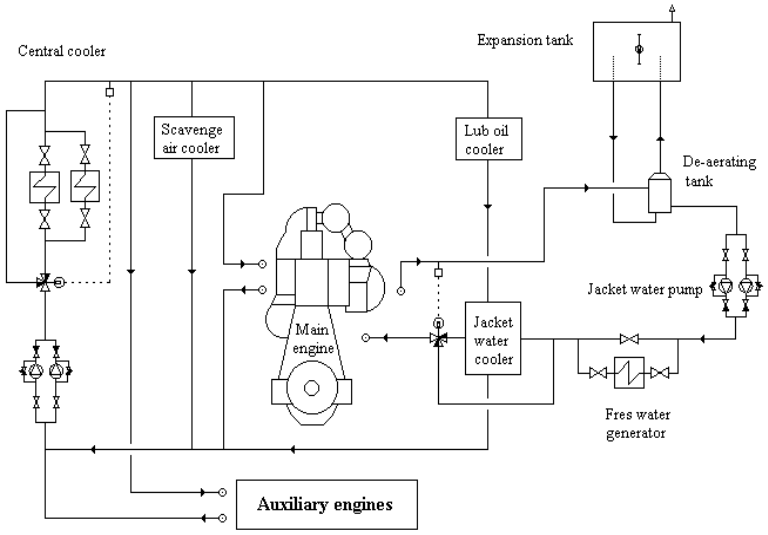

Fig. 3. The seawater circuit diagram URL 1.

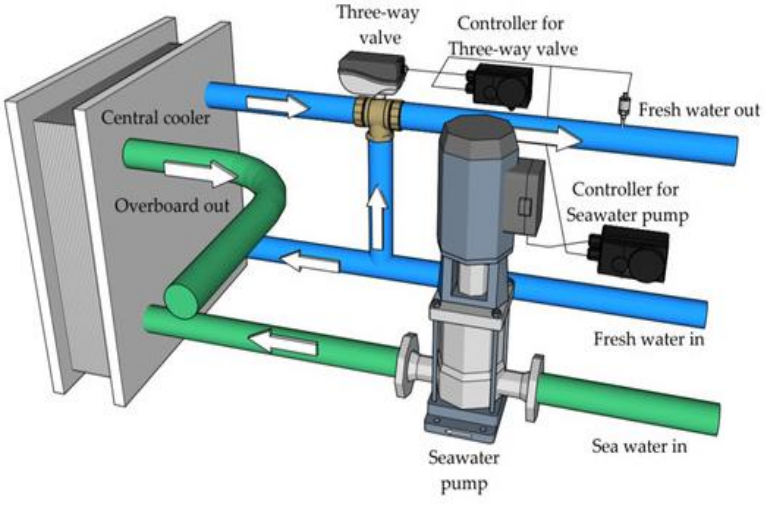

Fig. 4 Configuration of the ship's central cooling system (Lee et al., 2021).

On ships, seawater is used to recover waste heat from the cooling water of diesel ships, usually through the pump used for seawater recirculation. In this process, cooling water (freshwater) recovers waste heat from various heat sources on board and transfers it to seawater via a central cooling water cooler (Lee et al., 2015).

In ships, seawater forms the basis of the ship's working principles. Therefore, the effect of mucilage will be too much. Seawater Inlet Chest Filters/Valves, Seawater LT Cooler, Air Cooler, Oil Cooler, Ballast Water Filters, Evaporators, Emergency Fire Pumps are the first parts to be affected by mucilage. The study results of the images taken from the ships that passed through the Turkish Straits and experienced malfunction between May and December 2021 and the opinions of the repair teams were taken into consideration.

Discussion and Conclusion

The mucilage effect on the ships showed its effect in the Turkish Straits and the Sea of Marmara in May 2021, and the cleaning work started with the rapid reaction of the authorized bodies of the Republic of Turkey is significant (TR Ministry of Environment, 2022). Mucilage cleaning works are significant for ships navigating the Turkish Straits and the Sea of Marmara. The most crucial element of the ships sailing on a dynamic surface is their safety while navigating. The most crucial factor during the voyage is the safety of navigation (Usluer et al., 2021). The Sea of Marmara, the most significant component of the Turkish Straits Sea area, is an inland sea with a surface area of 11 111 square kilometers (Gazioğlu et al., 2002). As a result of oceanographic measurements, it has been understood that the low salty surface water from the Black Sea can be renewed every 5 to 6 months, and the salty bottom water from the Mediterranean can be renewed every 6 to 7 years. The mucilage structure felt in the Sea of Marmara in 2021 harms marine life; it has been determined that it forms at the bottom of the sea and on the sea's surface disrupts the life cycle. According to the latest findings, there are dense mucilage layers in the depth range of 5 to 30 m. This range also covers the generalship type's draught level that uses the Turkish Straits and the Sea of Marmara.

Sea saliva is formed from organic compounds secreted into the environment by the excessive increase in phytoplanktons formed in the marine environment. These organic compounds swell when they contact water, become visibly slimy and sticky, forming sea saliva. As a result of the samples taken from the Sea of Marmara and its examination, it was understood that eight groups were formed from 47 species. These eight groups also consisted of Amoebozoa, Ciliata, cladoceran, Copepoda, Foraminifera, Nematoda, nauplii larvae, and veliger larvae in the mucilage samples (Balkis-Ozdelice, et al., 2021). According to the operating principles of the ship's propulsion and management systems, the required cooling process of the closed-circuit engine cooling water, fuel and lubricating oils used for reasons such as preventing mechanical wear, reducing thermal stresses, keeping the combustion efficiency at an optimum level, is done utilizing used seawater from external. During the operation of the ship's engine, the seawater used for the cooling process is pre-filtered with the filters in the seawater inlet chests. It is pumped to the heat exchangers utilizing seawater pumps. The cooling process must be completed with a closed-circuit mechanism and the working principle of the cooling liquids at the required level. After this process, it is pressed into the sea again without contact with any polluting factor through seawater circuits.

Seawater inlet filters;

Mucilage deposits/residues settling in the filter pores cause clogging quickly. As a result of clogging, the water flows from the sea decrease and will not flow at the pressure required for circulation. Since the circuit will have difficulty completing the circulation, temperature rise and overheating will occur in the main engine, generators, compressors, and cooling systems.

Fig. 5. Seawater Inlet filters after mucilage effects (DTO, 2021)

Since it will cause thermal stress in the working mechanism, there will be difficulties transferring and listening to the rudder. It will cause many unexpected failures in the Turkish Straits and similar narrow channels and crossings.

Low Temperature Seawater cooler;

Even if there is a filter at the seawater inlets, mucilage residues and residues will leak from the filters and plates and cause blockages in the cooling channels. Seawater coolers will suddenly increase the freshwater (jacket water) temperature in the main engine, generators, and diesel equipment by disrupting the cooling regime. The low-temperature circuit (L.T.) is used in machines in the low-temperature compartment and is directly connected to the central seawater cooler; therefore, its temperature is lower than the high-temperature circuit (H.T.). L.T circuit consists of all backup systems. The total amount of low-temperature fresh water in the system and the amount of high-temperature freshwater are kept in balance by an expansion tank common to both systems. The expansion tank used for these systems is filled from the booster system or distilled water tank using a freshwater (F.W) filling pump.

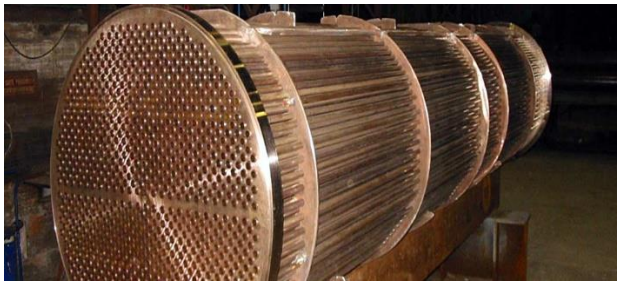

Fig. 6. Cooler example URL 2.

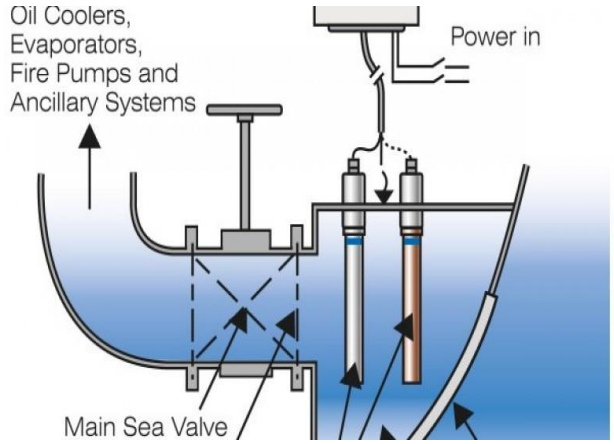

Fig. 7. Seawater cooler working principle (Vyasmetal, 2022).

The high-temperature circuit in the central cooling system consists of the jacket water system of the main engine, where the temperature is relatively high. The H.T. water temperature is adjusted by low-temperature freshwater, and the system generally consists of the main engine's jacket water system, fresh water generator, standby diesel generator (D.G.), lubricating oil filter for stuffing box, and drain tank. High-temperature coolant is circulated by two electric coolant pumps, one in use and one in standby mode. On the other hand, the backup diesel generator is kept warm by the circulation system of the diesel generator in use. When the main engine is stopped, it is kept warm by the H.T. cooling water from the diesel generator. The water can be heated with a steam-heated fresh-water heater if this is not enough.

Marine engine's lube oil cooler's primary purpose is to cool the turbine oil. The oil heated during operation is carried out as the cooling water flows in the direction of the pipe along a serpentine path along the shell side of the bundle forming the cooler. The heat generated due to working in the system is transferred from the oil to the water, keeping the oil temperature within the ideal operating range.

Fig. 8.Lube Oil Cooler example (URL 3).

Due to the marine engine working principle. The heat that works causes the transfer of foreign materials in the oil to drop outside the tubes. The two-edged status could explain this; first, the build-up on the shell side of the tubes becomes an insulator reducing the ability of heat to be transferred and build-up of contaminates, sections of the bundle will become plugged, restricting the flow and further reducing heat exchange.

Since the filters clogged due to mucilage block the cooling channels, they will prevent the cooling of the air from passing through the air cooler and prevent the system from operating efficiently. Decreased amount of oxygen in the uncooled air will increase the operation of the marine engine and the combustion pattern of the fuel and increase the exhaust temperature. Thus, the marine engine efficiency will be improved.

Ballast Water Treatment system filters are indispensable for ships. In general, the transmittance of UV purification filters is between 20 and 50 microns. Ballast water pumps try to provide movement by sending mucilage-effective water through the circuit. Meanwhile, the filters of the circuit will be clogged. Although it will try to clean itself with its back-flush feature, it will not be very effective due to the sticky property and residues of the mucilage. Thus, since the circuit pressure cannot complete the circuit, a pressure difference will occur and the system will collapse. The treatment system, which is suddenly clogged and cannot clean itself, will hinder the operational safety of the ship. As a result, a Ballast

treatment system without a filter will be preferred, which will result in worse results.

The evaporator is the crucial part of the ship that converts Seawater to Freshwater on a Ship; in other words, it is explained as a Fresh Water Generator. Freshwater is of vital importance in the ship because freshwater is used for drinking items, meal cooking, washing everything, and even running other important machinery which uses freshwater as a cooling medium. Evaporators work by drawing water from the sea. Mucilage particles attached to the water-absorbing filters and passing through the filter can clog the ejectors and plate coolers. In this way, there will not be enough vacuum. It will prevent the water, which is the system's working principle, from boiling sufficiently by heating. It will spoil the density of the water that needs to be prepared for use.

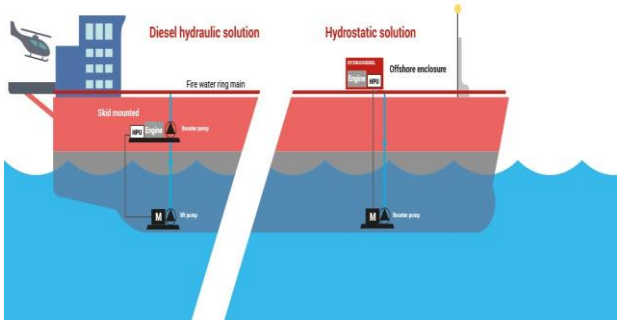

Fig. 9. Off-Shore Fire pumping Systems URL 4 (2022).

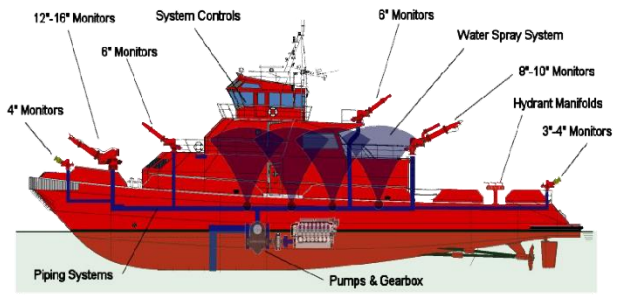

Fig. 10.Fire suppression system ship fire extinguishers (URL 5).


Fig. 11. Seawater inlet Filters after mucilage at 2021 (DTO, 2021).

Emergency fire pumps do an essential mission onboard. It should always be available for emergencies. It is necessary to be used in navigation, and it can be controlled by frequently using it when leaving the port and at anchorage areas. In places where mucilage is observed intensely, the pump filters will be clogged to draw water from deep and shallow water levels. It can even cover the seawater inlet filter, cutting off the flow of water and preventing emergency response.

Mucilage is highly felt in the Turkish Straits, especially in the Sea of Marmara in the spring of 2021. It has been effective starting from natural life to sea vehicles, from sea tourism to many environmental problems. There are copper and aluminum-containing Anode and Cathode structures that can be built especially for sea creatures, called Marine Growth, and placed close to the filtered and water-taking structures of the ship. These structures work to prevent the heating of the working machines and equipment and to perform the cooling processes. Its work prevents sea creatures from living in the structure with the effect of electric current and copper oxide into the water taken from the sea. Examples of mussels, one of the creatures that can enter and live on ships with seawater, filter and clean more than 150 liters of water per day. Therefore, sea creatures are a structure that can reduce the pollution caused by external effects in seawater in natural selection. In general, anti-fouling paints are used to prevent marine species from trying to survive by sticking to the hull/hull of the ship, which is constantly used in maritime. It is immediately apparent that the living things sticking to the hull can help filter and clean the water, which has a mucilage effect.

In addition, another issue encountered in the determinations made is that the ship cooling system carries out the process of receiving and sending 500 cubic meters of water from the sea on average per hour. Meanwhile, anti-fouling systems, which negatively affect the life cycle with electric current, can harm sea creatures that can clean up pollution such as mucilage by affecting 12.000 cubic meters of seawater with only one ship. The mucilage problem helped to see the following truth. It is the embodiment of the pollution of the seas due to human beings and their indifference and the deterioration of the natural marine life as a result. The importance of releasing industrial wastes into the sea without control and the necessity of using sea-friendly products should be understood.

Developed maritime countries are approaching these similar problems with more nature and sea-friendly solutions. These solutions are gaining more importance through IMO and are starting to be used. With the new perspective brought to the anti-fouling application, thanks to the film layer applied to the ship's hull or ultrasonic systems that prevent biofilm formation, both longer-lasting and more environmentally friendly results can be obtained.

New technology and requirements have developed more environmentally friendly products. These products, which can be applied to the hull, work in harmony in the body and the cooling circuit filters.

Effective and continuous cooperation mechanisms should be developed with the Black Sea riparian

countries within the scope of reducing the level of inorganic nitrogen and phosphorus salts that make up the chemical structure of the existing water mixture in the water coming from the upper and lower water currents in the Strait of Istanbul to the Sea of Marmara with its upper flow. In addition, it is recommended to support the formation of ecological conditions that balance the existing phytoplankton population in the region of 0-14 meters where the effect of the upper layer is felt and up to 25 meters in deep places. In addition, within the possibilities, control, and protection of the species and numbers of upper-level organisms such as fish and shellfish fed by the rehabilitation and filtration of seawater can be ensured. As a result of these studies, policies suitable for fishing can be developed, and the migration of fish species, especially fish species, and protection of fish shelter and spawning areas between the Black Sea, Sea of Marmara and Aegean Seas, which are connected by the straits, which are international passageways.

The protection area status of the Strait of Istanbul, the Sea of Marmara, and the Strait of Canakkale, which form the Turkish Straits Sea Area, needs to be improved with the effect of mucilage. It is recommended to carry out studies to take samples from the coastal organization of the transitional waters, in cooperation with the state authority and academic institutions, especially between the Black Sea entrance of the Strait of Istanbul and the Sea of Marmara exit of the Strait of Canakkale.

Maritime transport is an essential part of global transport. Especially during the Pandemic, the importance of logistics, especially sea transportation, has increased a lot. With the increase in maritime transport, there has been an increase in the trade capacity and potential in the world's seas. IMO and maritime states have protected maritime seas with international and national regulations. However, although the regulations worked for control, they could not prevent the formation of the mucilage structure as in the Sea of Marmara in May 2021. Mucilage plays a vital role in the daily working operations of the ship, especially in maritime transport. The water requirement from the sea is used in many areas in ship operations and is specially used as cooling water in machinery operations. Since the inlet places of the systems and circuits that draw water with the mucilage effect, especially the filter clogging will significantly and primarily affect the safety of navigation. Machine failures in areas with natural valley features such as the Sea of Marmara and especially the Turkish Straits can cause environmental pollution and loss of life and property (Uflaz et al., 2021). For this reason, it is vital to find and use rules, methods, and technologies that will both increase the prevention of mucilage and reduce the effect of mucilage on ship operations. The main task is to evaluate marine pollutants and return the marine ecosystem to its natural state. As a result, the factors contributing to the mucilage phenomenon encountered in the Sea of Marmara are not only caused by sea vessels. Coastal industrial facilities, maritime convenience facilities, and ships are the main reasons. In order to eliminate these effects, it is necessary to develop mucilage and similar pollution control systems and ultimately to contribute to the natural cleaning systems of the marine ecosystem.

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