An important issue of the second and third categories is that the origin of pollution should be accounted: the geochemical and geophysical, as well as biological endemics are of great importance in the formation of morbidity at certain areas, but pollution implies dispersion haloes, produced by human activity of any kind. Nevertheless, the endemics are also environmental diseases in there pure sense and could be attributed to these or separate category.

At the same time we face the problems in defining the exact causes of many diseases and environmental and status of the environment is often is only a component of the mix, as it is established for cardiovascular diseases [3] and cancer [1]. For example, a massive research in selected European countries (Belgium, Finland, France, Germany, Italy, and the Netherlands) demonstrated that 3–7% of the annual burden of disease in the participating countries is associated with the environmental pollution, primarily PM2.5, secondhand smoke, traffic noise and radon [5]. This brings us to the fact that certain diseases might be attributed to few categories of environmental diseases simultaneously. However, this shouldn't be considered as an major obstacle for the classification, it is rather an issue of interpretation, which should be solved depending on the purpose of research where the most important fact is partially environmental nature of the disease

What is more important and is out of the given research scope, whether there is a possibility to manage the level of diseases propagation by environment quality enhancement [8].

The final classification is yet to be established since we are constantly revising our understanding of the environment role in the health formation.

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UDC 579.2

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ABOVE AND BELOW: INVESTIGATING THE SEA SURFACE MICROLAYER AND ITS ECOLOGICAL IMPORTANCE FOR CLIMATE CHANGE MONITORING

Annotation. The sea surface microlayer (SML), a thin boundary between the ocean and atmosphere, harbors a rich and diverse bacterial community. This unique environment, distinct from the underlying water, exhibits remarkable adaptations to survive harsh conditions and constant UV radiation.

This report delves into the ecological significance of SML bacteria, highlighting their crucial role in nutrient cycling, greenhouse gas exchange, and carbon sequestration, and their potential implications for monitoring climate change dynamics.

Key words: Sea surface microlayer, marine microbes, climate change

The sea surface microlayer (SML) represents a thin (<1 mm [1]) boundary between the ocean and the atmosphere, possessing unique physical and chemical properties. Numerous studies of SML aimed to reveal its physical properties and chemical composition [2], [3]. Now we also know that this environment harbors a rich and diverse bacterial community that has been reported to be distinct from the bacteria of the underlying water (ULW) [4], characterized by adaptations that allow them to flourish in harsh conditions of the water surface, with rapid fluctuations in temperature and salinity, and constant impact of harmful UV radiation [5]–[8]. This review aims to illuminate the significance of the SML bacteria, emphasizing their ecological importance and potential implications for climate change monitoring.

Ecological Significance of SML Bacteria

The bacterial communities inhabiting the SML play a critical role in essential ecosystem functions, including nutrient cycling [9], carbon sequestration [10], and the production of secondary metabolites [11]. SML bacteria are involved in the exchange of trace gases, including greenhouse gases, between the ocean and the atmosphere. For instance, they mediate the production and consumption of dimethyl sulfide (DMS), a compound that influences cloud formation and subsequently affects the Earth's radiation budget [12]. Additionally, by binding dissolved organic carbon during growth and respiration, SML bacteria influence CO_2 concentrations [13], [14]. Bacteria can alter some dissolved organic matter (DOM) from fresh to more refractory material, thus preventing it from being used by other microbes and storing this fraction of organic matter in a water column for a long time [15]. Considering that the balance of refractory and labile DOM in the SML affects carbon cycling in the underlying water, it is crucial to study the role of SML bacteria in greater detail.

Challenge and Future directions

Despite the growing recognition of the importance of SML bacteria, several challenges persist in studying them. The dynamic nature of the SML [16], sampling difficulties [17], and limited knowledge of microbial interactions within this environment pose significant hurdles. To advance our understanding of SML bacteria and their role in climate change dynamics, it is imperative to integrate interdisciplinary approaches such as metagenomics, metabolomics, and remote sensing techniques.

The BASS Project

To comprehensively explore various aspects of the SML, including its bacterial inhabitants, we contribute to the international project BASS – Biogeochemical Processes and Air-Sea Exchange in the Sea-Surface Microlayer [18] led by Professor Dr. Oliver Wurl from University of Oldenburg, Germany. Our research aims to deepen the understanding of the differences between the microbial communities of SML and ULW by employing new methods of physiological and genetic assessment of marine microbes. We combine fluorescent microscopy-based techniques to estimate bacterial activity, particularly respiration and protein production, across different bacterial taxa. Additionally, we analyze genetic capabilities and protein production to create a comprehensive profile of the bacterial inhabitants of the SML. To our knowledge, we are the first researchers that, with the help of modern sampling techniques, are able to apply the shotgun metagenomics approach to identify genes responsible for the production of compounds crucial for survivability in the harsh conditions of the water surface. Our focus includes mechanisms of UV-damaged DNA repair and enzymes involved in carbohydrate and amino acid transformation.

Conclusion

The exploration of SML bacteria offers a fascinating window into the complex and interconnected dynamics between the ocean and the atmosphere. These microorganisms, with their unique adaptations and ecological significance, play a crucial role in vital ecosystem functions, carbon cycling, and trace gas exchange. However, studying SML bacteria poses challenges due to the dynamic nature of the SML and limited knowledge of microbial interactions. To overcome these obstacles, interdisciplinary approaches are essential. The ongoing BASS project exemplifies the collaborative effort to unravel the complexities of the SML and its bacterial inhabitants. By unraveling the secrets of the SML bacteria, we can unlock vital insights into the impacts of climate change and develop effective strategies for its mitigation and conservation of our planet's delicate ecosystems.

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