【Grant-in-Aid for Transformative Research Areas（B）】

A Study of Cross-scale Analysis from Cells to Environmental Water（Cross-scale analysis）

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Research Area Information	Number of Research Area : 23B401　Project Period (FY) : 2023-2025 Keywords : Chemical sensor, Microfluidic device, Pattern recognition

Purpose and Background of the Research

●Outline of the Research

This project aims to establish a concept of cross-scale analysis in water environments, through the development of chemical sensor technologies. As described in Sustainable Development Goals (SDGs), the protection of water environments is a significant social issue. **To this end, the qualitative and quantitative investigation of causative species is required to identify their effects on ecological systems. However, analytical methods with sufficient requirements for on-site sensing have not been established yet.**

In this research project, we employ mechanisms to recognize causative species at molecular levels for the development of chemical sensors. **The chemical sensors are applied to the comprehensive analysis at cell and ocean scales, of which the technologies and methodologies will open a new avenue for the protection of water environments.**

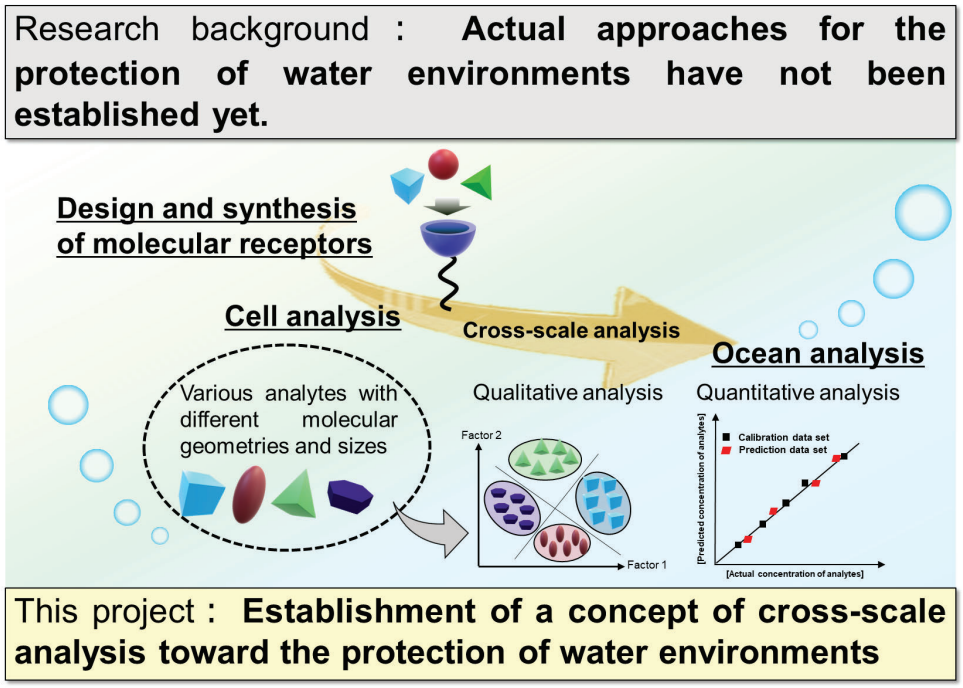

Figure 1. Aim of cross-scale analysis.

●Significance of cross-scale analysis

Causative species (i.e., analytes) in water are invisible-sized molecules, thus the designs of molecular recognition materials (i.e., receptors) considering structural geometries and molecular sizes of analytes are required. By employing the receptors, chemical sensors can visualize recognition information upon analyte capture**. In this project, we apply chemical sensor devices to cross-scale analysis for the investigation of effects on ecological systems.**

Figure 2 illustrates a molecule (i.e., a cyclic structure), a cell (i.e., a red circle), and an ocean (i.e., blue waves), which indicates the concept of cross-scale (i.e., an arrow) for comprehensive analysis in water environments.

Figure 2. Illustrated concept containing a molecule, a cell, and an ocean for cross-scale analysis.

Expected Research Achievements

●Role of Group A01

Various structural chemical species numerously exist in water environments. To efficiently detect such invisible analytes in water, the designs of artificial receptors considering structural geometries and molecular sizes of analytes are required. Hence, **Group A1 assigned as molecular scales aims to develop artificial receptors based on molecular recognition chemistry**.

●Role of Group B01

To investigate the effects of causative species in the aqueous environment, the employment of advanced *in vitro* evaluation systems is a potent approach. **Group B01 assigned as cell scales aims to develop the advanced Gut-on-a-Chip systems by integrating ultra-sensitive sensor arrays combined with artificial receptors for the real-time evaluation of the effects of causative species at the cellular level**.

●Role of Group C01

In situ sensing is essential for understanding vast ocean-scaled environments. Owing to the following reasons;1) the diversity of target species, 2) miniaturized ocean observation platforms, technologies for not only the miniaturization of sensor sizes but also the improvement of power efficiency are necessary. **Group C01 aims to establish microTAS technologies for extreme environments, focusing on fluidic delivery techniques as the key to realizing ultra-compact sensor devices based on molecular recognition technology**.

●Ripple effect

Based on fusion technologies of nano electrochemistry, molecular recognition chemistry, and microfluidics, this project attempts to establish fundamental analytical methods for multi-analyte detection. **We believe that the technologies and methodologies established in this project will be further applied to water cycle analysis**.

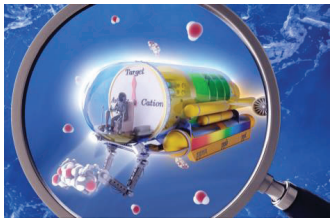

Figure 3. Conceptual figure of a chemical sensor for cross-scale analysis.

Homepage Address, etc.	The Minami group (Head Investigator): https://www.tminami.iis.u-tokyo.ac.jp/en The research project “Cross-scale analysis”: https://www.tminami.iis.u-tokyo.ac.jp/cross-scale