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# Carbon Negative Emission Approach with ICA Technology - Proposal of Sewerage Blue Carbon Scheme and Solutions

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**Abstract:** Decarbonization efforts to mitigate global warming are widely required. It is necessary to consider appropriate contribution measures in the field of sewage treatment. As a means to achieve this, the authors focused on "Blue Carbon," which is one of promising nature-based negative emission technologies (NETs). Blue carbon is carbon dioxide absorbed and sequestrated by marine ecosystems, and the supply of nutrients from watersheds is an important key to its expansion. In this study, the authors propose the "Sewerage Blue Carbon Scheme" that contributes to decarbonization through the blue carbon by supplying nutrients necessary for the growth of marine ecosystems with appropriately controlling the quality of wastewater treatment plant effluent to coastal areas. As a solution to achieve this, Blue Carbon cyber physical system (CPS) is under development, incorporating instrumentation-control-automation (ICA) such as quality control of treated sewage discharge, coastal area simulation and other related technologies.

**Keywords**: Blue carbon; Nutrients supply; Quality control of treated sewage discharge; Cyber physical system (CPS)

## Introduction

Sewerage systems are now required to play a variety of roles, not just preserving the water quality of public water bodies, which they have traditionally contributed to. As an example of new roles, it is expected that the marine area, which is one of the destinations for sewage discharge, will contribute to the creation of bountiful coastal areas that can foster sustainable fishery activities.
Nutrient salts are essential for the habitat and growth of aquatic organisms. Japanese government and municipalities are now trying to realize not only clean but abundant seas by making it possible to supply nutrients to specific sea areas, ensuring biodiversity and sustainable use of marine resources. As an extension of this, seaweed beds, which contribute to the biodiversity, can also be expected to play a role in absorbing and sequestrating $CO_2$ (Blue Carbon [1]).
This study proposes the Sewerage Blue Carbon Scheme, which focuses on the blue carbon as a future measures that will simultaneously realize the contribution of the sewerage system to bountiful coastal areas and contribution to decarbonization.

## Proposal: Sewerage Blue Carbon Scheme

The basic concept of this Scheme is to realize appropriate supply management of nutrients by controlling the quality of treated sewage as shown in **Figure 1**, and to promote blue carbon sinks through the maintenance and expansion of seaweed beds (seagrass, seaweed, etc.) that are the main body for $CO_2$ absorption and sequestration in the coastal areas.
As the main means to realize the above concept, the authors is developing (1) blue carbon management and control technology and (2) blue carbon measurement technology. The former is technologies for promoting and certifying $CO_2$ absorption and sequestration using carbon and nutrients dynamic evaluation and monitoring data. The latter is technologies for monitoring target field conditions such as changes in water quality and side effects such as red tides associated with the supply of nutrients and measures the amount of carbon sequestration by the blue carbon and acquires data to reflect in (1).

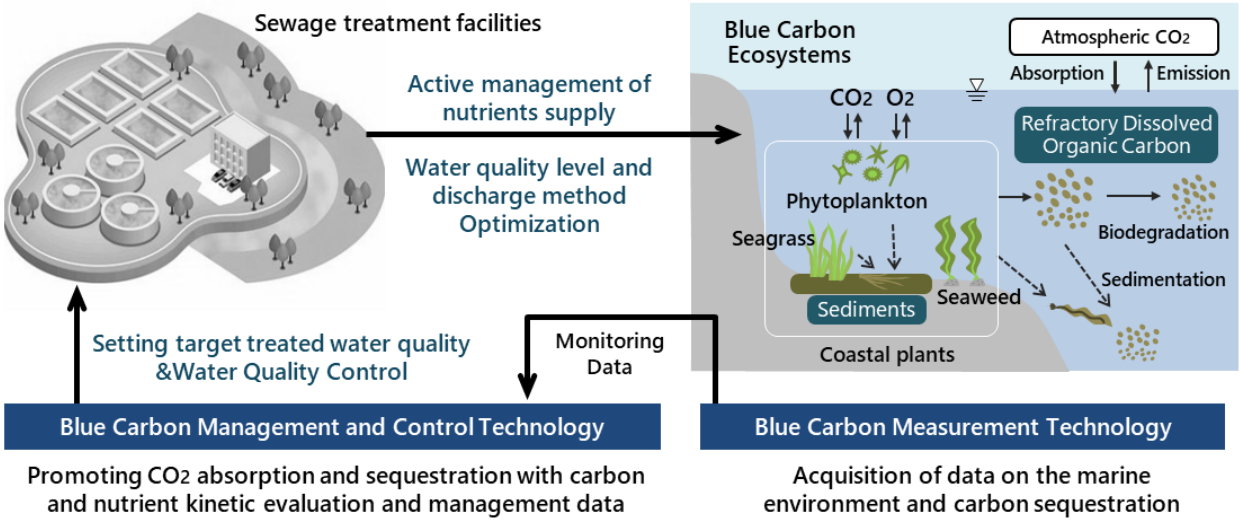


**Figure 1** Outline of Blue Carbon Scheme utilizing Sewage Treatment Facilities

Blue Carbon Solutions with ICT (Instrumentation, Control and Automation)

As a means of realizing the above-mentioned concept, the authors are designing the functional requirements of the solutions shown in **Figure 2** and developing corresponding technologies. The aim of this solution is to promote $CO_2$ absorption and sequestration by the blue carbon ecosystems and to manage the data required to accumulate scientific knowledge and obtain carbon offset credits. The main technology is based on ICA in the water field.

The proposed solution consists of 1) system that measures the target coastal area, 2) CPS (Cyber Physical System) that sets appropriate planning and control targets for nutrients supply based on the measured information, and 3) control system that manages quality of treated sewage discharge according to the control targets.

1) The measurement system acquires data to monitor side effects (red tide, etc.) associated with increasing nutrients supply and to evaluate $CO_2$ absorption and sequestration. For example, conventional chlorophyll-a sensor and RDOC (Refractory Dissolved Organic Carbon) sensor, which will be developed in the near future, will be applied to this system.

2) CPS evaluates the amount of nutrients required for the blue carbon ecosystems and fisheries in the target coastal areas, and sets the amount of nutrients (nitrogen and phosphorus) to be supplied from treated sewage discharge. In order to conduct this evaluation, water quality distribution simulations and ecosystem models in coastal areas are applied. In order to appropriately quantify the ecosystem effects of nutrients derived from treated sewage discharge, algal growth tests are underway in model coastal areas and experimental facilities. The results of the growth test will be reflected in the ecosystem model.

3) The control system applies water quality control technology incorporating the activated sludge process, which is typical sewage treatment in Japan. This technology is a representative ICA technology in the water field. For example, in order to make the nitrogen concentration of the treated water quality follow the target value, the measured values of the ammonia nitrogen sensor installed in the reactors can be used to appropriately adjust the nitrification and denitrification levels [2].

By linking the three systems described above, it is expected to promote $CO_2$ absorption and sequestration in the blue carbon ecosystems. Details of development achievements of the solutions will be explained in the workshop presentation.

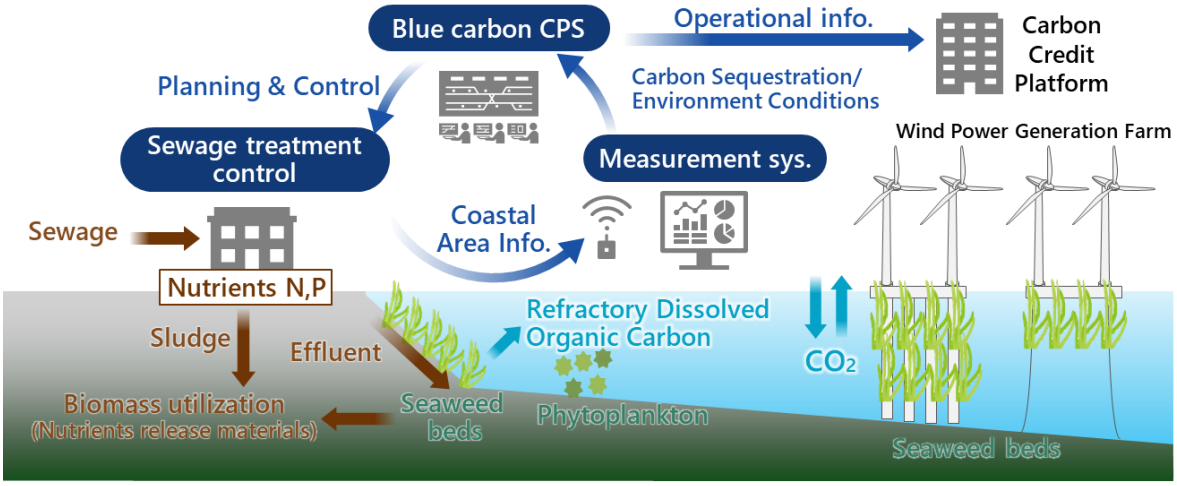


**Figure 2** Blue Carbon Solutions with water-related ICT

Future Works for Decarbonization

The proposed concept is actively being further materialized, researched, investigated, and developed in the industry-government-academia collaboration project including the authors [3]. The social implementation of the measures for the blue carbon requires the agreement and cooperation of many stakeholders. For this reason, in addition to technical issues, discussions are also held with government officials (departments such as sewerage, environment, fisheries, etc.) and fisheries cooperatives to ensure consistency with related water quality regulations and sewerage infrastructure plans.
Decarbonization is an urgent issue for a sustainable society, and the authors would like to establish the ICA technology in the water field that can be implemented in the society more quickly.

Acknowledgements

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