Nitrogen circulates through the atmosphere, land, water, and ecosystems. Especially, when the concentration of nitrogen in water is increased, it causes eutrophication and red tide which deteriorates water quality, toxins to human and aquatic ecosystem, and fish mortality. This ultimately leads to socioeconomic problems such as increase in water purification and sewage treatment costs to minimize the effect of nitrogen pollution. In particular, the previous studies show that the growth of green algae and cyanobacteria can only ultimately be controlled when nitrogen is managed in parallel with phosphorus management. Recently, the need for strengthening nitrogen management has been presented in national plans and related policy research such as “2050 Sewer Policy Vision (2012)”, “Roadmap for Evaluating and Management of Pollutants in Public Water (2014)”, “The Second National Sewerage Comprehensive Plan (2015)”, and “National Water Environment Management Plan (2017)”. However, the water quality management policy for the public waters has been promoted mainly as a limiting factor to control the occurrence of green algae and eutrophication, and thus the nitrogen management has been somewhat passive.

- The domestic nitrogen inflow and emission status are surveyed based on the results of the previous nitrogen mass balance study and the analysis data of the “National Water Environment Management Plan(2017)”. As of 2014, annual domestic nitrogen inflow and outflow were 6.02 million tons and 1.36 million tons, respectively. The largest amount of nitrogen was released to
the air (59.8%), followed by rivers and the ocean (12.0%). The amount of nitrogen discharged into the rivers accounted for 36.7% of the total sewage treatment and non-point sources of pollution in the city. Nitrogen emission loads by pollutant sources are highest in the land area, followed by living system, livestock, and industry. Especially, the land system suffers mostly from the non-point sources of pollution and most of the point sources of pollution are in the living system, which makes the management according to the characteristics of each source necessary.

Nitrogen emission from point sources of pollution was identified using national pollution survey data (15). The **public sewage treatment facilities** with a capacity of 500 m$^3$/day or more accounted for 89.5% of total nitrogen emissions, indicating that management of public sewage treatment facilities needs to be implemented first. In addition, by discharge region, it shows the highest amount of emissions in Region III, and 21% of the total nitrogen emissions from the public and wastewater treatment facilities were directly discharged to the coast.

Nitrogen contamination in public waters such as river, lake, groundwater, and ocean was investigated. First, based on the total nitrogen standard set at the lake, it is estimated that all 49 major lakes are not achieving the targets, so improvement in the management is urgent. Compared with the OECD member countries, the nitrate concentration of domestic rivers is relatively high and since the pollution degree of total nitrogen has recently shown a tendency of stagnation on the declining trend, it is necessary to reduce nitrogen pollution continuously. This is due to the insufficient management of the nitrogen source of tributaries and the influence of the emission characteristics. In the mainstream section of the Nakdong River, it is evident that the nitrogen concentration tends to increase towards the downstream, due to the influx of polluted tributaries.

It was also found that the number of times that the water quality standard of nitrate nitrogen was exceeded increased continuously, and it is necessary to manage the source of nitrogen pollution in both surface and groundwater considering the characteristic of groundwater interacting with the surface water. In the case of the ocean, the pollutant load discharged directly to the coast from all point source facilities accounts for 22.2% of the total nitrogen discharge, which affects the occurrence of red tide. Therefore, it is necessary to manage the source of nitrogen pollution originating from the land to reduce the incidence of hazardous red tides.
The effluent water quality standard for nitrogen in public sewage treatment facilities, the largest point-source of pollution, was strengthened from 60 mg/L to 20 mg/L in 2001 and has been maintained. This is in contrast to a 10-fold increase for phosphorous over the same period. On the other hand, according to the probability distribution of the nitrogen concentration of the sewage treatment water, the sewage treatment process is not based on the best possible technology, but is only operated in accordance with the predetermined discharge water quality standards. This point needs to be compared with the efforts of advanced countries such as Japan and the United States to try to introduce the best technology while varying the water quality standards according to regional characteristics, technology level and regulatory system.

In order to evaluate the feasibility of reinforcing nitrogen management of point sources of pollution, we evaluated the effect of the scenario in which the nitrogen quality standard in the main stream of Nakdong River was strengthened using the water quality model. When the total nitrogen concentration was lowered to 10mg/L or less uniformly, it was concluded that the nitrogen concentration in the public waters decreased to some extent, which means strengthening the nitrogen regulations of the point sources of pollution contributed to the water quality improvement in the public waters. In addition, it is estimated to be technically possible to treat up to 3~10mg/L of total nitrogen based on the analyses of multiple cases. When the effluent total nitrogen standard is enforced to 15mg/L, the standard excess rate of total 625 facilities in operation is 1.3%, which is not unreasonable at the present treatment level, but at 10mg/L, the water quality standard excess rate was 24.5%, suggesting that many facilities need to improve. The approximate remodeling costs for facilities exceeding water quality standards are estimated to be up to 2.6 trillion won, and it is expected that the step-by-step improvement of the priority investment in the water-sensitive area can reduce the cost by at least 200 billion won.

In order to strengthen the regulation standards such as current effluent and discharge allowance standards, it is necessary to divide them into two strategies and proceed each in phases. First, the establishment of the environmental standard of nitrogen in the public waters should take precedence and the management of the nitrogen type such as nitrate nitrogen should accompany it. It is necessary to set the nitrogen target of the stream considering the characteristics of each water system and stream, and to select the key areas requiring priority management, so that the nitrogen and phosphorous are managed together effective-
ly. Second, among the point sources of pollution, the nitrogen standard for the effluent of the public sewage treatment plant which contributes heavily to nitrogen emission should be rationally adjusted. The criteria for the effluent standards of the sewage treatment plant should be set up to ensure optimum management considering the characteristics of the public waters, the flow rate, and the technical conditions of the treatment facilities. To do this, it is necessary to examine the various factors influencing nitrogen treatment, such as the winter season and coastal area, to verify the final feasibility by carrying out a pilot project to reduce the input cost and minimize the facility change and installation. In addition, it is necessary to review the problems that may arise during the enhancement of nitrogen treatment and to provide techniques for enhancing the elimination effect, so as to improve institutional compliance and early settlement in the field.

In addition to these basic improvements, synergy effects should be induced by linking with the system already being implemented to improve water quality in the public waters and to manage the public sewage treatment plant. It is necessary to examine the nitrogen management in conjunction with the watershed sewer plan that can set customized effluent standards considering the characteristics of each watershed first and apply it to the place where the watershed sewer project is actually proceeding to examine the effect and applicability. In addition, in order to manage nitrogen emitted from non-point sources, it is necessary to set the total nitrogen as the total amount of the target substance and activate the reduction plan for each pollutant source by using the existing nitrogen amount and load calculation method. At the same time, it is necessary to carry out continuous linkage management for reuse of the wastewater to achieve greater reduction with more optimal technologies. Effective customized nitrogen permit emission standards for each workplace need to be established and managed in conjunction with the emission impact analysis part. Finally, overall nitrogen sources should be managed in conjunction with various non-point source management systems. Nitrogen should be managed according to the priority of the stage based on the rationalization of the basic environmental facility management, so that at least the same level of effect as the total phosphorus can be achieved.

**Keywords**
- Nitrogen Management
- Public Sewage Treatment Facilities
- Effluent Water Quality Standard
Key References

- Canadian Water Network (2015), *Options for Improved Nutrient Removal and Recovery from Municipal Wastewater in the Canadian Context*.

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