WATER QUALITY AND AGRICULTURE

Total Maximum Daily Load (TMDL) Management System in Korea

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1. Overview of TMDL

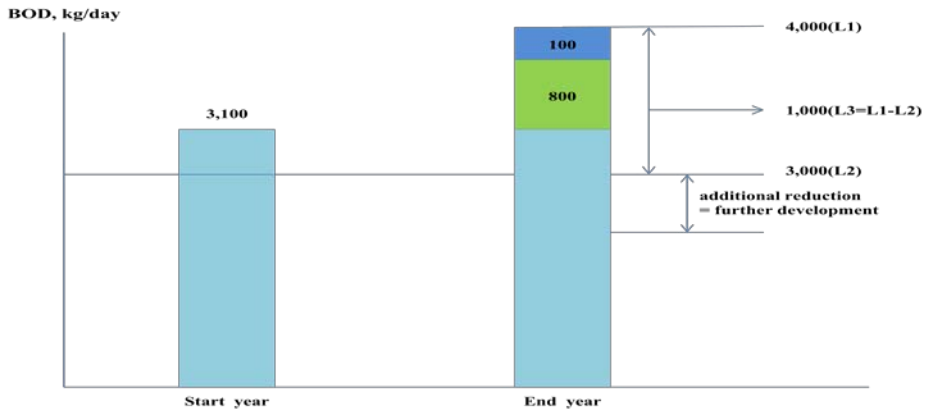
Total Maximum Daily Load (TMDL) is a regulation system that controls the quantity of pollutants discharged from each watershed nationwide to be within the scope of load allocation, by means of setting a water quality target achievable at each end site of watersheds, calculating load allocation permissible to achieve the target.

As the capacity for local development would increase as much as discharged pollution load is reduced in a watershed, the effort itself to conserve water quality becomes the incentives for development in the area.

For instance, when assuming that discharged load of biochemical oxygen demand (BOD) is 3,100 kg/day in the start year, and that the pollution load discharged from population growth and alternation of land use amounts to 800 kg/day, and the pollution load from development plans account for 100 kg/day, the discharged pollution load (L_1) would increase up to 4,000 kg/day in the end year.

When discharged pollution load (load allocation) for meeting the water quality target is estimated to be 3,000 kg/day (L_2), load reduction target (L_3) is 1,000 kg/day (L_1-L_2) in the end year. Therefore, the water quality is improved due to reduction of discharged pollution load compared with the start year, resulting in securing more incentives for development. Moreover, when reducing the pollution load beyond the load reduction target (L_3), it also could be used as additional capacity for development.

Concept of TMDL



The TMDL management system is a policy for the new era to achieve both economic development and watershed conservation with a scientific approach, going beyond conventional policies which focus only on regulations for water conservation.

Firstly, the TMDL management system develops the most efficient and scientific management approach to manage the pollution load which is discharged from pollution sources in watershed. In order to meet and stay on the water quality target, the pollutant load in watershed is to be calculated using a scientific method such as a water quality modelling, etc. Since the water quality is controlled based on the calculated pollution load, it is enable to minimize inconsistency and adverse impact of existing monolithic regulation on permissible concentration and land size (e.g. regulation on building area), which results in effective and flexible enforcement of environmental regulations.

Secondly, the TMDL management system is an advanced water quality policy, which aims at not only regulating water quality but also revitalizing local economy while protecting water quality through promoting the planning of local development and pollutant reduction together.

Thirdly, the management of large-scaled watershed can be performed in more efficient manner thanks to the TMDL management system since the system clarifies the responsibility of each relevant entity by means of identifying each pollution load by local government, sub-local government and individual polluter, with a view to meeting and staying on the water quality target.

Lastly, water quality target, basic plan and implementation plan must be established based on active participation and cooperation of stakeholders in each watershed, in order to carry out the TMDL management system more practically and efficiently.

2. Background of TMDL Introduction

Summer is usually along with heavy and intensive rainfalls in Korea, which causes repeated droughts and floods. Rapid economic growth has increased the demand for water tremendously and the accelerated urbanization has caused deterioration of water quality in rivers and lakes, which results in the increase of social conflicts regarding water use among various stakeholders. In addition, the total coverage of impervious surfaces increases due to rising urbanization and shortened run-off time of rainwater. All the above factors have made the management of water quality more difficult in Korea.

In the past, the central government was the only authority to manage water resources. As the central government gave it to local governments for more efficient management, it was required to consider that the local governments have a tendency to put more priority on economic development rather than conservation of the environment. Hence, the central government needed to make a policy for both economic development and the environment in which clarifies the responsibility and duty of local governments given the environmental volume.

The nationwide introduction of TMDL management system is indispensable for environmental conservation of pubic watershed, considering the current situation where water resources are gradually being reduced. In addition, implementation and performance review of TMDL management system are performed at the central government level for identifying environmental responsibilities of each local government and resolving conflicts potential.

3. Introduction of TMDL

The environmental policy of Korea has begun with the enactment of *the Environmental Prevention Act* in the 1960s. However, it only confined to some part of the health sector. Full-scaled management on water quality was realized by *the Water Quality Conservation Act* in the 1990s. Unfortunately, it was not quite successful regarding improvement of water quality since it only focused on point pollution sources like environmental infrastructures, etc.

Since the 2000s, the watershed management system, which manages the entire environmental factor of watershed persistently, has been introduced. This system categorizes watersheds nationwide specifically like Han River and Geum River. Accordingly, appropriate policies are adopted as well.

The framework for Total Maximum Daily Load (TMDL) was initially developed by the Special Comprehensive Measures for Water Quality Management on Upper Stream of Han River including Lake Pal-Dang(Nov.1998). The legal ground for its implementation was provided by *the Act on Improvement of Water Quality and Support for Residents in the Han River Basin* (Feb.1999) and *the Act on Water Management and Resident Support* for Han, Yeongsan, Seomjin River Basins respectively (Jan.2002).

4. Design of TMDL System

The TMDL management system is to be designed by setting up achievable water quality target, that is acceptable by local community and relevant enterprises from the perspective of economy and technology. The TMDL management system is operated considering the fairness among local authorities and enterprises, given various factors like purpose of watershed use, affordable environmental costs, costs for pollutant reduction, etc. Furthermore, the system is also designed in accord with local policies including development plans that the local community has pursued.

The water quality standards in accordance with *the Framework Act on Environmental Policy* are the administrative target that the central and local governments should meet, which apply all of water quality parameters to each watershed (e.g. watershed : 8 parameters including BOD + 20 health-related parameters, swamps and lakes : 9 parameters like COD + 20 health-related parameters). However, the water quality target under each *Act on Improvement of Water Quality and Support for Residents* for four major river basins respectively is the management target to be achieved within a certain period of time in order to implement the TMDL system, which embodies the government's willingness to clarify the liability among local governments by means of designating some parameters such as BOD and T-P for the boundary between Province and Metropolitan City (or Special City) as well as between City and County. Meanwhile, businesses where discharge more than 200 tons of pollutants should be regulated by being allocated pollution load.

As the TMDL system has been implemented, government subsidies are supported to invest into environmental fundamental facilities above all, including establishment or extension of waste water treatment plants with the aim of meeting the water quality target. In addition, the River Basin Fund is provided to support the development of TMDL basic plan and implementation plan for Metropolitan Cities, Special Cities and Provinces, carry out TMDL basic surveys like water quality and flow survey, and operate TMDL management centers.

5. Implementation Procedure of TMDL

5.1. Basic Principle of TMDL

The central government lays a foundation for implementing the TMDL system by means of identifying necessary matters for the TMDL implementation and making guidance on how to establish a TMDL plan. This includes the period of TMDL management, pollutants and quantity of flow to be managed, etc.

5.2 Establishment of Water Quality Target

The water quality target is the criteria for setting up the TMDL target. It is decided given the use of river (e.g. drinking water, Agricultural water), density of pollution source, current status of local development and investment into environmental infrastructure, soundness of water quality and aquatic ecosystem, etc.

The water quality targets of river basin are notified by the Minister of Environment, governors or mayors. In particular, the Minister of Environment notifies the water quality target for the boundary between Provinces and Cities. Governors and mayors should obtain permission from the Minister of Environment before applying for permission of a basic plan on downstream of watershed in their jurisdiction. The plan must attain the water quality target for the boundary between Provinces and Cities specifically notified by the Minister of Environment.

Current Status of Water Quality Target by River Basin

	Total	Han river	Nakdong river	Geum river	Yeongsan&Seomjin river
Total	146	49(1)	41	32(2)	24(2)
Boundary between Cities and Provinces	37	12	8	10	7(1)
Jurisdiction of Cities and Provinces	109	37(1)	33	22(2)	17(1)

※ In the above table, the brackets implies that a target is not set up due to brackish water.

Current Status of Water Quality Target on Boundary between Cities and Provinces in 3rd Stage (2016~2020)

Geum-river Basin('16~'20)		
Geumbon C	BOD	1.0
	T-P	0.014
Geumbon D	BOD	1.0
	T-P	0.020
Geumbon F	BOD	1.0
	T-P	0.018
Yoodeung A	BOD	1.2
	T-P	0.032
Gabcheon A	BOD	5.2
	T-P	0.200
Geumbon G	BOD	2.3
	T-P	0.081
Byeongcheon A	BOD	2.3
	T-P	0.163
Miho B	BOD	4.1
	T-P	0.140
Geumbon H	BOD	2.9
	T-P	0.094
Geumbon K	BOD	3.0
	T-P	0.085

Yeongsan-river Basin('16~'20)		
Yeongbon A	BOD	2.4
	T-P	0.082
Hwangryong A	BOD	2.2
	T-P	0.060
Yeongbon B	BOD	4.8
	T-P	0.187

Seomjin-river Basin('16~'20)		
Seombon C	BOD	1.5
	T-P	0.040
Yocheon B	BOD	1.5
	T-P	0.063
Seombon E	BOD	1.3
	T-P	0.030

Han-river Basin('13.6~'20)		
Hangang G	BOD	1.7
	T-P	0.042
Tancheon A	BOD	6.8
	T-P	0.454
Jungnang A	BOD	8.6
	T-P	0.575
Anyang A	BOD	6.2
	T-P	0.558
Hangang I	BOD	4.1
	T-P	0.236
Gulpo A	BOD	7.9
	T-P	0.959

Nakdong-river Basin('16~'20)		
Nakbon A	BOD	1.4
	T-P	0.057
Nakbon F	BOD	1.9
	T-P	0.058
Guemho B	BOD	3.3
	T-P	0.093
Guemho C	BOD	3.5
	T-P	0.149
Nakbon G	BOD	2.8
	T-P	0.075
Hwacheon A	BOD	1.2
	T-P	0.047
Milyang A	BOD	1.4
	T-P	0.031
Nakbon L	BOD	2.9
	T-P	0.065

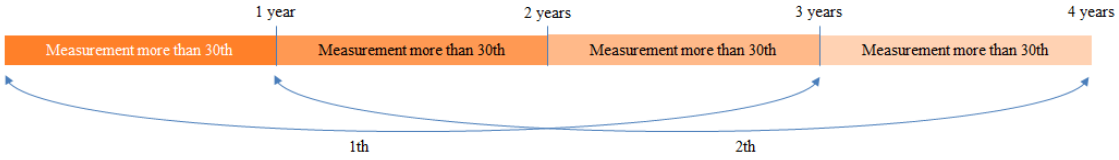
5.3 Development of TMDL Basic Plan

Once the water quality target is set, governors and mayors decide load allocations of pollutants by watershed or sub-local government in order to attain and maintain the target. The basic plan designates load allocations by watershed in the jurisdiction of Provinces and Cities, and load allocations by sub-local government.

5.4 Development of TMDL Implementation Plan

Governor and mayors develop the detailed local development plans and the annual plans for pollution reduction, with a view to meeting the load allocation of each watershed and sub-local government designated by the above basic plan.

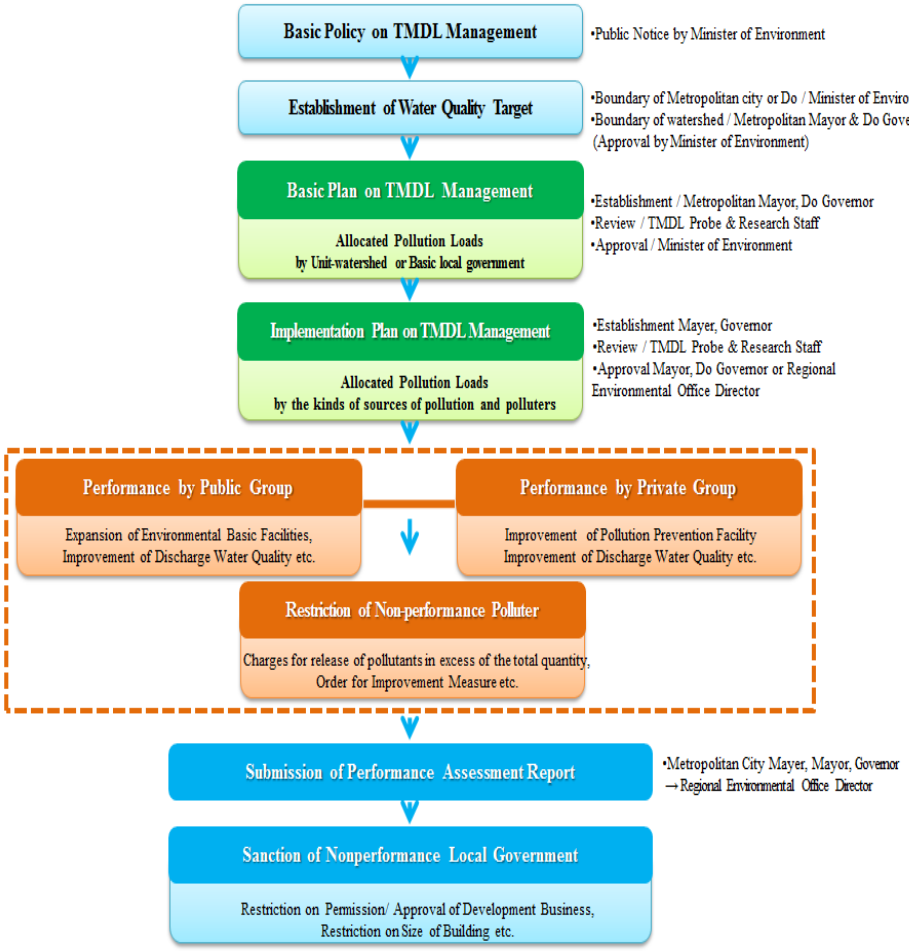
The areas where the TMDL Implementation Plan is applied are cities or counties in which their annual average value exceeds the water quality target two times in a row, resulting from that the water quality is measured over 30 times per year at the end of watershed.



5.5 Performance Evaluation of TMDL Implementation Plan

Implementation of the TMDL system is evaluated every year, given the matters to be implemented in the year as prescribed by the TMDL implementation plan. As a result of the evaluation, when it is admitted that smooth implementation of TMDL system is needed, the central government may ask a governor or mayor to establish and take necessary measures: for example, restriction on development projects such as urban development and industrial complex, suspension or cutbacks of financial support, restriction on installation or modification of facilities where discharging wastewater.

Implement Procedure of TMDL System



6. Achievement and Prospect of the TMDL system

Since the TMDL system has been implemented starting from Nakdong River Basin in 2004, the discharged load that flows from Nakdong river, Geum river, Yeongsan river and Seomjin river to down streams had drastically decreased to 213,322kg/day in 2010 (the end year of the 1st stage), down 39.6 % from 353,348kg/day in 2002, even though generated BOD load had markedly increased during the same period.

	2004(A) (kg/day, BOD)	2010(B) (kg/day, BOD)	Reduced Quantity(A-B) (kg/day, BOD)	Variation Rate (1-B/A)
Total	353,348	213,322	▽140,025	39.6%
Nakdong River	176,080	105,711	▽70,369	40.0%
Geum River	126,163	74,272	▽51,891	41.1%
Yeongsan&Seomjin River	51,105	33,339	▽17,765	34.8%

As a result of performance evaluation on all watersheds in Han River, the pollution load stood at 33,709kg/day in 2012, down 18.7% from 41,470kg/day in 2009. In particular, BOD concentrations in major drinking water resources such as Mulgeum, Lake Daecheong and Lake Juam as well as end sites of

river basin has been improved as ranging from 55.5% to 88.8% compared with that of 2004 when the TMDL system was started.

	Watershed	Water Quality Target (mg/L, BOD)	2004 (mg/L, BOD)	2010 (mg/L, BOD)	Improvement Rate(%)	Remarks
Nakdong River	Nakbon K	3.0	2.7	2.4	11.2	conservation area for drinking water, Mulgeum
Geum River	Geumbon F	1.0	0.9	0.8	11.2	conservation area for drinking water, Daechong lake
	Geumbon K	3.0	4.6	3.1	32.6	representative sites (end sites)
Yeongsan river	Boseong B	1.6	1.5	1.3	13.4	conservation area for drinking water, Juam lake
	Yeongbon B	5.6	9.0	5.0	44.5	representative sites (end sites)

This remarkable performance is attributed to the introduction of TMDL system, which results in the development and application of pollutant reduction technologies, the inducement and encouragement of the environmentally friendly development, and the improvement of water quality flown from pollutant-discharging facilities.

The TMDL system eases the conflicts among local authorities in charge of upstream and downstream management respectively, and contributes to consolidating community spirit based on mutual cooperation by means of clarifying responsibility of local government, sub-local government, individual polluter and allocating pollution load to each of them.

In addition, local development projects are undertaken while taking account of the designated pollution load, with the efforts toward low impact development and reduction of existing pollution sources. Hence, the TMDL system contributes to inducing local development given the environment and furthermore enhancing the sustainability.

Currently, it is required for the TMDL system to set up the water quality target and parameters considering each characteristic of watershed, going beyond simple parameters like BOD or T-P. Therefore, it is expected to expand and diversify the scope of TMDL system through putting additional parameters for managing non-biodegradable substances and introducing TMDL system for tributaries given unique characteristics of each area.

For keeping the TMDL system sustainable, new reduction technologies and approaches must be developed. As it also needs to verify reduction approaches that are not authorized due to their difficulties in quantifying reduction volume (e.g. road-cleaning) or managing persistently, it is expected to diversify reduction approaches and carry out continuous R&D projects.

Furthermore, for efficient and active implementation of TMDL system, it is essential to secure the cooperation of all stakeholders in each watershed and voluntary participation of the private sector. Therefore, it is forecasted to transform the framework of TMDL system from the central government-led system to local community-led one based on active cooperation among the central government, local governments, private enterprises and local residents, by means of building a consortium and network by watershed, invigorating the Water Emissions Trading (WET) system through expansion of private facilities where load allocation is designated, etc.