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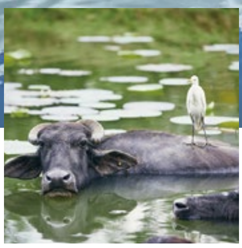
Outlook on Water Environmental Management in Asia



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Water Environmental Partnership in Asia (WEPA)
Ministry of the Environment, Japan
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Outlook on Water Environmental Management in Asia 2021

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Ministry of the Environment, Japan
1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-8975 Japan
Tel: +81-(0)3-3581-3351
http://www.env.go.jp/en/

Institute for Global Environmental Strategies (IGES)
2108-11 Kamiyamaguchi, Hayama, Kanagawa 240-0115 Japan
Tel: +81-(0)46-855-3700
http://www.iges.or.jp/

The team for WEPA Outlook 2021 includes the following IGES members:

[Drafting team] (Affiliation is correct at the time of writing, [ ] indicates part written by the author)
supervised by:

Mizuno, Osamu	Principal Fellow, Adaptation and Water [WEPA Message, Ch1]

(*Alphabetical order)

Inamura, Yukako	Policy Researcher, Adaptation and Water [China]
Kumar, Pankaj	Senior Policy Researcher, Adaptation and Water [Indonesia, Lao PDR, Malaysia]
Kyogoku, Tomoko	Senior Coordinator, Strategic Management Office [WEPA Message, China]
Mitra, Bijon Kumer	Senior Policy Researcher, Adaptation and Water [Cambodia, Myanmar]
Murase, Noriaki	Programme Manager, Natural Resources and Ecosystem Services [WEPA Message, China]
Pham, Ngoc Bao	Senior Water and Sanitation Specialist, Adaptation and Water [Thailand, Viet Nam]
Shivakoti, Binaya Raj	Senior Water and Adaptation Specialist, Adaptation and Water [Nepal, Philippines, Sri Lanka]
Taguchi, Toru	Policy Researcher, Climate and Energy [Japan]
Takeda, Tomoko	Water and Disaster Risk Reduction Specialist, Natural Resources and Ecosystem Services [WEPA Message, Ch1, Korea]
Yagi, Kazuyuki	Programme Manager, Adaptation and Water [Ch1]

[Supporting team]

Kitamura, Eiko	Publication Coordinator, Strategic Management Office

Printed in Japan

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Background to the Publication

COVID-19, which first occurred in December 2019, has morphed from a mere dangerous regional health threat to an all-consuming global pandemic and economic disaster. Under this environment, the importance of public health, including improvement of the water environment, has become even more critical globally. Asia comprises 30% of the world's land area and 30% of the world's freshwater resources, which is shared among 60% of the world's population. As the area's populations and economies expand, Asia continues to face serious water pollution issues, leading to degradation of the living environment, reduction in available water, and loss of ecosystem services. In this context, coupled with the recent outbreak of COVID-19, the need to improve the water environment has been strongly recognized.

The Ministry of the Environment, Japan proposed the establishment of an initiative called the Water Environment Partnership in Asia (WEPA) at the Third World Water Forum in 2003, aiming to solve the region's water pollution issues in terms of governance, and in 2004, WEPA started initiating activities.

WEPA has conducted capacity development of stakeholders as well as sharing of information and knowledge for finding solutions to water environmental issues under the partnership of 13 Asian countries, namely Cambodia, China, Indonesia, Japan, Republic of Korea, Lao PDR, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand and Viet Nam.

Considering the importance of a common understanding among stakeholders to solve water quality issues in the region, the "WEPA Outlook on Water Environmental Management" has been periodically prepared by utilizing accumulated information and knowledge, as well as the human network developed under this initiative. The report aims to provide the most up-to-date and useful information on the environment and its management in Asia, with a target audience of policymakers, experts and others in the water sector of the region. Four former editions of the Outlook were launched in 2009, 2012, 2015, and 2018 respectively during the World Water Forums in Istanbul, Marseille, Daegu-Gyeongbuk, and Brasilia, in order to provide a useful source of information for stakeholders working on water quality issues in other parts of the world.

This report is the fifth edition of the series, and consists of two main chapters: Chapter 1 – "Outlook on Water Environmental Management in WEPA Countries" and Chapter 2 – "Country Profiles of Water Environmental Management in WEPA Countries". The first chapter presents the results of analysis on institutional frameworks for water environmental management in the WEPA partner countries. Directly following this foreword readers will also find WEPA's key recommendations describing its commitments to sustainable water environmental management, made through discussions held in WEPA annual meetings and workshops. This fifth edition also aimed at providing higher quality information by improving the compatibility of the information between countries, clearly indicating the changes over time, and enhancing the description of "compliance with regulations", which was proposed as a priority issue in "WEPA Basic Policy in the 4th Phase".

The "WEPA Outlook on Water Environmental Management 2021" was originally scheduled to be published at the ninth World Water Forum in Dakar, Senegal, which has been postponed from March 2021 to March 2022 due to the COVID-19 pandemic. However, while the Forum has been rescheduled, publication of the WEPA outlook will proceed as planned in December 2021, three years since the previous edition, considering the importance of periodically reviewing the situation of water environmental management in the Asian region. It is hoped that this report, together with the four former editions, will serve as useful tools and points of reference for those involved in related issues in Asia and other regions of the world, and contribute to sustainable water environmental management.

December 2021
Ministry of the Environment, Japan
Institute for Global Environmental Strategies
(WEPA Secretariat)

Key messages from the Water Environment Partnership in Asia (WEPA)

1 The Asian region continues to experience rapid population growth, urbanization, industrialization and changing consumption patterns. It is also beginning to observe severe negative impacts due to climate change, which has exacerbated the challenges surrounding water resources in the region. Volumes of wastewater and pollution loads discharged into the environment are constantly rising, deteriorating water quality across the region. Leadership at local, national, and regional levels is required to address this issue, especially in setting appropriate emission targets.

2 Achieving Sustainable Development Goal (SDG) 6 on water and sanitation is essential, and due to its role in mutually reinforcing other SDGs, it is key also in ensuring their achievement, including those related to health and biodiversity.

3 Moreover, during the unprecedented global pandemic of COVID-19, water management has been shown to play a vital role in maintaining public health. It is a life-saving commodity, and is used for drinking and cooking, washing, sanitation, disinfection by boiling, producing critical medicines and medical equipment, among countless other uses required to fight the pandemic. Improving water environment governance, therefore, was found more relevant to prevent and deal with similar pandemics in the future. However, care must be taken so that new policies and governance tools for fighting pandemics do not incur negative trade-offs in the water environment. Conversely, water environmental management policies must not generate negative trade-offs in countermeasures against COVID-19 and other pandemics. To avoid these trade-offs and maximize co-benefits between policies pertaining to COVID-19 and water management, government agencies responsible for water management should be included in the wider coordination process for COVID-19 countermeasures within each government.

4 Based on 17 years of accumulated experience, WEPA partner countries hold the following views in common in addressing the above challenges:

a. There is no "one size fits all" solution to solve the challenges across the region, thus appropriate solutions need to be based on local contexts – and where feasible, holistic approaches should be adopted to minimize or prevent pollution at source while maximizing the effective and efficient reuse and recycling of water throughout its life cycle.

b. Reliable and timely data on water quality and pollution loads plays an essential role in evidence-based decision-making to ensure sustainable water governance, and consequently improves water environment. However, in many cases, such data is not available in the region due to the pervasive lack of reliable monitoring system, caused by inadequate monitoring facilities and human resources, especially in technical capacity. Therefore, it is crucial to invest in both the 'hardware' and 'software' of water monitoring and reporting, as well as ensure monitoring results are made widely and easily available to all relevant stakeholders, such as via digital platforming.

c. Further technical innovation is required to improve wastewater treatment efficiency to reduce pollutant loads in water bodies, as well as raise rates of water reuse and recovery of useful by-products such as nutrients. Realization of such requires providing an environment conducive to change, including creation of effective water quality legislative frameworks via improved wastewater and sludge management, enhanced human and institutional capacity, and the political will to enforce regulations and penalties.

d. Selection of wastewater treatment technologies should be based on site-specific contexts that account for natural and socioeconomic conditions and level of development. Appropriate low-cost, environmentally sound and socially acceptable technologies that are simple to use and maintain should be prioritized over conventional, high-cost approaches.

e. Scientific evidence-based knowledge in formulating effective policies and regulations should be utilized, including promotion of dialogue among policymakers and researchers, to improve water environmental management.

f. Ensuring financial sustainability in wastewater and sludge management through innovative and sustainable financing mechanisms needs to be developed urgently.

g. The active involvement of various stakeholders, including private sector and local communities in water environmental management should be promoted. Special care must be taken to ensure the views of multi-stakeholders disproportionately affected by water environment management (or the lack thereof) are well represented during decision-making processes.

h. Enforcement of legal frameworks, regulations and detailed rules or guidelines regarding domestic and industrial wastewater management, including effluent monitoring procedures and analytical methods continue to be challenging, especially under new social distancing measures and limited human resources. There is a need to continue efforts to overcome this challenge, and for the partner countries to continue working together to comply with regulations and share experiences.

5 Focal agencies of WEPA countries related to the water environment will continue to contribute to the successful implementation of the 2030 Agenda for Sustainable Development through improving water environmental management.

6 WEPA will continue to facilitate the exchange of lessons and knowledge among the partner countries through the WEPA database, policy dialogues, workshops, and country projects. WEPA also supports partner countries' specific policy challenges, through implementing well-designed action programs. Practical lessons learned and knowledge accumulated from the action programs are shared not only among partner countries but also wider audiences through the WEPA database. WEPA intends to strengthen interactions with other like-minded networks, international organizations and donor agencies to explore opportunities to maximize the impacts of its activities.

7 Envisaging the wellbeing of populations and sustainable development in the region, the WEPA partners hereby commit to improving the water environment via enhancing cooperation, sharing knowledge, and taking actions in water governance. We believe such efforts will also contribute to improved capacity building of the relevant stakeholders, and smooth implementation of the 2030 Agenda for Sustainable Development.

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* Focal Person
(As of March 2021)

Cambodia

Rady Phin*, Director, Department of Water Quality Management, General Directorate of Environmental Protection, Ministry of Environment

Chandath Him, Deputy Director, Department of Air Quality and Noise Management, General Directorate of Environmental Protection, Ministry of Environment

China

Li Liping*, Division Director, Policy Research Centre for Environment and Economy (PRCEE), Ministry of Ecology and Environment

Li Yuanyuan, Policy Research Centre for Environment and Economy (PRCEE), Ministry of Ecology and Environment

Indonesia

Budi Kurniawan, Deputy Director, Inventory and Pollution Load Allocation, Ministry of Environment and Forestry

Herry Hamdani*, Deputy Director of Pollution Control from Small Scale Enterprises and Nonpoint Sources, Directorate for Water Pollution Control, Ministry of Environment and Forestry

Safrudin Hermanto, Inventory and Pollution Load Allocation, Ministry of Environment and Forestry

Lao PDR

Phengkamla Phonvisai*, Deputy Director General, Department of Pollution Control and Monitoring, Ministry of Natural Resources and Environment

Somsanouk Phommakhot, Director of Pollution Control Division, Department of Pollution Control and Monitoring, Ministry of Natural Resources and Environment

Sengkeo Tasaketh, Deputy Director of Pollution Control Division, Department of Pollution Control and Monitoring, Ministry of Natural Resources and Environment

Japan

Seiji Tsutsui*, Director, Water Environment Division, Environmental Management Bureau, Ministry of the Environment

Hiroyasu Kawashima, Deputy Director, Water Environment Division, Environment Management Bureau, Ministry of the Environment

Shinya Matsumoto, Chief of Sewerage Section, Water Environment Division, Environment Management Bureau, Ministry of the Environment

Republic of Korea

Taejin Park*, Senior Researcher, Water Environmental Engineering Research Division, Water Environment Research Department, National Institute of Environmental Research (NIER)

Jaeho Lee, Researcher, Water Supply and Sewerage Research Division, Environmental Infrastructure Research Department, National Institute of Environmental Research (NIER)

Malaysia

Hin Lee Lee*, Senior Research Officer, Environmental Water Quality Research Unit, Water Quality and Environmental Research Centre, National Water Research Institute of Malaysia (NAHRIM), Ministry of Natural Resources and Environment

Shin Ying Ang, Research Officer, Water Treatment Technology Research Unit, Water Quality and Environmental Research Centre, National Water Research Institute of Malaysia (NAHRIM), Ministry of Natural Resources and Environment

Myanmar

Tin Tin Thaw*, Deputy Director, Environmental Quality Standard Division, Environmental Conservation Department, Ministry of Natural Resources and Environmental Conservation

Nepal

Madhav Dev Acharya*, Senior Divisional Engineering Geologist, Water Resources Division, Water and Energy Commission Secretariat (WECS)

Janak Kumar Jha, Economist, Socio-economic and Environment Division, Water and Energy Commission Secretariat (WECS)

Philippines

Vincente B. Tuddao Jr.*, Assistant Regional Executive Director for Technical Services, MIMAROPA Region, Department of Environment and Natural Resources (DENR)

Erlinda A. Gonzales*, Technical Officer as Environmental Consultant, Environmental Management Bureau, Department of Environment and Natural Resources (DENR)

Sri Lanka

R.M.S.K. Ratnayake*, Director, Environmental Pollution Control, Central Environmental Authority

Himali Karunaweera, Assistant Director, Environmental Pollution Control, Central Environmental Authority

Duggath Mudiyanselage Smathilaka Senarath Bandara, Senior Environmental Officer, Central Environmental Authority

Thailand

Chaiyo Juisiri*, Director of Inland Water Sub-division, Pollution Control Department, Ministry of Natural Resources and Environment

Kindao Intarukdach, Environmentalist, Senior Professional level, Pollution Control Department, Ministry of Natural Resources and Environment

Chayawee Wangcharoenrung, Director of Industrial Wastewater Division, Water Quality Management Bureau, Pollution Control Department, Ministry of Natural Resources and Environment

Viet Nam

Nguyen Minh Cuong*, Deputy Director, Department of International Cooperation, Science and Technology, Vietnam Environment Administration, Ministry of Natural Resources and Environment (MONRE)

WEPA Advisory Board Members

Motoyuki Suzuki, Professor emeritus at the University of Tokyo

Mitsumasa Okada, Vice President, the Open University of Japan

Koichi Fujie, Visiting Professor, Institute of Advanced Sciences, Yokohama National University

Kensuke Fukushi, Professor, Integrated Research System for Sustainability Science, the University of Tokyo

So Kazama, Professor, Graduate School of Engineering, Tohoku University

Yoshitaka Ebie, Senior Researcher, Centre for Material Cycles and Waste Management Research, National Institute for Environmental Studies

Ikuro Kasuga, Associate Professor, Graduate School of Engineering, the University of Tokyo

Yoshihiko Matsui, Professor, Graduate School of Engineering, Hokkaido University

*Masaaki Hosomi, Professor emeritus at Tokyo University of Agriculture and Technology**

* *Professor Hosomi passed away in September 2020. We would like to express our deepest gratitude to him for his great contribution to WEPA during his life and pray for his soul.*

Abbreviations

ADB	Asian Development Bank
AMDAL	*Analisis Manajemen Dampak Lingkungan* (Environmental Impact Assessment Statements) (Indonesia)
As	Arsenic
ASEAN	Association of South-East Asian Nations
ASM	Academy of Sciences Malaysia (Malaysia)
AWQS	Ambient Water Quality Standards (Sri Lanka)
B.E.	Buddhist Era (Thailand)
BAPPENAS	*Badan Perencanaan Pembangunan Nasional* (Ministry of National Development Planning) (Indonesia)
BFAR	Bureau of Fisheries and Aquatic Resources (Philippines)
BOD	Biochemical Oxygen Demand
BOI	Board of Investment (Sri Lanka)
Cd	Cadmium
CDOs	Cease and Desist Orders (Philippines)
CEA	Central Environmentl Authority (Sri Lanka)
CEM	Centre of Environmental Monitoring (Viet Nam)
Chl. a	Chlorophyll a
COD	Chemical Oxygen Demand
COD_{Mn}	Chemical Oxygen Demand (potassium permanganate method)
Cr	Chromium
CSDGs	Cambodia's Sustainable Development Goals Frameworks (Cambodia)
CSO	Central Statistical Organization (Myanmar)
CSO	Civil Society Organization
CWTP/CWTF	Centralized Wastewater Treatment Plants/Facilities
DA	Department of Agriculture (Philippines)
DAO	DENR Administrative Order (Philippines)
DAS	*Daerah Aliran Sungai* (watersheds) (Indonesia)
DENR	Department of Environment and Natural Resources (Philippines)
DENR-NCR MBSCMO	Department of Environment and Natural Resources-National Capital Region Manila Bay Site Coordinating and Management Office (Philippines)
DEWATS	Decentralized Wastewater Treatment System
DHM	Department of Hydrology and Meteorology (Nepal)
DILG	Department of Inferior and Local Government (Philippines)
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DISI	Directorate of Industrial Supervision Inspection (Myanmar)
DKI Jakarta	*Daerah Khusus Ibukota Jakarta* (Special Capital Region of Jakarta) (Indonesia)
DO	Dissolved Oxygen
DOE	Department of Environment (Malaysia)
DOH	Department of Health (Philippines)
DoNRE	Department of Natural Resources and Environment (Viet Nam)
DONRE	Department of Natural Resources and Environment (Lao PDR)
DOSM	Department od Statistics Malaysia (Malaysia)
DPCM	Department of Pollution Control and Monitoring (Lao PDR)
DPWH	Department of Public Works and Highways (Philippines)
DWSSM	Department of Water Supply and Sewerage Management (Nepal)
EC	Electric Conductivity
ECD	Environmental Conservation Department (Myanmar)
EIA	Environmental Impact Assessments
EMB	Environmental Management Bureau (Philippines)
ENRC	Environment and Natural Resources Code of Cambodia (Cambodia)
EPL	Environmental Protection license (Sri Lanka)
EPL	Environmental Protection Law (Lao PDR)
EQA	Environmental Quality Act (Malaysia)
EQS	Environmental Quality Standards (Japan)
ESC-BORDA	Environmental Sanitation Cambodia-Bremen Overseas Research and Development Association (Cambodia)
FAO	Food and Agriculture Organization
FCB	Faecal Coliform Bacteria
FMB	Forest Management Bureau (Philippines)
GAP	Good Aquaculture Practice
GB	Chinese National Standards (China)
GB/T	Recommended Standards (China)
GDP	Gross Domestic Product
GES	General Effluent Standards (Philippines)
GIS	Geografic Information System
GoN	Government of Nepal (Nepal)
Hg	Mercury
HMs	Heavy Metal(s)
IETS	Industrial Effluent Treatment Systems (Malaysia)
IGES	Institute for Global Environmental Strategies
IMF	International Monetary Fund
IPL	Industrial Processing Law (Lao PDR)
IWK	Indah Water Konsortium (Malaysia)
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
KRA	Key Result Area (Philippines)
LGUs	Local Government Units (Philippines)
LKR	Sri Lankan Rupee(s) (Sri Lanka)
LLDA	Laguna Lake Development Authority (Philippines)
LSB	Lao Statistics Bureau (Lao PDR)
LWUA	Local Water Utilities Administration (Philippines)
MAFRA	Ministry of Agriculture, Food and Rural Affairs (Korea)
MARD	Ministry of Agriculture and Rural Development (Viet Nam)
MEE	Ministry of Ecology and Environment (China)
MENR	Ministry of Environment and Natural Resources (Sri Lanka)
MEPA	Marine Environment Protection Authority (Sri Lanka)
MIME	Ministry of Industry, Mine and Energy (Cambodia)
MLD	Million Liters Per Day
MLIT	Ministry of Land, Infrastructure, Transport (Korea)
MMDA	Metro Manila Development Autority (Philippines)
MND	Ministry of National Defence (Korea)
MOC	Ministry of Construction (Viet Nam)
MOE	Ministry of Environment (Korea)
MOEC	Ministry of Environment (Cambodia)
MOEF	Ministy of Environment and Forestry (Indonesia)
MOEF	Ministry of Forests and Environment (Nepal)
MoEJ	Ministry of the Environment, Japan (Japan)
MOEWRI	Ministry of Energy, Water Resources and Irrigation (Nepal)
MOF	Ministry of Finance (Viet Nam)
MOH	Ministry of Health (Viet Nam)
MoH	Ministry of Health (Lao PDR)
MOHA	Ministry of Home Affairs (Viet Nam)
MOIC	Ministry of Industrial and Commerce (Lao PDR)
MOIF	Minsitry of the Interior and Safety (Korea)
MOIT	Ministry of Industry and Trade (Viet Nam)
MoNRE	Ministry of Natural Resources and Environment (Thailand)

MONRE	Ministry of Natural Resources and Environment (Viet Nam)
MONRE	Ministry of Natural Resources and Environment (Lao PDR)
MONREC	Minisry of Natural Resourecs and Environmental Concervation (Myanmar)
MOST	Ministry of Science and Technology (Viet Nam)
MoSTE	Ministry of Science, Technology and the Environment (Malaysia)
MoSTI	Ministry of Science, Technology and Innovation (Malaysia)
MOT	Ministry of Transport (Viet Nam)
MoWRAM	Ministry of Water Resources and Meteorology (Cambodia)
MPI	Ministry of Planning and Investment (Viet Nam)
MPWT	Ministry of Public Work and Transport (Cambodia)
MPWT	Ministry of Public Works and Transportation (Lao PDR)
MRC	Mekong River Commission
MRD	Ministry of Rural Development (Cambodia)
MSDP	Myanmar Sustainable Development Plan (Myanmar)
MWQI	Marine Water Quality Index (Thailand)
MWQI	Marine Water Quality Index (Malaysia)
MWR	Ministry of Water Resources (China)
MWS	Ministry of Water Supply (Nepal)
MWSS	Metropolitan Water Works and Sewerage System (Philippines)
NCSD	Nationa Council for Sustainable Development (Sri Lanka)
NDWQS	National Drinking Water Quality Standards (Nepal)
NEA	National Environmental Act (Sri Lanka)
NEAP	National Environmental Action Plan (Cambodia)
NEB	National Environmental Board (Thailand)
NEDA	National Economic and Development Authority (Philippines)
NEQA	National Environmental Quality Act (Thailand)
NEQEG	National Environmental Quality (Emission) Guidelines (Myanmar)
NESAP	National Environment Strategy and Action Plan (Cambodia)
NGDWQ	National Guidelines for Drinking Water Quality (Malaysia)
NGO	Non Governmental Organization
NH_3	Ammonia
NH_3-N/ NH_4-N	Ammoniacal/Ammonia/Ammonium Nitrogen
NH_4^+	Ammonium
NIA	National Irrigation Administration (Philippines)
NIER	The National Institute for Rnvironmental Research (Korea)
NIWR	Norwegian Institute for Water Research
NLCDC	National Lake Conservation Development Committee (Nepal)
NO_3/NO_3^-	Nitrate
NO_3-N	Nitrate Nitrogen
NOV	Notice of Violation (Philippines)
NPC	National Planning Commission (Nepal)
NPC	National Power Corporation (Philippines)
NRESRI	Natural Resources and Environmental Statistic and Research Institute (Lao PDR)
NWP	Myanmar National Water Policy (Myanmar)
NWQS	National Water Quality Standards (Malaysia)
NWRB	National Water Resources Board (Philippines)
NWRP	National Water Resources Policy (Malaysia)
NWSDB	National Water Supply and Drainage Board (Sri Lanka)
ONEP	Office of Natural Resources and Environmental Policy and Planning (Thailand)
PAB	Pollution Adjudication Board (Philippines)
Pb	Lead
PC	City of Provincial People's Committee (Viet Nam)
PCB	Polychlorinated Biphenyl
PCD	Pollution Control Department (Thailand)
PD	Presidential Decree (Philippines)
PEZA	Philippine Economic Zone Authority (Philippines)
pH	Potential of Hydrogen
PHP	Philippine Peso (Philippines)
PNSDW	Philippines National Standards for Drinking Water (Philippines)
PO_4/PO_4-P	Phosphate
PROPER	*Program Penilaian Peringkat Kinerja Perusahaan* (Program for Pollution Control Evaluation and Rating) (Indonesia)
PUPR	Ministry of Public Works and Housing (Indonesia)
RA	Republic Act (Philippines)
RPJMN	*Rencana Pembangunan Jangka Menengah Nasional* (National Medium-Term Development Plan) (Indonesia)
RPJPN	*Rencana Pembangunan Jangka Panjang Nasional* (National Long-Term Development Plan) (Indonesia)
RTG	Royal Thai Government (Thailand)
SD	Transparency (secchi disc)
SDGs	Sustainable Development Goals
SEPA	State Environmental Protection Administration, China (China)
SIA	Social Impact Assessments
SMEs	Small and Medium Enterprises
SPAN	*Suruhanjaya Perkhidmatan Air Negara* (National Water Services Commission) (Malaysia)
SpTPs	Septage Treatment Plants
SS	Suspended Solids
SSD	Sewerage Service Department (Malaysia)
STPs	Sewage Treatment Plants
SWML	Scheduled Waste Management License (Sri Lanka)
TCB	Total Coliform Bacteria
TDS	Total Dissolved Solids
THB	Thai Baht (Thailand)
TKN	Total Kjehldahl Nitrogen
TMDL	Total Maximum Daily Load System
TN/T-N	Total Nitrogen
TOC	Total Organic Carbon
TP/T-P	Total Phosphorus
TPLC	Total Pollutant Load Control System (Japan)
TSA	Tonle Sap Authority (Cambodia)
TSL	Tonle Sap Lake (Cambodia)
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
USD	United States Dollars
VEA	Viet Nam Environment Administration (Viet Nam)
VIPs	Ventilated Improved Pit Latrines
VOCs	Volatile Organic Compounds
WECS	Water and Energy Commission Secretariat (Nepal)
WEPA	Water Environment Partnership in Asia
WHO	World Health Organisation
WISA	Water Service Industry Act (Malaysia)
WQC	Water Quality Criteria (Indonesia)
WQG	Water Quality Guidelines (Philippines)
WQI	Water Quality Index (Korea)
WQI	Water Quality Index (Thailand)
WQI	Water Quality Index (Viet Nam)
WQI	Water Quality Index (Malaysia)
WQMA	Water Quality Management Areas (Philippines)
WQMACA	Water Quality Management and Conservation Area (Philippines)
WWTPs	Wastewater Treatment Plants
WWTS	Wastewater Treatment System
Zn	Zinc
MEP	Ministry of Environmental Protection (China)

Chapter

1

Outlook on Water Environmental Management in WEPA Countries

Outlook on Water Environmental Management in WEPA Countries

The Water Environment Partnership in Asia (WEPA) was formed to address issues related to the water environment in the 13 partner countries by improving water environmental governance, with the aim of promoting knowledge sharing among partner countries towards finding solutions. Because each WEPA partner country faces different water-related environmental problems, due to differing natural and socioeconomic conditions, each has developed unique policies and measures designed to tackle these problems. Providing a review of the above, therefore, is deemed useful to bring to light any differences and commonalities, as well as issues in the water environmental management framework among the WEPA partner countries, and promote deeper discussion based on a common understanding.

To this end, this chapter summarizes the state of water environmental management in WEPA partner countries based on the country profiles in the following chapters and attempts to identify common challenges.

This chapter also provides a snapshot of the current water environmental management frameworks in the partner countries from the following perspectives:

- Legal framework, including objectives of water environmental management and ambient water quality standards
- Institutional framework for water environment management
- Monitoring framework of water environment
- Enforcement framework including measures to ensure implementation and compliance, focusing on wastewater management

Given the problems faced by the countries differ in both type and scale, we set out to solely provide a country-based overview of the progress made in the policies and measures related to the water environment, and attempted to avoid any inter-country comparisons or evaluations of progress.

1 | Outlook of Water Environmental Governance

1.1 New Policy Development and Legislation

All WEPA countries have established basic environmental laws stipulating protection of human health by ensuring protection of a safe environment as a basis for sustainable development, and these objectives also apply for water environmental management. Table 1.1 lists the basic environmental laws and laws or acts specific to pollution control in WEPA countries. In recent years, WEPA countries have been highly active in establishing or improving policies and legal frameworks for better water governance. The major recent developments since the time information was collected for WEPA Outlook 2018 on policies, laws and regulations relevant to the water environment in the WEPA countries include:

- In Cambodia, Sub-decree on Management of Sewage and Wastewater Treatment System, enacted in Dec. 2017, which provides a mandate for management of sewage systems and wastewater treatment systems to sub-national authorities. The final draft revision of Sub-decree on Water Pollution Control, which is to include revisions of water quality standards and effluent standard, is under development.
- In China, the Environmental Protection Law and the Water Pollution Prevention and Control Law were amended in 2018, the latter (Water Pollution Prevention and Control Law) of which stipulates requirements for wastewater prevention and treatment. As for seawater, the Law on the Protection of the Marine Environment was amended in 2017. Further, the Environmental Protection Tax Law was enacted in 2018. China also introduced the Pollution Discharge Permit system, which includes wastewater control requirements in 2018 as a trial.
- In Indonesia, Law No. 17/2019 (Law on Water Resources) was enacted in 2019 focusing on holistic water resource management in line with the SDGs. New elements introduced through Law No. 17/2019 include establishment of a water resource information system for more comprehensive monitoring, and licensing and empowerment for

authorities engaged in water resource supervision and management. Currently, with technical support from WEPA through an Action Programme, the Ministry of Environment and Forestry of Indonesia is drafting the related framework and regulations, and in particular, a technical Guideline for introducing and implementing the Total Maximum Daily Load (TMDL) approach in selected river basins across the country.

- In Japan, a partial revision of the Johkasou Act was enacted and promulgated in 2019 to convert old type johkasou and improve johkasou management. In addition, a new Basic Plan on Water Cycle was enacted in 2020.
- In Republic of Korea, the Framework Act on Water Management was newly established in 2018 to encompass the concept of integrated water resources management. The previous Water Quality and Ecosystem Conservation Act was expanded in 2018 to encompass the entire water environment, and was developed into the Water Environment Conservation Act. Since 2020, total organic carbon (TOC) has been used as a parameter to monitor organic substances in addition to COD_{Mn}, due to the difficulty of monitoring non-degradable organic substances.
- In Lao PDR, the Environmental Protection Law was amended and enacted in 2018, containing measures for the protection, mitigation and restoration of the environment as well as guidelines for environmental management and monitoring. The National Strategy on Rural Water Supply, Sanitation and Hygiene 2019–2030 No. 0947/MoH was approved and issued in 2019.

Table 1.1 Basic environmental laws and laws or acts specific to pollution control in WEPA countries

Country	Basic Environmental Law	Law or Act specific to Pollution Control
Cambodia	Law on Environmental Protection and Natural Resources Management	Law on Water Resource Management
China	Environmental Protection Law	Water Pollution Prevention and Control Law Marine Environmental Protection Law Action Plan for Prevention and Control of Water Pollution
Indonesia	Law concerning Environmental Protection and Management	Government Regulation concerning the management of Water Quality and Control of Water Pollution Law on Water Resources
Japan	Basic Environmental Law	Water Pollution Control Law Law Concerning Special Measures of Lake Water Quality Law Concerning Special Measures for Conservation of the *Seto* Inland Sea Law Concerning Special Measures for the Restoration of the *Ariake* and *Yatsushiro* Seas Law Concerning Special Measures for the Protection of Water Quality in Water Resources Areas for the Purpose of Preventing Specific Trouble
Republic of Korea	Framework Act on Environmental Policy	Framework Act on Water Management Water Environment Conservation Act Acts for the designated rivers Marine Environment Management Act
Lao PDR	Environmental Protection Law	Water and Water Resources Law Industrial Processing Law
Malaysia	Environmental Quality Act	Environmental Quality Order 2015
Myanmar	Environmental Conservation Law	The Conservation of Water Resources and Rivers Law
Nepal	Environmental Protection Act	Water Resources Act (under development)
Philippines	Philippine Environmental Policy Philippine Environmental Code	Clean Water Act
Sri Lanka	National Environmental Act No.47	Marine Pollution Prevention Act of No. 35
Thailand	Enhancement and Conservation of National Environmental Quality Act	Groundwater Act
Viet Nam	Law on Environmental Protection	Law on Water Resources

- In Myanmar, the National Environmental Policy was developed in 2019; also developed was the Myanmar Sustainable Development Plan (MSDP) 2018–2030. The National Surface Water Quality Standards are under development.
- In Nepal, following the enactment of a new Constitution in 2015, the Environment Protection Act was enacted in 2019. The National Environmental Policy and National Water Resources Policy were both put in place in 2020. The Water Supply and Sanitation Act is currently awaiting approval and the National Water Resources Act is being drafted.
- In the Philippines, newly developed is DAO (DENR Administrative Order) 2019-15, which designates the Boracay Island Water Quality Management and Conservation Area (WQMACA) as well as creation of its Governing Board. Boracay Island, one of the country's major tourist destinations, was closed for six months for environmental rehabilitation and redevelopment. DAO 2018-12, also new, designates two Water Quality Management Areas and their Governing Boards, for the Upper and Lower Amburayan River System (UARS/LARS).
- In Sri Lanka, the Ambient Water Quality Standards (AWQS) were established under the National Environmental (Ambient Water Quality) Regulations, No. 01 of 2019. A comprehensive river water monitoring program and a program to protect the Kelani River started in 2020.
- In Thailand, a new Decree on Industrial Effluent Control Standard (2016) went into effect in June 2017. The country's Master plan for Water Quality Management was developed for 2018–2037 and includes a target for improving surface water quality in 59 areas (48 main rivers).
- In Viet Nam, the Revised Law on Environmental Protection 2020 was approved by the National Assembly in November 2020, which will come into effect on January 1, 2022. In May 2017, Decision No. 622/ QD-TTg by the Prime Minister was made for the issuance of the National Action Plan for Implementation of the 2030 Sustainable Development Agenda.

1.2 Institutional Arrangements

Throughout all WEPA partner countries, water environments are managed by ministries or agencies responsible for environmental protection, along with related ministries (Table 1.2). Ministries or agencies responsible for water resource management and public works also play key roles. As for pollution control, this is generally headed by the environmental line agency (environment ministry); however, the responsibility to control industrial wastewater is also vested in industrial and economic development sector agencies in some countries, and this requires communication and coordination among the relevant ministries. For industrial zones or special economic zones containing agglomerations of factories, different laws and regulations are often applied, which also mandate the installation of centralized wastewater treatment facilities. Different agencies, such as industrial estate authorities, handle water pollution control in such special zones in many countries. In most countries, industries are required to provide notification to designated authorities (at national or local levels) or apply for approval or permits therefrom before commencing operations that discharge effluent, the requirements for which vary by type and size of industry.

In some countries, efforts are underway to integrate these distributed responsibilities into one or more ministry or agency. For example:

- In China, the Ministry of Ecology and Environment (MEE) was newly established by integrating the National Development and Reform Commission (NDRC), the Ministry of Land and Resources (MLR), and other practice protection departments in 2018.
- In Korea, responsibilities which were previously spread across different ministries (e.g., large rivers/streams were under Ministry of Land, Infrastructure, Transport (MLIT), small streams/creeks were under the Ministry of Interior and Safety, lakes were under Ministry of Agriculture, Food and Rural Affairs, and sewerage was under the Ministry of Environment) were all restructured for management under the Ministry of Environment (MOE) in 2019 under the concept of Integrated Water Resource Management (IWRM).

1.3 Ambient Water Quality Standards

With the exception of Myanmar, all WEPA countries issue ambient water quality standards (Table 1.3).

- In the case of Myanmar, the Environmental Conservation Law enacted in 2012 stipulates the establishment of ambient water quality standards for surface water, marine water and groundwater.

Table 1.2 Main responsibilities for water resource management in WEPA countries

Country	Agency	Responsibilities
Cambodia	Ministry of Environment	Environmental impact assessment (EIA), inventory development, developing sub-decrees to prevent and reduce pollutions, monitoring pollution sources, inspections, etc.
	Ministry of Water Resources and Meteorology	Water management, conservation, monitoring
	Ministry of Public Work and Transport	Urban wastewater management
	Tonle Sap Authority	Management/conservation/development in Tonle Sap Lake and relevant areas
China	Ministry of Ecology and Environment	Supervision and management of water environmental protection
	Ministry of Agriculture and Rural Affairs	Supervision and management of rural environment
	Ministry of Water Resources	Management of water resources
	Ministry of Natural Resources	Management of ocean resources
Indonesia	Ministry of Environment and Forest	Water quality management, pollution control
	Ministry of Public Works and Housing	Water resource management focusing on quantity and water uses
	State Ministry of National Development Planning	Overall national development
Japan	Ministry of the Environment	Water environment conservation, industrial wastewater regulation, and maintenance and management of Johkasou
	Ministry of Land, Infrastructure, Transport and Tourism	Water resource management, and maintenance and management of river and sewage
Republic of Korea	Ministry of Environment	Water quality management of public water and sewerage
Lao PDR	Ministry of Natural Resources and Environment	Protection of natural resources (including water)
Malaysia	Ministry of Environment and Water	Water quantity and quality management
	Ministry of Health	Drinking water quality
Myanmar	Ministry of Natural Resources and Environmental Conservation	Formulation of national environmental quality standards, including water quality standards, water quality monitoring, enforcement
	Ministry of Planning, Finance and Industry	Regulate industrial water use and discharge
Nepal	Ministry of Forests and Environment	Environmental protection
	Ministry of Water Supply	Water supply, sewerage management
	Ministry of Energy, Water Resources and Irrigation	Water resource development, water quality monitoring
	Water and Energy Commission Secretariat	Water resources development, policy and program formulation
Philippines	Department of Environment and Natural Resources	Prevention and control of pollution
	National Water Resources Board	Coordinate/manage water resources
	Department of Public Works and Highways	National sewerage and septage management
Sri Lanka	Ministry of Environment	Environment and natural resources management
Thailand	Ministry of Natural Resources and Environment	Management of water resources
Viet Nam	Ministry of Natural Resources and Environment	Management of water resources

The National Surface Water Quality Standards are under development. As of December 2020, 38 parameters were listed with threshold values for protecting aquatic ecosystems and human health.

- Among the most recent, Sri Lanka established the ambient water quality standards for surface water in 2019 (National Environmental (Ambient Water Quality) Regulations, No. 01 of 2019).

Table 1.3 Ambient water quality standards in WEPA countries

Country	Surface Water	Groundwater	Marine Water	Sources
Cambodia	Water Quality Standards in Public Water Areas	Water Quality Standards in Public Water Areas	Water Quality Standards in Public Water Areas	Sub-Decree on Water Pollution Control (No.27, 1999)
China	Environmental Quality Standards for Surface Water	Quality Standard for Ground Water	Sea Water Quality Standard	Environmental Quality Standards for Surface Water (GB3838-2002) Quality Standard for Ground Water (GB/T 14848-9) Sea Water Quality Standard (GB3097-1997)
Indonesia	Water Quality Criteria	Water Quality Criteria	Standard Quality of Seawater	Government Regulation Number 82 (2001) Decree of the State Minister of the Environment Number 51 (2004)
Japan	Environmental Quality Standards for Water Pollution	Environmental Water Quality Standards of Groundwater	Environmental Quality Standards for Water Pollution	Environmental Quality Standards for Water Pollution (1971, last amended in 2016) Environmental Water Quality Standards of Groundwater (1998, last amended in 2012)
Republic of Korea	Environmental Standards for Water Quality and Aquatic Ecosystem	Environmental Standards for Water Quality and Aquatic Ecosystem*	Environmental Standards for Water Quality and Aquatic Ecosystem	President Decree under Framework Act on Environmental Policy (1990)
Lao PDR	Surface Water Quality Standard	Groundwater Quality Standard*	N/A	Agreement of National Standards of Environment in Laos (2009)
Malaysia	National Water Quality Standard, National Lake Water Quality Criteria and Standard, National Standard for Natural Recreational Water Quality	Groundwater Quality Standard	Marine Water Quality Criteria and Standard	National Water Quality Standards National Lake Water Quality Criteria and Standard Groundwater Quality Standard Marine Water Quality Criteria and Standard National Standard for Natural Recreational Water Quality
Nepal	**	**	N/A	Nepal Gazette (No. 10, 16 June 2008)
Philippines	Water Quality Guidelines and General Effluent Standards of 2016	Water Quality Guidelines and General Effluent Standards of 2016	Water Quality Guidelines and General Effluent Standards of 2016	Water Quality Guidelines and General Effluent Standards of 2016
Sri Lanka	Ambient Water Quality Standards		N/A	National Environmental (Ambient Water Quality) Regulations, No. 01 of 2019
Thailand	Surface Water Quality Standards	Groundwater Quality Standards*	Coastal Water Quality Standards	Notification of the National Environmental Board, No. 8, 1994 Notification of the National Environmental Board, No. 20, 2000
Viet Nam	National Technical Regulation on Surface Water Quality	National Technical Regulation on Ground Water Quality	National Technical Regulation on Coastal Water Quality	QCVN08:MT2015/BTNMT National Technical Regulation on Surface Water Quality QCVN09:MT2015/BTNMT National Technical Regulation on Groundwater Quality QCVN10:MT2015/BTNMT National Technical Regulation on Coastal Water Quality

N/A: not applicable.
* For groundwater used for drinking, the groundwater quality standard for drinking is applied.
** Nepal sets different water quality guidelines according to the objective (e.g., for recreation and for protection of aquatic ecosystem) or sector (for drinking water, irrigation water, livestock watering, and industry).

Classification and indicators

Water bodies are mostly classified based on the required quality for water use (ambient water quality standard) in WEPA countries, with the number of classes of such varying according to country.

Regarding indicators, the total number and parameters varies by country, but all standards include physical, metal, organic nutrient and microbiological indicators. The numbers of parameters used for ambient water quality standards for surface water are shown in Fig. 1.1.

Monitoring framework for Ambient Water Quality

Of the 12 WEPA partner countries that issue ambient water quality standards, 11 conduct regular ambient water quality monitoring for public water bodies (Table 1.4).

- In Nepal, systematic ambient water quality monitoring is not conducted for public water bodies; instead, water quality is monitored by different ministries and agencies. For example, regular water quality monitoring of the Bagmati River is conducted by the High Powered Committee, which has published data for the general public since 2014. Ministry of Energy, Water Resources and Irrigation (MEWRI) monitors river and lake water quality.
- National and/or local governments conduct ambient water quality monitoring of public water bodies periodically in the other 11 countries, while the number of monitoring stations, frequency, and number of indicators differ.

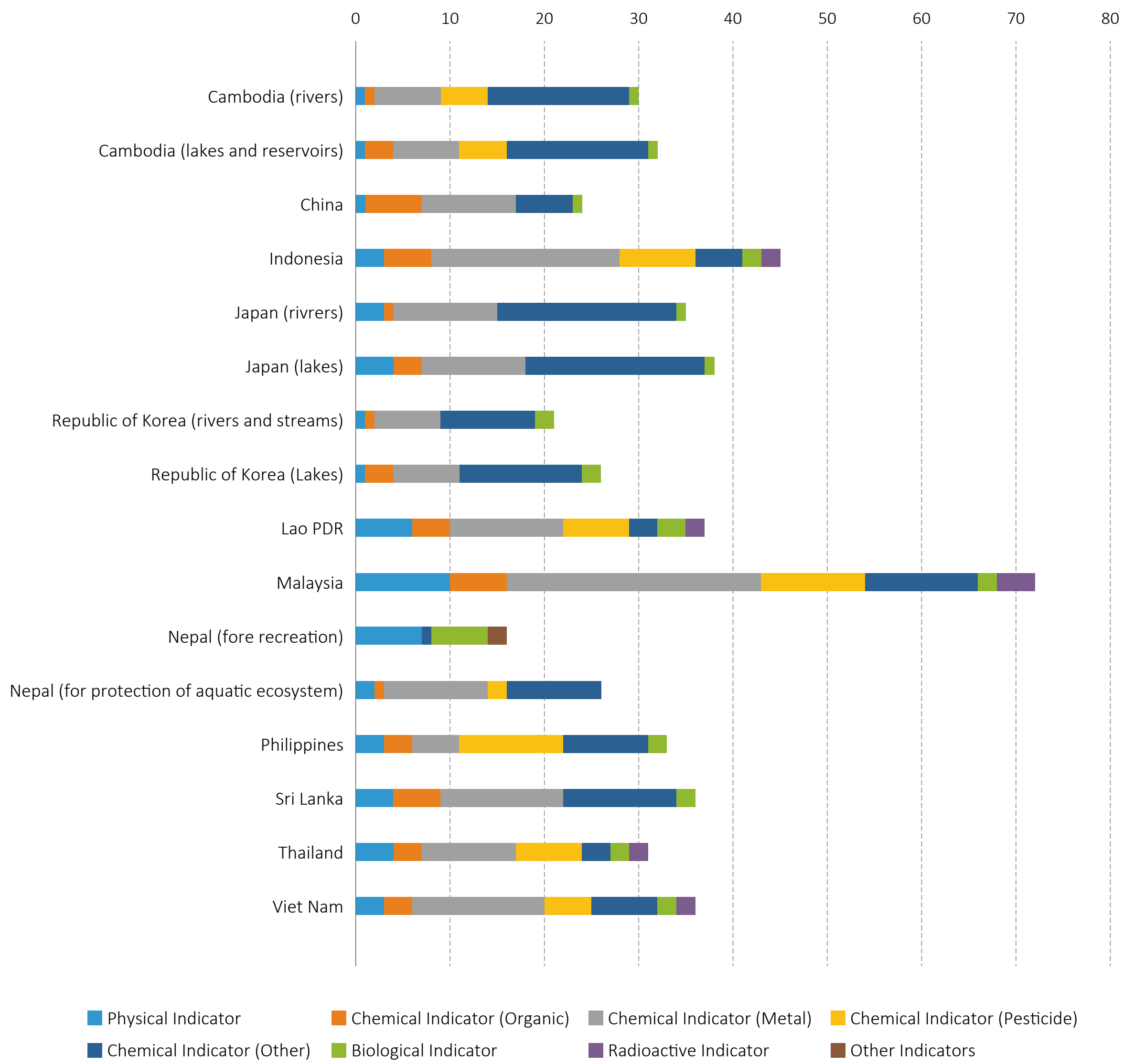


Figure 1.1 Numbers of indicators in use for ambient water quality standards for surface water

Table 1.4 Status of ambient water quality monitoring for public water bodies in selected WEPA countries

Country	No. of Monitoring Stations	Indicator	Responsible Intuitions	Year*
Cambodia	Rivers: 7 Lakes: 3 Coastal: 7 Sites for Mekong River: 19	Parameters stipulated in Water Quality Standard in public water areas (MOEC; 7 for surface water, 7 for coastal water, MoWRAM; 18)	Ministry of Environment, Ministry of Water Resources and Meteorology	2020
China	Rivers: 1,610 Lakes and Reservoirs: 110 Groundwater: 16,292	Parameters stipulated in Environmental Quality Standard (24 for rivers and lakes, 39 for groundwater, 35 for sea water)	Local government (Ministry of Ecology and Environment)	2019
Indonesia	Rivers: 510 Lakes: 10	Parameters stipulated in Water Quality Standard (45 for rivers and lakes)	Regency/municipal government, (Ministry of Environment and Forestry for water sources in two or more provincial regions)	2020
Japan	Indicators for human health protection: Rivers: 3,876 Lakes and Reservoirs: 405 Sea: 1,037 Indicators for the living environment: Rivers: 4,568 Lakes and Reservoirs: 477 Sea: 2,027 Groundwater: 3,191	Parameters stipulated in Environmental Standards	Local government (Ministry of the Environment)	2020
Republic of Korea	Rivers: 5,589 Lakes: 368 Estuaries: 668 Groundwater: -	Parameters stipulated in Environmental Standards (26 for rivers, 30 for lakes, 20 for groundwater)	National Institute for Environmental Research, local environmental agencies	2020
Lao PDR	93 stations	Parameters stipulated in Environmental Standards (30+ Parameters)	MRC, NRESRI and DPCM	2020
Malaysia	Rivers: 1,353 Coastal: 151 Groundwater: 119	Parameters stipulated in National Water Quality Standards, etc. (30 for rivers, 17 for groundwater, 29 for Marine)	Ministry of Environment and Water	2020
Myanmar	Rivers: 15/26 Lakes: 21/8 Groundwater: 3/0 (ECD/Forest Department)	18 parameters by ECD, 30 parameters by Forest Department	Environmental Conservation Department/ Forest Department	2020
Philippines	Rivers: 321 classified principal rivers Lakes: Laguna de Bay lake Coastal: 39 priority recreational waters Groundwater: 88	Parameters stipulated in DAO 2016-08 or Water Quality Guidelines and General Effluent Standards of 2016	Environmental Management Bureau (DENR)	2001–2019
Sri Lanka	Rivers: 9 Tanks: 3 (>111 points)	Parameters stipulated in Environmental Standards (36 Parameters)	Central Environment Authority (CEA)	2020
Thailand	Rivers:59 Lakes: 6 (368 points) 75 automatic monitoring stations (surface water) Groundwater: 1,162	28 parameters (surface water) 30 parameters (coastal water) 38 parameters (groundwater)	Ministry of Natural Resources and Environment (MoNRE)	2020
Viet Nam	360 stations (surface water by MONRE) 100 stations (surface water by line ministries) 23 automatic monitoring stations (by central level) Over 80 automatic monitoring stations (local level)	Parameters stipulated in the Circular 24/2017/TT-BTNMT	Ministry of Natural Resources and Environment (MONRE)	2020

* "Year" refers to the year the information was provided by the related country, unless otherwise specified by the related country.

Evaluation of Monitoring Results

Each WEPA country evaluates results of national ambient water quality monitoring for public water bodies. Table 1.5 provides a summary of the evaluation methodologies used.

Table 1.5 Evaluation methodologies used for water quality monitoring in the selected WEPA countries

Country	Evaluation Methodology
China	Classification of monitoring station based on results of monitoring and Environmental Quality Standard (Surface water, groundwater, and sea water)
Indonesia	Achievement rate of environmental standard for water in public water zones (Surface water)
Japan	Achievement rate of environmental standard for water in public water zones (Surface water, marine water and groundwater)
Republic of Korea	Achievement rate of environmental standard for water in public water zones (surface water and groundwater). Water Quality Index (WQI) is also used and evaluated in 7 levels
Malaysia	Classification of monitoring station based on monitoring results and Water Quality Index (WQI) (calculated by monitoring results of 6 indicators: DO, BOD, COD, NH_3-N, SS, pH) (Surface water and marine water) Percentage of samples exceeding the national guideline for raw drinking water quality (groundwater)
Philippines	Achievement rate of environmental standard for water in public water bodies and rating based on the achievement rate of each water body (Surface water and marine water)
Thailand	Classification of monitoring station based on monitoring results and Water Quality Index (WQI) (calculated by monitoring results of 8 indicators: pH, DO, BOD, TS, FCB, NO_3,TP, SS) (Surface water)
Viet Nam	Classification of monitoring station based on monitoring results and Water Quality Index (WQI)

- The evaluation methodologies applied in these countries can be roughly divided into two types:
  - i) The first involves setting classes of water bodies in advance, such as in Japan, Republic of Korea, and the Philippines. In this method, based on the results of water quality monitoring, governments determine whether each water body satisfies the Environmental Quality Standard or not, which is used to express the overall water environmental standard for these countries as a percentage. By using this evaluation method, whether the water body is suitable for the water use determined in advance can be evaluated.
  - ii) The second type involves categorizing monitoring stations based on the results of water quality monitoring and classification in the Environmental Quality Standard. For example, in China, river sections are categorized into six classes (I, II, III, IV, V and worse than V) based on the classification stipulated in its Environmental Quality Standard. Based on this evaluation, whether the water use designated for a water body under investigation is suitable or not can be identified at the monitoring stations.
- In Malaysia, Thailand, and Viet Nam, the same evaluation concept is applied, but they use the Water Quality Index (WQI) instead of classification within the Environmental Quality Standard. Republic of Korea has also introduced a WQI system, with 7 levels. WQI is calculated by formulas developed in these countries. The related governments also provide results of national water quality monitoring using this index on an annual basis.

Disclosure of Ambient Water Quality Monitoring Results

The results of monitoring are evaluated annually in many WEPA countries for information disclosure and policy evaluation.

- The state of water quality is mainly reported to the general public via published environmental quality reports, and the following countries enable public access to environmental reports giving comprehensive assessments of water quality on websites: China, Indonesia, Japan, Republic of Korea, Malaysia, the Philippines, Thailand, and Viet Nam. In Cambodia, monitoring reports are published quarterly. In Nepal, the most recent report was Environment Statistics of Nepal 2019.
- In some countries, such as China, Republic of Korea, Thailand and Viet Nam, the public can view real-time monitoring data on a website, which is uploaded from continuous monitoring stations.

1.4 Wastewater Management and Effluent Standards

Identification of Pollution Source

Among the 13 WEPA countries, seven have attempted to implement inventory surveys for different sectors in order to identify pollution sources quantitatively. Indonesia and Viet Nam, in particular, are now aiming to improve their inventory survey systems as their respective national governments regard them as ineffective.

Table 1.6 summarizes the details of pollution load surveys in selected WEPA countries, in which it can be seen that frequency, targeted area/basin and indicators differ. Countries such as China, Philippines, and Thailand calculate pollution loads generated from the whole country, while others such as Japan, Indonesia and Republic of Korea evaluate pollution loads discharged to targeted rivers or lakes.

As shown in Fig. 1.2, the domestic sector is a major pollution source in most of the surveyed countries or basins. However, if the pollution load from industry is added to agriculture as pollution sources to be regulated by effluent standards, the percentage of pollution load from this aggregated source accounts for about 20 to 60% of the total, which is above that of the domestic sector in some countries or basins.

Table 1.6 Details of Pollution Load Investigation in selected WEPA countries

Country	Responsible Institute	Starting Year	Frequency	Target Area/Basin	Indicator	Source
China	Ministry of Environmental Protection (currently; Ministry of Ecology and Environment)	1997– (Report on the State of China's Environment) 2006–2009 (National Census of Pollution Source)	Annual	Whole country	COD NH_3	Report on the State of China's Environment 1st National Census of Pollution Source
Indonesia	Ministry of Environment and Forestry	2001 (year regulation was established)	Annual	Priority rivers and lakes	BOD COD TSS	Ministry of Forestry and Environment
Japan	Ministry of the Environment	1978– (Total Pollutant Load Control System) 1985– (Pollution Control system under the Law Concerning Special Measures for Conservation of Lake Water Quality) 1977– (Nation Census of water pollution source)	About once in five years	*Tokyo* Bay, *Ise* Bay, *Seto* Inland Bay (Total Pollutant Load Control System) Targeted Lakes (Pollution Control system under the Law Concerning Special Measures for Conservation of Lake Water Quality)	COD TN TP	Total Pollutant Load Control System Pollution Control system under the Law Concerning Special Measures for Conservation of Lake Water Quality National Census of water pollution source
Republic of Korea	Ministry of Environment	-	-	Four Major Rivers	BOD	National Institute for Environmental Studies
Philippines	Environmental Management Bureau/DENR	2005	-	Whole Country	BOD	National Water Quality Status Report
Malaysia	DOE/Ministry of Environment and Water	-	Annual	Whole Country/ Selected River Basin	BOD NH_3 SS	Environmental Quality Report
Thailand	PCD/MONRE	2006, 2015	-	Whole Country	BOD	State of Pollution Report

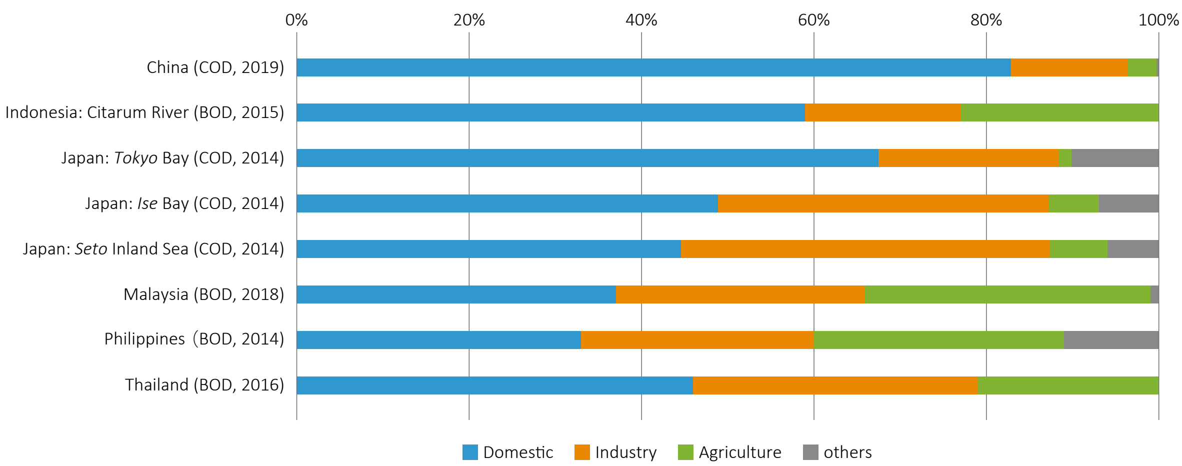


Figure 1.2 Pollution sources by sector in selected WEPA countries

Effluent Standards

Quality Control is a basic approach for managing domestic and industrial wastewater in WEPA countries. All countries except Myanmar set national effluent standards for domestic and industrial wastewater.

- In Myanmar, national effluent standards are now under consideration. The National Environmental Quality (Emission) Guidelines (NEQEG) was released on 29 December, 2015, which provide the basis for control of liquid discharges. A total of 71 industry-specific effluent levels have been set out in the NEQEG. Yangon city has provincial effluent standards.
- China, Japan, and Republic of Korea apply the Total Pollutant Load Control (TPLC) system or Total Maximum Daily Load (TMDL) approach to the whole country or specific water bodies, in addition to effluent control. Malaysia and Indonesia have also been working on introducing the TMDL approach for specific water bodies, and Thailand is also studying its introduction.

Industrial Wastewater Regulations

Industrial wastewater has been identified as one of the major causes of water pollution in WEPA countries, although its load on water bodies differs from country to country. With the aim of preventing or mitigating such water pollution, all WEPA countries have established management systems in efforts to enable control over wastewater discharged from industry. However, challenges remain in implementation for many of the countries.

Industrial wastewater in the region

The industrial sector is not necessarily the largest contributor in terms of organic pollution load in WEPA partner countries such as China, Philippines, Malaysia and Thailand. This is partly because these countries started to tackle the issue of industrial wastewater from the late 1970s and early 80s, by which wastewater from factories – especially large-scale factories and those in industrial zones – was treated to comply with pollution control regulations. However, industrial wastewater remains a major source of water pollution in certain industrial wastewater management basins, where inadequately treated wastewater is discharged into the water environment. In addition to organic pollutants, toxic substances contained in industrial wastewater are of high concern to policymakers in the region.

Effluent Standards for industrial wastewater

Pollution control is a major policy area for industrial wastewater regulations in all WEPA countries. Table 1.7 shows the purpose, targeted industry and structure of the standard in each country. As shown, while differing in the details for each country, for water quality control, effluent standards are established for industrial effluent in all WEPA countries except Myanmar.

- In some countries such as Cambodia, Indonesia, Lao PDR and Philippines, all industries are subject to effluent standards, regardless of size or type. Conversely, in countries such as Malaysia and Japan standards are based on volumes of discharged wastewater. For example, in Malaysia, effluent standards do not apply to industries producing industrial effluent or mixed effluent of less than 60 m^3/day.
- In all WEPA countries with industrial effluent standards, general standards cover all types of industry or industries without specific standards. In some countries, standard values are categorized based on the type of receiving body and size of the related industry. In addition to general standards, some countries have specific standards (stricter or looser) for specific types of industry. For example, China has 63 specific standards based on the type of industry, and Indonesia has 44. Moreover, Indonesia, China, Japan and Republic of Korea have provincial standards that account for local conditions of the water environment.
- In Republic of Korea, ecotoxicity has been included since 2007 as a parameter under the permissible discharge limits, and in 2019, the ecotoxicity management system was expanded to cover 82 types of industrial facilities. Since 2020, TOC has been used as a parameter to monitor organic substances in addition to COD_{Mn}, due to the difficulty of monitoring non-degradable organic substances.

Effluent monitoring

Monitoring of effluent quality is a key tool for checking compliance with effluent standards at factories. Table 1.8 summarizes the responsibility for monitoring of effluent quality, reporting of the monitoring result and inspection in WEPA countries. In principle, owners of pollution sources are obligated to monitor effluent quality and report the results of monitoring to government or public authorities throughout most of the WEPA partner countries. In some WEPA countries, governments or

Table 1.7 Industrial effluent standards in WEPA countries

Country	Targeted Industry	Structure of Standard	Source
Cambodia	All industries designated by the Sub-Decree	Standard values for two different types of receiving body (Protected public water areas/Public water areas and sewers) For areas requiring special treatment for protection of human health and biodiversity, MOEC can establish separate effluent standards	Sub-Decree on Water Pollution (under updating)
China	Any pollution sources (Category I pollutants)	One integrated standard 63 specific standards based on type of industry Provincial standard	Integrated wastewater discharge Standard (GB 8978 1996), etc.
Indonesia	All industries	General industrial effluent standards Specific quality standard for 44 industry	Regulation (20/1990) Decree (No.5/2014)
Japan	All industries (for hazardous pollutants) Industries with volumes exceeding 50 m^3/day (for other pollutants)	National standard Prefectural stringent standard Provisional standard for specific industry	Water Pollution Prevention Act
Republic of Korea	Wastewater discharging facilities prescribed by Enforcement Decree	Effluent standards for water pollutants (7 parameters) Permissible discharge limits for hazardous pollutants (32 parameters)	Water Environment Conservation Act
Lao PDR	All industries, regardless of size and type	National Environmental Standards Specific standard for livestock industry	National Environmental Standard, 2017
Malaysia	Environmental Quality Act, 1974 Environmental Quality (Industrial Effluent) Regulation 2009 defines a list of premises to which these regulations do not apply	Environmental Quality (Industrial Effluent) Regulation 2009 Environmental Quality (Crude Palm Oil) Regulation 1997 Environmental Quality (Raw Natural Rubber) Regulation 1978	Environmental Quality Act, 1974 Environmental Quality (Industrial Effluent) Regulation 2009
Myanmar	National Environmental Quality (Emission) Guidelines (NEQEG) stipulate the industries to be covered	National Environmental Quality (Emission) Guidelines (NEQEG)	National Environmental Quality (Emission) Guidelines (NEQEG)
Nepal	-	Tolerance limits for industrial effluent discharged into inland surface waters (generic) Tolerance limits for specific industrial effluent discharged into inland surface waters Tolerance limits for industrial effluent discharged into public sewers Tolerance limits for wastewater discharged into inland surface waters from combined wastewater treatment plants	Environment Protection Act
Philippines	All point sources of pollution	Effluent Standard (DAO 2016-08) for all point sources Effluent Standard (DAO 2007-26) for agricultural purposes	Water Quality Guideline and General Effluent Standards of 2016
Sri Lanka	All industries (a license is required)	Tolerance Limits for the Discharge of Industrial Waste Tolerance Limits for Waste from 3 industries	National Environmental (Protection and Quality) Regulations, No.1 of 2008 Wastewater Discharge Standards
Thailand	Industry regulated by Factory Act	General effluent standard (31 parameters), and type-specific effluent standards	Enhancement and Conservation of National Environmental Quality Act
Viet Nam	-	National Technical Regulation on Industrial Wastewater (two standards for two receiving waters) National Technical Regulations for specific industries	National Technical Regulation on Industrial Wastewater

Table 1.8 Responsibility for effluent monitoring in WEPA countries

Country	Responsibility of industry/government for effluent monitoring
Cambodia	All business operators are obliged to self-monitor effluent and submit periodic reports of results to MOEC. MOEC conducts regular on-site inspections.
China	National and local governments are responsible for supervising the implementation of integrated wastewater discharge standards.
Indonesia	All industries are required to send wastewater samples to registered laboratories once a month or more frequently depending on their activities, with the analysis reports then submitted every six months to local authorities and the MoEF. Local and national authorities have the right of access and sampling of effluent at any time.
Japan	Industries are responsible for implementing monitoring, recording and storing the results of effluent monitoring. Local governments have the right to request industries to report their results and conduct inspections.
Republic of Korea	Every business operator or operator of prevention facilities shall record and maintain the operating status of the relevant discharging facilities and prevention facilities, as prescribed by Ordinance of the Ministry of Environment when operating discharging facilities and prevention facilities. The Minister of Environment or a Mayor/provincial (*Do*) Governor may require business operators or operators of prevention facilities to submit the necessary reports or materials in order to verify whether such facilities meet the standards for effluent water quality. Public officials appointed by Minister of Environment have the right to conduct inspections.
Lao PDR	All industrial factories are required to install wastewater treatment systems and the necessary facilities to monitor and analyze water samples. The monitoring report results are then submitted to the Director of the Industry Department of the Ministry or respective province.
Malaysia	The owner/occupier of a premises shall conduct performance monitoring of the components of the effluent treatment system in the manner as specified in the Guidance issued by Department of Environment. The owner/occupier of a premises equipped with an industrial effluent treatment system shall maintain records of the manufacturing processes, operation, maintenance and performance monitoring of the industrial effluent treatment system. Records thereof shall be made available for inspection by authorized officers.
Myanmar	The Pollution Control Division of ECD, General Administration Department, Directorate of Industrial Supervision Inspection, and Directorate of Industrial Collaboration are responsible for inspection of effluent quality. Local and regional offices of ECD are tasked with regular monitoring of effluent quality, and ECD headquarters is directly involved in effluent monitoring upon notification of major environment pollution issues.
Nepal	Public entities have the responsibility of monitoring.
Philippines	The EMB-DENR monitors the quality of effluent through the discharge permitting system, while industries are encouraged to undertake self-monitoring of the quality of discharges.
Sri Lanka	Industries have the responsibility for implementing industrial effluent monitoring. Local offices of the central environmental agency have the right to conduct inspection of industries.
Thailand	Industries have the responsibility for implementing industrial effluent monitoring and reporting their results to various ministries. Ministry of Industry and Ministry of Natural Resource and Environment have the right to conduct inspection of industries.
Viet Nam	Industries have the responsibility for implementing industrial effluent monitoring and reporting their results to MONRE. MONRE has the right to conduct inspection of industries.

public authorities request owners of pollution sources to report results of monitoring periodically as well as conduct on-site inspections if necessary.

- In Myanmar, monitoring of effluent quality comes under the responsibility of respective divisions/offices of the national government. In Nepal, public entities have the responsibility for implementing industrial effluent monitoring. While some industries conduct monitoring, their results are used only for reference. In the Philippines, EMB-DENR monitors the quality of effluent through the discharge permitting system, while industries are encouraged to undertake self-monitoring of the quality of their discharges.
- In Japan, Republic of Korea, Malaysia, and Thailand, online monitoring of effluent was introduced for pollution sources with certain volumes of effluents. On the other hand, monitoring is not always conducted by owners or managers despite their obligation to do so, and results are not always stored for easy access or do not reach the intended authorities. This means authorities can neither assess the state of compliance nor effectiveness of any measures taken. Keeping records of monitoring results was not an obligation affecting business entities in Japan until a revision to the Water Pollution Control Law in 2010 mandated the recording and storing of results, with penalties applied in the event of non-compliance.

Results of monitoring

National governments in some WEPA countries evaluate the compliance status of industrial wastewater standards based on the results of monitoring or inspection by the government or self-monitoring by industry. Figure 1.3 shows the compliance rate of industrial effluent standards in selected WEPA countries. As can be seen in the figure, compliance rates in Malaysia, Japan, Republic of Korea and China exceed 90%. In many other countries rates are lower, and in some counties national governments do not endorse compliance rates based on levels of accuracy.

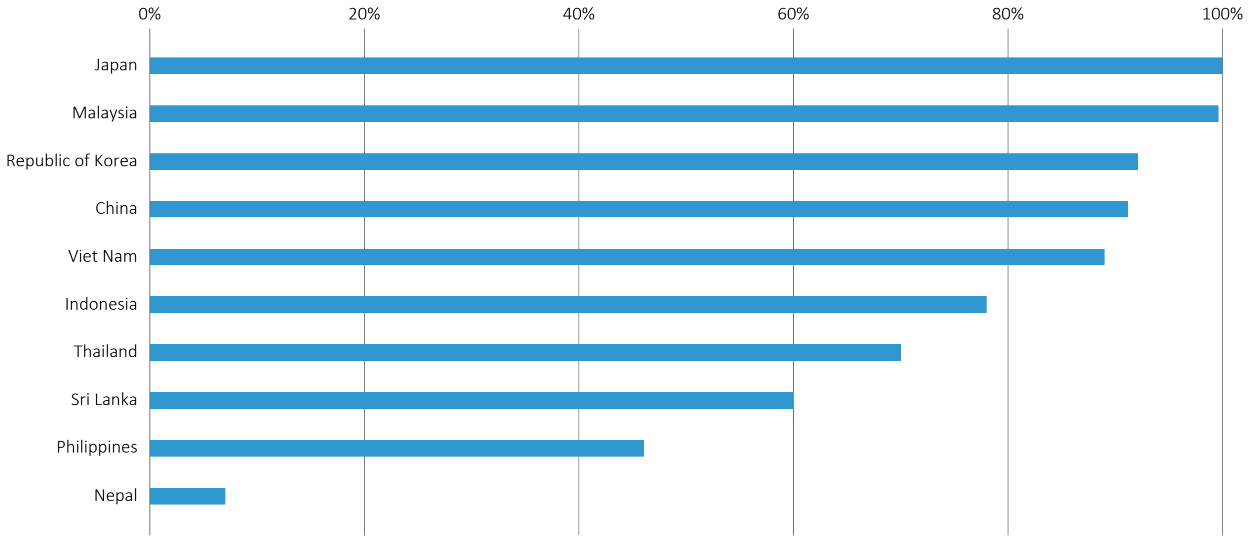


Figure 1.3 Compliance rate of industrial effluent standards in WEPA countries

Encouraging industry to comply with regulations

Penalty systems are sometimes ineffective in promoting compliance; instead, governments attempt to raise compliance through other measures.

- One of such measures is the PROPER program (*Program Penilaian Peringkat Kinerja Perusahaan* (Program for Pollution Control Evaluation and Rating)) in Indonesia, which encourages industries to comply with environmental regulations by publishing their environmental performance, including whether they meet designated effluent qualities or not.
- Japan has introduced provisional effluent standards of lower severity for specific types of industry that do not currently meet the original standards, in order to encourage technical improvements over certain time periods.
- Malaysia also has rules to exempt the immediate need for compliance with effluent standards for treatment facilities under construction or undergoing upgrades.
- The Philippines provides rewards to individuals, private organizations and other entities from the National Water Quality Management Fund for outstanding and innovative projects, technologies, processes and techniques, and activities.

Domestic Wastewater Treatment

Centralized approach

The use of sewerage systems is the typical approach for domestic wastewater treatment, particularly in urban areas of Asian countries. Figure 1.4 shows the sewerage treatment coverage rates for domestic wastewater in WEPA countries. Coverage in Malaysia, the Republic of Korea, and Japan is currently nearly 80% or more; that in China, Thailand, and Vietnam falls to about 40%, 30%, and 10%, respectively. In comparison, the coverage rate of sewerage treatment facilities in other WEPA countries is less than 10%.*1 In Lao PDR, there is no urban sewerage collection system or centralized wastewater system. Urban wastewater treatment rates in Cambodia, Myanmar, Nepal, Viet Nam, Sri Lanka, and Indonesia are higher than those of rural areas but still

*1 However, it must be stressed that the coverage ratio alone cannot be used as the basis for comparing different countries because calculation methodologies vary according to the country.

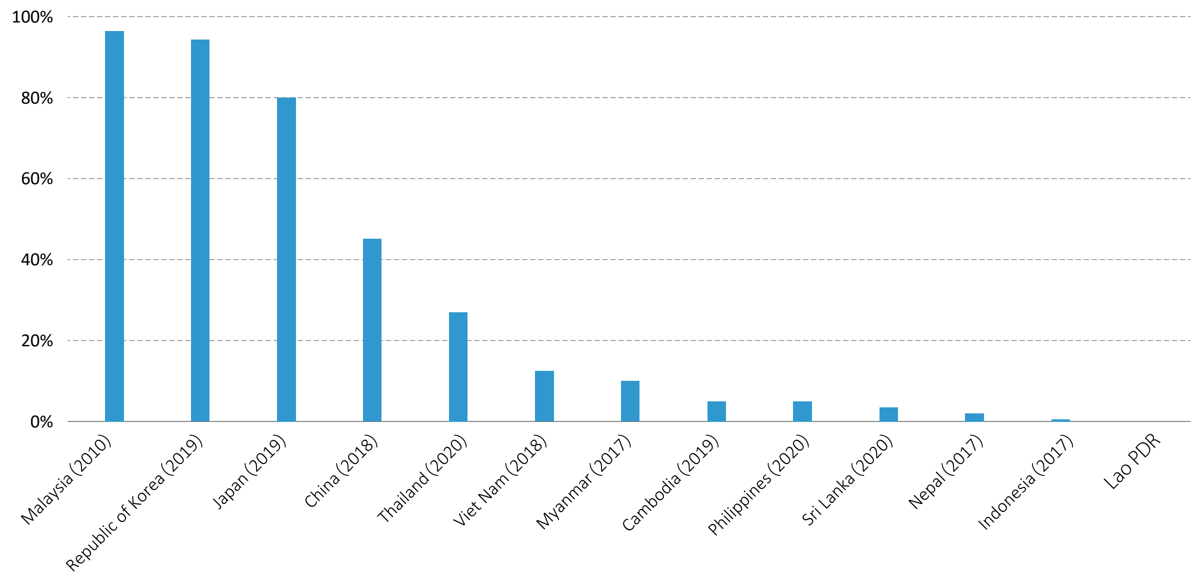


Figure1.4 Service coverage rates of sewerage treatment in WEPA countries

below 20%. Meanwhile, wastewater treatment rates in rural areas are much lower in most countries, with the exception of Japan, Malaysia and the Republic of Korea. Such differences in sewerage treatment coverage rates could be attributable to the size of the respective WEPA country's economy, based on a positive correlation between the coverage ratio for sewerage treatment in WEPA countries and per capita GDP; in most Asian countries with ongoing low coverage ratios for sewerage treatment, per capita GDP remains below 4,000 USD. It can therefore be surmised that the construction of capital intensive large-scale sewage treatment plants is economically challenging for such countries. According to UN data (UNDP 2006), constructing sewage treatment plants is two to three times more costly than installing septic tanks.

Time, continuous investment (including cost of operation and maintenance), capacity development, and vast amounts of infrastructure construction will be required to build, operate and maintain centralized wastewater systems to obtain similar domestic wastewater treatment rates as developed countries. As this may not always be an economically or environmentally feasible option for many of the WEPA countries, alternative solutions to conventional centralized wastewater management are being explored. In this context, decentralized wastewater treatment systems (DEWATS) have received increasing attention from WEPA countries as a promising approach to address the limitations described above. Interest in DEWATS is rising due to their potential to reduce treatment cost over the long term, simpler operation, and less environmental impacts in construction while achieving a comparable BOD removal rate. Good examples have been observed in case studies from Indonesia, Malaysia, and the Philippines, among others.

On-site treatment (septic tank)

In areas without access to sewerage treatment services, on-site treatment using individual septic tanks to treat black water from toilets is common, especially in urban areas. Figure 1.5 illustrates coverage rates of septic tanks in WEPA countries and cities and the rate of access to sewer networks. While the definitions used in the data do not hold for all countries, it can be seen that coverage rates for septic tanks are particularly high in urban areas where coverage rates of sewerage treatment are low. It shows that around 95% of households in Viet Nam's urban areas have a septic tank, with respective figures for Thailand, the Philippines, and Indonesia of 87%, 83%, and 80%. This means that septic tanks will continue to play an important sanitation role as a basic facility for millions of the region's population for the foreseeable future.

However, wastewater treatment using individual septic tanks presents issues in respect of prevention of water pollution. Most septic tanks are often of non-standard design, improperly constructed, inaccessible for desludging, and are not regularly maintained or desludged, which affects BOD removal efficacy. Lower BOD removal rates for septic tank treatment, which are 30–60% based on results from several studies, than those for sewerage removal using aeration is partly due to improper management of the tanks. For example, an estimate showed that 75% of septic tanks in Viet Nam and 66% in Indonesia have never been emptied (World Bank 2015).

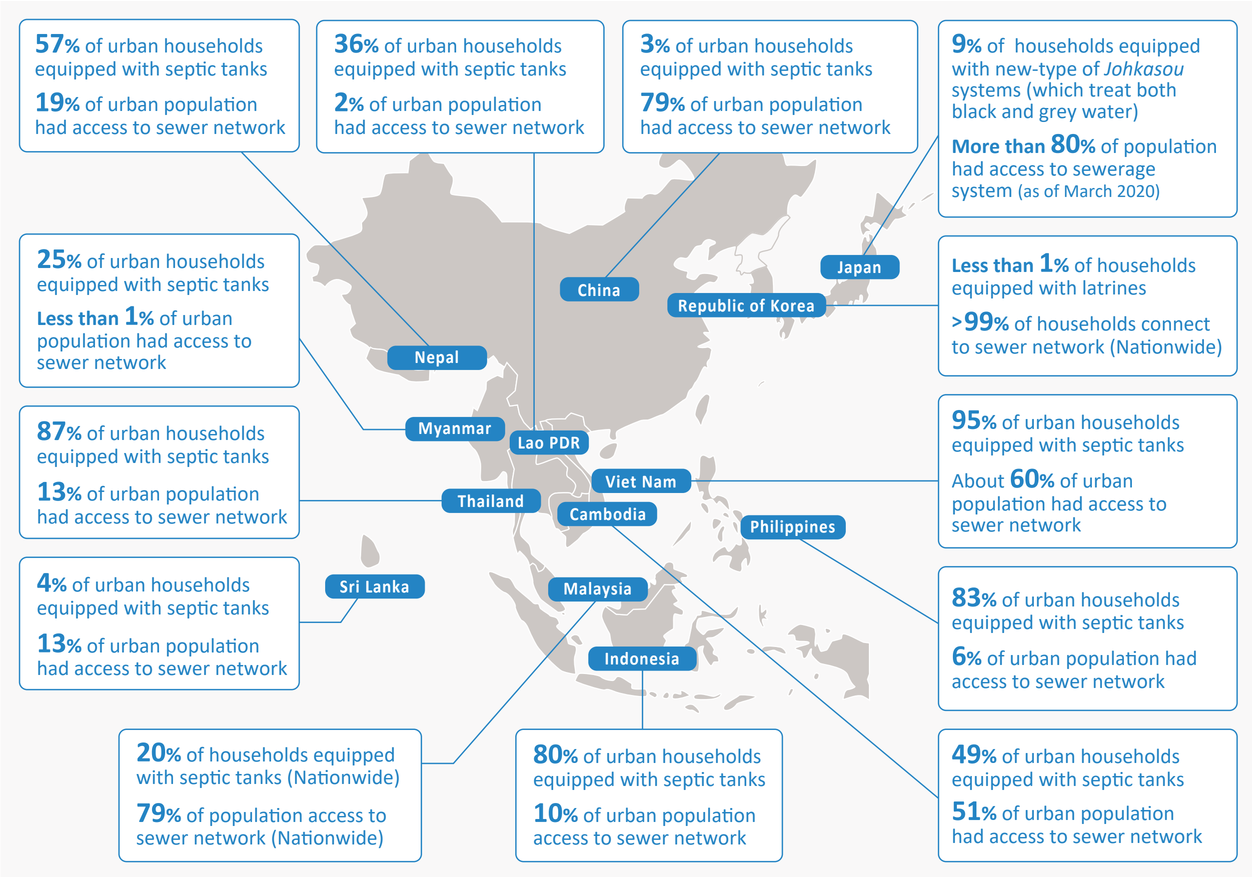


Figure 1.5 Septic tank coverage and ratio of access to sewer network in WEPA Countries

(Source: Created based on data from WHO and UNICEF 2019)

(Note that connection to a sewer network does not guarantee proper treatment of wastewater, which could be a factor behind differences in numbers between Figure 1.4 and Figure 1.5.)

In addition, septic tanks treat only black water; grey water, such as from kitchens or bathrooms, is discharged untreated. To mitigate and prevent water pollution, domestic wastewater (both grey and black) should be adequately treated using high-performance treatment processes with high rates of pollution removal, especially in areas without access to sewerage treatment.

Another big concern currently facing many WEPA countries is the inappropriate management of fecal sludge (also referred to as "septage") generated by septic tanks. Figures reported for safe disposal or treatment of septage vary widely, such as below 1% in Nuwara Eliya of Sri Lanka, 4% in Indonesia, 10% in the Philippines (mainly in Metro Manila), 4% in Viet Nam (World Bank 2013), and 30% in Thailand (AECOM &SANDEC 2010). In many cases, septage management is not prioritized by either central or local governments, or the efforts made by governments do not suit local social or economic conditions of the communities, which leads to operational issues with the septage management system planned for introduction. In Indonesia, for instance, while over 150 septage treatment plants have been constructed since the 1990s, due to the lack of effective septage emptying services, many plants stopped functioning and less than 10% still operate – and of these many fail to function properly (World Bank 2016) (WEPA 2019).

To date, most urban areas have heavily relied on informal, 'on-call' septage emptying and collection services, which are sometimes provided by unregulated private companies with low levels of service quality for desludging. Perhaps the most problematic aspect of this system is the illegal dumping, carried out by such desludging companies, of septage into nearby rivers or canals. This has resulted from the lack of effective formal septage emptying and collecting mechanisms, limited treatment facilities and capacity, cost and/or time savings related to long-distance transport, and obligatory septage disposal fees at treatment plants. As a result, most of the urban human waste is not safely collected, managed or treated before being released into the environment, contaminating both groundwater and surface water, spreading high levels of pathogens into the urban water environment and transmitting fecal-associated infections (Bao 2021).

2 | Challenges of and opportunities for collaboration on water environmental governance among WEPA countries

WEPA Outlook 2018 identified the common challenges on water environmental governance, and in particular for industrial wastewater management, as follows (WEPA 2018):

Deficiency of laws, lack of detailed rules for implementation: In some cases, different laws and regulations related to industrial wastewater management have different obligations, which can lead to confusion on the ground. Some countries need detailed rules or guidelines for implementation; for example, if no guidelines exist and industry uses different effluent monitoring procedures and analytical methods, which makes assessment of effluent quality data less reliable and less comparable, this will create problems in proving noncompliance.

Weak coordination among agencies: There are at least two ministries (covering environmental and industrial sectors) at the national level related to industrial wastewater management, which creates overlapping responsibilities, weak coordination and conflicts of interest (i.e., industrial development vs. environment conservation), which may negatively affect implementation in some countries.

Availability of information: Information on industries and their wastewater – not only number and type of industry but also wastewater volume and quality data – is insufficient in partner countries. In particular, information on small and medium-sized industries is difficult to obtain despite the high likelihood that they pollute local water bodies. The lack of systematically organized and stored inventory data may prevent effective or strategic planning and implementation of control measures.

Accessibility of information: The lack of willingness to share information, as well as lack of information itself also act as barriers for planning and implementation due to the sensitivity surrounding industrial wastewater management, as experienced by the WEPA secretariat in its industry sector interviews. There is a sense of mistrust and paranoia concerning how data will be used, i.e., a worry that data believed to be confidential may be used to 'name and shame.' Further, data-sharing between governmental agencies takes place, which illustrates weak coordination and can also complicates data collection by WEPA Focal Points in partner countries, as they have to go through separate sectoral ministries to obtain the data.

Reliability of data: Low reliability of data on quality of effluent, etc. is also pointed out as a problem by some WEPA countries. This is likely to be due to many reasons, such as laboratory capacity and lack of standardized method for sampling and analysis.

Lack of human resources: Partner countries often cite a lack of human resources in national and local government as a barrier to enforce regulations, not only in terms of staffing levels but also implementation capacity.

Lack of finances: In particular, finances are needed to establish databases and inventories, as well as to conduct effluent or ambient water monitoring to check on the state of compliance.

Since the publication of the WEPA Outlook 2018, WEPA has been discussing and communicating the common challenges among the partner countries and identifying opportunities for collaborations through annual meetings, international workshops, Action Programs, questionnaire surveys, and daily communications.

As a result, it has been reconfirmed that the common challenges identified in WEPA Outlook 2018 still remain among the key common challenges for the WEPA countries, although their contexts, significance, and characteristics differ from those in 2018. Some additional interests and opportunities for collaborations to overcome the identified challenges have emerged through these discussions, which are summarized below:

Sound enforcement of laws and regulations

As described at the beginning of this chapter, it is observed that WEPA countries have made significant progress on establishing or improving policies and legal frameworks to improve water environmental governance in recent years, including updates to basic legal frameworks on water environmental governance and institutional arrangements, setting up new ambient water quality standards, initiating comprehensive monitoring strategies, and introducing new regulatory frameworks on industrial wastewater management. However, it remains a common challenge for WEPA countries to ensure the appropriate implementation and enforcement of such policies and regulations. In this context, WEPA Phase IV (April 2019 – March 2024) activities will prioritize promotion of capacity enhancement of government officials to ensure sound enforcement of laws and regulations.

Capacity building and information sharing for specific policy tools for water environment governance

Most of the WEPA countries have basic laws and regulations on water environmental governance in place. However, such legal systems are sometimes considered insufficient for addressing existing challenges on water environmental governance. In this respect, some countries have already introduced additional policy tools to address such challenges, which other countries are taking an interest in for applicability to their contexts.

One of such policy tools is the Total Maximum Daily Load (TMDL) approach. The TMDL system requires a much higher level of technical rigor and coordination between national and local governments than the basic set of laws and regulations. It also requires a more comprehensive data set on pollution loads as well as analysis for its implementation.

Another example is the Water Quality Index (WQI). WQI has already been introduced in some WEPA countries, and others are also expressing interest in its utilization. One of the virtues of WQI is its simplicity, which makes it advantageous as a tool for communicating with the general public. It is also broadly understood among WEPA countries. On the other hand, WQIs cannot be developed solely through scientific analysis, as they also involve policy-based decision making as well as coordination among key agencies and stakeholders for their development.

WEPA countries are working on mutual understanding and information-sharing to promote practical policy tools, such as the development and implementation of TMDL and WQI.

Strong horizontal coordination

The issue of and need for horizontal coordination among agencies is clearly acknowledged among the WEPA countries, and **"Weak coordination among agencies"** was listed as one of the common challenges in the WEPA Outlook 2018. The coordination issue is also closely linked with another common challenge, **"Deficiency of laws, lack of detailed rules for implementation"**, because this challenge often emerges from distributed or overlapping obligations (e.g., *"different laws and regulations related to industrial wastewater management have different obligations"*), which itself results from weak coordination among agencies.

To address such challenges, some WEPA countries have recently taken concrete steps. For example, China established the Ministry of Ecology and Environment (MEE), which was then integrated with the National Development and Reform Commission (NDRC), the Ministry of Land and Resources (MLR), and other practice protection departments in 2018. In Korea, previously disparate responsibilities across different ministries were all restructured for management under the Ministry of Environment (MOE) in 2019. Based on the assumption that such fundamental restructuring of institutional arrangement tends to be associated with high transaction costs, it might be useful to share such experiences among WEPA countries on how such costs can be lowered. Other countries may wish to take different approaches that will not affect existing institutional arrangements at such a large scale but could still ensure a high level of coordination among the concerned agencies. Either way, WEPA counties might find it useful to share their experiences to improve horizontal coordination.

Strong vertical coordination

While it was not mentioned in WEPA Outlook 2018, vertical coordination between national and local government has also emerged as another critical common challenge among WEPA countries. The challenge has been especially highlighted in discussing the TMDL approach. Strong coordination and clear definitions of the boundaries related to the responsivities among national and local governments, together with enhancement of the capacities of officials of local governments have been considered as essential elements for successful implementation of the TMDL approach, while such coordination is also required in the operation of the standard laws and regulations. Hence better relationships between national and local governments has become one of the topics that WEPA countries may wish to pursue further through discussions.

Strategic deployment of DEWATS

A common understanding exists among WEPA countries that sewerage systems represent a key infrastructure for domestic wastewater treatment, especially in urban areas. Further efforts are needed to increase sewerage treatment coverage rates in many WEPA countries, and in this respect WEPA countries have agreed to keep sharing information on sewage systems. However, given the scope of WEPA and the Focal Persons of partner countries, the following two topics have been highlighted as promising areas of cooperation among WEPA countries through information sharing and capacity-building efforts. One issue concerns improving levels of management of existing septic tanks and their septage. The performance of domestic wastewater of septic tanks is very low in many cases, resulting from improper tank management. Further, septage generated from septic tanks is often treated very poorly and sometimes illegally dumped into public waters. There is clearly much room for improvement in the management of existing septic tanks and their septate.

The other issue concerns strategic deployment of decentralized wastewater treatment systems (DEWATS). Septic tanks have certain technical limitations on their performance, regardless of maintenance levels. One of such limitations is that septic tanks in many WEPA countries treat only black water; grey water, which has a high BOD pollution load, is discharged untreated. In this respect, the strategic deployment of DEWATS such as *Johkasou* in Japan has become a focus of future cooperation under WEPA. The plan for strategic deployment of DEWATS should be carefully crafted based on thorough investigation of the roles of DEWATS and their complementarity with sewerage systems.

Holistic approaches for IWRM and SDGs

In recent years, recognition is growing within the international community of the need to introduce and implement more holistic approaches to address environmental issues, including water environmental governance, whenever appropriate. This topic is deeply embedded in the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs) adopted by the UN General Assembly in 2015. For water, Integrated Water Resource Management (IWRM) is defined under SDG 6.5 that states "By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate." UN-Water explains the rationale for introducing IWRM as follows; *"Many different sectors are dependent on water, and as a result, where water resources are limited, conflicts over use arise. The commonly fragmented management of water resources is particularly inept at solving such conflicts and ensuring sustainable use of the resource. Water resources are naturally confined to water basins so from an ecological perspective, it would be most appropriate to manage these resources at this scale."*

Another important aspect requiring a holistic approach relates to the interconnectivity of various social, economic, and environmental agendas. SDGs are not a bundle of 17 independent goals but a set of aspects society needs to shed equal light on for their development. The 2030 Agenda for Sustainable Development clearly states that *"the interlinkages and integrated nature of the Sustainable Development Goals are of crucial importance in ensuring that the purpose of the new Agenda is realized."* Water is considered a key element to achieving many other SDGs. UNESCAP depicts this critical role of water in SDGs via a diagram (Fig. 1.6) by placing water at its center (UN ESCAP 2017). River

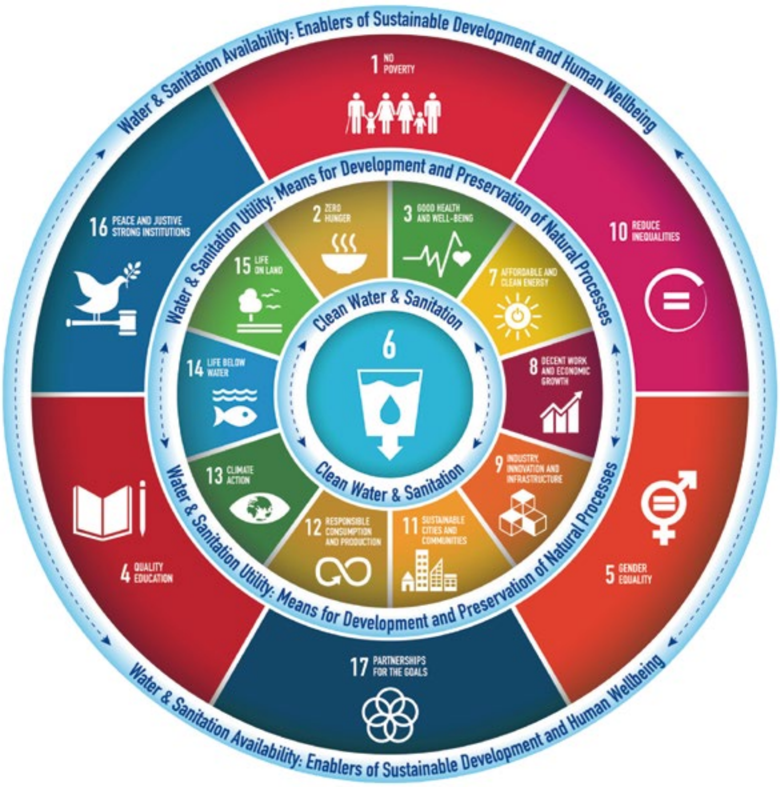


Figure 1.6 SDG 6 on water and sanitation is a core requisite goal for sustainable development (Source: UNSCAP 2017)

basin management can act as a pragmatic entry point to capitalize on as a spatial unit of IWRM implementation for sound water cycle management and to implement SDGs holistically, such as through established institutional mechanisms like the Mekong River Commission, which is shared by several WEPA countries (Shivakoti 2021).

The current COVID-19 pandemic has brought this interconnectivity of various social issues into clear focus. Wastewater service providers and regulatory monitoring agencies, both acting as frontline service providers in the fight against COVID-19, are having to adjust to vastly different working conditions. Governments and businesses have also had to adjust to the diversion of fiscal expenditure towards COVID-19 response and recovery measures (OECD 2020). COVID-19 can also aggravate the living conditions of vulnerable communities that have already suffered the effects of polluted water resources. With the understanding of the importance of holistic approaches, many WEPA countries have attempted to introduce new schemes (see section 1.1 above). However, information on the experiences and good practices on implementing such holistic approaches is still limited, and on this point, this presents WEPA countries with a good opportunity for information exchange and mutual learning.

Other topics that may require attention

Naturally, the challenges faced by WEPA countries are not limited to the above. Whenever requested by WEPA countries and where appropriate, WEPA will pick up new topics for further deliberation. The list of possible topics include:

- Agricultural wastewater management
- Quality control of monitoring data
- Standardization of various procedures and regulations in the region
- Deployment of economic instruments
- Application of nature-based solutions
- Environmental awareness-raising
- Climate change and water environmental governance
- Transboundary water issues
- Wastewater reuse and resource recovery
- Private-public partnerships
- Access to international finance sources though developing project concepts
- Engagement of local communities in water environmental governance
- Partnership with other international initiatives

3 | Way Forward

WEPA has witnessed significant and steady progress on water environmental governance among the partner countries in recent years, especially on the policy and legal frameworks and institutional arrangements. However, many areas still require attention, as explained above. Nonetheless, this is undoubtedly an encouraging record and clear evidence that all WEPA countries have committed to better water environmental governance for the counties and the region, no matter how difficult the challenges faced. In this regard, the partner countries have agreed to keep promoting cooperation under WEPA, which is regarded as a highly useful platform for policy development, capacity-building, information sharing, and mutual learning.

By making the best use of its instruments, such as annual meetings, international workshops, Action Programs, and web-based databases, WEPA is best positioned to work together and serve all partner countries for better water environmental governance. We look forward to 2024, when we will once again report on the remarkable progress made on water environmental governance in the region.

Chapter

2

Country Profiles of Water Environmental Management in WEPA Countries

2.1 Cambodia

1 | Country Information

Table 2.1.1 Basic indicators

Land Area (km^2)		181,035 (2013)*
Total Population		15,288,489 (2019)*
GDP (current USD)		27.08 billion (2019)**
GDP per capita (current USD)		1,643 (2019)**
Average Precipitation (mm/year)		1,840 (1901–2016)***
Total Renewable Water Resources (km^3)		476.1 (2017)
Total Annual Freshwater Withdrawals (billion m^3)		2.184 (2017)
Annual Freshwater Withdrawals by Sector	Agriculture	94% (2017)
	Industry	1.51% (2017)
	Municipal (including domestic)	4.48% (2017)

(Source: FAO 2020, *Ministry of Planning 2019, **World Bank 2020a, ***World Bank 2020b)

Figure 2.1.1 Tonle Sap Lake

2 | State of Water Resources

Cambodia is located in the middle reach of the Lower Mekong Basin and 86% of its land area, including Tonle Sap Lake (TSL), drains into the Mekong River (FAO 2020). The floodplains, TSL, and the Mekong Delta are the major sinks of sediments and nutrients, which are essential for aquatic ecosystems and agriculture. The Mekong-TSL is one of the world's unique aquatic ecosystems, in that high flow conditions of the Mekong River in the wet season induces reverse flow through the TSL River into the lake. Due to the reverse flow as well as runoff from tributaries around the lake, the TSL transforms in size by six times on average, reaching approximately13,000 km^2 with an average depth of 8–10 m (TSA 2015). In the subsequent dry season, water draining out of the lake is critical for the overall flow condition in the downstream Mekong Delta. The Bassac River splits from the mainstream Mekong River and further splits into numerous channels, forming a wedge shaped delta in Vietnam. The Mekong Delta is a major grain basket for both Cambodia and Vietnam. This distinctive hydrological cycle and associated sediment and nutrient regime is vital for aquatic biodiversity, including migrating fish, and Tonle Sap Lake forms the sole source of livelihood for about 40% of Cambodia's population (MRC 2010).

Cambodia has an ample supply of water, mainly from the Mekong River, Tonle Sap River, Bassac River and other tributaries, but most parts of the country encounter water shortages during the dry season, especially for domestic and irrigation uses. Water in Cambodia remains regulated only in part, resulting in an overabundance of water during the rainy season and deficiency in the dry season.

Groundwater availability is estimated at 17.6 billion m^3 (MoWRAM 2012), which is primarily used for household water supply, irrigation and industry. Groundwater use is increasing by 10% every year, and many places in Cambodia have experienced overuse of groundwater due to rapid population growth and increasing demands from agriculture and industry (UNDP 2020); for example, an average groundwater level decline of 14 cm per year was reported for wells in Prey Veng and Svay Rieng between 1996 and 2008 (Johnston et al. 2013).

3 | State of Ambient Water Quality

3.1 Rivers

The water quality of rivers was assessed as good and water pollution is not considered to be a significant problem (MOEC 2020). However, in recent years water quality deterioration has been reported in river water bodies. Water quality monitoring conducted by Department ofWater Quality Management, Ministry of Environment of Cambodia (MOEC) at the Chroy Changva Station of the Mekong river showed a rising trend in nutrient pollution in river water since 2011 (Figure 2.1.2). Although concentrations of total nitrogen (T-N) remained below the national standard value, it exceeded the national standard value in 2018 and 2019. Total phosphorus (T-P) concentrations exceeded the national water quality standard from 2012 to 2019. However, Biological Oxygen Demand (BOD), and Chemical Oxygen

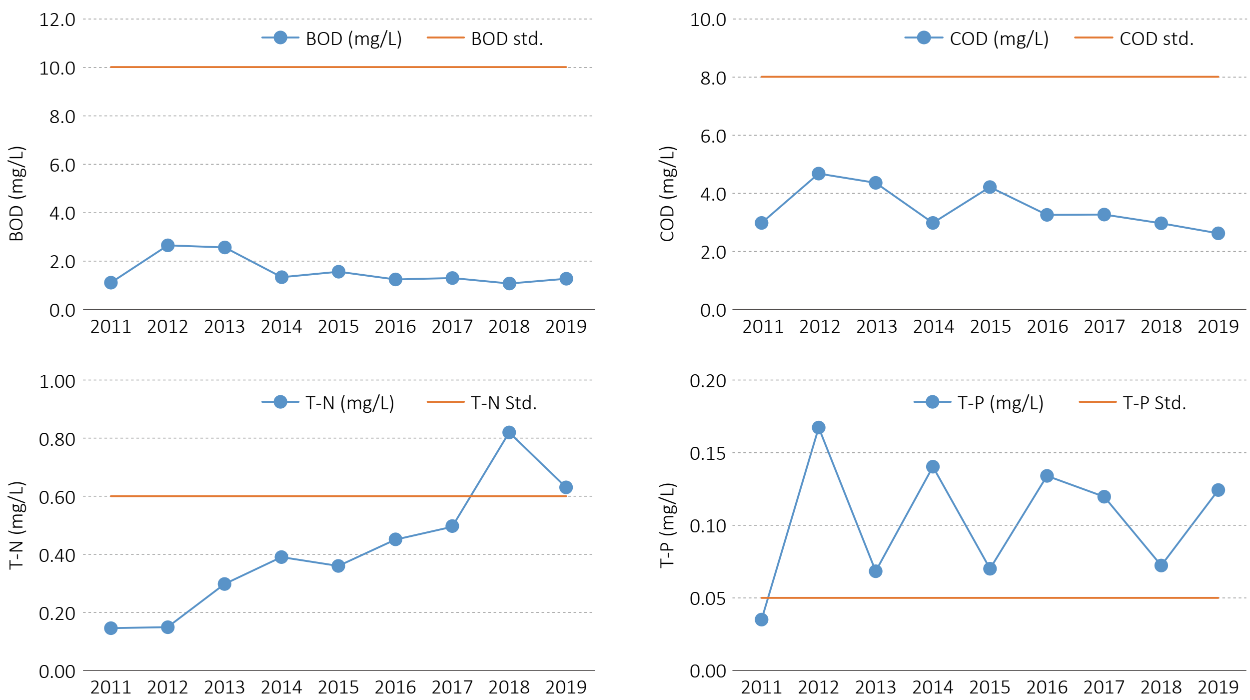


Figure 2.1.2 Water quality of Mekong River at Chroy Changva Station (Source: MOEC 2020)

Demand (COD) values imply that organic pollution is low.

3.2 Lakes and Reservoirs

Tonle Sap Great Lake (TSL) is the largest freshwater lake and a unique flood-pulse in Southeast Asia. It covers an area of 13,000 km^2 during the rainy season and shrinks to 2,500 km^2 during the dry season. About 1.7 million people live in 1,037 fishing villages of TSL and surrounding floodplains and their livelihoods directly depend on TSL's resources (Shivakoti and Bao 2020). However, due to degradation of the TSL water environment, caused by the inflow of anthropogenic pollutants, the livelihoods of millions of local residents is affected (Ung et al. 2019). Water quality in TSL was monitored by the Department ofWater Quality Management, MOEC at the Chhnok Trou village from 2011 to 2019, and also revealed deterioration of water quality of TSL (Figure 2.1.3). According to the monitoring data, both BOD and COD

Figure 2.1.3 Water quality of Tonle Sap Lake at Chhnok Trou village, 2011–2019 (Source: MOEC 2020)

values remained well within the national water quality standard for lakes, which implies organic pollution is not a major issue for water environment management in TSL. In contrast to BOD and COD, concentrations of T-N and T-P exceed the water quality standard for most of the monitoring period, which indicates TSL water could be highly polluted by agricultural pollution such as runoff of fertilizer, manure, which can also derive from household products such as soap and detergent.

3.3 Coastal Water

Cambodia's coastal shoreline is 435 km long on the Gulf of Thailand, and the seaward boundary of the coastal zone has been delimited as the outer limit of the country's exclusive economic zone with an area of 55,600km^2. The landward boundary of the coastal zone has not yet been satisfactorily defined, but is currently considered to be about 5 km from the shore. The coastal zones are situated in the four provinces of Koh Kong, Kampot, Sihanoukville and Kep municipalities. In general, coastal water is considered to be of fairly good quality, but development activities such as those in economic zones and seaports may exert a negative influence on coastal water and coastal ecosystems if sound management of solid and liquid wastes generated from those activities has not been properly implemented. According to the results of monitoring in 2018, concentrations of T-N, T-P and oil and grease exceeded the national water quality standard for coastal water, which indicates anthropogenic activities are the main threats for the coastal water environment.

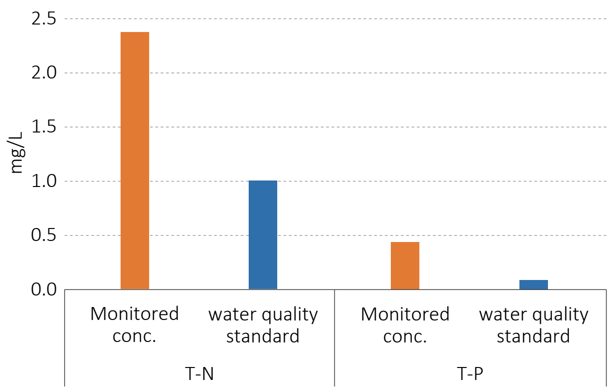


Figure 2.1.4 Coastal water quality in Kep Municipality, 2018
(Source: MOEC 2020)

3.4 Groundwater

Groundwater in Cambodia is generally of good quality, and dependency on groundwater as a source of domestic water is as high as 62–100% (MoWRAM 2008). However, high levels of arsenic, iron, manganese, fluoride, and total dissolved solids (salinity) are observed in some areas (UNDP 2020). Arsenic concentrations in groundwater in many parts of Cambodia exceeded both the WHO standard of 10 mg/L and the Cambodia National Drinking Water Quality Standard of 50 mg/L. Many shallow wells are also contaminated by fecal coliforms (IWMI 2013).

4 | State of Wastewater Treatment

Sewerage and sanitation in Cambodia are not well developed and types in existence are aging or constructed in the old colonial period. In most places, wastewater is primarily treated by septic tanks and discharged to the environment. As of 2019, only three centralized wastewater treatment plants (CWTPs) are under operation, located in Battambang City, Siem Reap City and Preah Sihanouk City (Rady 2020). Further, Phnom Penh has natural lagoons that receive wastewater from the drainage system. The current centralized WWTPs can treat only 5% of urban wastewater (Heng 2019). Monthly service fees have been collected by the Department of Public Work and Transport for the centralized wastewater treatment facilities, such as in Preah Sihanouk City, where fees of 2.5 to 1,125 USD are collected per building based on building category.

Cambodia has prioritized the development of sewerage systems and centralized wastewater treatment in several locations, and the urban wastewater management plan has selected priority towns for future centralized WWTPs in Cambodia (Table 2.1.2). In addition to centralized systems, NGOs such as ESC-BORDA promote decentralized wastewater treatment solutions in schools, communities, hospitals, and small and

Table 2.1.2 List of existing and future centralized wastewater treatment plants

Location of Centralized WWTPs	Capacity (m^3/day)	Status
Battambang city	2,800	In operation
Siem Reap City	8,000	In operation
Preah Sihanouk City	25,000	In operation
Poipet City	3,000	Feasibility study
Srei Saophoane City	3,000	Feasibility study
Kampot City	6,000	Feasibility study
Kep City	3,000	Feasibility study
Phnom Penh	30,000	Feasibility study
Takhmao City	12,000	Feasibility study
Pursat City	6,000	Feasibility study
Kratie City	6,000	Feasibility study
Steung Sen City	3,000	Feasibility study
Bavit city	3,000	Feasibility study

(Source: Heng 2019)

medium-sized enterprises. To date, ESC-BORDA has implemented 62 DEWATS across Cambodia (BORDA 2017).

5 | Frameworks for Water Environmental Management

5.1 Legislation

The current legislative framework for water environment management in Cambodia is shown in Figure 2.1.5. Under it, the protection and promotion of environmental quality and public health is the objective of natural resource management including water (Article 1, Law on Environmental Protection and Natural Resource Management). The Law on Water Resources Management (2007) includes aspects of water quality management, such as requiring wastewater discharge licenses or permission for activities that could have negative impacts on water quality and human and ecosystem health (Article 22), as well as designations for dangerous or restricted zones for water use where the water quality, quantity and ecological balance are endangered (Article 23).

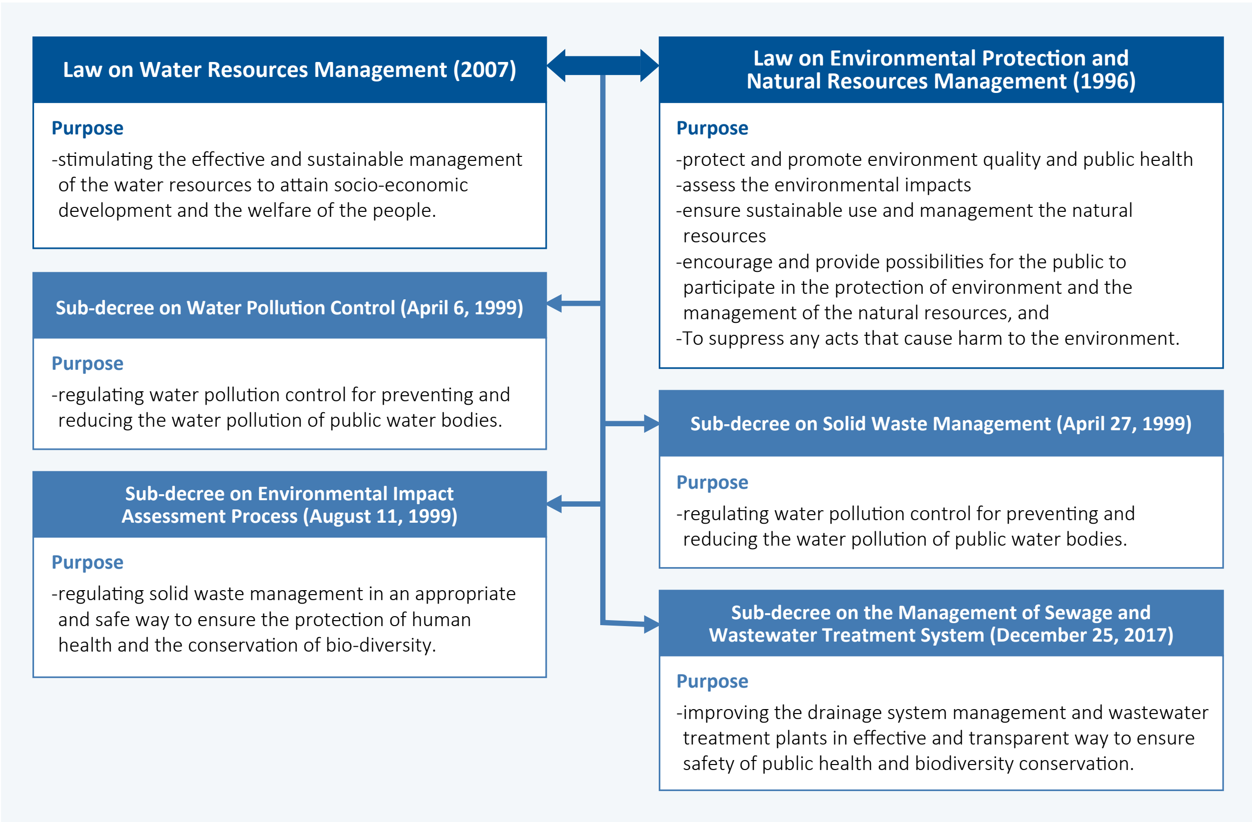


Figure 2.1.5 Legislative framework of water environment management in Cambodia

Details on water environmental conservation measures can be found in the Sub-decree on Water Pollution Control, established in 1999 under the Law on Environmental Protection and Natural Resources Management. This sub-decree aims to regulate various activities that could pollute and/or have already polluted public water areas (e.g., rivers, lakes, groundwater, and sea water). Ambient water quality standards for human health and bio-diversity (Article 7), as well as effluent standards for pollution sources (Article 4) are set by this sub-decree. Other elements of the sub-decree include monitoring of pollution sources and their effluents (Chapter 4), monitoring of public water areas (Chapter 5), and inspection rules (Chapter 6). Other sub-decrees under the Law on Environmental Protection and Natural Resources Management, such as the Sub-decree on Solid Waste Management and the Sub-decree on Environmental Impact Assessment Process, also contain articles related to water environmental conservation.

Currently, two new pieces of legislation are being drafted in relation to water quality management, namely the Law on Sewerage System in Cambodia by Ministry of Public Works and Transport (MPWT) and the Sub-decree on Water Quality by the Ministry of Water Resources and Meteorology (MoWRAM). The sub-decree on Water Pollution Control (April 6, 1999) is being updated to reflect the context of Cambodia.

5.2 Institutional Arrangement

In Cambodia, several ministries deal with water environment management (Table 2.1.3). MOEC is responsible for protection and management of the environment and natural resources in the country based on the Law on Environmental Protection and Natural Resource Management (Article 9), and local authorities such as provincial and municipal environmental departments are in charge of water environmental management, such as water quality monitoring. MoWRAM was established in 1999 as lead water sector agency, and exercises overall responsibility for water management and conservation including Integrated Water Resource Management (IWRM). Ministry of Public Work and Transport is responsible for urban wastewater management. Other important agencies include Ministry of Industry, Mine and Energy (MIME), and Ministry of Rural Development (MRD), Tonle Sap Authority (TSA).

Table 2.1.3 Institutional arrangement of water environment management in Cambodia

Agency	Responsibilities
Ministry of Environment (MOEC)	- Assess the environmental impact (EIA) of all existing and proposed projects/activities (Article 6) - Research and assessment of environmental impacts on natural resources (Article 9) - Provide recommendations to other concerned ministries to ensure conservation and rational use of natural resources (Article 9) - Develop inventories of pollution sources (Article 12) - Develop sub-degrees to prevent and reduce pollution (Article 13) - Monitor pollution sources and natural resource development activities (Article 14) - Conduct inspection of pollution sources (Article 15) and order improvement for violations (Article 20)
Ministry of Water Resources and Meteorology (MoWRAM)	- Water management and conservation through Integrated Water Resource Management (IWRM)
Ministry of Public Work and Transport (MPWT)	- Urban wastewater management
Ministry of Industry, Mine and Energy (MIME)	- Drinking water supply for cities and towns
Ministry of Rural Development (MRD)	- Clean water supply for rural areas
Tonle Sap Authority (TSA)	- Coordinate management, conservation, and development in Tonle Sap area and relevant areas

5.3 Ambient Water Quality Standards

Ambient water quality standards

Ambient water quality standards for public water areas are set by the Sub-decree on Water Pollution Control (April 6, 1999). There are two kinds: the first covers biodiversity conservation, which is designated for rivers (five parameters), lakes and reservoirs (seven parameters), and coastal water (seven parameters); and the second covers public health, which designates standard values for 25 parameters related to harmful effects on human health. These water quality standards will also be revised through amendment of the sub-decree on Water Pollution Control. There is no groundwater quality standard, but water quality is assessed by standards designated for specific uses, such as national drinking water quality standards.

Water quality monitoring framework

Since the promulgation of the Sub-decree on Water Pollution Control in 1999, MOEC has been responsible for regular control and monitoring of water pollution in public water areas throughout Cambodia. MOEC monitors river water quality at seven points, coastal water quality at seven points and lake water quality at three monitoring points every month. Water quality is analyzed at MOEC laboratories. Further, under the Mekong River Commission Water Quality Monitoring Network Program, MoWRAM measures water quality monthly at designated stations in rivers and related tributaries. Details of the water quality monitoring framework are shown in Table 2.1.4.

Table 2.1.4 Water quality monitoring framework of MOEC and MoWRAM

Item	MOEC	MoWRAM
Name of monitoring parameters	Surface water: pH, Total suspended solids (TSS), COD_{Mn}, BOD, Chromium (Cr^{6+}), T-N, T-P Sea: pH, COD_{OH}, Dissolved oxygen, Coliform, Oil & Grease, T-N, T-P	T °C, pH, EC, Alkalinity/ Acidity, DO, COD, BOD, T-P, T-N, NO_3-N, NH_4-N, Feacal coliform, TSS, Calcium, Magnesium, Potassium, , Sulfate (SO_4^{2-}), Chlorine
Number of sampling points	17	19
Frequency of monitoring	Monthly	Monthly
Frequency of monitoring report published	Quarterly	-

5.4 Effluent Standards

Effluent standards

Aiming at managing effluents discharged from pollution sources, the Effluent Standard for Pollution Sources Discharging Wastewater to Public Water Areas of Sewers was established under the Sub-decree on Water Pollution Control. Standard values are set for 52 parameters, such as temperature, pH, BOD, heavy metals, agricultural chemicals, and organic solvents. In principle, the standards are applied to all industries and other pollution sources designated by the sub-standards. For areas which require special treatment for protection of human health and biodiversity, MOEC can establish separate effluent standards for pollution sources in the area (Article 5 of the sub-decree). As mentioned in section 6.1.1, the Sub-decree on Water Pollution Control is being updated to reflect the context of Cambodia. The effluent standard will be updated through amendment of the Sub-Decree on Water Pollution Control.

Effluent inspection procedure

Under the Sub-decree on Water Pollution Control, all business operators are obliged to self-monitor effluent and submit periodic reports of results to MOEC. However, as some do not, MOEC conducts regular on-site inspections to check whether they are in compliance with effluent standards, which involves taking and analyzing water samples of effluent as well as treated water. Two types of monitoring programs are in place at pollution sources: (i) regular effluent monitoring at normal factories and hotels, conducted at 90 day intervals, and (ii), regular effluent monitoring at factories that use chemicals and/or chemical compounds for production, which should be conducted at 45 day intervals.

Measures against non-compliance

When violations of effluent standards are found, MOEC issues written orders to industries to correct current activities in order to be in compliance with the standards. Industries are fined and punished for violations in the monitoring and reporting of, and compliance with effluent standards stipulated under the Sub-decree on Water Pollution Control for failure to act on orders issued by MOEC.

5.5 Major Policies on Water Environmental Management

The major ways in which Cambodia has responded to date have been legislative, in the form of pollution related decrees and laws, creation of an institutional framework – especially under MOEC and MoWRAM – as well as introduction of monitoring and enforcements. One such response is the National Water Resource Policy for the Kingdom of Cambodia, developed by MoWRAM in 2014. Its main objectives are: (i) protect, manage and use water resources in an effective, equitable and sustainable manner; (ii) solve water issues in collaboration with related institutions within public and private sectors; (iii) develop and carry out the national strategy and policy towards water resource management; (iv) direct stakeholders for developing, managing and utilizing water resources; and (v) achieve the national policy objective on poverty reduction and sustainable national economy development. The Cambodia National Environmental Action Plan (NEAP) 1998–2002 is the first environmental action plan initiated by MOEC to develop and implement to integrate environmental concerns as well as decision-making processes of various stakeholders into national policies. NEAP incorporates issues relevant to the water environment from the viewpoints of fisheries, Tonle Sap Lake, wetlands, public health (water borne diseases), as well as minimizing environmental impacts from energy industries (hydropower, oil and gas industries).

6 | Recent Developments in Water Environmental Management

There are several developments in government policies that will have significant impacts on water environment management, as follows:

i. Sub-decree on Management of Sewage and Wastewater Treatment System, enacted on 25 Dec. 2017, which provides a mandate for management of sewage systems and wastewater treatment systems to sub-national authorities.

ii. Development of draft Environmental Code (ENRC), which consolidates several existing legislative arrangements for environmental protection and conservation of natural resources, including provisions for waste and pollution control and implementation of SDGs.

iii. Development of draft Sub-decree on self-monitoring and report, which aims to enhance monitoring of high potential pollution sources by installation of real-time online monitoring equipment and regular reporting to MOEC.

iv. Updating of Sub-decree on Water Pollution Control, which is to include revisions of water quality standards and effluent standard.

7 | Challenges and Future Plans

Based on the current state of water quality management in Cambodia, several key management challenges have been identified, as follows:

1. Lack of specific water quality management policy and strategies
2. Weak inter-ministerial coordination for water environment management
3. Improvement of human resources and institutional capacity, especially MOEC, in order to implement Cambodian Sustainable Development Goals framework (CSDGs), National Environment Strategy and Action Plan (NESAP) and ENRC
4. Development of sewers and wastewater treatment to deal with drainage problem and pollution of water bodies; Master plan for sewerage and drainage sector for towns/country also required
5. Barriers to appropriate management of water quality due to insufficient equipment for laboratory/field testing
6. Shortage of expert technical officers at national and local levels to carry out adequate water quality management and enforcement
7. Budget limitations of government, especially for improvement of capacity of laboratories in terms of facility infrastructure/equipment and human resources

In order to overcome these challenges the following actions will need to be taken by the line ministries and agencies:

i. Initiation of development of the National Water Quality Management Strategies by MOEC

ii. Strengthening collaboration with other countries for capacity development on water quality monitoring and enforcement

iii. Enhancing cooperation with development partners to construct planned central sewage treatment plants in priority cities

iv. Establishment of inter-ministerial coordination mechanisms, to enhance cooperation among line ministries such as Ministry of Environment, Ministry of Water Resources and Meteorology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Mines and Energy, and Council for the Development of Cambodia towards sound management of water environment in Cambodia

2.2 China

1 | Country Information

Table 2.2.1 Basic indicators

Land Area (km²)		9.6 million (approx.) (2018)
Total Population		1.4 billion (2019)
GDP (current USD)		14,723 billion (2020)*
GDP per capita (current USD)		10,484 (2020)*
Average Precipitation (mm/year)		651.3 (2019)**
Total Renewable Water Resources (km³)		2,904.1 (2019)**
Total Annual Freshwater Withdrawals (billion m³)		602.12 (2019)
Annual Freshwater Withdrawals by Sector	Agriculture	61.16% (2019)**
	Industry	20.22% (2019)**
	Municipal (including domestic)	14.48% (2019)**

(Source: National Bureau of Statistics of China 2020, *IMF 2020, **MWR 2019)

2 | State of Water Resources

China's total freshwater resources are the fourth largest in the world. However, due to its large population, water resources per capita are only about 2,300 m³, which is only a quarter of the global average (Chinese Hydraulic Engineering Society 2016). Moreover, water resources are unevenly distributed – rich in the southern areas and poor in the northern areas. In 2019, precipitation across China tended to be low in the northwest and high in the southeast (MWR 2019).

There are 45,203 rivers in China, with a total length of 1.51 million km (MWR 2011a). Of these, the Yangtze River, Yellow River, Pearl River, Songhua River, Huai River, Hai River, and Liao River constitute the seven major river basins. There are also numerous lakes, over 2,800 of which are 1 km² or larger, covering a total area of about 78,000 km². The five largest freshwater lakes are Boyang Lake, Dongting Lake, Taihu Lake, Hongze Lake, and Chao Lake, all located around the middle and lower reaches of the Yangtze River.

Most of China's water resources are surface water, with groundwater resources amounting to 819.15 billion m³ in 2019. Looking at the breakdown of water use by source, 80% of the total water use was surface water and about 20% was groundwater, but groundwater use was higher in some regions. In the Yellow River basin, many cities experienced problems such as land subsidence due to over-pumping of groundwater.

Table 2.2.2 Overview of China's seven major rivers

	Drainage Area (km²)	Length (km)	Annual Flow (100 million m³)
Yangtze River	1,782,725	6,300	9,857
Yellow River	752,773	5,464	592
Songhua River	561,222	2,308	818
Liao River	221,097	1,390	137
Pearl River	442,527	2,214	3,381
Hai River	265,551	1,090	163
Huai River	268,957	1,000	595

(Source: National Bureau of Statistics of China 2020)

3 | State of Ambient Water Quality

According to the 2020 Ecological and Environmental Status Bulletin of China's Ministry of Ecology and Environment (MEE), surface water pollution across China has reduced. Assessments were conducted for surface water quality, which is classified according to five categories of water resources (Grade I to Grade V) based on the environmental standards for surface water (see Table 2.2.3). Figure 2.2.1 shows surface water quality in 2020, broken down by percentage. Seawater and

Table 2.2.3 Classification of water quality standards for surface water

Grade	Description
I	Mainly for headstreams and national nature preserves
II	Mainly for drinking water resources in first-class protected areas, protected areas for precious fish, and spawning areas for fish and shrimp
III	Mainly for drinking water resources in second-class protected areas, protected areas for fish, and swimming areas
IV	Mainly for industrial water resources and recreational use with no human contact with water
V	Mainly for agricultural water resources and water areas required for landscapes

(Source: MEE 2002)

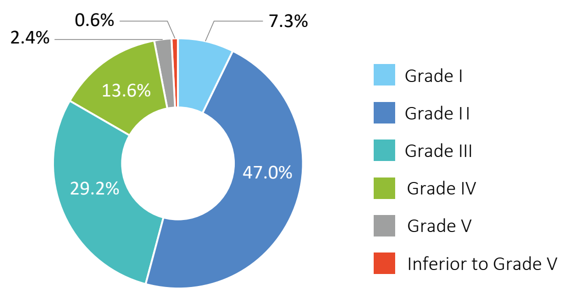


Figure 2.2.1 Surface water quality, by percentage

(Source: MEE 2020)

groundwater were also assessed based on surface water categories according to their respective water quality standards (see Table 2.2.4 and Table 2.2.5).

Table 2.2.4 Classification of seawater quality standards

Grade	Description
I	Suitable for marine fishing, marine nature preserves and protected areas for rare or endangered marine organisms
II	Suitable for marine cultivation, bathing, marine sports or recreation activities involving direct human contact with marine water, and for sources of industrial use of water related to human consumption
III	Suitable for water resources for general industrial use
IV	Suitable only for harbors and ocean development activities

(Source: MEE 1997)

Table 2.2.5 Classification of groundwater quality standards

Grade	Description
I	Reflects the low content of chemical components of groundwater, applicable to various purposes
II	Reflects the relatively low content of chemical components of groundwater, applicable to various purposes
III	Reflects the medium content of chemical components of groundwater. Based on GB5749-2006, primarily applicable to concentrative drinking water sources and industrial and agricultural use water
IV	Reflects the relatively high content of chemical components of groundwater. Based on industrial and agricultural use water requirements and benchmark value of human health, primarily applicable to agricultural water and partial industrial use water. After being properly processed, applicable as drinking water
V	Reflects the high content of chemical components of groundwater. Not applicable as drinking water. Selection of such category of water depends on other purposes

(Source: Standardization Administration, 2017)

3.1 Rivers

According to the national monitoring results, the overall water quality of 10 major water systems (Yangtze River, Yellow River, Pearl River, Songhua River, Huai River, Hai River, Liao River, rivers flowing through Zhejiang and Fujian provinces, rivers in the northwest, and rivers in the southwest) was between Grade I to Grade III for 87.4%, and inferior to Grade V for 0.2% (MEE 2020), which represents a broad-based improvement compared to 2013 (see Table 2.2.6). Figure 2.2.2 shows the water quality in 2020 for 10 major water systems. Rivers in northwest China, Zhejiang and Fujian region and southwest China and river basins of the Yangtze River and Pearl River were of excellent quality. The water quality of Yellow River, Songhua River, Huai River was fairly good, and Liao River and Hai River were slightly polluted.

Table 2.2.6 Water quality of 10 major water systems in China (2013, 2020)

Year	Grade I–III	Grade IV–V	Inferior to Grade V
2013	71.7%	19.3%	9.0%
2020	87.4%	12.3%	0.2%

(Source: MEE 2020)

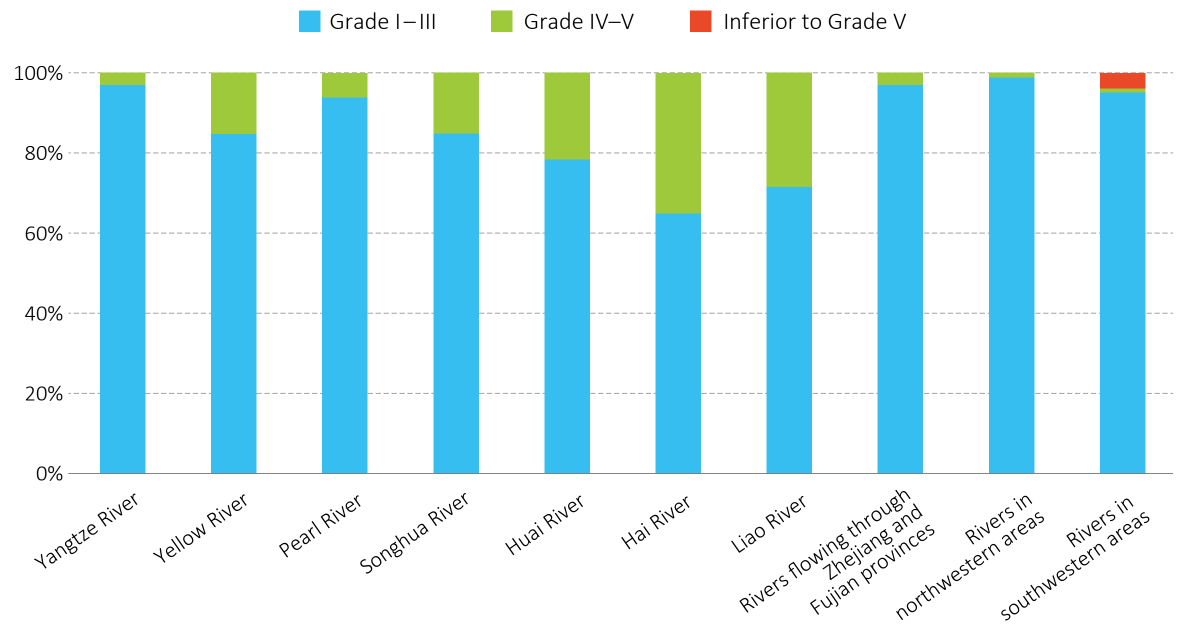


Figure 2.2.2 State of water quality of 10 major water systems in China (Source: MEE 2020)

3.2 Lakes and Reservoirs

In 2020, 76.8% of the 112 major lakes and reservoirs across the country met the criteria for environmental standards of Grade I-III and 5.4% of Inferior to Grade V. The main indicators used to signify the existence of pollution were total phosphorus, COD (chemical oxygen demand), and Permanganate index. Of the 110 lakes and reservoirs where nutrients were monitored, 9.1% were under oligotrophic status, 61.8% were under mesotrophic status, 23.6% were under slight eutrophication, 4.5% were under intermediate eutrophication, and 0.9% were under severe eutrophication (MEE 2020).

3.3 Nearshore sea areas*1

The water quality of coastal waters has steadily improved. According to the 2020 monitoring results, 77.4% of areas were classified as Grade I or II (National Seawater Quality Standards), an improvement of 0.8 percentage points compared to the previous year. Moreover, 9.4% of the water bodies were below Grade IV, representing a drop (improvement) of 2.3 percentage points compared to the previous year. Major pollutants were inorganic nitrogen and active phosphate (MEE 2020).

3.4 Groundwater

According to the results of the 2020 groundwater quality monitoring, of the 10,171 monitoring sites, 13.6% were classified as of Grades I–III, 68.8% as Grade IV, and 17.6% as Grade V. Among the 10242 shallow groundwater monitoring sites, 22.7% were classified as Grades I-III, 33.7% as Grade IV, and 43.6% as Grade V. Major indicators exceeding the standard were manganese, water hardness, and total dissolved solids.

4 | State of Wastewater Treatment

Since 2011, the Chinese Government started monitoring COD and ammonia nitrogen from agricultural plantations, fisheries, and livestock farms. Total COD discharge in 2018 was 5,842,000 tons, and of this amount, 81.6 % resulted from household discharge. Furthermore, 90.5% of the ammoniacal nitrogen discharge results from household discharge (China Statistical Yearbook on Environment 2019*2). In 2019, there were 2,471 urban domestic wastewater treatment facilities nationwide, with a capacity of 178.63 million m^3/day in 2019, and the volume of annual urban domestic treated wastewater was 52,585 million m^3, with a treatment rate of 96.81%.

5 | Frameworks for Water Environmental Management

5.1 Legislation

The Constitution of the People's Republic of China stipulates that the protection and improvement of the ecological and living environment and the prevention of pollution are responsibilities of the state. The Environmental Protection Law of the People's Republic of China stipulates that "the State shall strengthen the protection of air, water and soil, and establish and improve corresponding investigation, monitoring, appraisal and restoration systems." The Environmental Protection Law of the People's Republic of China was revised in 2014 and went into effect on 1 January 2015. With regard to the prevention of water pollution in surface water and groundwater, the Law on Water Pollution Control sets surface water environmental standards, groundwater environmental standards, and water pollutant discharge standards. The Water Pollution Control Law was also amended in 2017. As for seawater, the Law of the People's Republic of China on the Protection of the Marine Environment was enacted in 1982, which established water quality standards for seawater; this law was amended in 2017. In addition to the above laws, the Environmental Protection Tax Law was enacted in 2018, and regulations and administrative orders/regulations related to water pollution prevention also exist, such as the collection of an environmental protection tax from companies that directly discharge pollutants, based on discharge amount. Provinces and cities have also set their own environmental standards.

5.2 Institutional arrangements

The Ministry of Ecology and Environment (MEE) was established in 2018 by the 13th National People's Congress, subsequent to formation of the Ministry of Environmental Protection (MEP), by upgrading the State Environmental Protection Administration (SEPA) in 2008 and amalgamating with sections responsible for environmental protection in the National Development and Reform Commission, the Ministry of Land and Resources, Ministry of Agriculture, State Oceanic Administration, and others.

MEE is responsible for establishing and improving the fundamental system in China with respect to the ecological environment. Its roles include forming collaborations with other governmental departments to

*1 Nearshore waters: refers to the sea area stipulated in the National Marine Functional Zoning (2011-2020).
*2 NBS and MEE. China Statistical Yearbook on environment 2019. https://navi.cnki.net/KNavi/YearbookDetail?pcode=CYFD&pykm=YHJSD&bh=

initiate the formulation and implementation of national ecological and environmental policies and plans as well as to draft laws and regulations, and to formulate departmental rules; forming collaborations with other governmental departments to compile and supervise the implementation of ecological and environmental plans and water functional zoning plans for key regions, river basins, sea areas, and drinking water source areas; and to organize the formulation of ecological environmental standards and formulate ecological environmental benchmarks and technical specifications (MEE 2021a).

Provinces and municipalities also play an important role in pollution control through establishing local laws and standards.

5.3 Ambient Water Quality Standards

The surface water environmental quality standards set five categories for 24 basic parameters. Groundwater quality standards set standards for 39 parameters, and the seawater quality standards set standards for 35 parameters. Separate water quality standards exist for fisheries and irrigation.

Water Quality Monitoring

In 2020, there were 1,937 surface water sections (sites) under the national monitoring program, including 1,614 water sections in seven major river basins of the Yangtze River, Yellow River, Pearl River, Songhua River, Huaihe River, Haihe River and Liaohe River as well as rivers in Zhejiang and Fujian, and rivers in northwestern and southwestern parts of China. In addition, water quality monitoring was carried out in 112 major lakes (reservoirs), at 10,171 groundwater quality monitoring points of natural resources authority (7,923, 910, and 1,338 groundwater monitoring points in plain basins, karst mountainous areas, and bedrock in hilly mountainous areas respectively), and at 10,242 groundwater quality monitoring points of water resources authority (mainly shallow groundwater) (MEE 2020)*3. Analytical methods for water quality are described in the respective water quality standards; i.e., Surface Water Environmental Standards (GB3838-2002), Groundwater Quality Standards (GB/T14848-2017), and Seawater Quality Standards (GB3097-1997).

5.4 Effluent standards

The effluent quality of municipal wastewater treatment plants is regulated by the Discharge Standard of Pollutants for Municipal Wastewater Treatment Plant (GB 18918-2002), which sets effluent standards for 19 basic parameters and 43 optional parameters for municipal wastewater treatment plants nationwide. Certain regions have independently introduced their own effluent standards at the local level. Discharge concentration limits of industrial wastewater pollutants are stipulated by the discharge standards of water pollutants of corresponding industries, such as steel, meat processing, etc. If there is no industrial discharge standard for any given industry, the limits shall be implemented in accordance with the Integrated Wastewater Discharge Standard (GB 8978-1996). At present, there are 65 national water pollutant discharge standards in China.

Measures against non-compliance

The 2017 amendments to the Water Pollution Control Law have strengthened the penalties for violations. In response to a violation, the government's environmental protection section issues an order to the violating company to correct the situation, as well as restricts or suspends production operations, and imposes a fine of not less than 100,000 yuan and not more than 1 million yuan, in cases of (1) discharging pollutants without obtaining a pollutant discharge permit in accordance with the law; (2) exceeding discharge standards or total volume control indicators; (3) falsifying wastewater quality data; and (4) discharging pollutants without properly operating sewage treatment facilities (Lin 2020).

5.5 Measure Policies on Water Environmental Management

The Five-Year Plan for China's National Economic and Social Development is China's basic policy document, and also sets targets for achieving water environment management. The National Five-Year Plan on Water Pollution Control in Major River Basins has also been formulated as an important water environment management policy document.

In April 2015, China's State Council released the Water Pollution Prevention Action Plan (Water Ten Articles) and has made efforts to resolve certain issues. The Water Ten Articles call for: (1) overall control of pollutant discharge; (2) promotion of transformation and updating of economic structure; (3) a focus on water resources saving and conservation; (4) strengthening of scientific and technological support; (5) giving full play to the function of market mechanisms; (6) tightening of

*3 http://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/202105/P020210526572756184785.pdf environmental law enforcement and supervision; (7) effective strengthening of water environmental management; (8) providing a full guarantee of water ecological environment safety; (9) defining and fulfilling the responsibilities of each party; and (10) strengthening of public participation and social supervision (MEE 2015). The articles also set numerical targets such as limiting the national water consumption to 670 billion m^3 or less by 2020, increasing the percentage of water quality of Grade III or higher in seven river basins including the Yangtze and Yellow Rivers to 70%, and increasing the urban sewage treatment rate to 95% (MEE 2015).

6 | Recent Developments in Water Environmental Management

During the 13th Five-Year Plan period adopted by the National People's Congress in March 2016, China formulated the Ecological Environmental Protection Plan to further improve the quality of the environment and enhance governance capacity. The government set a goal to improve the quality of the environment by 2020, to mitigate vulnerabilities in the ecological environment.

The water quality target set in the 13th Five-Year Plan for 2016–2020 was to increase areas of Grade III by 4% and reduce areas of Grade V and below by at least 4.7%. By the end of FY2019, the percentage of water bodies designated as Grade III and above had increased from 67.9% in 2017 to 74.9%, and the percentage of water bodies inferior to Grade V had decreased from 8.3% in 2017 to 3.4% (Chinese Academy of Environmental Planning, 2020). Moreover, COD and ammonia nitrogen had been reduced respectively by 13.8% and 15.0% by the end of 2020 (Chinawater net 2021).

7 | Challenges and Future Plans

Although the overall quality of China's water environment has been improving, there is still more work to be done. Some localities still have a relatively extensive development mode, and their environmental infrastructure needs to be improved; the country's overall water ecological condition still lags behind developed regions in the world; the water environment risks in some localities demand attention, including risks of environmental emergencies and sediment pollution (MEE 2021).

The 13th Five-Year Plan ended at the end of 2020, and the Outline of the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 was approved by the National People's Congress in March 2021.

In the 14th Five-Year Plan, the following strategies to improve the water environment have been formulated (Xinhua News Agency, 2021).

- Improving the level of rural infrastructure and public services
  - Improve rural infrastructure, including water, electricity, roads, and gas (24-2)*4
  - Promote the treatment of domestic wastewater in rural areas (24-3)

- Improving the quality and stability of ecosystems
  - Strengthen ecological protection and management of major rivers, lakes and wetlands (37-1)
  - Improve policies on land and sea use for ecological protection and restoration (37-2)
  - Promote the establishment of basin-wide ecological compensation measures for major river basins (37-3)

- Environmental improvement
  - Improve water pollution prevention measures, watershed management and coordination (38-1)
  - Strengthen comprehensive management for major river basins, lakes, urban and coastal waters (38-1)
  - Reduce COD and total ammonia nitrogen emissions by 8% each (38-1)
  - Eliminate inferior to Grade V water bodies in principal (38-1)
  - Promote the relocation and renovation of industries with heavy pollution in major river basins (38-1)
  - Implement comprehensive prevention and management plans for water and soil environmental risks (38-1)
  - Strengthen the prevention and control of plastic pollution (38-1)
  - Promote full coverage of urban sewage pipe networks (38-2)
  - Upgrade sewage treatment (38-2)
  - Promote centralized sludge incineration and detoxification treatment (38-2)
  - Achieve 90% detoxification treatment rate for urban sludge (38-2)

*4 The number in the prentices indicates the section in the 14th Five-Year Plan.

- Achieve 25% or more of recycled water use in cities at and above the prefectural level with water shortages (38-2)
- Establish an ecological environment management system that integrates above and below ground as well as land and sea (38-5)
- Realize the issuance of pollution discharge permits for point source polluters (38-5)
- Improve management and protection systems for rivers and lakes, and strengthen the system of river chiefs and lake chiefs (38-5)
- Improve the vertical management system of monitoring, supervision and law enforcement of ecological and environmental institutions under provinces (38-5)
- Promote comprehensive law enforcement reform for ecological environment protection (38-5)
- Increase the disclosure of environmental protection information and strengthen the establishment of a corporate environmental governance system (38-5)
- Improve public supervision, and reporting and feedback mechanisms (38-5)
- Promote the participation of social organizations and the general public in environmental governance (38-5)

2.3 Indonesia

1 | Country Information

Table 2.3.1 Basic indicators

Land Area (km^2)		1,904,569 (2017)*
Total Population		267.7 million (2018)**
GDP (current USD)		970 billion (2019)**
GDP per capita (current USD)		4,200 (2019)**
Average Precipitation (mm/year)		2,702 (2020)***
Total Renewable Water Resources (km^3)		2,019 (2011)
Total Annual Freshwater Withdrawals (billion m^3)		222.6 (2019)****
Annual Freshwater Withdrawals by Sector	Agriculture	85.2% (2017)
	Industry	4.1% (2017)
	Municipal (including domestic)	10.7% (2017)

(Source: FAO 2020, *World Atlas 2017, **World Bank 2018, ***World data atlas 2020, ****Ministry of Public Works and Housing 2019a)

Figure 2.3.1 Citarum River in Bandung, Indonesia

2 | State of Water Resources

Water resources in Indonesia account for about 6% of the world's water resources or about 21% of total water resources in the Asia-Pacific region. Total water availability is estimated at 690 billion m^3/year whereas total demand is 175 billion m^3/year. However, the available water is unevenly distributed spatially and temporally (Table 2.3.2).

Table 2.3.2 Spatial distribution of water availability

Island	million m^3/year
Java	164,000
Sumatera	840,737
Sulawesi	299,218
Kalimantan	1,314,021
Bali and Nusa Tenggara	49,620
Maluku	176,726
Papua	1,062,154
Total	**3,906,476**

(Source: ADB 2016)

As of 2014, the total reservoir capacity was 12.6 billion m^3, or 49.2 m^3 per capita, which is half the capacity prior to 1945 (105.5 m^3 per capita) (ADB 2016). To enhance water security, the government planned to build 49 new reservoirs with total capacity of 3 billion m^3 between 2015 and 2019 (Government of Indonesia 2015).

Indonesia has almost 8,000 watersheds (*Daerah Aliran Sungai* [DAS]), which are managed in 131 river basins. Five river basins (304 DAS) cross international boundaries (Malaysia, Timor-Leste, and Papua New Guinea), 29 basins (859 DAS) cross provincial boundaries, and 37 basins are considered as having national strategic importance (ADB 2016).

3 | State of Ambient Water Quality

3.1 Rivers

There are 5,590 major watersheds in Indonesia, divided into 131 river basin territories. Status of surface water quality compliance against the national guidelines and its provincial distribution in Indonesia are shown in figures 2.3.2 and 2.3.3, respectively. The percentage of heavily polluted rivers, as defined by Class II Water Quality Criteria in Government Regulation No. 22/2021, exceeded 70% in 2016. As a result of monitoring 44 large rivers across Indonesia, it was found that only four met Class II standards throughout the year (ADB 2016). A recent research by the Indonesian Ministry of Environment and Forestry showed that at present 75% of rivers in the country are seriously polluted, 52 of which are categorized as heavily polluted, and 118 watersheds out of 450 monitored watersheds are critically polluted.

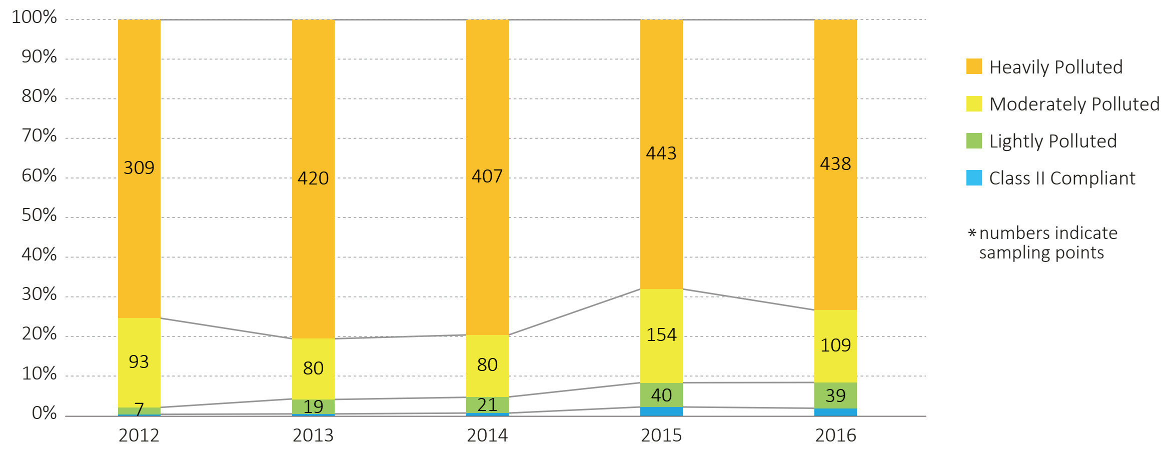


Figure 2.3.2 Status of compliance with water quality in Indonesia (Source: created by WEPA based on data from MOEF 2017)

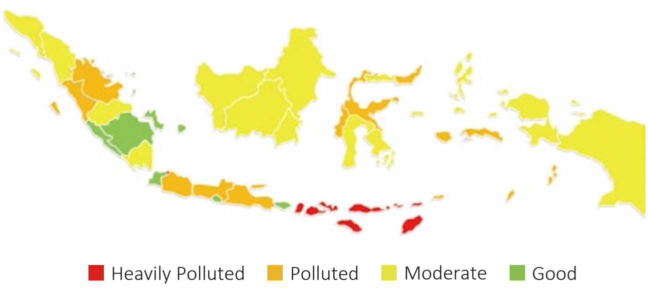


Figure 2.3.3 Provincial distribution of surface water quality (Source: ADB 2016)

Water quality data covering five key indicators for the majority of river bodies in Indonesia for 2019 is shown in Figure 2.3.4 (PUPR 2019b). It can be seen that most of the rivers are moderately to severely polluted, especially in terms of *E.coli*.

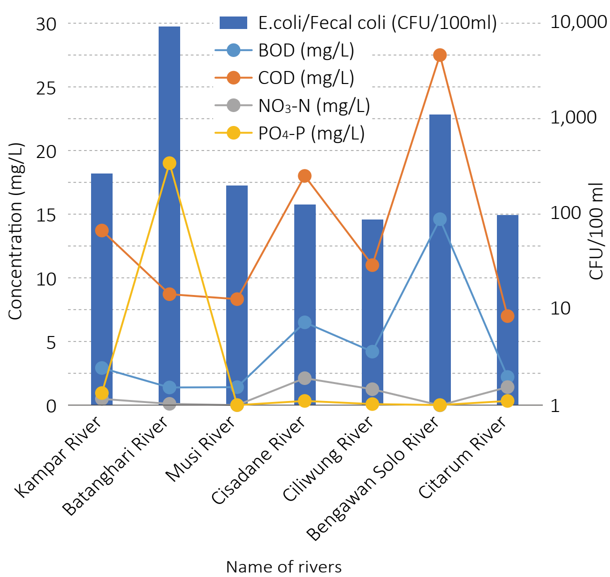


Figure 2.3.4 Water quality of major rivers in 2019 in Indonesia (Source: PUPR 2019b)

3.2 Lakes and Reservoirs

Similarly, with conditions in rivers, there is significant pressure on water quality in lakes from various sources, such as domestic activities, agriculture, livestock, forestry and industry. Water quality monitoring of 15 lakes on the government's priority list revealed that most fell into the hyper-eutrophic category (ADB 2016).

3.3 Coastal Water

Indonesia is the largest archipelago in the world, with 13,466 islands, about 5.8 million km^2 of sea area and 81,000 km of coastline. Pollution threatens the Indonesian seas.

3.4 Groundwater

Groundwater is an important water source and the potential of groundwater basins is promising on several islands, with a total area of 907,615 km^2 and total basin capacity of about 520 billion m^3/year (Table 2.3.3).

Table 2.3.3 Regional distribution of groundwater potential

Region	Number of basins	Area (km^2)	Volume (million m^3/year)	
			Unconfined	Confined
Sumatera	65	272,843	123,528	6,551
Java and Madura	80	81,147	38,851	2,046
Kalimantan	22	181,362	67,963	1,102
Sulawesi	91	37,778	19,694	550
Bali	8	4,381	1,577	21
West Nusa Tenggara	9	9,475	1,908	107
East Nusa Tenggara	38	31,929	8,229	200
Maluku	68	2,583	11,943	1,231
Papua	40	26,287	222,524	9,098
Total	**421**	**907,615**	**496,217**	**20,906**

(Source: ADB 2016)

Indonesian Ministry of Health Regulation with Decree No. 416/1990 aimed at water quality monitoring looks for different provisions and controls which stipulates groundwater quality standards. In Jakarta, 45% of groundwater shows contamination by faecal coliform and 80% by *E. coli*. Major sources of contamination include septic tank leakage, discharge of untreated domestic wastewater, landfill leachate, and industrial effluent contamination. Saltwater intrusion due to overexploitation is common in coastal aquifers (ADB 2016).

4 | State of Wastewater Treatment

Wastewater and major pollutants

Domestic wastewater contains large amounts of chemical oxygen demand (COD), nutrients, and faecal coliform, and is the largest contributor to surface water pollution in Indonesia. Agricultural wastewater contains COD, nutrients, fertilizer such as urea and triple superphosphate, and pesticides, and is a non-point source of pollution. Industrial wastewater contains a wide variety of pollutants depending on industrial activity (e.g., Chromium (Cr) in tanning, Mercury (Hg) in illegal mining, color in textiles). The practice of using wastewater in fishponds previously was widespread but is now declining due to health concerns. Using wastewater to produce fish feed, like duckweed, offers a safer alternative (UNESCO 2017).

Domestic wastewater

In urban areas (population 110 million), about 1% of the wastewater is safely collected and treated, whereas in rural areas (population 130 million) wastewater is neither collected nor treated (ADB 2016).

Industrial wastewater

There are about 24 thousand large- or medium-scale industries and about 3.5 million small-scale industries in Indonesia, employing a total workforce of 14.8 million. Food and beverage, textile, vehicle, and petrochemical industries have all seen positive growth rates based on GDP in recent years. Industries including cement, pulp and paper (capacity over 300,000 t-pulp/year), upstream petrochemicals, industrial estates, shipyards with graving docks, explosives, and smelting are obligated to obtain an Environmental Impact Assessment (AMDAL) permit to conduct business according to the Decree of Ministry of Environment concerning Type of Business Plan/ Activity Required Environmental Impact (MOE Decree No. 5/2012).

There are various frameworks to assist green industries, such as the government-based soft loan program, which supports investment in waste reduction and management. This program targets small and medium-sized enterprises (assets less than 10 billion Indonesian Rp) with maximum loans of 5 billion Indonesian Rp.

Green Industry Standards have been laid out in Law on Industrial Affairs (Law No. 3/2014). Eight industries have individual standards under this law: cement, pulp and paper, ceramic tiles, textile dyeing, milk powder, crumb rubber, ribbed smoked sheet rubber, and inorganic fertilizer.

5 | Frameworks for Water Environmental Management

5.1 Legislation

For water environmental management, there are two primary regulations: Law on Water Resources (Law No. 17/2019) and Government Regulation concerning the Management of Water Quality and Control of Water Pollution (Government Regulation No. 82/2001). The purpose of the former is holistic water resource management (both quality and quantity) in line with the SDGs, whereas the latter's is to focus on water quality management and pollution control – specifically strict implementation of water quality standards, effluent standards and TMDLs. To improve implementation of these guidelines and regulations in the field, some new elements have since been introduced through Law No. 17/2009, such as establishment of a water resource information system for more comprehensive monitoring, and licensing and empowerment for authorities engaged in water resource supervision and management.

The objective of environmental management in Indonesia is to enable environmentally sustainable development, and the basic legislative structure for water environment management is shown in Figure 2.3.5. Integral water resources management is regulated by Law No. 17/2009. The main subjects regulated in this Law on Water Resources include state control and people's rights to water; the authorities and responsibilities of the Central Government and Regional Governments in the management of water resources, water resources management, water resources utilization permits, water resources information system, empowerment and supervision, funding, rights and obligations, society participation, and coordination. Apart from that, it also regulates the provisions regarding criminal investigation and provisions for violations of the provisions of this Law.

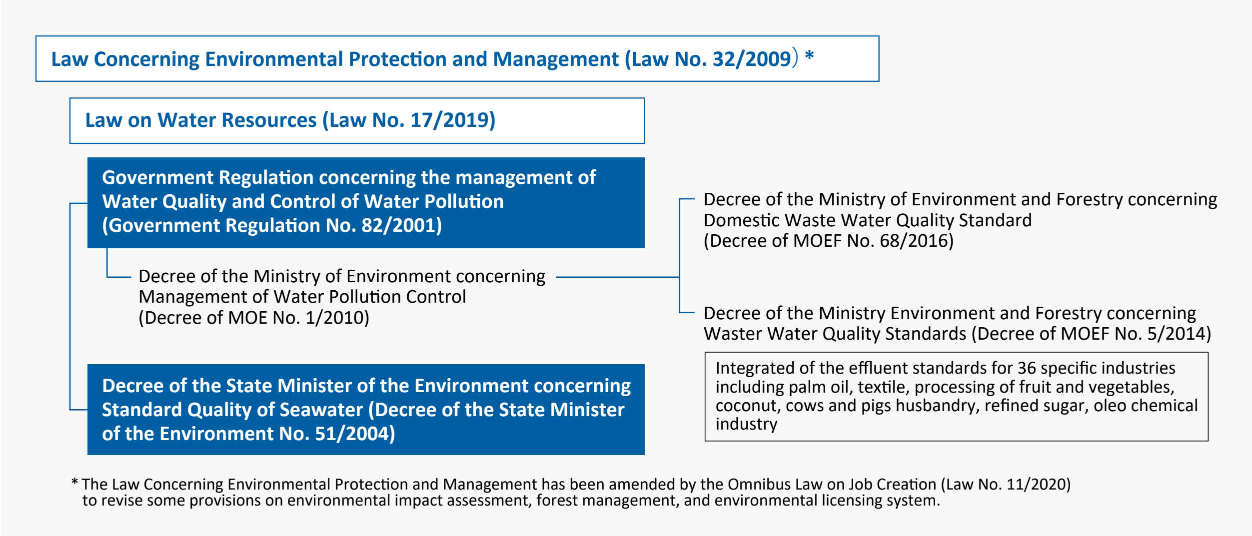


Figure 2.3.5 Basic legislative structure for water environment management

The Government Regulation No. 22/2021 strives to regulate the inventory of water bodies which consists of the identification and characterization of water bodies, including surface water and groundwater and different pollutants (point as well as non-point source). It also regulates economic instruments for water pollution control.

5.2 Institutional Arrangement

The Long-Term Development Plan 2005–2025 (RPJPN: Law No. 17/2007) stipulates the role of government as facilitator, regulator, and development catalyzer to increase the effectiveness of public services (ADB 2016).

In Indonesia, several ministries deal with water management, such as the Ministry of Environment and Forestry (MOEF), Ministry of Public Works and Housing (PUPR) and State Ministry of National Development Planning (BAPPENAS). MOEF is responsible for water quality management and pollution, PUPR deals with water resource management especially focusing on quantity and water uses, and BAPPENAS is responsible for the overall national development.

5.3 Ambient Water Quality Standards

Water quality criteria (WQC) are set as the benchmarks for water quality conservation under the Government Regulation No. 22/2021. These criteria are the minimum standards set by the national government, though local governments are free to set their own, which may be even stricter and include additional parameters in accordance with local settings.

To date, water quality standards have been developed for surface inland water bodies such as rivers, lakes (approved in 2001) and coastal waters (approved in 2004), though no standards have been developed and approved for groundwater, which is a matter of concern. Nationally, river water quality is presently monitored through 510 water quality monitoring sites, and for lakes there are 10.

WQC sets standard values for different parameters in four classes, which are determined based on the type of water usage (Table 2.3.4). However, as rivers have not been fully categorized into classes, the state of water quality in the country is evaluated based upon compliance of values with Class II. The Decree of the State Minister of the Environment concerning Standard Quality of Sea

Table 2.3.4 Classes of inland water quality

Class	Designation	Standard (mg/L)					
		BOD	COD	Cl_2	Phenol	Total Coliform	*E. coli*
I	Drinking water	2	10	0.03	0.001	1000	100
II	Water recreation facilities	3	25	0.03	0.001	5,000	1,000
III	Freshwater for fish, farming and husbandry	6	50	0.03	0.001	10,000	2,000
IV	Crops irrigation	12	100	0.03	0.001	10,000	2,000

(Source: Purwati et al. 2019)

Water (MOE Decree No. 51/2004) stipulated three sets of standards for coastal water quality: Marine water quality standards for ports and harbours (Annex I in MoE Decree 51/2004), standards for marine recreation (Annex II) and standards for marine ecosystems (Annex III). Water quality standards for marine ecosystems, notably, are subdivided further into clarity, TSS, temperature and salinity for coral, mangrove, and sea grass (lamun) (Table 2.3.5).

As with water criteria for surface water, local governments can set stricter standards, such as the Regulation of the Governor of DKI Jakarta Province No.93/2006, which applies stricter standards for capitals of provinces and the special region of Jakarta (DKI Jakarta Province).

Water quality monitoring framework

Water quality monitoring schemes are determined under the Management of Water Quality and Control over Water Pollution Government Regulation as follows:

1. Monitoring of water sources in the regency/municipal region is carried out by the regency/municipal government.
2. Monitoring of water sources in two or more regency/municipal regions within one province is coordinated by the provincial government and carried out by each regency/municipal government.
3. Monitoring of water sources in two or more provincial regions and/or water sources on borders with other countries is observed by the national government.

Water quality observations are carried out at least once in six months and results are submitted to the ministry of environment and forest. The mechanisms and procedures for water quality monitoring are stipulated further in detail through ministerial decree.

5.4 Effluent Standards

Effluent standards

National wastewater quality standards are specified by governmental regulation after due consideration of suggestions from related government agencies (Government Regulation No. 22/2021). As with water quality standards, provincial governments can specify similar or tighter wastewater quality standards than the national wastewater quality standard.

Table 2.3.5 Coastal water quality standards for marine ecosystems

No.	Parameter	Unit	Standard value		
			Coral	Mangrove	Sea grass
Physical parameters					
1	Clarity	m	>5	-	>3
2	Odor	-	Normal		
3	Turbidity	NTU	<5		
4	TSS	mg/L	20	80	20
5	Refuse	-	undetected		
6	Temperature	°C	28–30	28–32	28–30
7	Oil film	-	undetected		
Chemical parameters					
1	pH	-	7.0-8.5		
2	Salinity	‰	33–34	34	33–34
3	DO	mg/L	>5		
4	BOD	mg/L	20		
5	Free ammonia (NH_4-N)	mg/L	0.3		
6	Orthophosphate (PO_4-P)	mg/L	0.015		
7	Nitrate nitrogen (NO_3-N)	mg/L	0.008		
8	Cyanide (CN)	mg/L	0.5		
9	Sulphides	mg/L	0.01		
10	PAHs	mg/L	0.003		
11	Phenols	mg/L	0.002		
12	PCB	µg/L	0.01		
13	Surfactants (MBAS)	mg/L	1		
14	Oil and grease	mg/L	1		
15	Pesticides	mg/L	0.01		
16	Tributyltin (TBT)	µg/L	0.01		
Dissolved metals					
1	Hg	mg/L	0.001		
2	Cr^{6+}	mg/L	0.005		
3	As	mg/L	0.012		
4	Cd	mg/L	0.001		
5	Cu	mg/L	0.008		
6	Pb	mg/L	0.008		
7	Zn	mg/L	0.05		
8	Ni	mg/L	0.05		
Organic parameters					
1	Total coliform	MPN/100mL	1,000		
2	Pathogens	nb/100mL	undetected		
3	Plankton	-	No abnormal blooms		
Radioactive parameters					
1	Radioactive substances	Bq/L	4		

General industrial effluent standards were first created in Government Regulation No. 20/1990. Under the Decree of Ministry of Environment No. 3/1991 (no. KEP-03/MENKLH/II/1991), specific effluent standards were first identified for 14 industrial activities, which then increased to 21 by the Decree of Ministry of Environment No. 51/1995. However, these Decrees were merged into the Decree of Ministry of Environment and Forestry No. 5/2014, which integrated the effluent standards of 36 industries in those Decrees. Local governments such as in DKI Jakarta, West Java and Jogjakarta have established tighter wastewater quality standards than the national government.

Effluent inspection procedure

All industries are required to send wastewater samples to registered laboratories once a month or more frequently depending on their activities, with the analysis reports then submitted every six months to local authorities and the MOEF. Local and national authorities have the right of access and sampling of effluent at any time.

Measures against non-compliance

In the absence of any economic tools or concrete plans for water quality management and enforcement of regulations, Indonesia has some judicial and non-judicial measures for managing non-compliance with effluent water quality standards. In order to enforce the water management guidelines, effluent standards for industrial and domestic sectors were approved in 2014 and 2016 respectively, with either the Environmental Agency of Local and Provincial government or MOEF managing inspections in accordance with to the permit issued.

While each industry has an obligation to monitor the quality of effluent once a month, rates of effluent discharge and pH are monitored daily. Reporting is done every three months, inspections for which involve a three-step process: a) on-site inspection, b) submittal of effluent quality report by the industry, and c) online report submission.

Based on Article 76 of Law No. 32/2009 on Environmental Protection and Management, the Minister, Governor, Regent, or Mayor can impose administrative sanctions on business actors in accordance with the degree of violation of environmental permits (e.g., effluent quality), which include:

a. Written warning
b. Government coercion
c. Freezing of environmental permits
d. Revocation of environmental permit

Although an enforcement regulation previously existed, the Minister of Environment and Forestry introduced a new aspect of monitoring of effluent quality, which stipulates it be performed automatically, continuously and online, under Decree of the Minister of Environment and Forestry No. 93/2018 (No. P.93/MENLHK/SETJEN/KUM.1/8/2018).

Compliance management

The Program for Pollution Control Evaluation and Rating PROPER: *Program Penilaian Peringkat Kinerja Perusahaan* is executed to encourage compliance of companies with applicable rules and regulations, and the results are published as information reflecting the reputation of companies in respect of environmental management. In 2016, 1,895 companies were rated under the PROPER program (Table 2.3.6).

Table 2.3.6 PROPER evaluation levels

Performance level	Category	Number of companies in 2016
Gold	Zero emissions	12
Green	Beyond compliance	172
Blue	Compliance	1,422
Red	Failure to reach requirements	284
Black	Non-compliance, and insignificant efforts at improvement	5
Total		**1,895**

(Source: MoE 2017)

5.5 Major Policies on Water Environmental Management

The Long-Term Development Plan 2005–2025 (RPJPN) presents the main policies and strategies, which in turn sets the direction for the National Medium-Term Development Plan (RPJMN) 2015–2019, which includes the following targets regarding conservation of the water environment:

- Rehabilitation of 5.5 million ha of Indonesian Forest
- Increase community involvement in watershed management through development of Community Plantation Forest, Community Forest, Village Forest, development of ecotourism and development of non-timber forest products
- Rehabilitate 3 million ha and construct 1 million ha of irrigation networks

- Establish flood management schemes in 33 river basins
- Improve water quality in 15 lakes and 5 rivers

Analysis of watershed status, water source protection and restoration is to be carried out in four priority watersheds (Ciliwung, Citarum, Kapuas and Siak) and vegetation management is to be conducted in 26 sub-priority watersheds.

Presidential Decree No. 33/2011 lays out the national policy of water resource management from 2011 to 2030.

6 | Recent Developments in Water Environmental Management

Regarding the Sustainable Development Goals (SDGs), the Ministry of National Development Planning (Bappenas) is assigned to coordinate the entire process of planning, implementation, monitoring as well as evaluation and reporting by involving all stakeholders.

Indonesia maintains a working relationship based on mutual trust between all stakeholders, consisting of the government, CSO, philanthropy and business, and academics. Active engagement of all stakeholders is encouraged and enhanced by their involvement and representation in the Implementing Team and Working Group within the SDGs National Coordinating Team. All stakeholders are not only involved in the implementation, but also in determining the direction of SDG implementation.

The national medium-term development plan (RPJMN) 2015–2019 targets universal access to water and sanitation by 2019. Since 2019, WEPA started implementing a WEPA Action Program in Indonesia, providing technical support to the Indonesian Ministry of Environment and Forestry of Indonesia (MOEF) to develop a "Guidelines on Implementation of Total Maximum Daily Load (TMDL) as Water Quality Management Approach". The introduction and implementation of the Guidelines is expected to address water pollution caused by domestic and industrial wastewater, which has been a longstanding issue in Indonesia. The final draft of the Guidelines is going to be finalized by the MOEF, in collaboration with the Institute of Technology Bandung (ITB) and the WEPA Secretariat.

Indonesia's specific response to achieve its SDG targets on water quality (SDG targets 6.2, 6.3 and SDG target 6.A specifically) is described in Table 2.3.7.

Major flagship program for improvement of water environment

Indonesia has developed and implemented the Eco-riparian Program, a water body restoration program that aims to improve water quality and restore ecological and socio-cultural functions of water bodies. The Program includes:

1. Maintaining quantity and continuity of water and prevent flooding
2. Improving water quality and restore aquatic ecosystems
3. Revitalizing environmentally friendly river-based culture
4. Empowering local communities in water protection and management
5. Implementing regulations that strengthen water quality management and control water pollution

Table 2.3.7 Country's response to achieving SDG 6

Response	Yes	No	If yes, please provide short description
Mapping of agencies for SDG targets 6.2 and 6.3	✔		- Ministry Public work and Settlement and Ministry of Environment and Forestry
Set up/revision of country's indicator on SDG targets 6.2 and 6.3	✔		- By 2030, achieving access to improved sanitation and hygiene adequate and equitable for all, and stop the practice of defecation in open spaces, paying special attention to the needs of women and vulnerable groups of people.
Available datasets to measure progress of SDG targets 6.2 and SDG targets 6.3	✔		- Central Bureau of Statistics (BPS): National Socio-Economic Survey (Susenas) health and housing modules. - Ministry of Public Works and Settlements: Annual Report.

7 | Challenges and Future Plans

Challenges: Overall, key challenges are divided into the following four categories:

- **Institutional Challenges:** Challenges in coordination and integration at the implementation level
- **Enforcement challenges:** Limited number of environmental inspectors at the local level
- **Resource and financial challenges:** Limited budgetary allocation to control water pollution and limited number and quality of human resources that handle water protection and management at the local level
- **Technical challenges:** The necessary of increasing the capacity of innovation in developing and applying science and technology related to water protection and management

Table 2.3.8 Necessary actions to address the above mentioned challenges

Challenges	Necessary actions to be taken
Institutional Challenges	i. Need to build an effective system in implementing joint programs and actions between related ministries and institutions and communities
Enforcement Challenges	i. Increasing the number of inspectors and training on inspection and enforcement of environmental law ii. Encourage policy makers at the local level to empower environmental inspectors
Resource and financial Challenges	i. Increasing the capacity of local governments with guidance and budgetary assistance ii. Implement an effective incentive and disincentive system for local government
Technical Challenges	i. Increased collaboration between researchers and managers in the development and application of science and technology ii. Increasing the technical capacity of staff and managers in industry and government agencies in water protection and management

2.4 Japan

1 | Country Information

Table 2.4.1 Basic indicators

Land Area (km²)		377,977 (2020)
Total Population		125.9 million (2020)
GDP (current USD)		4,956.4 billion (2018)
GDP per capita (current USD)		35,280 (2018)
Average Precipitation (mm/year)		1,668 (2017)
Total Renewable Water Resources (km³)		430 (2017)
Total Annual Freshwater Withdrawals (billion m³)		79.3(2017)
Annual Freshwater Withdrawals by Sector	Agriculture	68% (2017)
	Industry	14% (2017)
	Municipal (including domestic)	18% (2017)

(Source: See References)

Figure 2.4.1 Lake Biwa in Shiga Prefecture, Japan

2 | State of Water Resources

Japan is located in the eastern monsoon region of Asia and noted for having one of highest accumulations in the world. The annual mean precipitation is 1,668 mm, about 1.4 times the global annual mean (inland area, 1,171 mm). On the other hand, on a per capita basis (annual mean precipitation × land area ÷ total population) this is about 5,000 m³/person/year, about a quarter of the world amount. In terms of available water resources per capita, it is about 3,400 m³/person/year, which is less than half of the world average (about 7,300m³). Moreover, most of the available water is discharged to the ocean unused due to the steep topography, very short streams as well as intensive rainfall in rainy and typhoon seasons.

3 | State of Ambient Water Quality

The main objectives of protecting the water environment in Japan are human health and environmental conservation, for which environmental standards for ambient water quality have been established in the Basic Environment Law as the acceptable levels of water quality to be maintained in public waters. As such, there are two related Environmental Quality Standards (EQS) for water– one for human health, which are uniform standards applicable to all public water bodies nationally, and the other for conservation of the living environment, which is applied to all public water bodies.

In most locations, EQS for human health have been attained with a 99.1% compliance rate in fiscal year 2018. EQS for conservation of the living environment have been achieved, with an 89.6% rate of compliance for biochemical oxygen demand (BOD) or chemical oxygen demand (COD), the representative water quality indicators of organic contamination (Figure 2.4.2).

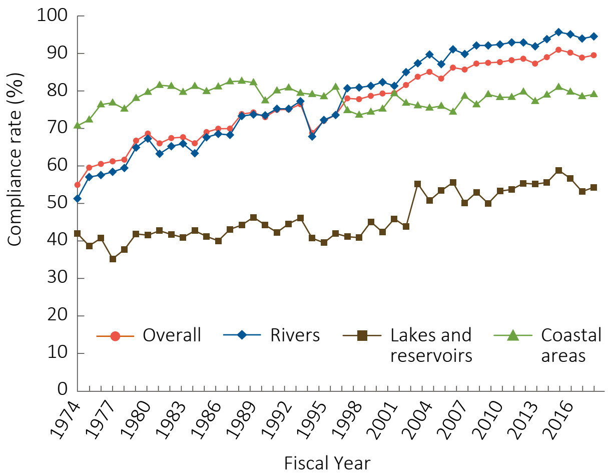


Figure 2.4.2 Shift in environmental standard compliance rate (BOD and COD) (Source: MoEJ 2020)

3.1 Rivers

The compliance rate for rivers is 94.6%, the highest among the different types of water bodies. A trend of rising compliance was observed until 2015, after which it plateaued for a few years, but in general a high water quality has been maintained.

3.2 Lakes and Reservoirs

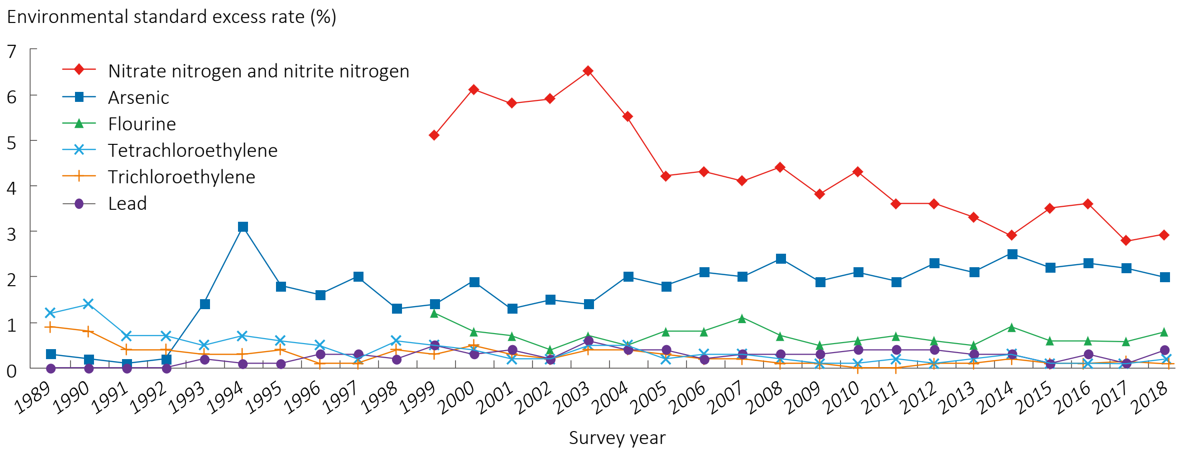
The compliance rate for lakes and reservoirs recorded is 54.3%. While the rate has improved compared to before 2000, it has hovered around 55% in recent years. The compliance rate for total nitrogen and total phosphorus for lakes and reservoirs was low at 48.8%.

3.3 Coastal Water

The compliance rate for coastal waters is 79.2%, and for total nitrogen and total phosphorus in coastal waters was 92.1%, which is higher than the previous year's record.

3.4 Groundwater

Of the 3,206 wells tested in 2018, 181 (or 5.6%) exceeded standards for some EQS. Among others, values for nitrate nitrogen and nitrite nitrogen exceeded the standards (Figure 2.4.3), the main causes of which are considered to be nitrogen load from excessive fertilization, inappropriate livestock excreta treatment facilities and domestic wastewater.



Note 1. Wells measured in general survey differ by year.

Note 2. Environmental standards related to groundwater contamination were established in 1997. Standards preceding this year are considered evaluation criteria. In addition, the evaluation criteria for arsenic was revised from "under 0.05 mg/L" to "under 0.01 mg/L", and for lead from "under 0.1 mg/L" to "under 0.01 mg/L" in 1993, and for trichloroethylene from "under 0.03 mg/L" to "less than 0.01 mg/L" in 2014.

Note 3. Nitrate nitrogen, nitrite nitrogen and fluorine were added to environmental standard items in 1999.

Figure 2.4.3 Environmental standard excess rates for groundwater (by item) (Source: MOEJ 2021)

4 | State of Wastewater Treatment

Access to domestic wastewater treatment facilities*1 in Japan stood at 91.7% for the population as a whole, as of the end of FY 2019 (except for some municipalities in Fukushima, which lacked survey data due to the Great East Japan Earthquake).

As shown in Figure 2.4.4, rates for those with access to domestic wastewater treatment facilities are low in municipalities with small populations. Further, for areas of low population density, it is noted that decentralized domestic wastewater treatment systems, or *Johkasou**2 are suitable, based on which *Johkasou* systems are expected to play a larger role in domestic wastewater treatment in the near future of Japan. Moreover, considering future social conditions anticipated in Japan such as low birth rate and longevity, and population decrease, it is assumed that both installations of new *Johkasou* as well as conversions of older-type ("*tandokushori*") *Johkasou**3 into newer-type ("*gappei-shori*") *Johkasou* will increase.

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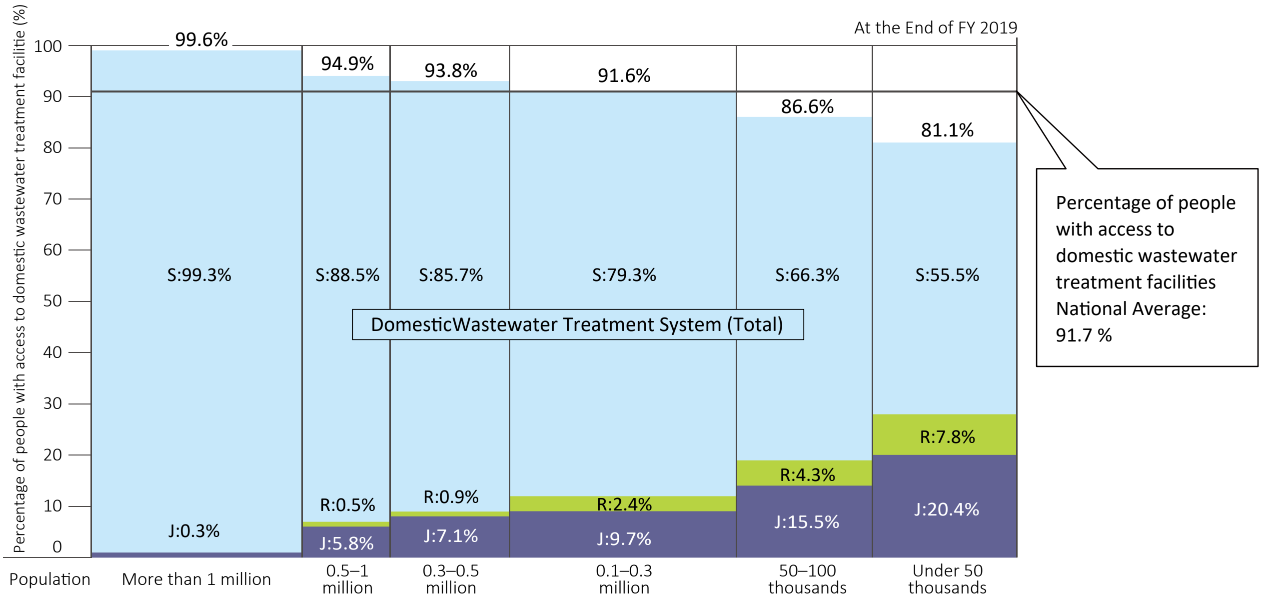
*1: Domestic wastewater treatment facilities do not include facilities that treat only black water and discharge grey water into the environment without treatment.

*2: A decentralized domestic wastewater treatment system widely used in rural areas of Japan. It can treat both black and grey water and obtain high quality effluent with aeration (less than BOD 20 mg/L according to the structural standard). Advanced types of *Johkasou* that can remove nitrogen or phosphorus are becoming increasingly prevalent recently. The *Johkasou* Law modified in 2005 defines the effluent water quality standard for *Johkasou*.

*3: *Tandoku-shori Johkasou* is an older-type *Johkasou* that treats only black water, and not grey water, and has therefore low effluent removal rates and higher pollution loads (eight times) than the newer *gappei-shori Johkasou*. Under the *Johkasou* Law, *Johkasou* indicates *gappei-shori Johkasou* that treats both black and grey water. *Tandoku-shori Johkasou* that does not treat grey water is, consequently, regarded as deemed *Johkasou*. New installations of the older type have been forbidden since 2000 based on the modified *Johkasou* Law of the same year. Although numbers of older *tandoku-shori Johkasou* are dropping, about 3.8 million are still in existence as of end of FY 2018. The issue of how to convert the older type to the newer type is very urgent.

With regards to installation of *Johkasou*, several subsidy programmes are provided by the MoEJ, such as the *Johkasou* Installation Promotion Programme, in which municipalities provide financial support to homeowners installing *Johkasou*, and the Municipal *Johkasou* Installation Programme, in which the government subsidizes municipalities installing *Johkasou*. In addition to installation subsidies, the government provides financial support for the removal of older-style *(tandoku-shori) Johkasou* to promote conversion to the newer-type *(gappei-shori) Johkasou*.

Regarding the various sewerage treatment systems, rural sewerage systems and *Johkasou* systems, it is important not only to develop domestic wastewater treatment facilities effectively and appropriately, corresponding to changing social conditions, but also to renovate, renew and operate existing facilities effectively, considering technological and financial aspects of these systems for the sustainable management of domestic wastewater treatment facilities.



*S: Sewerage system, C: Community sewerage treatement system, R: Rural sewerage system, J: *Johkasou* sysytem

Figure 2.4.4 Percentage of people with access to domestic wastewater treatment facilities by size of municipality (Source: MoEJ 2019)

5 | Frameworks for Water Environmental Management

5.1 Legislation

The purpose of the Basic Environmental Law is to "ensure healthy and cultured living for both the present and future generations of the nation as well as to contribute to the welfare of mankind" (Article 1 of the Basic Environmental Law). The EQS for water were established by the Basic Environmental Law as the administrative targets for ambient water quality.

The Water Pollution Control Law, enacted in order to protect human health and preserve the living environment sets provisions for water quality conservation such as effluent regulations from factories and business establishments, continuous monitoring of water quality and the total pollutant load control system. Other laws related to conservation of public water bodies are shown in Figure 2.4.5.

As a measure related to domestic wastewater management, the Sewerage Law was enacted in order to construct sewerage systems. In addition, the *Johkasou* Law for on-site packaged household wastewater treatment plants for areas without access to sewerage treatment was established, to define regulations relating to their installation, inspection, desludging and manufacturing.

Conservation of Water Quality in Public Water
- ◆ Basic Environment Law
  Environmental Quality Standards for Water Pollutants

General Measures
- ◆ Water Pollution Control Law
  Factory effluent control, notification of factory establishment, monitoring orders, continuous monitoring.
  Measures for household wastewater
- ◆ Sewerage Law
  Construction of sewerage
- ◆ *Johkasou* Law
  Installation of *Johkasou*, regulation of desludging and production, registration system of *Johkasou* installation worker, licence system of *Johkasou* desludging technician, etc

Special Measures in Enclosed Water Bodies

Lakes and Reservoirs
- ◆ Law Concerning Special Measures for Preservation of Lake Water Quality
  Planning of Plan for the Preservation of Lake Water Quality, Special Regulations

Estuaries
- ◆ Water Pollution Control Law
  Control of total pollutant load, and countermeasures against eutrophication

Seto Inland Sea
- ◆ The Law Concerning Special Measures for Conservation of the Seto Inland Sea

Ariake Sea/Yatsushiro Sea
- ◆ The Law Concerning Special Measures for the Restoration of the Ariake and Yatsushiro seas

Biwa Lake
- ◆ The Law Concerning Special Measures for the Restoration of the Biwa Lake

Potable Water Sources
- ◆ Law Concerning Special Measures for the Protection of Water Quality in Water Resources Areas for the Purpose of Preventing Specific Trouble

Groundwater Quality Conservation
- ◆ Basic Environment Law
  Environmental Quality Standards for Groundwater

General Measures
- ◆ Water Pollution Control Law
  Regulations for toxic substances from factories, purifying orders for polluted groundwater, and continuous monitoring

Sound Water Cycle
- ◆ Basic Law on Water Cycle
  Holistic and integrated implementation of policies on water cycle

Other Laws Related to Water Environment
- ◆ Law Concerning Special Measures against Dioxins
- ◆ River Law
- ◆ Drinking Water Sources Law
- ◆ Water Supply Law
- ◆ Law Rrelating to the Prevention of Marine Pollution and Maritime Disaster

Figure 2.4.5 Scheme of legal system for water environmental management in Japan (Source: MoEJ 2009)

5.2 Institutional Arrangement

Since water is involved in many aspects of our lives, five main ministries (Ministry of the Environment; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of Health, Labour and Welfare; Ministry of Agriculture, Forestry and Fisheries; Ministry of Economy, Trade and Industry) play key roles and collaborate in water environment management in Japan.

Table 2.4.2 Institutional arrangement of water environmental management

Name	Main Activities in charge
Ministry of the Environment	Formulating and implementing a wide range of water environment management policies such as formulation of ambient water quality standards, water quality monitoring of public water and publication of the results, effluent standard, *Johkasou* maintenance, etc.
Ministry of Land, Infrastructure, Transport and Tourism	Promoting sustainable river management through preparation of river-related development and management plans, disseminating sewerage policies and formulating and implementing policies related to the development and management of water resources.
Ministry of Health, Labour and Welfare	Formulating and implementing policies related to water supply system development and maintenance, water quality standards for drinking water, and security of drinking water quality.
Ministry of Agriculture, Forestry and Fisheries	Formulating and implementing policies related to the conservation and management of agricultural land and water contributing to the conservation of the rural environment, and the development of sewage treatment facilities in rural areas.
Ministry of Economy, Trade and Industry	Formulating and implementing policies such as industrial water supply development and wastewater treatment in the mining industry through the implementation of mine pollution prevention projects.

The Basic Law on Water Cycle was enacted in 2014 to promote integrated and comprehensive measures related to the water cycle. According to this act, the Headquarters for Water Cycle Policy, headed by the Prime Minister, was established in the Cabinet.

5.3 Ambient Water Quality Standards

Ambient water quality standards

Nationwide uniform standard values were set for 27 items as the EQS for water related to protection of human health (health items). In 1971, the EQS for water were established. Meanwhile, the EQS for water related to conservation of the living environment (living environment items) include environmental standards for 13 items, such as BOD, COD, and DO, as well as total nitrogen and total phosphorus, for prevention of eutrophication in lakes and coastal waters.

Moreover, as indicators of ambient water quality standards for the conservation of aquatic living resources, total zinc, nonylphenol and linear alkylbenzene sulfonic acid and its salt were registered in 2003, 2012 and 2013, respectively.

Monitoring framework

According to the Water Control Law, prefectural governors are required to conduct regular monitoring of public water bodies and groundwater, and report to MoEJ as well as inform the public on the state of water pollution in public water bodies and groundwater. Prefectural governments prepare monitoring plans and carry out regular water quality monitoring in cooperation with relevant national government organizations based on monitoring methods specified by MoEJ. Monitoring results at approximately 7,000 locations in public water bodies nationwide are publicly released on the MoEJ website (Figure 2.4.6).

Figure 2.4.6 Comprehensive information site on the water environment (Source: MoEJ 2020)

5.4 Effluent Standards

Effluent standards

Based on the Water Pollution Control Law, uniform effluent standards were established for 28 items related to protection of human health, which are applicable to factories and business establishments. Meanwhile, effluent standards for 15 items related to the living environment target only those factories and business establishments with daily effluent volumes exceeding 50m^3 per day. Local governments (prefectures and ordinance-designated cities) may establish stricter effluent standards than the national uniform standards when the national standards are considered insufficient to achieve water quality targets.

The total pollutant load control system is a discharge control mechanism to improve water quality by reducing total pollutant loads flowing into certain enclosed coastal waters, namely Tokyo Bay, Ise Bay, and the Seto Inland Sea, where due to the presence of populated and industrialized areas it is difficult to achieve EQS for water by regulating discharge based on only concentrations of regulated substances. Under the system, the national government sets targets for pollutant loads and periods, and the relevant prefectures stipulate the tangible methods required to meet the targets.

To date, COD loads have been steadily reduced in target water bodies since 1979 (Figure 2.4.7). Figure 2.4.8 shows the improvement in COD concentrations in Tokyo Bay, for example. Nitrogen and phosphorus loads have also been reduced since their addition as designated items under the system in 2001. In September 2016, Japan set forth its basic policy with the 8th phase of total reduction, with the target year of 2019.

Effluent inspection procedure

The Water Pollution Control Law stipulates monitoring and recording of the quality of effluent from factories and business establishments. Factories and business establishments located in total pollutant load control target areas are required to measure and record

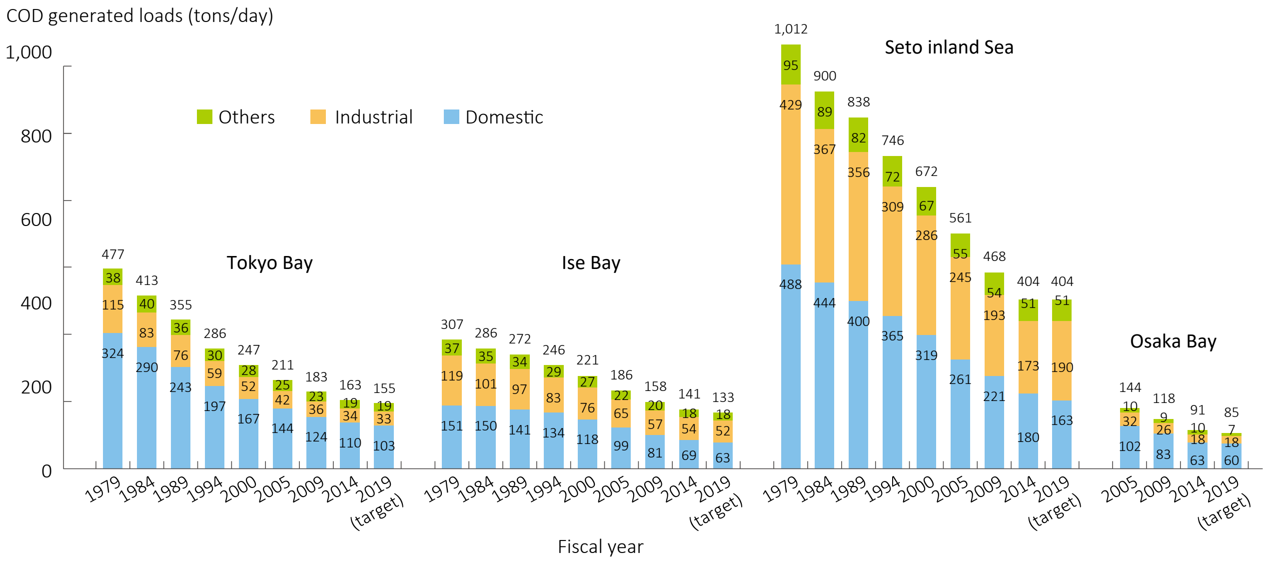
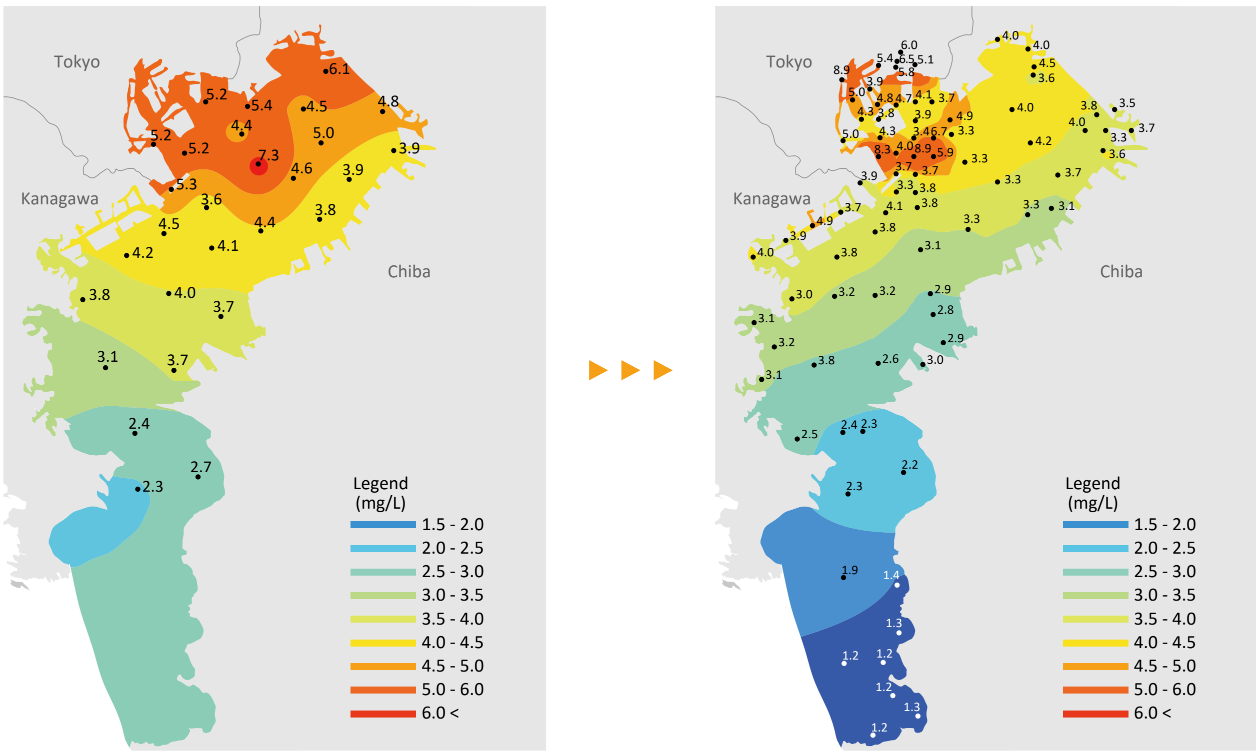


Figure 2.4.7 Challenges in pollution load and target value (in terms of COD) (Source: provided by MoEJ)



1982 – 1984 (average) 2016 – 2018 (average)

Figure 2.4.8 COD concentrations in Tokyo Bay (Source: provided by MoEJ)

pollution loads in discharged wastewater. Governors of prefectures and mayors of ordinance-designated cities can require reports to be submitted and conduct inspections of factories and business establishments on wastewater treatment methods and the quality/amount of wastewater in order to prevent violations, and are also authorized to take administrative measures in the event of violations, such as issuing orders for improvements according to the outcomes of reports and inspections.

Measures against non-compliance

If it is judged that the water discharged from factories and business establishments is unlikely to meet the effluent standard (or will exceed the standard), administrative measures such as operational improvement orders and business suspension orders are implemented. Penalties such as imprisonment or fines are additionally applied in cases where effluent standards are not met (or are exceeded) (in the case of standard violations).

6 | Recent Developments in Water Environmental Management

The various revisions of the laws related with water environmental management have taken place according to the times and demands of society. Recent developments of water environmental management are summarized below.

Proactive measures to prevent groundwater pollution (2011 revision of the Water Pollution Control Law)

In general, groundwater is widely used as valuable freshwater resources in Japan owing to its good water quality and low variation in water temperature. However, groundwater pollution cases due to the leakage of harmful substances such as trichlorethylene from factories and business sites are continuously confirmed each year. Such groundwater pollution is caused by aging production facilities and storage facilities used in industry, as well as leakage of harmful substances due to operational errors during the use of production facilities.

Given these circumstances, in order to effectively prevent groundwater contamination, obligations to not only report on establishment of facilities that store hazardous substances but also to comply with structural standards as well as monitor and record periodic inspections of facilities that use and store hazardous substances were implemented (Figure 2.4.9).

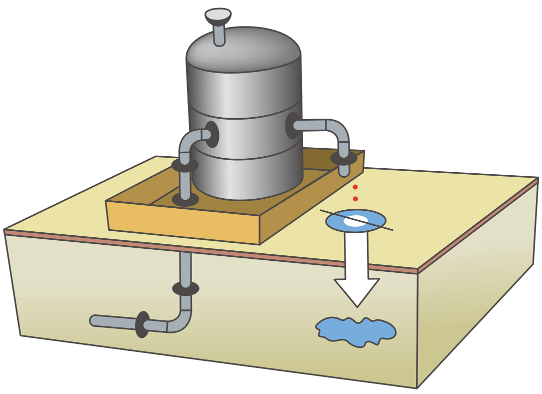


Figure 2.4.9 Underground infiltration of hazardous substances from production facilities (Source: provided by MoEJ)

Monitoring of radioactive materials (2013 revision of the Water Pollution Control Law)

Based on the serious environmental pollution resulting from leakage of radioactive materials from the Fukushima Daiichi Nuclear Power Plant during the Great East Japan Earthquake of March, 2011, monitoring of radioactive materials in public water bodies and groundwater was implemented. Results from such monitoring are evaluated and disclosed periodically by trusted sources.

Ambient water quality standards (2016)

Ambient water quality standards consist of items for protection of human health (health items) and items for conservation of the living environment (living environment items). Regarding health items, 27 items are set for public waters, including heavy metals such as cadmium and lead, organochlorine compounds and agricultural chemicals, and 28 items are set for groundwater. Standards for living environment items have been set for BOD, COD, total nitrogen, total phosphorus, total zinc, etc. The types of environmental standards for each water area are being designated based on these standards in accordance with the purpose of water usage. A study on levels of dissolved oxygen concentrations in lake bottom water, added to the standards in March 2016, is underway for water areas the type designation of which is to be specified by the national government.

Regulation of the discharging of effluent (partial amendment of effluent standards) (2019)

According to the Water Pollution Control Law, nationwide uniform effluent standards are set for water discharged from factories or workplaces with Specified Facilities (including the Specified Facilities in Designated Areas) into areas of public waters, to preserve water quality. In view of the challenges related to achieving uniform effluent standards immediately, of the substances for which standards have been set, values for boron, fluorine, nitrate nitrogen, and cadmium were reviewed. As a result, new provisional effluent standards went into effect from July 2019 for boron, fluorine, nitrate nitrogen, etc., and from December 2019 for cadmium.

Johkasou Law (partial amendment of effluent standards) (2019)

As part of the development of sewage treatment facilities, *Johkasou* maintenance activities are being promoted in each municipality by utilizing national treasury subsidies, etc., based on the "Regional Plan for Establishing a Recycling-based Society". In particular, regarding the conversion from *tandoku-shori Johkasou* (single treatment septic tanks) to *gappei-shori Johkasou* (dual treatment septic tanks), the subsidy rate has been raised for projects of municipalities that promote in-house plumbing work in conjunction with the introduction of energy-saving septic tanks. To further support this movement, a partial amendment to the *Johkasou Law* was enacted and issued in June 2019, and went into effect in April 2020.

Enactment of the new Basic Plan on Water Cycle (2020)

The Basic Act on Water Cycle was enacted in 2014 as a new act aimed at advancing policies related to the water recycle in a unified manner. In 2015, based on this act, a Basic Plan on Water Cycle was prepared. In the plan, river basin management was established as a measure aimed at a healthy water cycle, under which the various stakeholders concerned are to collaborate in each river basin to ensure a healthy water cycle. Based on the results of the evaluation of changes in the situation regarding the water cycle and the effects of measures related thereto, The Basic Act on the Water Cycle calls for the Basic Plan on Water Cycle to be reviewed and, as necessary, modified every five years or so. The new Basic Plan on Water Cycle, formulated in June 2020, includes three main priorities: (1) Water-cycle innovation through river basin management, (2) Realization of a safe and secure society through sound water cycle initiatives, and (3) Passing on an abundant society to future generations through a sound water cycle.

7 | Challenges and Future Plans

Improvement of water quality of lakes

Although the water quality of lakes is gradually improving, the actual achievement rate of environmental standards is low at around 50%. Many issues have emerged such as low oxygenation at lake bottoms, occurrence of water plants, decreased native species and a decline in hauls of fish due to changes in ecosystems, as well as a weakening of the relationship between people and lakes due to decreased contact. There are plans to adopt various regulatory measures related to water quality improvement, as well as comprehensively promote the development of sewerage treatment and *Johkasou* in the future. Lakeside environments are also to be preserved, such as through the conservation of vegetation and aquatic life in lakeside areas from the viewpoint of conservation and restoration of purification and biodiversity.

Restoring Bountiful Seas

Water quality is preserved by human interventions in harmony with nature. Bountiful seas, rich in biodiversity and productivity, are known as "satoumi" and it is important to promote the creation of satoumi in inland seas and bays close to where people live.

In addition to conventional efforts to improve water quality and conserve natural seashore, the Ministry of the Environment, Japan promotes policies combining meticulous nutrient management, and the preservation, restoration and creation of tidal flats and seaweed beds. The policies are based on a report issued in March 2020 entitled "Environmental conservation measures of the Seto Inland Sea in the future", as well as the statement of opinion issued in January 2021 on "Direction of reviewing the measures on environmental conservation of the designated water in the Seto Inland Sea".

Initiatives on global water issues

Taking advantage of experiences in overcoming serious water pollution, it is quite important that Japan contributes to the preservation and improvement of the water environment in other countries including developing countries. As such, Japan will utilize its technologies and knowledge to promote initiatives in international cooperation and partnerships, such as institutional transfer and technology support. After the end of the global pandemic of the new coronavirus infection occurred in 2019, it could be required to create a society focusing on global environment and public health more than ever.

Considering these situations, it could be also crucial that the Japanese government will continue to conduct the "Water Environmental Partnership in Asia (WEPA)" as well as public-private partnerships for the promotion of Japanese wastewater treatment technologies in other countries.

2.5 Republic of Korea

1 | Country Information

Table 2.5.1 Basic indicators

Land Area (km²)		100,341 (2015)
Total Population		52 million (2019)
GDP (current USD)		1,647 billion (2019)*
GDP per capita (current USD)		31,846 (2019)
Average Precipitation (mm/year)		1283.4 (2019)
Total Renewable Water Resources (km³)		132.3 (2020)**
Total Annual Freshwater Withdrawals (billion m³)		25.1 (2020)
Annual Freshwater Withdrawals by Sector	Agriculture	61% (2020)
	Industry	9% (2020)
	Municipal (including domestic)	30% (2020)

(Source: *Korean Statistical Information Service (2020) (1,919 trillion won (seasonally adjusted, current prices)), **Sewage statistics by Korean Ministry of Environment)

Figure 2.5.1 The Han River in Seoul, the Republic of Korea

2 | State of Water Resources

Alongside exponential growth in GDP, per capita water use in the Republic of Korea has also grown. However, it has seen a marked decrease in recent years; per capita water use is currently 485 m³/year*1, whereas availability is 1,553 m³/year (Lee et al. 2019). Seasonal variation in water availability remains a challenge for the country's water management, especially in light of water-related disasters exacerbated by climate change. About two-thirds of the annual precipitation falls in the monsoon season between June and September. There are four major river basins in Korea, namely the Han, Geum, Nakdong and Yeongsan-Seomjin.

3 | State of Ambient Water Quality

There are 1,936 sampling points for ambient water quality, which is measured against a composite water quality index divided into seven levels (Ia: Very good, Ib: Good, II: Moderately good, III: Moderate, IV: Moderately bad, V: Bad, VI: Very bad). Water quality is assessed and publicly disclosed for key sampling points as shown in Figure 2.5.2 (MOE 2020, NIER MLIT 2020).

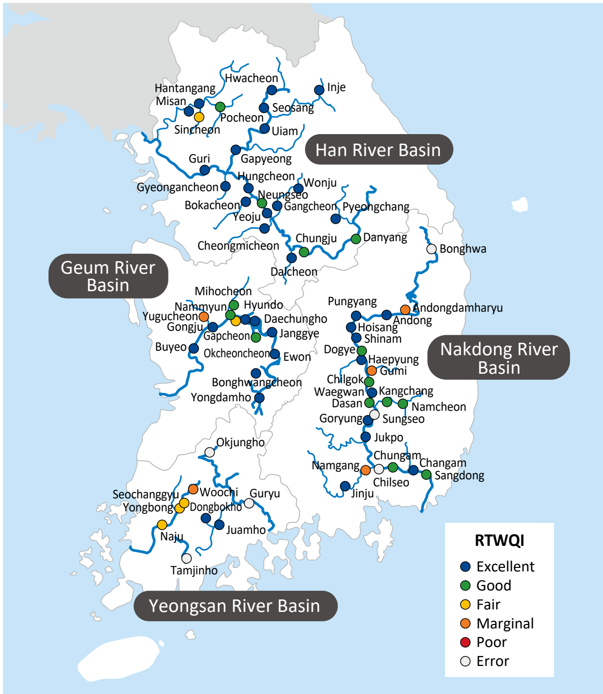


Figure 2.5.2 Water Quality Index of ambient water in the Republic of Korea (Source: Park 2020)

3.1 Rivers

All streams nationwide are classified into 115 sections and water quality targets have been established for each. Water quality in the country has steadily improved overall since the late 1990s, due to increasing public interest. Figure 2.5.3 shows the trend of water quality in selected points in four major river systems (Paldang (Han), Mulgeum (Nakdong), Daecheong (Geum), and Juam (Yeongsan-Seomjin)) in terms of BOD. During 2017–2019, average BOD values were stable at 1.2–1.3 mg/L, and average COD values have slightly improved from 4.2 to 3.9 mg/L (Figure 2.5.4).

*1 Calculated by dividing total water use (25.1 billion m³/year) by population (51.78 million) (Statistics Korea, 2020).

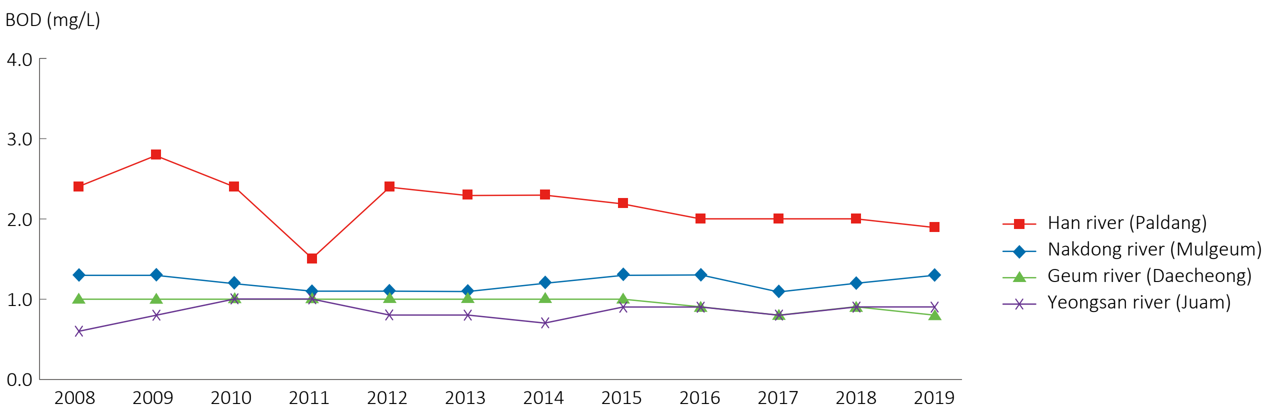


Figure 2.5.3 Changes in BOD values in four major rivers (2008–2019) (Source: MOE 2020)

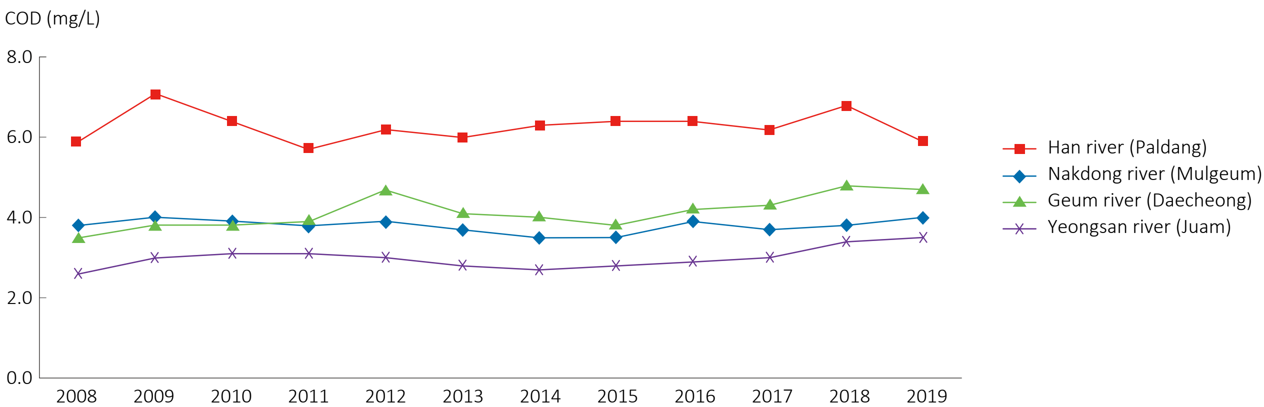


Figure 2.5.4 Changes in COD values in four major rivers (2008–2019) (Source: MOE 2020)

3.2 Lakes and Reservoirs

As with river water quality, that of lakes and reservoirs also shows a trend of improvement and stabilization in recent years. Table 2.5.2 shows recent water quality trends in selected reservoirs.

Table 2.5.2 Recent annual average water quality values for Lake Paldang, Andong, Daechong, and Juam

Year	BOD (mg/L)	COD (mg/L)	NO_3-N (mg/L)	PO_4-P (mg/L)	E.coli (CFU/100mL)
2017	1.2	3.0	1.083	0.005	36
2018	1.3	3.1	1.041	0.007	17
2019	1.1	3.1	1.072	0.006	19

(Source: MOE 2020)

3.3 Coastal Water

The Korean marine environment monitoring network is composed of port, coastal/offshore, environmental management waters, and estuaries, and monitoring is carried out seasonally (February, May, August, and November) at 417 monitoring stations. Additionally, automatic continuous monitoring is conducted in Sihwa Lake, Masan Port, Ulsan Port, Yeosu New Harbor, and the coastal areas of Busan (MLIT 2020). Coastal water quality standards were introduced in 2018 (Ministry of Oceans and Fisheries, No.10/2018), and the Water Quality Index (WQI), comprising five levels, is calculated as described in Tables 2.5.3a to c.

Table 2.5.3a WQI calculation method for coastal water quality

Category	Water Quality Index*
I (very good)	≤ 23
II (good)	24 – 33
III (moderate)	34 – 46
IV (bad)	47 – 59
V (very bad)	≥ 60

(Source: Ministry of Oceans and Fisheries 2021)

$$* \ \mathrm{WQI}=10\times[\mathrm{DO}]+6\times([Chl.a]+\frac{[SD]}{2})+4\times([DIN]+\frac{[DIP]}{2})$$

Figures in square brackets [ ] represent scores based on Table 2.5.3b. DO: Dissolved Oxygen, Chl.a: Chloropyll a, SD: transparency (secchi disc), DIN: dissolved inorganic nitrogen, DIP: dissolved inorganic phosphorus.

WQI trends of each sampling area are publicly disclosed on the NIER website. The example shown in Figure 2.5.5 is of Incheon Port.

Table 2.5.3b WQI calculation method for coastal water quality

Score	Parameter Chl.a, DIN, DIP (µg/L)	DO (%), SD (m)
1	< reference value	> reference value
2	< 110% of reference value	> 90% of reference value
3	< 125% of reference value	> 75% of reference value
4	< 150% of reference value	> 50% of reference value
5	≥ 150% of reference value	≤ 50% of reference value

(Source: Ministry of Oceans and Fisheries 2021)

Reference values vary according to sea area, as shown in Table 2.5.3c.

Table 2.5.3c WQI calculation method for coastal water quality

Ecological zone	Parameter Chl.a (µg/L)	DO (%)	DIN (µg/L)	DIP (µg/L)	SD (m)
East Sea	2.1	90	140	20	8.5
Korea Strait	6.3		220	35	2.5
Southwest sea	3.7		230	25	0.5
Central West Sea	2.2		425	30	1.0
Jeju	1.6		165	15	8.0

(Source: Ministry of Oceans and Fisheries 2021)

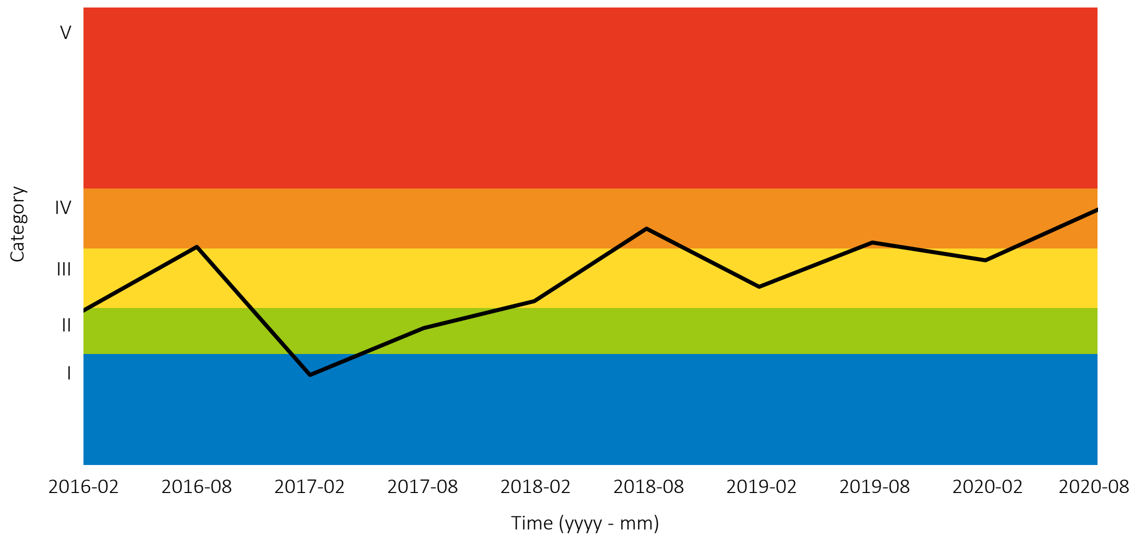


Figure 2.5.5 Trend of WQI in Incheon Port (2016–2020) (Source: NIER MLIT 2020)

3.4 Groundwater

Prior to 2018, groundwater had been managed by various acts under the control of different ministries, namely, Ministry of Environment (MOE), Ministry of Land, Infrastructure and Transport (MLIT), Ministry of Agriculture, Food and Rural Affairs (MAFRA), Ministry of the Interior and Safety (MOIS), and Ministry of National Defense (MND) (Kang et al. 2020). In 2018, the government passed the landmark Framework Act on Water Management (No.15653/2018), which transferred all groundwater-related responsibilities to MOE. According to Korea Environment Corporation (2021), 1,140 monitoring sites have been set up as of 2020, and a total of 3,725 sites are planned to be established by 2030. Kang et al. (2020) observe that strategic scaling up of groundwater use is essential in climate change adaptation, especially in light of the increasing frequency and intensification of droughts.

4 | State of Wastewater Treatment

In 2017, 2.16 million m^3/day of domestic wastewater and 4.01 million m^3/day of industrial wastewater was generated, and the treatment rate of both was 100%; 93.6% of domestic wastewater was treated centrally and 6.4% with decentralized treatment (MOE 2018). The domestic wastewater tariff is staggered according to discharge volume; for example, in Incheon in 2016 the wastewater tariff was 0.31 USD/m^3, 0.48 USD/m^3, 0.83 USD/m^3 respectively for 15 m^3, 50 m^3, and 100 m^3 (IBNet 2020).

Public awareness regarding wastewater treatment is high. In 2017, a decision was made to construct Seung-Gi Wastewater Treatment Plant of Incheon City underground to protect the breeding site of the black-faced spoonbill (*Platalea minor*). Although numbers are gradually increasing (Sung et al. 2017), the black-faced spoonbill is on the endangered list, with 3,941 birds observed as of January 2017 (BirdLife International 2021).

The number of industries is still climbing in the country; however, the volume of industrial effluent discharged is stable, as a result of water reuse and conservation efforts by industries and governments.

5 | Frameworks for Water Environmental Management

5.1 Legislation

The basic law for the environmental management policy of the country is the Framework Act on Environmental Policy, under which environment quality standards are established. The Framework Act on Water Management was newly established in 2018 to encompass the concept of integrated water resources management. This novel initiative streamlined the previously fragmented water-related matters using a more holistic approach, and various amendments to other legislations were made accompanying this change.

The previous Water Quality and Ecosystem Conservation Act was expanded in 2018 to encompass the entire water environment, and was developed into the Water Environment Conservation Act. Figure 2.5.6 shows the legislative framework related to water environmental management in the country.

Basic policy direction of water environmental management

The Ministry of Environment has established five core strategies for the period of 2016–2025 under the framework of water environmental management, as below:

1. Establishing a harmonious water cycle
2. Securing clean water through integrated basin management
3. Improving the index for aquatic ecosystems
4. Establishing framework for safe water environment
5. Creating economic and cultural value related water environment

The water quality monitoring framework was first established in 1967, with standards first set up in 1978.

5.2 Institutional Arrangement

In line with the approach to manage water from an integrated perspective, responsibilities which were previously spread across different ministries (for

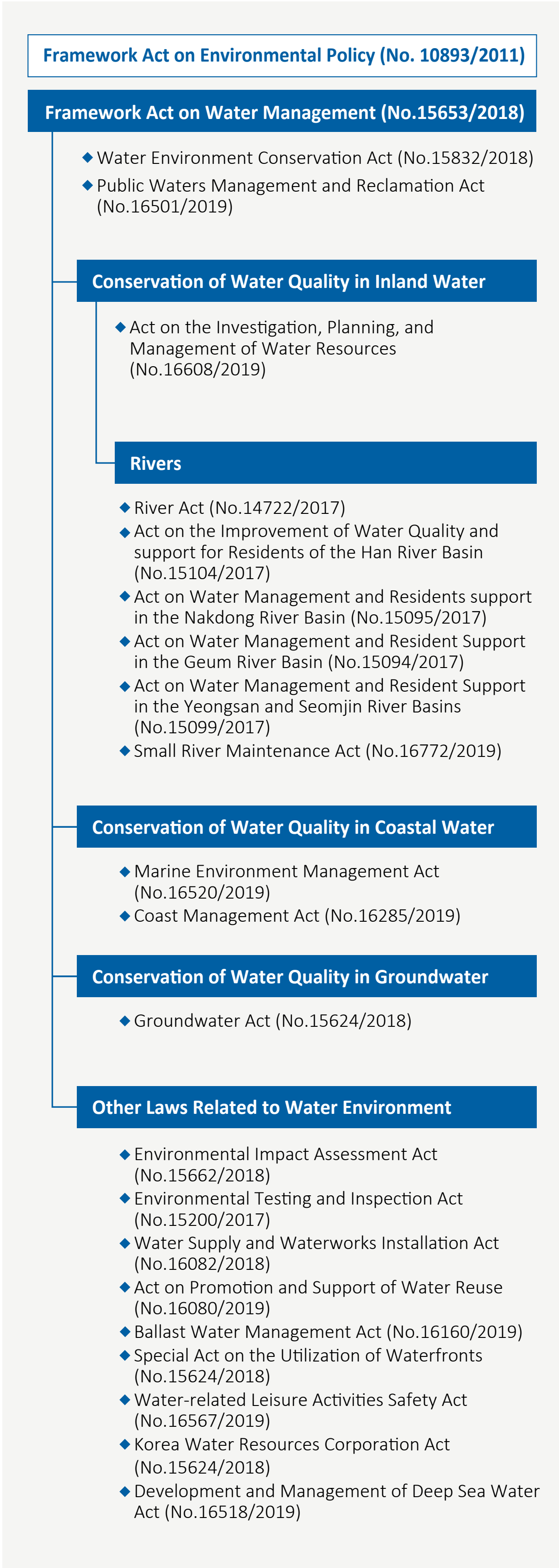


Figure 2.5.6 Legislative chart for water quality management

(Source: created by IGES based on KLRI 2020, MOE 2020) example, large rivers/streams were under MLIT, small streams/creeks were under the Ministry of Interior and Safety, lakes were under Ministry of Agriculture, Food and Rural Affairs, and sewerage was under the Ministry of Environment) were all restructured for management under the MOE.

The National Institute for Environmental Research (NIER) conducts monitoring of environmental water quality.

The following local environmental agencies conduct monitoring and legal enforcement:

- Han River Basin Environmental Agency
- Geum River Basin Environmental Agency
- Nakdong River Basin Environmental Agency
- Yeongsan River Basin Environmental Agency
- Daegu Regional Environmental Agency
- Wonju Regional Environmental Agency
- Jeonju Regional Environmental Agency

These regional environmental agencies, together with the Water Environment Research Center, Research Institute of Public Health and Environment, K-Water, and the Korean Rural Community Corporation form a multi-stakeholder consortium that implements the water quality monitoring framework.

5.3 Ambient Water Quality Standards

There are two water quality standards for surface water. The first cover the protection of human health and apply to both rivers and lakes, for which there are currently 20 parameters, such as Cd, As, and PCB, with plans to increase parameters to 30 by 2025. The second, split into two cover the living environment (residential environment criteria) and rivers and lakes/marshes, respectively. Standards for the living environment for rivers include pH, BOD, TOC, SS, DO, TP, total coliform, and fecal coliform; standards for lakes/marshes include pH, TOC, SS, DO, TP, TN, Chl.a, total coliform, and fecal coliform.

For groundwater, different standards are applied according to water usage purpose. Drinking water standards established under the Drinking Water Management Act are applied for drinking water use with 51 parameters. For other purposes such as domestic, farming and fisheries and industrial uses, groundwater standards are used to evaluate groundwater quality, with 14 to 19 parameters, based on usage.

Special metropolitan cities, provinces or “Do” can establish more stringent or expanded environmental standards than the national standards where necessary in consideration of local environmental conditions (Article 10 (3) Framework Act on Environmental Policy).

Monitoring of water quality in public water bodies and groundwater

Water quality is monitored through a nationwide monitoring network in accordance with category: 26 items for rivers, 30 for lakes and marshes, and 20 for groundwater. In particular, there are 70 automatic operating monitoring stations for surface waters. Water quality is monitored by measuring five common items such as DO, TOC, pH and 17 optional items, including VOC. To raise inspection efficiency, monitoring spots are classified according to usage: river water, lake water, groundwater, coastal water, drinking water, irrigation water, industrial water and river water flowing through cities.

5.4 Effluent Standards

As of 2019, 58 water pollutants have been identified under the legal framework, of which seven parameters (BOD, COD/TOC, SS, TN, TP, total coliform, ecotoxicity) are used for effluent standards, and 32 parameters are monitored as hazardous pollutants under the permissible discharge limits.

Industrial facilities are categorized into the following five levels according to discharge volumes.

- Level I: ≥2,000 t/day
- Level II: 700 ≤ discharge < 2,000
- Level III: 200 ≤ discharge < 700
- Level IV: 50 ≤ discharge < 200
- Level V: others

In 2007, ecotoxicity was first included as a parameter under the permissible discharge limits under the Water Quality and Ecosystem Conservation Act, and in 2019, the ecotoxicity management system was expanded to cover 82 types of industrial facilities. Ecotoxicity is analyzed with water fleas (*Daphnia magna*).

Since 2020, TOC has been used as a parameter to monitor organic substances in addition to COD_{Mn}, due to the difficulty of monitoring non-degradable organic substances, which gives higher values for TOC than COD.

Effluent monitoring

The annual calendar of monitoring, together with demarcations, is as follows:

- By May: Industrial facilities analyze samples, and submit data with justifications
- By July: Regional Environmental Agencies review and verify reports, and take/analyze samples
- By December: National Institute of Environmental Research confirms the data and conducts metadata analysis
- By following March: Ministry of Environment discloses data to the public

6 | Recent Developments in Water Environmental Management

Inclusion of the concept of integrated water resource management as part of the governance of water management has had a large impact throughout all aspects of water management in the country. While it has allotted more responsibilities to MOE, it has also resulted in a devolution of responsibilities for water environment management from central to local governments. Regarding the SDGs, achievement of indicator 6.3.2., "water bodies having good ambient water quality" is reported at 93% as of 2020.

7 | Challenges and Future Plans

The inclusion of integrated water resource management together with devolution of responsibilities regarding water environmental management from central to local governments has added another dimension to the challenge of restructuring, which requires a viable strategy and detailed plan to be rapidly laid out in order bring about institutional cooperation.

As a result of the restructure, responsibilities and activities of the Ministry of Environment have expanded rapidly, which makes it more difficult to prioritize projects regarding water environment management.

Other technical challenges currently faced include distortion of the water cycle (due to climate change and other environmental causes), increased non-degradable organic matter in effluent, difficulty of managing non-point pollution sources, and the need to add ecotoxicity standards based on other aquatic organisms. To combat these various challenges, a holistic and comprehensive review of projects is being carried out.

2.6 Lao PDR

1 | Country Information

Table 2.6.1 Basic indicators

Land Area (km²)		236,800 (2019)
Total Population		7.12 million (2019)
GDP (current USD)		19.1 billion (2019)
GDP per capita (current USD)		2,670 (2019)
Average Precipitation (mm/year)		1,834 (2019)*
Total Renewable Water Resources (km³)		333.55 (2011)**
Total Annual Freshwater Withdrawals (billion m³)		7.32 (2017)**
Annual Freshwater Withdrawals by Sector	Agriculture	95.9% (2017)**
	Industry	2.3% (2017)**
	Municipal (including domestic)	1.8% (2017)**

(Source: Department of statistics, Lao 2019, *Bank of the Lao PDR 2020, **FAO 2021 (estimated))

Figure 2.6.1 Mekong River in Luang Prabang, Lao PDR

2 | State of Water Resources

Lao PDR has rich water resources. Average annual rainfall at higher elevations in the southern part of the country is around 4,000 mm and in the northern valleys is around 1,300 mm. With a population of approximately 7.12 million, per capita annual water availability is around 55,000 m³, the highest of the WEPA partner countries. Despite this, water supply capacity is limited due to the country's inadequately developed water infrastructure (MONRE 2019).

As with other Southeast Asian countries, seasonal distribution of water resources is uneven in Lao PDR – about 80% of annual precipitation occurs during the rainy season (May to October) and 20% in the dry season (November to April). In the dry season, flows of the Se Bang Fai, Se Bang Hieng and Se Done Rivers that run through the central and southern parts of the country drop to 10–15% of the annual average.

There are 62 main river basins in Lao PDR (MONRE 2019), a country where 90% of the territory lies within the Mekong River basin. Its tributaries contribute the equivalent of 35% of the average annual flow and account for 25% of the catchment area of the basin (MRC 2005). In 2015, 71% of the population was using improved sanitation, while 76% had access to improved drinking water sources (WHO 2017).

3 | State of Ambient Water Quality

Surface water quality in Lao PDR is considered good, although deterioration is observed in the rivers and tributaries in urban areas due to a rise in untreated or insufficiently treated wastewater and wastes. No urban center, including the capital Vientiane, has comprehensive piped sewerage systems nor wastewater collection, treatment or disposal systems. On the part of the Mekong River downstream from Vientiane, for example, low concentrations of dissolved oxygen (DO) have been observed (MRC 2010).

Mining activities and hydropower generation are the major sources of degradation, especially in terms of sedimentation. Wastewater and water run-off from agricultural activities are also potential sources of high nutrients and toxic chemicals originating from fertilizer and pesticide use (MRC 2010).

Inadequate management of solid waste in urban areas is another cause of concern for water quality, especially in the rainy season (MONRE 2012). Hazardous and infectious wastes are disposed of together with other wastes in the same locations, but landfill sites are not monitored for impacts of leachate on groundwater quality and runoff into surface water (rivers and lakes) during the rainy season.

3.1 Rivers

For sustainable water resource management planning, the Provincial Department of Natural Resources and Environment (MONRE) frequently monitors the water quality – with special priority given for riverheads and watersheds. Water samples are collected at a frequency of every three months, which started in 2015. Both in-situ and laboratory analysis for key water quality parameters are performed, and water quality trends are assessed to evaluate their effects on ecosystems. River water quality in Lao PDR is generally considered to be good, although human impacts on the river water quality are increasing (Table 2.6.2). Result shows that except for a few monitoring stations, the water quality of most of the water sampling locations are not affected by anthropogenic activities in their surroundings. This is a good sign that water resources can be managed sustainably, as long as management strategies are in place as and when needed.

As most of the country's area is located in the low-lying deltaic zone, excessive sediment load is the primary quality problem for the whole country, especially in the wet season.

Under different funding agencies, water quality monitoring was conducted from 2009 to 2015 in the mainstream of the Mak Hiao River and its major tributaries, the Hong Ke and Hong Xeng Rivers in Vientiane province. The results in terms of biochemical oxygen demand (BOD) are shown in Figure 2.6.2, which shows that BOD concentrations range from 2.1 mg/L to 29.2 mg/L (MONRE 2019). Water was found to be highly polluted especially in urban areas.

Table 2.6.2 Levels of human impacts on water quality and water quality class for the protection of aquatic life 2007–2011 at the Mekong, Lao PDR water quality monitoring stations

Monitoring sites	Human impacts on water quality					Water quality class for the protection of aquatic life							
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011	2012	2013	2014
Houa Khong	C	B	B	C	B	A	A	A	A	A	B	B	B
Luang Prabang	B	C	B	C	B	A	A	A	B	A	A	B	B
Vientiane	C	C	B	C	A	A	A	A	A	A	A	B	B
Savannakhet	C	C	C	B	C	A	A	A	A	A	A	B	B
Pakse	B	B	B	C	A	A	A	A	A	A	A	B	B

Notes: Impacts (A: No impact; B: Low impact; C: Medium impact; D: High impact/
Water quality for aquatic life (A: Excellent quality; B: Good quality; C: Moderate quality; D: Poor quality) (Source: Kongmeng and Larsen 2016)

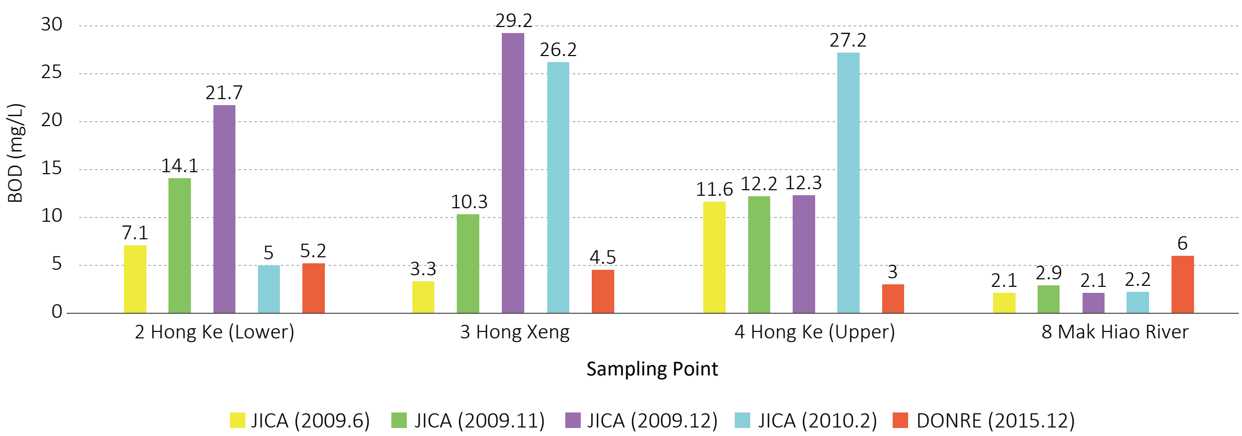


Figure 2.6.2 Comparative study of river water quality in terms of BOD for four major river bodies under five different works
(Source: MONRE 2019)

Under a scheme supported by the World Bank, the water quality of 11 major rivers around Laos was analyzed, the results of which are shown in Table 2.6.3. As the results suggests, river bodies around Vientiane, followed by Savannakhet, show relatively high concentrations of water quality parameters compared to the national water quality standard, mainly chloride, sulphate, EC, and alkalinity, owing to the impact of higher anthropogenic activities like mining activities. Further, runoff from agricultural activities and improper sewage management are also responsible for water quality deterioration.

Table 2.6.3 Statistical summary of river water quality from 11 different monitored river bodies around Laos PDR

	Province								
	Vientiane CT	Vientiane PV	Savannakhet	Sekong		Champasak		Attapue	
River	Namguem	Namguem	Xe Champone	Xe Nam Noy	Houay Lam Phan	Xe Kham Por	Xe Nam Noy	Xekong	Xe su
Depth	0.12 m	0.2 m	0.03 m	0.03 m	0.03 m	0.03 m	0.03 m	0.03 m	0.03 m
TEMP. (°C)	25.8	25.7	28.2	28.5	26.3	28.7	25.9	28.4	26
pH	7.67	7.7	7.12	7.73	7.5	6.89	7.25	7.3	7.68
TSS (mg/L)	12.83	1.5	0.88	2.56	4.66	1.8	3.75	14.83	65.66
TDS (mg/L)	116	109	157	76	25	44	25	55	78
EC (µS/cm)	115.8	109.1	156	75.2	24.8	44	25	54.7	78
Ca (mg/L)	30.02	29.36	8.12	10.02	2.3	6.16	12.88	7.21	8.4
Mg (mg/L)	2.82	4.22	1.74	1.15	1.42	1.9	0.18	1.58	1.69
Na (mg/L)	1.84	1.66	5.82	0.4	0.94	1.04	1.22	1.32	2.7
K (mg/L)	1.7	1.15	0.82	0.2	0.82	0.05	1.05	0.59	1.28
ALK (mg/L)	82	68	17.5	29	11	22	28	26	30.2
Cl (mg/L)	10.95	19.25	15.1	5.25	0.48	0.25	6.25	0.25	0.25
SO_4 (mg/L)	5.73	6.92	4.93	2.23	5.19	4.93	4.8	5.73	9.84
NO_3 (mg/L)	0.03	0.01	0.04	0.1	0.06	0.05	0.2	0.07	0.09
NH_4 (mg/L)	0.02	0.01	0.04	0.02	0.06	0.16	0.01	0.03	0.14
TN (mg/L)	0.28	0.35	0.39	0.25	0.38	0.29	0.27	0.19	0.24
PO_4 (mg/L)	0.01	0.02	0.01	0.04	0.03	0.06	0.06	0.05	0.04
TP (mg/L)	0.09	0.08	0.04	0.05	0.08	0.09	0.09	0.1	0.15
DO (mg/L)	7.36	7.27	7.18	7.77	8.24	6.85	8.31	7.62	8.02

(Source: MONRE 2019)

3.2 Lakes and Reservoirs

Perennial ponds, marshes and oxbow lakes are common in the lowland floodplains of Lao PDR, which are usually shallow and vary greatly in size during the year and serve as habitats for many types of aquatic plants, mollusks, crustaceans, amphibians and reptiles. Currently, data on the water environment in lakes and reservoirs is available only on a project basis. For example, water quality monitoring was conducted in the reservoirs of the Nam Ngum dams (Nam Ngum 2 and Nam Ngum1) from 2006–2011 as part of a hydropower development project, and the results of monitoring at nine monitoring stations (see Figure 2.6.5) shows a decreasing trend for dissolved oxygen (DO) levels in some stations compared with national standard value of 6mg/L (Figure 2.6.3). Total phosphorus levels in some stations in 2009 also highly exceeded the national standard (0.05 mg/L) (Figure 2.6.4). Fertilizers and detergents are suspected as the potential sources of pollution (Komany 2011).

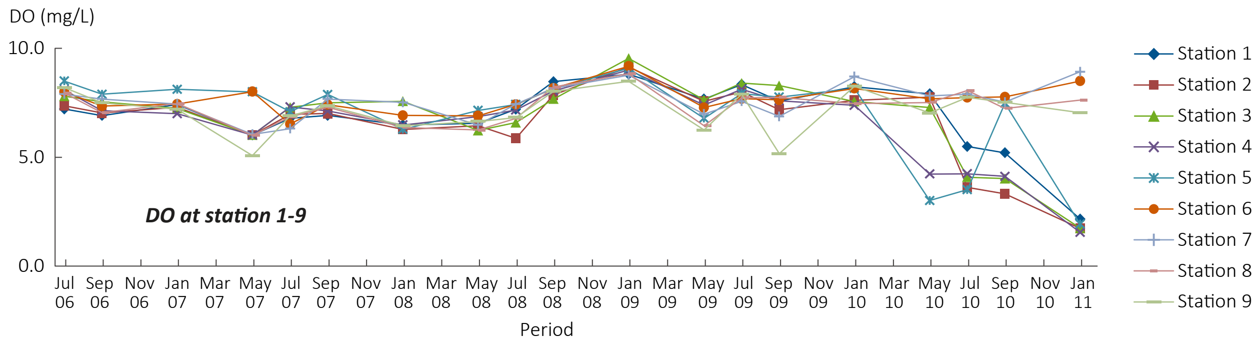


Figure 2.6.3 DO levels at monitoring stations at the Nam Ngum Dams (Source: Komany 2011)

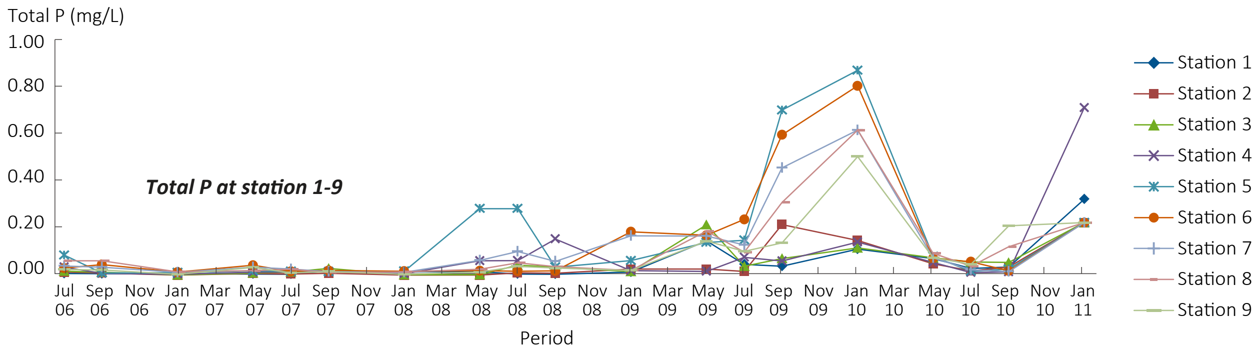


Figure 2.6.4 TP levels at monitoring stations at the Nam Ngum Dams (Source: Komany 2011)

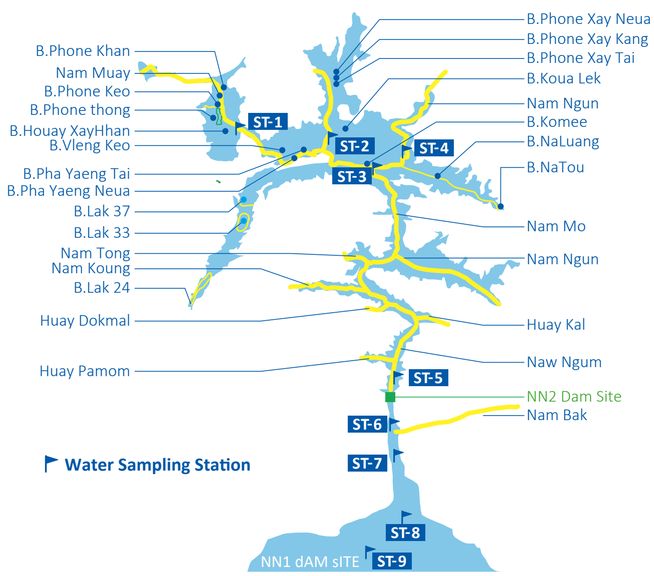


Figure 2.6.5 Monitoring stations of the Nam Ngum Dams (Source: Komany 2011)

3.3 Groundwater

Groundwater information, including resource potential, uses and quality is very limited in the country. Since surface water is abundant for supply, groundwater is regarded as a source only when and where surface water is not available (Chanthavong 2011). However, groundwater is an important source of domestic water, small-scale irrigation and small-scale industry. It is also used as a source for urban water supply, although covering only around 5% of the total water production volume (if spring water is included in this definition, about 20% of the total water production is covered by subsurface water) (Chanthavong 2011). According to the Lao Social Indicator Survey (MoH and LSB 2012), around 32% of Lao households use groundwater or springs for drinking purposes. As for quality, arsenic contamination has been detected near the border with China (MRC 2010) and in Attapeu province.

4 | State of Wastewater Treatment

Wastewater and major pollutants

Both domestic and industrial sectors release various pollutants. Domestic wastewater contains large amounts of COD, nutrients, and faecal coliform, and is the largest contributor to surface water pollution. Agricultural runoff primarily contains nutrients from excess usage of fertilizers and pesticides, hence causing a diffused source of pollution. Industrial wastewater contains a wide variety of pollutants, depending on the nature of raw materials used, processing units and final production outputs. It commonly contains various heavy metals, grease, oil, and such like.

Domestic wastewater

In order to handle these increasing levels of domestic pollutants, the government of Laos is also promoting decentralized wastewater treatment (DEWAT) systems. Table 2.6.4 shows the transition to DEWAT system development around the country and it indicates there is a significant increase in capacity of DEWAT system in the country. As of 2017, a total capacity of 464.8 m^3/day DEWAT system is functional in the country (MONRE 2019).

Table 2.6.4 Status of domestic (decentralized) wastewater treatment system

No	Year	Location	Treatment capacity (m^3/day)	User
1	2009	Vientiane Capital	10	125
2	2010	Vientiane Capital	11.2	146
3	2010	Vientiane Capital	7	116
4	2011	Louanphabang Province	15	208
5	2011	Khammoan Provive	70	700
6	2011	Khammoan provive	30	300
7	2012	Vientiane Capital	26	455
8	2013	Vientiane Province	3	66
9	2014	Attapeu province	14	163
10	2014	Attapeu province	14	235
11	2014	Vientiane procince	160	1,600
12	2014	Champasak Province	15	300
13	2015	Champasak Province	8	150
14	2015	Vientiane Capital	6.4	80
15	2015	Vientiane Capital	1.5	50
16	2015	Houaphan province	14	161
17	2015	Louanphabang Province	10	500
18	2015	Vientiane Capital	10.2	-
19	2016	Xekong Province	35	50 bed
20	2016	Bokeo Province	1	220
21	2017	Louanphabang province	5	-
		Total	**464.8 m^3/d**	

Industrial wastewater

Most industries and factories in Lao PDR dispose of their industrial waste water directly into surface water bodies such as ponds and rivers; however, such ponds lack the sheeting to prevent infiltration of various pollutants from untreated wastewater entering underground bodies. Small factories in Lao PDR have ponds for industrial effluent disposal, and some large-scale industries have their own wastewater treatment plants including both anaerobic and aerobic treatment units, such as Beer Lao company, Coca-Cola company and Sun Paper company, the mining sector and other industries (MONRE 2019).

5 | Frameworks for Water Environmental Management

5.1 Legislation

The Environmental Protection Law (EPL) Amendment 2018 is the cornerstone to Lao PDR's environmental legislation. Containing measures for the protection, mitigation and restoration of the environment as well as guidelines for environmental management and monitoring, it is specifically aimed at protecting nature, human health, richness of the country's resources and facilitating the process of sustainable development. According to EPL, the Ministry of Natural Resources and Environment (MONRE) is responsible for coordinating different line agencies in establishing rules and regulations pertaining to the management of the environment, conducting research and development related to pollution control technologies and science, and for overall management and pollution control (EPL 2018).

EPL-2018 grants MONRE the monitoring and enforcement authority to inspect and issue administrative and civil actions against regulated point sources within its jurisdiction. In reality, EPL-2012 lacked the necessary efficacy in terms of granting enforcement powers to MONRE or its environmental and natural resources agencies, such as DPCM, regarding industrial pollution sources (EPL 2018). Instead, the Industrial Processing Law (IPL) Amendment No. 026/NA, dated December 27, 2013 authorized by the Ministry of Industrial and Commerce (MOIC) acts as primary enforcement authority over most factories, including in imposing effluent and emission standards as part of certain operating permits, requiring self-monitoring reports from certain factories, conducting inspections, taking samples, shutting down factory operations, and issuing administrative, civil, and criminal actions or penalties (EPL 2018). As a result of overlapping and fragmented legislative bodies, no single ministry is responsible for overall environmental compliance and enforcement of pollution sources in Lao PDR (EPL 2018).

The Law on Water and Water Resources, promulgated in 1996, stipulates the principles of management, utilization and development of water. Its purpose is to secure the quantity and quality of water by meeting the population's needs as well as ensuring environmental sustainability, but lacks clarity on the issue of water supply and wastewater. In response to this, the new Water Supply Law was drafted by the Ministry of Public Works and Transportation (MPWT) with the assistance of the World Bank, which was approved by the National Assembly in November 2009. However, as most of its stipulations focused on water supply services, provisions for sanitation and sewerage, which it lacked, are planned to be added by decree. To reflect these changes, a revision of the Water and Water Resources Law was proceeded with the assistance from the Asian Development Bank (ADB).

The Law on Water Resource Amendment was adopted by the National Assembly in 2017. This amendment aims to develop water resources in an environmentally sound and sustainable manner and in accordance with the international best practices to ensure water resources and ecosystems are protected. New provisions have been added on water right and use, including wastewater discharge permits, wetland and water resource protection, groundwater management, and reservoir management. Additionally, the Law expands on the terms and conditions of large-, medium- and small-water uses and includes an article on environmental flows of hydropower as well as a stipulation on irrigation use. The Law also grants greater responsibility to MONRE to develop and implement management plans of river basins throughout the country.

Another promising addition is the requirement to set minimum water flows as minimum thresholds for all water resources in order to meet the basic needs of those whose livelihoods rely on them as well as sustainability of the ecosystem within the affected area (Phonvisai 2017).

Other laws, such as the Forestry Law and Mining Law are also relevant to water environmental management as shown in Figure 2.6.6.

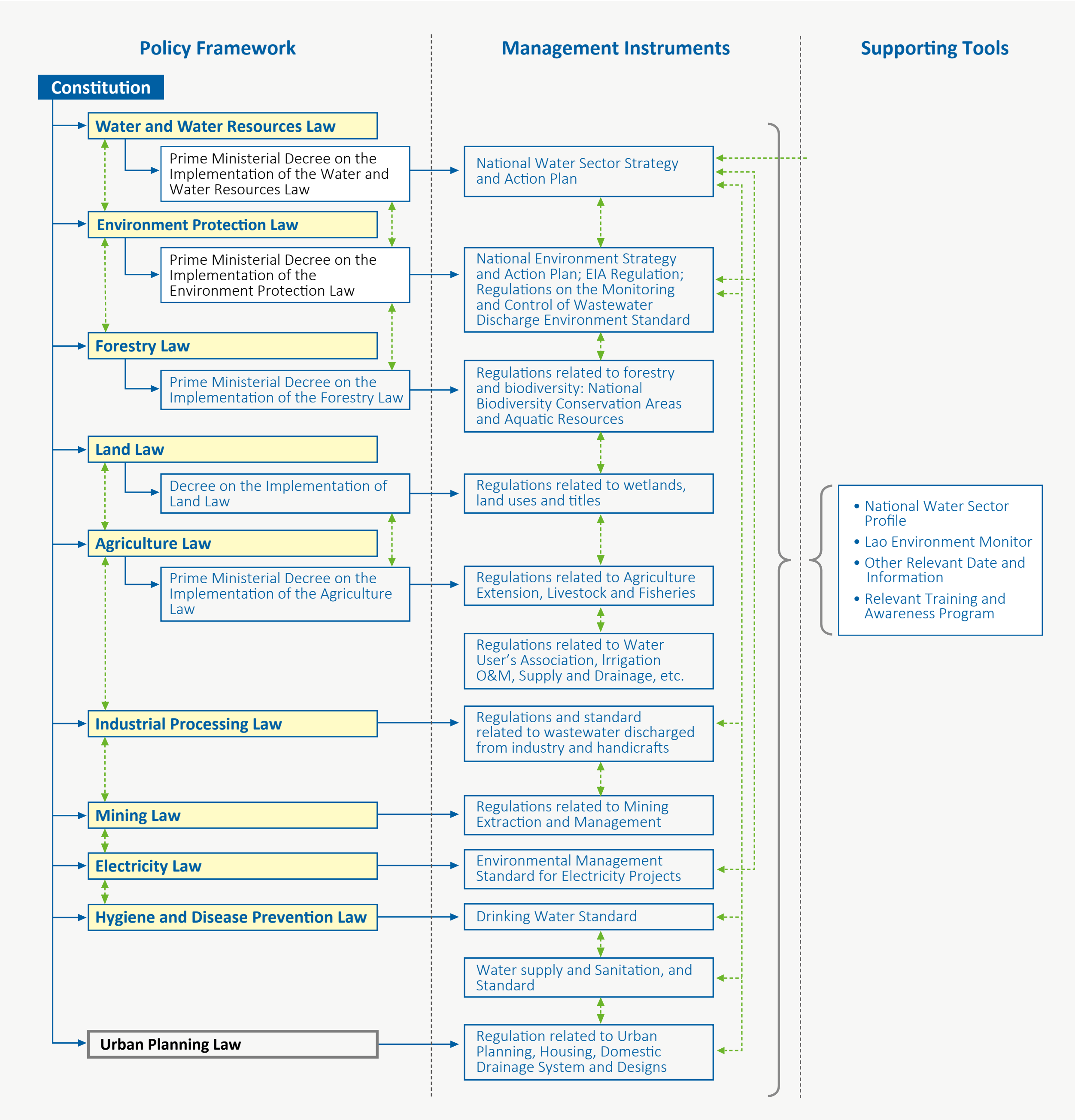


Figure 2.6.6 Legislation system of water environmental management in Lao PDR (Source: MoEJ 2009)

5.2 Institutional Arrangement

The functions and responsibilities of the Ministry of Natural Resources and Environment (MONRE) were revised in accordance with Prime Minister's Decree No. 451/PM of 23 December 2019 MONRE has broad responsibilities, including protection of the nation's natural resources such as land and water resources, and protection and restoration of the environment. Within it sits the Department of Pollution Control and Monitoring (DPCM), in charge of water pollution management policies and plans, pollution aspects of environmental quality management plans, action plans for the reduction and elimination of water pollution, and emergency response plans. It is involved with and coordinates work to control, resolve and remediate contaminated water bodies and assess environmental damage from water pollution by recommending and implementing standards, measures, criteria and methods for monitoring and management. Its responsibilities also include formulating the water pollution section of Laos's state of pollution report, developing systems, criteria, and codes of practice and methods for preventing water pollution.

5.3 Ambient Water Quality Standards

Ambient water quality standards

To improve ambient water quality on certain parameters, DPCM revised the National Environmental Standards of 7 December 2009 through comparison of updated data on the country's environmental quality with the standards set by international organizations as well as economic development of certain other countries. This led to an amendment of the National Environmental Standard, which was adopted by Prime Minister Decree No. 81/PM on 21 February 2017, that enforced regulations on air, noise, soil and waste quality for assessing and managing contaminants released into air, water and soil to protect human health and the environment. The ambient water quality standards are comprised of groundwater (drinking) quality standards and surface water quality standards as shown in Table 2.6.5 and Table 2.6.6 respectively.

Water quality monitoring framework

In Lao PDR, surface water is the major water source for urban water supply, while groundwater is usually the main source for rural populations in lowland areas, particularly in the central and southern parts of the country where the groundwater table is sufficiently high and of sufficient quality. In upland areas, particularly the north and east of the country, water is usually supplied by gravity flow systems, mostly from streams (surface water), but also from springs (groundwater), although this access tends to be limited to remote communities. According to a Lao PDR MONRE Report (2012), water quality is considered good, although deterioration is observed in rivers and tributaries in urban areas due to increasing untreated or insufficiently treated wastewater and wastes. Mining activities and hydropower generation are the major sources of degradation, especially

Table 2.6.5 Drinking water quality standard

Indicator	Parameter	Standard	Unit
Colour	-	10	Platinum-Cobalt (Pt-Co)
Taste	-	-	-
Odor	-	-	-
Turbidity	-	15	NTU
Potential of Hydrogen	pH	6.5–8.5	-
Total Solid	TS	1,000	mg/L
Aluminum	Al	0.2	mg/L
Ammonia	NH_3	1.5	mg/L
Iron	Fe	1.0	mg/L
Manganese	Mn	0.5	mg/L
Sodium	Na	250	mg/L
Copper	Cu	1.5	mg/L
Zinc	Zn	15	mg/L
Calcium	Ca	150	mg/L
Magnesium	Mg	100	mg/L
Sulphate	SO_4^{2-}	250	mg/L
Hydrogen Sulfide	H_2S	0.1	mg/L
Sodium Chloride	NaCl	320	mg/L
Chloride	Cl^-	250	mg/L
Fluoride	F^-	1.0	mg/L
Nitrate	NO_3^-	45	mg/L
Alkylbenzenesulfonate	$C_{18}H_{29}NaO_3S$	1.0	mg/L
Phenol compound	C_6H_6O	0.002	mg/L
Mercury	Hg	0.001	mg/L
Lead	Pb	0.01	mg/L
Arsenic	As	0.01	mg/L
Selenium	Se	0.01	mg/L
Chromium Hexavalent	Cr^{6+}	0.05	mg/L
Cyanide	CN^-	0.07	mg/L
Cadmium	Cd	0.003	mg/L
Barium	Ba	1.0	mg/L
Resident Chlorine (Disinfection)	Cl_2	>0.2	mg/L
SPC Bacteria (Standard Plate Count Method)	-	500	Colonies/cm³
Coliform bacteria	-	-	MPN/ 100 cm³
E.coli Bacteria	-	-	MPN/ 100 cm³

sedimentation. Water runoff from agricultural activities could become a source of high nutrients and toxic chemicals due to fertilizer and pesticide use. Litter, dust and dirt, oil and grease, particles of rubber compounds from tires, particles of metal, glass and plastic from vehicles, and lead are the commonly found pollutants. Urban drains also act as secondary sewers carrying industrial discharges, septic tank seepage and overflows into the system.

A brief summary of the surface water quality network in Lao PDR is shown in Figure 2.6.7, which shows that 93 monitoring stations with facilities to analyze over 30 water quality parameter are active in 18 provinces of the country.

Table 2.6.6 Surface water quality standard

Indicator	Parameter	Level of Water					Unit	Analysis
		1	2	3	4	5		
Colour, Odour and Taste	-	-	-	-	-	-	-	-
Temperature	t°C	-	-	-	-	-	°C	Thermometer
pH value	pH	6–8	6–8	5–9	5–9	-	-	Electrometric pH Meter
Dissolved Oxygen	DO	>7	6.0	4.0	2.0	<2	mg/L	Azide Modification
Electro-conductivity	Ec	<500	>1,000	>2,000	> 4,000	>4,000	µS/cm	Ec meter
chemical oxygen demand	COD	<5	5–7	7–10	10–12	> 12	mg/L	Potassium Dichromate Digestion; Open Reflux or Closed Reflux
Total coliform bacteria	-	-	5,000	20,000	-	-	MPN/100 ml	Multiple Tube Fermentation Technique
Faecal coliform bacteria	-	-	1,000	4,000	-	-	MPN/100 ml	Multiple Tube Fermentation Technique
Total Suspended Solids	TSS	<10	>25	>40	>60	>60	mg/L	Glass Fiber Filter Disc
Phosphate	PO_4	< 0.1	0.5	1	2	>2	mg/L	Ascorbic acid
Ammonium ion	NH_4+	>0.5	>1.5	>3	>4	<4	mg/L	Kjeldahl
Nitrate-Nitrogen	NO_3-N	-		5.0		-	mg/L	Cadmium Reduction
Ammonia-Nitrogen	NH_3-N	-		0.5		-	mg/L	Distillation Nesslerization
Phenol	C_6H_5OH	-		0.005		-	mg/L	Distillation, 4-Amino antipyrene
Copper	Cu	-		1.5		-	mg/L	
Nickel	Ni	-		0.1		-	mg/L	
Manganese	Mn	-		1.0		-	mg/L	
Zinc	Zn	-		1.0		-	mg/L	AA-Direct Aspiration
Cadmium	Cd	-		0.003		-	mg/L	
Chromium Hexavalent	Cr^{6+}	-		0.05		-	mg/L	
Lead	Pb	-		0.01		-	mg/L	
Mercury	Hg	-		0.001		-	mg/L	AA-Cold Vapour Technique
Asenic	As	-		0.01		-	mg/L	AA-Direct Aspiration, ICP
Cyanide	CN^-	-		0.07		-	mg/L	Pyridine-Barbituric Acid
Radioactive	Radioactive -α -β	-		0.1 1.0		-	Becqurel/L	
Organochlorine pesticide		-		0.05		-	mg/L	
Dichlorodiphenyltrichloroethane	DDT	-		1.0		-	µg/L	
alpha- Benzene hexachloride	α-BHC ($C_6H_6Cl_6$)	-		0.02		-	µg/L	GC
Dieldrin	$C_{12}H_8Cl_6O$	-		0.1		-	µg/L	
Aldrin	$C_{12}H_8Cl_6$	-		0.1		-	µg/L	
Heptachlor and heptachlor epoxide	$C_{10}H_5Cl_7$ $C_{10}H_5Cl_7O$	-		0.2		-	µg/L	

Figure 2.6.7 Network of surface water quality monitoring in Lao PDR

5.4 Effluent Standards

Effluent standards

The following effluent standards are stipulated under the National Environmental Standards issued in February 2017, the data of which is assessed against the MRC Water Quality Guidelines for the Protection of Human Health and the Protection of Aquatic Life.

The average chemical oxygen demand (COD) concentration at Vientiane was recorded at around 1.4 mg/L, compared to 2.7 mg/L at Champasack. COD concentrations at three stations in the Mekong River, Nam Nguem, Nam Xebang Fai and Nam Xe Done slightly exceeded the Mekong River Commission (MRC) Water Quality Guidelines for the Protection of Human Health of 5 mg/L. Other than a recorded pH of 9.9 for Luang Prabang, pH values for other areas along the Mekong River were within the water quality guideline for pH (pH values of 6 to 9 for both the protection of human health and the protection of aquatic life). The lowest pH measurement was observed at Vientiane monitoring station (pH = 6.2) while the highest pH measurement was observed at Luang Prabang monitoring station (pH = 9.9). Dissolved oxygen (DO) is one of the key water quality parameters monitored routinely by the MRC Water Quality Monitoring Network, and maintaining good water quality requires adequate concentrations of dissolved oxygen. In recognition of this, MRC member countries have jointly established target values for the protection of human health (≥ 6mg/L) and aquatic life (> 5 mg/L).

In general, the water quality of rivers within the Lao PDR is considered to be good; however, little information is available on groundwater quality despite its use as chief source of water supply in rural areas. No systematic monitoring of the impacts of fluoride, pesticide, nitrate from fertilizer or other chemical pollutants is carried out.

For standards of wastewater discharged from urban areas, buildings such as hotels, dormitories or hospitals are classified according to the number of rooms and volume of discharged wastewater. Buildings such as residences, temples, schools, offices, markets and restaurants are also classified according to floor area. For the wastewater treatment standards for public areas, classifications are in place for areas such as historical sites, public parks, water parks, and marshes and ponds.

The National Environmental Standard is enforced by Article 27 and 32 of the Environment Protection Law, and covers:

1. Ground water quality
2. Drinking water quality
3. Effluent standards
    a. Effluent from general factories
    b. Effluent from community households
    c. Effluent from general toilets
    d. Effluent from public canals
    e. Effluent from pig farms
    f. Effluent from car washes and gas stations

Effluent inspection procedure

According to the Regulation on Wastewater Discharge from Industrial Processing Factories issued in 2005 by the Ministry of Industry and Handicrafts (currently the Ministry of Industry and Commerce), all industrial factories are required to install wastewater treatment systems and the necessary facilities to monitor and analyze water samples. The monitoring report results are then submitted to the Director of the Industry Department of the Ministry or respective province. The industry department may dispatch factory environmental inspectors, who are permitted to enter all areas within factories to inspect, observe, measure, sample and monitor wastewater discharged into public water bodies.

Measures against non-compliance

Lao PDR has some judicial or non-judicial measures for cases of non-compliance in effluent water quality management. If violations are found by the industry department, certification for wastewater discharge is suspended and wastewater discharge is suspended or terminated until improvement and compliance is confirmed. Penalties for regulation violations are as follows: (1) first stage: warning, suspension of import/export, suspension of production, (2) second stage: fine of five to 10 times the certification fee, and (3) third stage: fine of 10–15 times the certification fee as well as penalties for non-compliance with other relevant regulations. Currently, DPCM is responsible for environmental quality monitoring and compliance enforcement and preparation for Lao PDR's state of pollution report, and provides data on air quality, noise levels, water quality, solid waste, hazardous substances and pollution problems throughout the country. Monitoring of environmental quality is intended to provide a grasp of the current ambient environment as well as to monitor the emissions and impacts of specific discharges.

6 | Recent Developments in Water Environmental Management

As regards current challenges, decision makers have approved several policy-oriented changes on existing regulations as well as introduced several new policies on the ground. Several of these are listed below:

- Law on Water and Water Resources, 2017
- Decree on National Environmental Standard passed on 2017Water and Water Resources Management, 2017
- Natural Resources and Environment Sector Vision towards 2030 and Ten-Year Strategy (2016–2025) and Natural Resources and Environment Sector Five year Action Plan (2016–2020), 22 September 2015
- Environment Impact Assessment Decree No. 112/PM, 2010
- Waste from Industry Processing Management Regulation 2012; and Industry Wastewater Discharge Regulation 2005
- National Strategy on Rural Water Supply, Sanitation and Hygiene 2019–2030 No. 0947/MoH was approved and issued in 2019
- Natural Resources and Environment Sector Vision towards 2030 and Ten-Year Strategy (2016–2025) and Natural Resources and Environment Sector Five year Action Plan (2016–2020), 22 September 2015

7 | Challenges and Future Plans

Although water quality is generally in good condition throughout the country, it has deteriorated in major urban areas in recent past times. No urban centers, including the capital Vientiane, have comprehensive piped sewerage systems or wastewater collection, treatment and disposal systems. The water quality of urban rivers may further deteriorate in the near future due to inflows of increasing volumes of untreated wastewater resulting from urban growth.

Overall, challenges for water environment governance can be summarized in the following categories:

a. Policy and legislation:

- Lack of national planning policy framework, monitoring and enforcement
- Lack of strict regulations to implement the laws in the field to control wastewater pollution and control
- Lack of criminal laws for pollution control

b. Institutional Framework:

- The absence of power leads to serious lack of compliance and major pollution issues
- Lack of technical skills and inadequate resources to support monitoring and enforcement
- Lack of cooperation and coordination of pollution control among the central and local governments and agencies concerned, due to silo-based thinking

c. Financial support:

- Lack of financial collection charges of pollutants released into the environment as no specific legislation is in force
- National government's annual budget is not sufficient

Future plans to address the above challenges

The national government is searching for potential solutions to address the above-mentioned challenges related to water environment, some of which are listed below:

1. Human resources development, i.e., capacity building for technical officers in government, who will become key personnel for water environment monitoring and governance through collaborations with technically advanced countries
2. Seeking financial/technological support from donor agencies for improving water environment in Lao PDR
3. Conducting the pilot project/program on wastewater treatment plant in Lao PDR
4. Developing technical guidelines/legislation on wastewater management and their strict implementation

2.7 Malaysia

1 | Country Information

Table 2.7.1 Basic indicators

Land Area (km^2)		328,550 (2018)*
Total Population		32.523 million (2019)**
GDP (current USD)		364.7 billion (2019)***
GDP per capita (current USD)		11,415 (2019)***
Average Precipitation (mm/year)		2,420 (2018)****
Total Renewable Water Resources (km^3)		580 (2017)*
Total Annual Freshwater Withdrawals (billion m^3)		6.707 (2017)
Annual Freshwater Withdrawals by Sector	Agriculture	45.7% (2017)
	Industry	29.9% (2017)
	Municipal (including domestic)	24.5%(2017)

(Source: FAO 2020, *World atlas 2018, **DOSM 2020, ***World Bank 2020, ****World weather online 2018)

Figure 2.7.1 Titiwangsa Lake in Kuala Lumpur, Malaysia

2 | State of Water Resources

Malaysia is a rich water resource country thanks to its high rainfall. In 2016, the highest annual rainfall was recorded at Kuching station with 5,423.0 mm, 877.5 mm higher than 2015, and the lowest was recorded at Temerloh station, with 1,397.8 mm (DOSM 2017). In terms of volume, this equates to 972.8 billion m^3. Of this, 495.71 billion m^3 is surface runoff, 64 billion m^3 goes to ground water and the remainder returns to the atmosphere through evapotranspiration (ASM 2014). The weather in Malaysia is characterized by two monsoon regimes – the Southwest Monsoon from late May to September, and the Northeast Monsoon from November to March. The Northeast Monsoon brings heavy rainfall, particularly to the east coast states of peninsular Malaysia and western Sarawak, whereas the Southwest Monsoon normally signifies relatively drier weather (MoSTI 2010). Malaysia depends heavily on surface water, mainly rivers, lakes, wetlands and reservoirs for water supply, which presently constitute 98% of total water supply for domestic, industrial and agricultural use. The remaining 2% comes from groundwater. About 80% of the water withdrawn from river systems is used for irrigation. Percentages of water withdrawn from surface water sources for domestic and industrial uses are expected to rise in the future. Potable water supply extends mostly throughout the country except for a few isolated spots where supply is challenged due to physical or geographical factors, for which wells or rural water supply scheme systems are provided.

According to ASM (2014), current water consumption is about 12.5 billion m^3/year, or less than 3% of the available runoff, but is expected to increase at about 5% annually due to rapidly rising populations and industrial growth to around 30.4 billion m^3/year by 2020, 60.8 billion m^3/year by 2040, and 121.6 billion m^3/year by 2060. Irrigation will continue to be the largest water user but its share is expected to be outpaced by domestic and industrial consumption.

3 | State of Ambient Water Quality

3.1 Rivers

The Water Quality Index (WQI) is used to evaluate the status of river water quality and the corresponding suitability in terms of water uses according to the National Water Quality Standards for Malaysia (NWQS). To assess river water quality, samples from all 638 rivers were investigated between 2010 to 2018. A total of 8,118 water samples were collected from 1,353 manually monitored stations, 1,252 stations designated for ambient and baseline studies, 55 upstream water intake stations, and 35 stations from the River of life project. The WQI for river water quality is calculated based on six parameters: DO, BOD, COD, NH_3-N (Ammoniacal nitrogen), SS, and pH (DOE 2018), and classified into three categories according to the index: clean, slightly polluted, and polluted. Results indicate that 357 rivers (i.e., 56%), 231 rivers (36%) and 50 rivers (8%) fall under clean, slightly polluted and polluted categories, respectively during the 10-year period (2008–2018) of analysis (DoE 2018), as shown in Figure 2.7.2. Figures 2.7.3 and 2.7.4 specifically show trends in river water quality based on BOD and NH_3-N sub-index, respectively (2008–2018). Based on Figure 2.7.3, river water quality exhibited a deteriorating trend from 2008 to 2017, but in 2018 showed signs of recovery owing to strict water quality regulation and management efforts. For 2017, of the 477 river waters analyzed, none fell into the clean category, 141 rivers (29.6%) were slightly polluted while the remaining 336 rivers (70.4%) were polluted. However, for 2018, 110 (17.2%) rivers were categorized as clean, and 271 (42.5%) and 257 (40.3%) rivers as slightly polluted and polluted, respectively. Regarding NH_3-N as shown in Figure 2.7.4, it can be seen that the number of rivers falling under the clean category improved although the total percentage shown in the figure is a lower number because of the increase in total number of rivers being investigated. Another water quality temporal trend (2008–2018) can be seen in Figure 2.7.5, showing SS. This indicates that in general water quality was improving from 2008 to 2015, but in 2016 and 2017 showed a declining trend. Again, for 2018, water quality improved despite additional rivers being included in the monitoring network. Heavy metals were also analyzed in terms of Mercury (Hg), Arsenic (As), Cadmium (Cd), Chromium (Cr), Lead (Pb), and Zinc (Zn). The results indicate that all water samples exhibited concentrations within the Class II limit for Cd, Pb, and Zn. About 99.87%, 99.45% and 98.63% of water samples were in Class II for Cr, Hg and As, respectively (DOE 2015).

River pollution is still a major issue in Malaysia despite substantial investment in and effort taken to improve and maintain river quality. Both point and non-point pollution sources are significant contributors to water pollution, and levels of BOD, NH_3-N and SS in the monitoring samples were high. High BOD is attributed to inadequate treatment of sewage or effluent from agro-based and manufacturing industries. Meanwhile, the major sources of NH_3-N were assumed to be animal farming and domestic sewage, and main sources of SS were improper earthworks and land clearing activities. The future scenario is predicted to be even more challenging in managing water pollution due to the presence of micro-pollutants and new emerging pollutants (NEPs) resulting from excessive use of pharmaceutical and personal care products, some of which are endocrine disruptors.

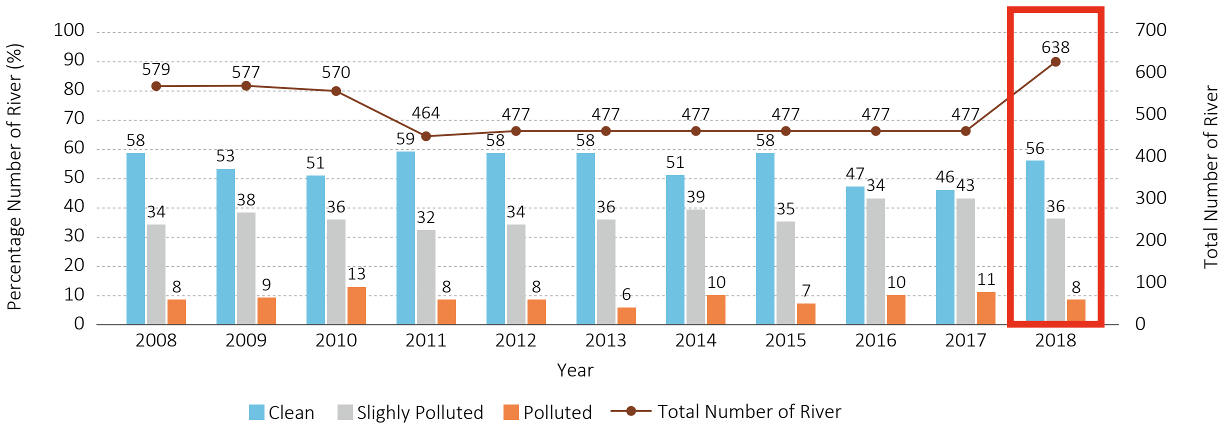


Figure 2.7.2 Trend in river water quality in Malaysia (2008–2018) (Source: DOE 2018)

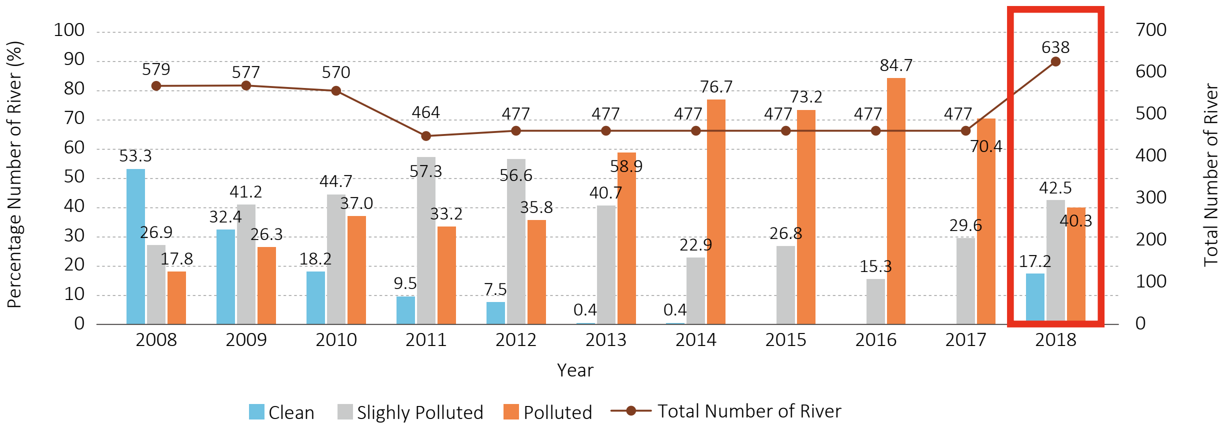


Figure 2.7.3 Trend in river water quality in Malaysia based on BOD sub-index (2008–2018) (Source: DOE 2018)

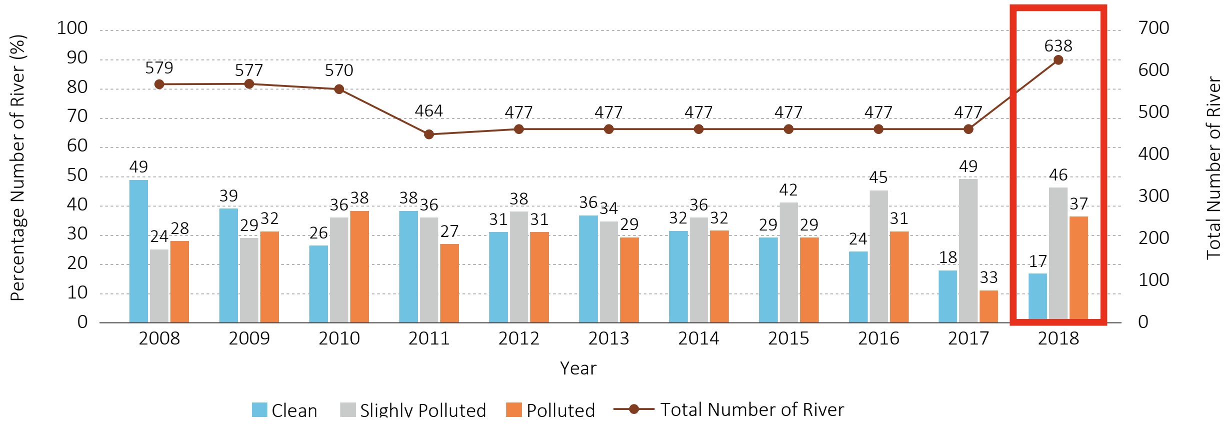


Figure 2.7.4 Trend in river water quality in Malaysia based on NH_3-N sub-index (2008–2018) (Source: DOE 2018)

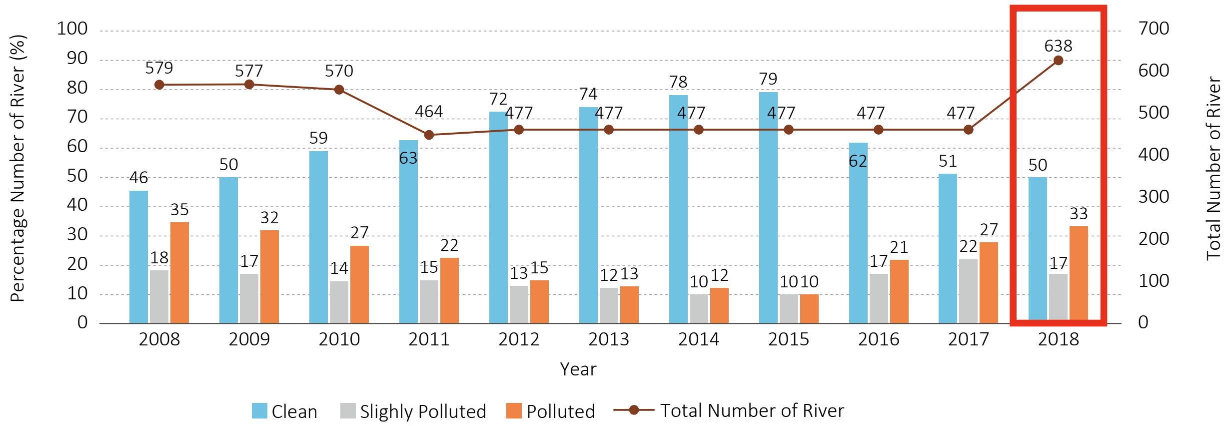


Figure 2.7.5 Trend in river water quality in Malaysia based on suspended solids (2008–2018) (Source: DOE 2018)

3.2 Lakes and Reservoirs

Since lakes and reservoirs are managed by different authorities, owners and operators, comprehensive water quality monitoring has not been conducted by the DoE and no water quality inventories exist for either water bodies. However, a study by the Institute of Environment and Water Resource Management and Teknologi Malaysia shows 62% of water bodies comprised of lakes and reservoirs to be eutrophic (Sharifuddin 2011).

3.3 Coastal Water

In 2015, monitoring was conducted from a total of 151 coastal, 76 estuary and 90 island stations, providing 590, 401, 353, samples, respectively, which were analyzed and reported based on the Marine Water Quality Index (MWQI). The index was developed based on seven main parameters: DO, Nitrate (NO_3), Phosphate (PO_4), Unionized Ammonia (NH_3), Faecal Coliform, Oil and Grease and Total Suspended Solids (TSS), and provides a score on a scale of 0–100 to determine the category of marine water quality, ranging from Excellent to Poor. The monitoring results showed water was Excellent at nine stations (6%), Good at 54 stations (36%), Moderate at 86 stations (57%) and Poor at two stations (1%). The trend in terms of Marine Water Quality Index (MWQI) for 2013 to 2015 is given in Figure 2.7.6, from which it can be seen that numbers of Good, Moderate and Poor water quality stations had increased in 2015, while Excellent stations had decreased compared to the previous year.

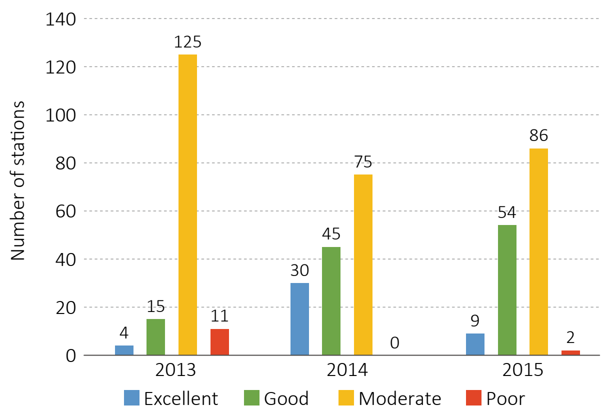


Figure 2.7.6 Trend in marine water status for coastal areas in Malaysia (2013–2015) (Source: DOE 2015)

3.4 Groundwater

According to ASM (2014), the groundwater resource is currently still underused owing to relatively higher exploration costs, and groundwater use is concentrated in the State of Kelantan. In Sarawak, a number of villages, especially along the coast, obtain water from groundwater due to the low cost-efficacy of laying pipes from central facilities to these isolated areas. Groundwater is also an important source of water supply in many small islands and is used in conjunction with surface runoff and rainwater.

The status of groundwater quality was evaluated using the National Guidelines for Drinking Water Quality (NGDWQ) 2000 from the Ministry of Health (revised in December 2000) as a benchmark. In 2015, 390 water samples were taken from 105 monitoring wells and analyzed for volatile organic compounds (VOCs), pesticides, heavy metals, anions, bacteria (coliform), phenolic compounds, total hardness, Total Dissolved Solids (TDS), pH, temperature, conductivity and DO. Results showed that all stations were within the NGDWQ values except for As, iron (Fe), manganese (Mn), total coliform and phenol.

4 | State of Wastewater Treatment

Wastewater and major pollutants

Concerning the different key pollutants (BOD, SS and NH_3-N) of water bodies, all the sources can be divided into five main categories as reported by DOE (2018): manufacturing industries, agriculture-based industries, wet market, sewage treatment plants and piggeries. In terms daily quantities of these pollutants released, from highest, the sources are sewage treatment plants, piggeries, agriculture-based industries, manufacturing industries, then wet markets for most of the key pollutants except for suspended solids, as shown in Table 2.7.2.

Table 2.7.2 Summary of sectoral load of key pollutants

Water Pollution Sources	BOD Load (Ton/Day)	SS Load (Ton/Day)	NH_3-N Load (Ton/Day)
Manufacturing Industries	55	35	5
Agriculture-based Industries	133	39	11
Wet Market	6	8	0.3
Sewage Treatment Plant	242	303	162
Piggery	217	450	27

(Source: DOE 2018)

Facilities and situation of wastewater treatment

Wastewater management and sludge collection and treatment were assigned to Indah Water Konsortium (IWK), a specialized organization. To improve operation and maintenance, IWK gradually took over sewerage systems of various sizes and types. From 1994 to 2008, over 8,800 became public systems and come under IWK's control, while over 3,000 systems remained under direct management of the owners and, thus, are classified as private systems. On average IWK took over 300 treatment facilities and 1,000 km of sewer network per year. However, in areas without large-scale sewerage systems, private developers continued to construct small-scale sewerage systems.

IWK, although not the owner of the public facilities, had the right to collect sewerage charges as it operated and maintained them. However, the charging system it introduced for individuals and enterprises subsequently received complaints from citizens and resulted in three reductions in charges (JSC 2011), which then led IWK into financial difficulties. as the charges could not cover the business expenses and collection of charges proved difficult. To avoid insolvency, which would have affected sewerage services, IWK was therefore placed under governmental control in 2000 and has since been managed as a private company with the government, under the Ministry of Finance, controlling capital expenditure. The role of implementing agency managing sewerage construction was then transferred to Sewage Service Department (SSD), supplementing its current role as sewerage industry regulator.

In 2006, the Malaysian Parliament passed the Water Service Industry Act (WSIA), which replaced the Sewerage Service Act. Under the previous legal arrangement, IWK had no right to oblige users to pay desludging costs and sewerage charges or to impose fines. As the new Act also integrates drinking water and sewerage services, it provides a level of holistic management to water supply since supply can be cut for users who default on paying charges. The new framework also reinforced SSD's roles and provided by law a new regulator, SPAN (*Suruhanjaya Perkhidmatan Air Negara* or National Water Services Commission).

SSD then became a project implementation agency, in charge of defining plans for new construction and upgrades of sewers and wastewater treatment plants. As was performed by IWK, SPAN thus handles monitoring and regulation of sewerage services. SPAN also aims to improve the quality of new systems constructed by the private sector through providing guidelines to ensure they are both built according to set standards and meet effluent quality requirements as determined by the Department of Environment. Accordingly, developers are obliged to select only those systems approved by SPAN.

According to IWK, in 2018, the company's service area is 88,741 km^2, and it operates and maintains 6,745 wastewater treatment plants, 1,188 pumping stations, and 19,134 km of sewer network, supporting the lives of approximately 25 million people.

Table 2.7.3 shows the status of wastewater treatment facilities in Malaysia. According to SPAN statistics, there were 10,773 public and private sewage treatment plants, while still a significant number of communal septic tanks, individual septic tanks and other sewage treatment system exists. This means that more than 12 million people are still using such facilities.

Table 2.7.3 Status of domestic wastewater treatment facilities (2018)

Sewage Facilities	Quantity	Population Equivalent (PE)
Public Sewage Treatment Plant (a+b)	6,932	26,128,858
a. multipoint Plant	6,830	17,513,195
b. regional Plant	102	8,615,663
Private Sewage Treatment Plant	3,841	4,010,610
Communal Septic Tank	4,231	515,527
Individual Septic Tank	1,357,553	6,998,919
Traditional System (Pour Flush)	1,185,032	5,925,160

(Source: SPAN 2018)

5 | Framework for Water Environmental Management

5.1 Legislation

The ultimate objective of Malaysia's environmental management (including water quality management) is to improve living standards and ensure a sustainable quality of life for its citizens. The National Policy on the Environment approved in 2002 states, "the nation shall implement environmentally sound and sustainable development for the continuous economic, social and cultural progress and enhancement of the quality of life of Malaysia" (MoSTE 2002). In line with this policy, the national policy set eight principles to integrate the economy and environment, namely stewardship of the environment; conservation of nature's vitality and diversity; continuous improvement in the quality of the environment; sustainable use of natural resources; integrated decision making; role of the private sector commitment and accountability; and active participation in the international community.

The Environmental Quality Act (EQA) 1974 (Amendments 2012) relates to the prevention, abatement and control of pollution, and enhancement of the environment. The Act ordains that the minister, after consultation with the Environmental Quality Council, may elaborate regulations for prescribing ambient water quality and discharge standards, and specifying the maximum permissible loads that may be discharged by any source into inland waters, with reference either generally or specifically to the body of waters concerned.

Over time, several amendments or additions were made to this Act. Some of the key subsidiary legislations related to water environment are as follows:

a. Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations 1977
b. Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978
c. Environmental Quality (Scheduled Wastes) Regulations 2005
d. Environmental Quality (Sewage) Regulations 2009
e. Environmental Quality (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations 2009
f. Environmental Quality (Industrial Effluent) Regulations 2009
g. Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015

Other laws and regulations are also shown in Figure 2.7.7.

There are some other important policies related to water Environmental Management. One of them is the National Water Resources Policy (NWRP), which was launched in March 2012 for the period from 2010 to 2050. It is aimed at determining the future direction of the water resources sector based on a review of the national water resources. NWRP for Malaysia provides clear directions and strategies in water resources management to ensure water security and sustainability for both humankind and nature.

Conservation of Water Quality

General

- Environmental Quality Act
- Environmental Quality Standards for Surface Water
- Effluent Discharge Standards

Specific Area

- Selangor Waters Management Authority Enactment (1999)
- Kedah Water Resources Enactment (2007)
- Sabah Conservation of the Environment Enactment
- Sabah Water Resources Enactment (1998)
- National resources and Environment Ordinance Sarawak

Specific Sector

Peninsular Malaysia

1. Agriculture
   Irrigation Areas Act (1953)
   Drainage Works Acts (1954)
2. Forestry
   National Forestry Act (1984)
3. Control of Rivers
   Water Acts (1920), Reviewed (1989)
   River Rights Enactment of Perak
   Kelantan River Traffic Enactment (1955)
   Pahang River Launches Enactment 6/49
4. Land Management
   National Land Code (1965)
   Land Conservation Act (1960)
   Earthwork by laws
5. Domestic Water Supply
   Water Service Indutry Act
6. Mining
   Mining Enctment (1936)
7. Local and Regional Planning
   Town and Country Planning Act (1976)
8. Fishery
   Fisheries Act (1963)
9. Others
   Local Government Act (1976)
   Street Drainage Building By law (1974, 1994-R)
   Geological Survey Act
   Ministerial Function Act (1969)

State of Sabah and Sarawak

1. Agriculture
   Drainage and Irrigation, Sabah Ordinace (15/1956)
   Drainage Works Ordinance Sarawak (1966)
2. Forestry
   Sabah Forest Enactment (1965)
   Forest Ordinance Sarawak, Cap126
3. Control of Rivers
   Sarawak Water Ordinance,
   Sarawak Riverine Transport Bill (1993)
4. Land Management
   Sabah Land Ordinance (1930)
   Sarawak Land Code (1958)
5. Domestic Water Supply
   Water Services Industry Act
6. Mining
   Mining Enactment (1960 Sabah)
   Mining Enactment (1949 Sarawak)
7. Local and Regional Planning
   Town and Country Planning
   Enactment Sabah Cap 141
   Town and Country Planning Sarawak Cap 87
8. Others
   Local Authority Enactment, Sabah Ordinance (11/1961)
   Local Authority Ordinance Sarawak Cap 117

Figure 2.7.7 Legislative chart for water quality management (Source: MOEJ 2009)

5.2 Institutional Arrangement

The Department of Environment (DOE) was originally created as the Environment Division, which was established in 1975 under the Ministry of Local Government and Environment. It has been reorganized several times due to the realignments of government ministries and agencies, and it is now under the Ministry of Environment and Water which newly established in April 2020. DOE is responsible for environmental protection, including water quality management. The mission of the Ministry of Environment and Water is to integrate the functions of water resources and water services, strengthen the management of the country's water ecosystem, and ensure adequate and sustainable water resources and supplies. The quality of drinking water is regulated by the Ministry of Health, and the National Water Commission regulates the entities involved in water supply and sewerage services under the Water Services Industry Act 2006 (Act 655), which came into effect in 2008. Local governments are involved in water resources planning and development.

5.3 Ambient Water Quality Standards

Water quality standards

National Water Quality Standards for Malaysia (NWQS), which applies to surface waters, sets out standard values for 72 parameters in six water use classes (Table 2.7.4.), the goal of which is not to meet the standards of a particular water class in all surface waters, but to improve water quality gradually in order to meet the standards of a water class higher than the current class.

Table 2.7.4 Water quality classes in the National Water Quality Standards

Class	Uses
I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
IIB	Recreational use with body contact.
III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
IV	Irrigation
V	None of the above.

(Source: DOE 2015)

For marine water quality, the Malaysian Marine Water Quality Index (MWQI) was established with seven sub-indexes.

While groundwater quality standards for Malaysia have not been established, based on the assumption that groundwater can potentially be used as an alternative source of surface water, the National Guidelines for Drinking Water Quality are referred as the benchmark for evaluating groundwater quality monitoring results.

Water quality monitoring framework

The Department of Environment (DOE) is responsible for conducting monitoring programs for rivers, marine waters and groundwater. In 1978 it implemented the National River Water Monitoring Program to determine river water quality status and detect changes over time.

River water quality monitoring

For 2018, 8,118 water samples from 638 rivers were analyzed based on sampling frequencies of 4 to 12 times per year. A total of 30 parameters were monitored and a water quality index was developed with six key indicator species: DO, BOD, COD, NH_3-N, SS and pH (DOE EQR 2018).

Coastal water quality monitoring

For 2018, 368 stations, comprising188 from coastal, 85 from estuaries, 95 from islands and the remaining 79 selected from islands were investigated. A total of 2,208 water samples were taken and analyzed from the 368 stations with sampling frequencies of six times per year. Twenty-nine parameters were monitored including six in-situ and 23 in laboratory. The Marine Water Quality Index (MWQI) was developed based on seven parameters: DO, NO_3, PO_4, NH_3, Faecal coliform, Oil and Grease, TSS.

Groundwater monitoring

For 2018, 109 tube wells were monitored based on specific land use: Agricultural (13), Urban & Suburban (12), Industrial Sites (19), Solid Waste Landfills (23), Golf Courses (7), Rural Areas (4), Ex-mining Area (Gold Mines) (3), Municipal Water Supply (5), Animal Burial Areas (14), Aquaculture Farms (7), Radioactive Landfills (1) and Resorts (1). A total of 17 parameters were analyzed in-situ (6 parameters) and Laboratory analysis (11 parameters). Various types of advanced sampling equipment such as hydro lift pumps, HDPE tubing, water depth sensors, generators, sampling bottles/preservative kits, coolboxes and multiprobes were used for increased accuracy. The Malaysia Groundwater Quality Index (MGQI) was developed to represent the groundwater quality status and categories, based on a scale of 0–100, which represents from Very Poor to Excellent. Parameters used for MGQI were pH, Fe, TDS, NO_3, *E. coli*, phenol and sulphate.

5.4 Effluent Standards

Effluent standards

The National Environmental Quality Act 1974 states that "no person shall, unless licensed, emit, discharge or deposit any environmentally hazardous substances, pollutants or wastes into any inland waters in contravention of the acceptable conditions specified under Section 21" (Section 25, National Environmental Quality Act 1974).

Effluent inspection procedure

Monitoring of effluent, as well as recording and maintenance of the monitoring results are obligations that all premises are required to fulfill under the environmental regulations on sewage and industrial effluents. Analytical methods and parameters to be monitored are designated. All premises are required to submit monthly effluent discharge reports to the DOE, either by the online reporting system or hard-copy submission. Authorized DOE officials can carry out inspections of all premises, including surprise inspections, to ensure compliance with all provisions in the act, and non-compliance results in immediate penalties to polluters. As a measure to improve effluent quality, industrial effluent treatment systems (IETS) were introduced with the aim of optimizing effluent treatment operations and maintenance by enabling preventive or corrective actions through the monitoring of treatment performance based on certain parameters. Through IETS, companies can benefit from the early identification of deficiencies, identification of proper dosages for chemicals (Keong 2008) and increased opportunities to identify preventive actions (How 2008). The DOE provides technical guidance to promote IETS. The guidance recommends that within each industry a competent person certified by the director-general of the DOE be on duty to supervise IETS. The use of IETS is expected to encourage industry as a whole to be more proactively engaged in pollution control but without invoking the level of enforcement present in the public sector.

The government can be seen to have extended diligent efforts in its monitoring of effluents from both domestic and industrial sectors with the use of key indicator species. Monitoring results for effluent quality in terms of compliance with national standards for both public sewage treatment plants and industrial sectors are shown in Table 2.7.5 and 2.7.6 respectively. Result shows a significant improvement in the rate of compliance in 2018 compared to 2010. In 2018, average rates of compliance of effluent monitoring sites for public sewage treatment plants and industrial sites with ambient guidelines were 97.8% and 99.6% respectively.

Measures against non-compliance

Since 2009, DOE has designed different enforcement measures and tools for maintaining the water environment. A brief snapshot of these, including penalties for defaulters, is shown in Table 2.7.7 (DOE 2018). Non-complying institutions or entities face penalties of up to 100,000 MYR or five year jail terms.

Table 2.7.5 Summary of public sewage treatment plants and status of compliance with Sewage Effluent Standards for 2010–2018

Parameter	Compliance Level (%) (Target>90%)									
	2010	2011	2012	2013	2014	2015	2016	2017	2018	Average
Suspended Solids (SS)	97.8	97.1	97.0	96.9	97.3	98.1	98.5	98.2	97.9	97.6
Biological Oxygen Demand (BOD)	95.2	94.8	93.9	93.7	94.7	96.3	96.2	97.7	95.4	95.3
Chemical Oxygen Demand (COD)	97.7	97.5	97.1	96.9	97.9	98.5	98.6	98.4	98.2	97.9
Oil & Grease	99.1	99.1	99.1	98.6	99.1	99.5	99.6	99.5	99.4	99.2
Ammoniacal Nitrogen (NH_3-N)	99.6	99.4	99.5	99.2	99.1	98.9	99.8	99.9	97.2	99.2
Average	97.9	97.6	97.3	97.1	97.6	98.3	98.5	98.7	97.6	97.8

(Source: SPAN 2018)

Table 2.7.6 Summary of industrial wastewater management and status of compliance with industrial wastewater management guidelines

Industrial effluents regulations				
YEAR	No. of Desktop Inspections	Compliance (%)	No. of Field Inspections	Compliance (%)
2018	4,549	99.6	5,663	99.6
2017	10,280	99.2	5,518	99.2
YEAR	No. Inspections		Compliance (%)	
2016	14,995		99.0	
2015	11,372		99.0	
2014	11,410		99.0	
2013	7,201		99.0	
2012	6,597		98.1	

(Source: DOE Annual report 2012–2018)

Table 2.7.7 Summary of different enforcement instruments and economic tools for water environmental management

S.No	Regulations	Enforcement agency	Enforcement method/Reporting	Penalty
1	EQ (Inustrial Effluent) Regulations 2009 - Industrial Effluent and Mixed Effluent	DOE	1. Self Regulatory Mechanism: a. Section 7: monitor COD and any parameter in Fifth Schedule b. Reporting: Monthly c. Section 9: Perfomance Monitoring of IETS- based on Guidance Document on Performance Monitoring of Industrial Effluent Treatment System d. Online Environmental Reporting (OER) 2. Site Inspection by DOE Officer	Section 32: Penalty- If convicted, maximum penalty of RM 100,000 or/and amximum 5 years jail and further fine of RM 1,000/day for continued offence
2	EQ (sewage) Regulations 2009	DOE	1. Self Regulatory Mechanism: a. Section 10: Monitor concentration of the specified parameters in Second Schedule b. Reporting: Monthly c. Online Environmental Reporting (OER) 2. Site Inspection by DOE Officer	Section 26: Penalty- If Convited, maximum penalty of RM 100,000 or/and maximum 5 years in jail and further fine of RM 1,000/day for continued offence
3	EQ (Control of Pollution from Solid Waste Transfer Station and Landfill) Regulations 2009	DOE	1. Self Regulatory Mechanism: a. Section 8: Monitor concentration of ammoniacal nitrogen from landfill on a continuous basis using online instrumentation system linked to DOE b. Section 8: Monitor concentration of the specified parameters in Second Schedule (limits) c. Section 11: Conduct performance monitoring of leachate treatment system d. Online Environmental Reporting (OER)	Section 29: Penalty- If Convited, maximum penalty of RM 100,000 or/and maximum 5 years in jail and further fine of RM 1,000/day for continued offence

5.5 Other Policies on Water Environmental Management

In order to manage the complex, interwoven issues of water environment, the Malaysia government has introduced several legislations and guidelines in terms of new standards, as well as revised existing standards as follows (DOE 2018):

a. Malaysian Groundwater Quality Standards and Index (2019) – Developed by DOE
b. National Lake Water Quality Criteria and Standards (2015) – Developed by NAHRIM (Approved by National Water Resources Council in 2015)
c. National Standard for Drinking Water Quality (2000) – Developed by Ministry of Health (MOH)
d. National Standard for Natural Recreational Water Quality and Guidelines for Natural Recreational Water Quality Monitoring (Marine and Fresh Water) (2017) – Developed by MOH
e. Guidelines for Packaging, Labelling and Storage of Scheduled Waste in Malaysia (2014) – DOE, NRE
f. Guidelines for Green Industry Practice: Juice Production Industry (2014) – DOE, NRE (Malay version)
g. Guidelines for Green Industry Practice: Printing Industry (2014) – DOE, NRE (Malay version)
h. Guidelines on the Disposal of Chemical Wastes from Laboratories (2015) – DOE, NRE
i. Guidelines of the Effluent Treatment System for Dairy Cattle, Beef Cattle and Buffalo Breeders (2016) – DOE, NRE (Malay version)
j. Guidelines on the Effluent Treatment System for Pig Breeders (2016) – DOE, NRE (Malay version)
k. Guidelines for Green Industry Practice: Food sector for Slaughtering and Processing of Poultry (2017) – DOE, NRE (Malay version)
l. Guidelines on Land Disturbing Pollution Prevention and Mitigation Measures (2017) – DOE, NRE
m. Environmental Impact Assessment Guidelines for Development in Slope and Hill Areas (2017) – DOE, NRE
n. Environmental Impact Assessment Guidelines for Development in Coastal Areas and Marine Parks (2017) – DOE, NRE

6 | Recent Developments in Water Environmental Management

The Eleventh Malaysia Plan 2016–2020 is seen as the final part toward achieving Vision 2020. Launched in 1991 by the government, Vision 2020 is an aspirational target aimed at Malaysia becoming a fully developed country economically, politically, socially, spiritually, psychologically, and culturally by 2020. The theme of the Eleventh Plan, "anchoring growth on people" has six 'strategic thrusts' and six 'game-changers' intended to reach the goals set out in Vision 2020 and create an inclusive nation with an advanced economy. In terms of water environment management, two of the core strategies are relevant here: 1) "Pursuing green growth for sustainability and resilience", expected to increase the quality of growth, strengthen food, water and energy security, lower environmental risks and ecological scarcities, and ultimately improve wellbeing and quality of life, and 2) "Strengthening infrastructure to support economic expansion", with a focus on (i) raising the financial sustainability of the water services industry by strengthening the tariff system and implementing joint billing for water and sewerage; (ii) expanding the network and treatment plant capacity through infrastructure investment and use of efficient technology through developing new treatment plants, increasing clean and treated water coverage and expanding connected water and sewerage services in rural areas; (iii) increasing efficiency and productivity of water and sewerage services through implementation of the Non-Revenue Water Reduction Programme and by rationalizing and upgrading sewage treatment plants; and (iv) strengthening the regulatory framework of the water services industry with the National Sewerage Master Plan, a water demand management master plan and promotion of waste to wealth initiatives.

7 | Challenges and Future Plans

The Environmental Quality Act 1974 was somewhat successful in reducing pollution through control of point and non-point sources, and continuous monitoring and assessment of the water environment. However, many challenges still remain. The new direction of water environmental management has been incorporated in the Eleventh Malaysian Plan and the new Environmental Protection Act draft. The following elements are also proposed by DOE to improve the nation's future water environment (Majid 2016): (i) Shifting the responsibility for pollution control to industry by incorporating regulation elements (new approach taken by the Department in the formulation of the new regulation for pollution control); (ii) re-strategize the enforcement programs and continuously improve compliance monitoring to secure better solutions for pollution prevention and control; (iii) increase use of ICT to reduce costs of enforcement to cover more pollution sources; promote self-regulation approaches to pollution control by identifying groundwater potential for areas where surface water is limited or unavailable; achieve better management of lakes and reservoirs by clarifying the roles and responsibility of relevant stakeholders; and carry out further studies and proper data management to fulfill this target.

Some of the additional challenges are as follows:

a. Illegal dumping of wastes into watercourses
b. Point source and non-point source pollution
c. Inability of Environmental Quality Act 1974 (Discharge control based on pollutant concentration) to deal with shrinking river carrying capacity; Inability of EQA 1974 to control pollution entering rivers
d. Lack of regulations or standards for wet market effluent, car washes, and laundry

For the way forward, the following key actions have been initiated:

a. Amendment of Environmental Quality Act 1974 – to be tabled in the Parliament in 2020
b. Amendment of Water Services Industry Act 2006
c. Water Resource Bill to be tabled in Parliament in 2020
d. Review of the River Water Quality Criteria and Standard for Malaysia – Inception Report (September 2019) – in progress
e. Malaysian Marine Water Quality Standards and Index – Revised and published
f. Malaysian Groundwater Quality Standards and Index – Study completed in 2017 – Published in 2019

2.8 Myanmar

1 | Country Information

Table 2.8.1 Basic indicators

Land Area (km²)		676,552 (2018)*
Total Population		53.04 million (2019)**
GDP (current USD)		86.93 billion (2019)**
GDP per capita (current USD)		1,407 (2019)**
Average Precipitation (mm/year)		2,340 (2008–2017)*
Total Renewable Water Resources (km³)		1,168 (2017)
Total Annual Freshwater Withdrawals (billion m³)		33.2 (2000)***
Annual Freshwater Withdrawals by Sector	Agriculture	89% (2017)
	Industry	1% (2017)
	Municipal (including domestic)	10% (2017)

(Source: ADB 2017, *CSO 2018, **World Bank 2020, ***FAO 2016)

Figure 2.8.1 Irrawaddy River in Nyaung-U, Myanmar

2 | State of Water Resources

Myanmar has an abundance of water resources, which are distributed unevenly spatially and temporally. Around 80% of the average annual rainfall of 2,340 mm falls during the monsoon season (May–October) and 20% in the dry season (CSO 2018). The catchment area of Myanmar's eight principal river basins is approximately 737,800 km^2, and there are two major natural lakes, the Inle Lake and Indawgyi Lake. Constructed reservoirs have a capacity of 15.46 km^3. The potential volume of groundwater resources in the country is 580 km^3, of which the estimated total renewable volume is 1,046 billion m^3 and per capita total internal water resources is 24,046 m^3/capita/year (FAO 2016). Total water development is 33.2 billion m^3, which represents 3% of the total renewable water resources in Myanmar. Approximately 91% of the total water withdrawal comes from surface water and 9% from groundwater. Groundwater is mostly used for domestic purposes (ADB 2017).

3 | State of Ambient Water Quality

3.1 Rivers

Myanmar is heavily dependent on inland surface waterbodies for domestic use, agricultural irrigation and industrial production. Water quality monitoring data of Bago River, Shwegyin River, and Sittaung River revealed that water environment conditions in these three rivers are generally good, however they vary from river to river. According to the water quality monitoring data in 2020, NO_3-N concentrations range from 97 µg/L in Bago River to 780 µg/L in Shwegyin River. In contrast, PO_4-P concentrations in Bago River water are around double those of Shwegyin River and Sittaung River (Figure 2.8.2). Wastewater and sewage from settlement areas is the main source of high levels of phosphorus, while nitrogen comes from run-off of fertilizers from agricultural areas (NIWR 2018).

3.2 Lakes and Reservoirs

Myanmar has a number of natural lakes, including Indawgyi Lake, Inle Lake, Inya Lake and Sunye Lake, which serve as source of waters for various purpose, and their biodiversity and scenic beauty make them popular tourist attractions. However, in recent years these lakes have faced degraded lake environments, such as increased water pollution, deforestation and illegal dumping of garbage. Inle Lake is the second largest natural lake. It has a surface area of 116 km^2 and total water inflow volume of 1,132 million cubic meter per year and is one of the major sources of water in the lake basin area. Annually it receives more than 0.3 million tourists (NIWR

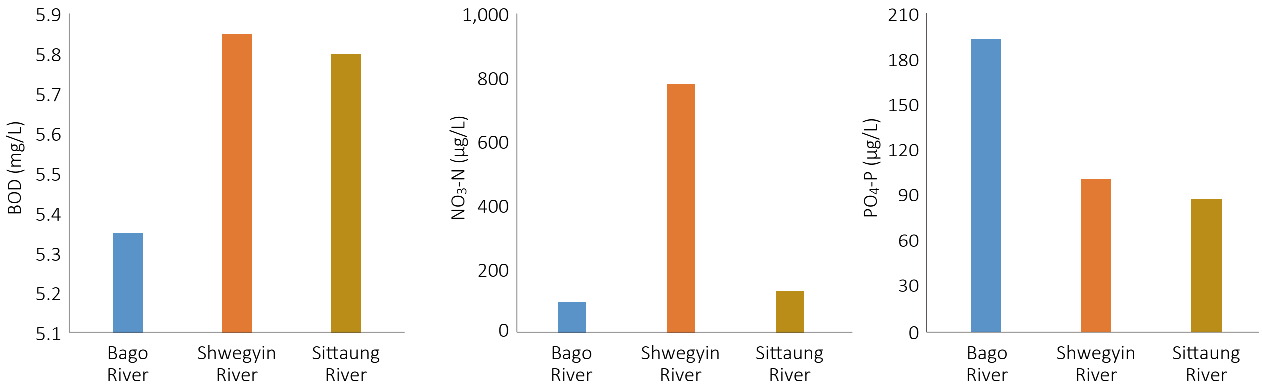


Figure 2.8.2 Water quality of selected rivers in Myanmar, 2020 (Source: FRI 2020)

2017). However, degradation of the lake environment is set to hinder its ecosystem services, and a water quality survey conducted during 2017–2018 raised concerns over water quality deterioration. It also reported that the values of COD were high for both 2017 and 2018 (Table 2.8.2), which indicates continued organic pollution.

Table 2.8.2 Water quality of Inle Lake, Myanmar, 2017–2018

no	parameter	value (2017 rainy season)	value (2018 rainy season)
1	Turbidity (Degree)	9.0	9.9
2	Dissolved Oxygen (mg/L)	5	5
3	Chemical Oxygen Demand (COD) (mg/L)	12	10

(Source: Yuasa et al. 2019)

3.3 Coastal Water

Myanmar has a 2,400 km long coastline bordering the Bay of Bengal and Andaman Sea. Pollution of costal water comes from coastal land as well as far inland. Major pollutants in coastal water include chemicals, nutrients, and heavy metals carried from farms, factories, and cities by streams and rivers into the sea. The marine water bodies around the country are also sometimes deteriorated by oil spills and leaks.

3.4 Groundwater

Groundwater is a vital source of water in many parts of Myanmar, and in some areas provides 80% of drinking and irrigation water supply (Viossanges et al. 2017). However, the limited amounts of data make it difficult to form a picture of overall groundwater quality (van Geen et al. 2014, Bacquart et al. 2015), and the usability of groundwater is affected by water quality issues. Elevated arsenic concentrations in groundwater exceeding the WHO guideline value for drinking water (10 µg/L) have been reported in many areas. Table 2.8.3 shows that of the 30,420 samples tested in the Dry Zone, 2% of them exceeded the arsenic value set in the National Drinking water Guideline (50 µg/L), whereas 80% of samples exceeded the WHO guideline value of 10 µg/L. In some locations, fluoride, nitrate, salinity, iron, manganese, and aluminum also exceeded WHO drinking water guidelines (Pincetti-Zúniga et al. 2020).

Table 2.8.3 Arsenic concentration in groundwater of Sagaing, Mandalay and Magway Regions

Region	Total samples	<10 µg/L	10–50 µg/L	>50 µg/L
		Percent of total sample		
Sagaing	8,611	79	19	2
Mandalay	21,257	81	18	1
Magway	552	81	17	2

(Source: Pavelic et al. 2015)

4 | State of Wastewater Treatment

Underinvestment in urban wastewater treatment infrastructure has resulted in significantly deficient wastewater treatment services throughout Myanmar. Only around 10% of wastewater generated is treated (United Nations World Water Assessment Programme 2017), and there are only two sewerage systems, one in each of the major cities of Yangon and Naypyidaw, which can collect only small amounts of the wastewater generated. The current capacity of Yangon city's sewage treatment facilities is 12,302 m^3/day (ECD 2019) covering only 7% of the city's population. That of Nay Pyi Taw city is 1,600 m^3/day, which services about 20% of the newly developed area of Naypyidaw, and 80% of areas still reply on septic tanks or pit latrines with slab (ECD 2019). Mandalay is a major city in central Myanmar with a population 1.2 million but lacks a central wastewater management system. Rapid growth of industrial sectors also increases the risk of water pollution due to insufficient capacity to manage industrial wastewater. A total of 41 industrial zones have been established in Myanmar, most of which lack centralized wastewater treatment facilities, although new industrial zones are planned to be equipped with them. In recent years the Government of Myanmar has undertaken several projects with the support of development partners, such as a project to upgrade the current capacity of wastewater treatment to 112,000 m^3/day in partnership with the Japan International Cooperation Agency (JICA), a project to establish an industrial wastewater treatment facility in Mandalay city under an environmental cooperation agreement with Japan, and a project to construct a central industrial wastewater treatment system with capacity of 230 m^3/day in Mandalay Industrial Zone (2) with financial aid from the Responsible Business Fund (Win 2019).

Table 2.8.4 Domestic wastewater treatment practices in urban areas

City name	Population (million)	Wastewater management practices
Yangon	5.2	i. Centralized wastewater treatment (12,302 m^3/day)
		ii. Septic tank
		iii. Pit latrine
Nay Pyi Taw	0.9	i. Centralized wastewater treatment (1,600 m^3/day)
		ii. Septic tank
		iii. Pit latrine
Mandalay	1.2	i. Septic tank
		ii. Pit latrine

(Source: ECD 2019)

5 | Frameworks for Water Environmental Management

5.1 Legislation

The current legislative framework for water environment management in Myanmar is shown in Figure 2.8.3. Maintaining a healthy and clean environment and conservation of natural and cultural heritage for the benefit of present and future generations is the objective Environmental Conservation Law 2012. Article 7 stipulates that EIAs and SIAs must be carried out for projects that may cause significant impact on the environment, the EIA process of which – according to Environmental Impact Assessment Guideline 2015 – must start with submission of project proposals to the Environmental Conservation Department. The National Environmental Quality (Emission) Guidelines was approved in 2015, which provide the basis for regulation and control of noise and vibration, air emissions, and liquid discharges from various sources in order to prevent pollution for purposes of protection of human and ecosystem health, and includes industry-specific guidelines on air pollution, wastewater, noise and odour. The objectives of the Conservation of Water Resources and Rivers Law 2006 are to conserve and protect water

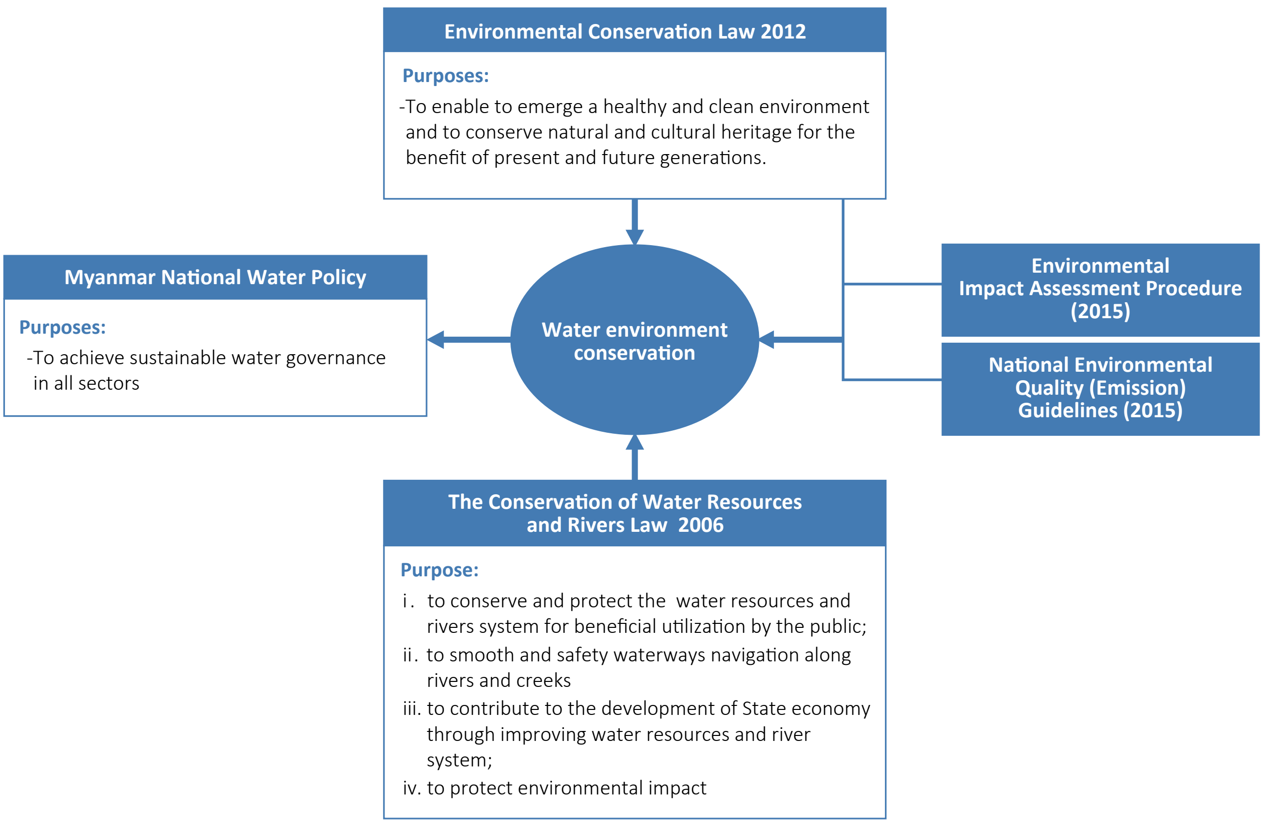


Figure 2.8.3 Legislative framework of water environment management in Myanmar

resources and river systems for beneficial public use and smooth and safe navigation, and contribute to the state economy through improving water resources and mitigating environmental impacts.

5.2 Institutional Arrangement

In Myanmar, several ministries deal with water environment management. Table 2.8.5 shows a list of agencies and their responsibilities for water environment conservation. Control of the disposal of wastewater from residences, office buildings and factories is the responsibility of the Ministry of Natural Resources and Environmental Conservation (MONREC). The Ministry of Planning, Finance and Industry is responsible for regulating industrial water use and discharge, and the City Development Committee is responsible for water supply and sanitation respective cities.

Table 2.8.5 Institutional arrangement for water environment management in Myanmar

Department	Ministry/organization	Responsibilities
Environmental Conservation Department	Ministry of Natural Resources and Environmental Conservation	Formulation of national environmental quality standards, including water quality standards, water quality monitoring, enforcement
Forestry Department	Ministry of Natural Resources and Environmental Conservation	Reforestation and conservation of forest including watershed areas
Irrigation and Water Utilization Management Department	Ministry of Agriculture, Livestock and Irrigation	Provision of irrigation water for farmland
Water Resources Utilization Department	Ministry of Agriculture, Livestock and Irrigation	Irrigation and rural water supply
Directorate of Water Resources and Improvement of River System	Ministry of Transport and Communication	River gradging, navigation and prevent river water pollution
Directorate of Industrial Supervision and Inspection	Ministry of Planning, Finance and Industry	Industrial water use and discharge
Department of Metrology and Hydrology	Ministry of Planning, Finance and Industry	Water assessment of major rivers
Department of Urban and Housing Development	Ministry of Construction	Domestic water supply
Department of Public Health	Ministry of Health and Sports Environmental Health,	Water quality assessment and control
Department of Development Affairs	Ministry of Border Areas Development Affairs	Rural water supply and sanitation
Department of Research and Innovation	Ministry of Education	Formulation National Standards
Water and Sanitation Department	City Development Committees (Yangon, Mandalay, Nay Pyi Taw)	Water supply and sanitation in city areas

5.3 Ambient Water Quality Standards

Ambient water quality standards

Myanmar currently has no ambient water quality standard. However, with the objective of stipulating national standards, as provided for under Paragraph (10) of the Environmental Conservation Law (*"the Ministry may stipulate the suitable surface water quality standards, water quality standards for coastal and estuarine areas, underground water quality standards, atmospheric quality standards, noise and vibration standards, emissions standards, effluent standards, solid waste standards and other environmental quality standards"*), the Environmental Conservation Department of MONREC in cooperation with other line ministries and international experts has been working on a draft of the surface water quality standard. Part of this process involved conducting a review of the standards of neighboring countries and developed countries, which led to over 600 parameters being selected for the screening process. Progress was then made on developing a draft for surface water quality standards. The draft was submitted to the National Surface Water Quality Standards, which include 36 parameters with threshold values for protecting aquatic ecosystems and human health. The Environmental Conservation Department (ECD) of MONREC aims to put into effect the National Surface Water Quality Standard in 2021 to thus establish a surface quality standard.

Water quality monitoring framework

Although there is no water quality standard in Myanmar, ECD and the Forestry Department of MONREC are responsible for managing water quality monitoring. As such, ECD monitors river water quality at 15 sampling points, lake water quality at 21 monitoring points and groundwater quality at three monitoring points quarterly or twice a year for 18 water quality parameters. The Forestry Department monitors water quality for 30 parameters at 26 sampling points for rivers and eight monitoring points in dams. Details of the water quality monitoring framework are shown in Table 2.8.6.

Table 2.8.6 Water quality monitoring framework of ECD and Forestry Department

Item	ECD	Forestry Department
Monitoring parameters	Temperature, Turbidity, Total dissolved solids (TDS), Conductivity, pH, Dissolved oxygen (DO), COD, BOD, Salinity, Total Ammonia, Total Nitrate, Total Phosphate, Copper, Lead, Arsenic, Mercury, Iron, Cadmium	pH, Conductivity, Color, Total Alkalinity, Turbidity, BOD, COD, Calcium, Magnesium, Potassium, Sodium, Chloride, Sulfate, Ammonia, Fluoride, Nitrate, Nitrite, Total nitrogen, Total phosphorus, Bromine, Mercury, Copper, Lead, Arsenic, Cadmium, Nickle, E.coli Bacteria, Orthophosphate, Silicon, Chromium
Number of sampling points	Rivers: 15 sampling points Lakes: 21 sampling points Groundwater: 3 sampling points	Rivers: 26 sampling points Dams: 8 sampling points
Frequency of monitoring	Seasonal (quarterly or twice/year)	Bimonthly
Frequency of publishing monitoring reports	Quarterly	-

5.4 Effluent Standards

Effluent standards

The National Environmental Quality (Emission) Guidelines (NEQEG) was released on 29 December 2015. These guidelines provide the basis for regulation and control of noise and vibration, air emissions, and liquid discharges from various sources in order to prevent pollution and provide protection for human and eco-system health. A total of 71 industry-specific effluent levels have been set out in the NEQEG. The guidelines for effluent levels cover thermal power, geothermal power, wind power, oil and gas, petroleum refining, natural gas processing, natural gas liquefaction, crude oil and petroleum product terminals, electric power transmission and distribution, gas distribution systems, petroleum-based organic chemicals manufacturing, plantation industrial/crop production, annual crop production, mammalian livestock production, poultry production, aquaculture, forest harvesting operation, meat processing, poultry procession, fish processing, food and beverage processing, dairy processing, vegetable oil production and processing, sugar manufacturing, breweries and distilleries, textiles manufacturing, tanning and leather finishing, sawmilling and manufactured wood products, board and particle-based products, pulp and/or paper mills, printing, large volume inorganic compounds manufacturing and coal tar distillation, petroleum-based polymers manufacturing, coal procession, nitrogen fertilizer manufacturing, phosphate fertilizer manufacturing, pesticide manufacturing, oleochemicals manufacturing, pharmaceuticals and biotechnology manufacturing, glass, and glass and mineral fibre manufacturing, ceramic tile and sanitary ware manufacturing, base metal smelting and refining, integrated steel mills, foundries, metal, plastic and rubber products manufacturing, semiconductors and other electronics manufacturing, solid waste management facilities, wastewater treatment facilities, health care facilities, and others.

Effluent inspection procedure

The Pollution Control Division of ECD, General Administration Department, Directorate of Industrial Supervision Inspection, and Directorate of Industrial Collaboration are responsible for inspection of effluent quality. Table 2.8.7 describes the responsibilities of each

Table 2.8.7 Effluent quality control agencies and their responsibilities

Agency	Responsibilities
Pollution Control Division of ECD	Monitor the effluent quality regularly
General Administration Department	Manage and issue liquor licenses
Directorate of Industrial Supervision Inspection (DISI)	Encourage the development of private industrial enterprises in accordance with the Industrial Enterprise Law
Directorate of Industrial Collaboration	To formulate policies and laws to accelerate growth of industries

agency. DISI performs monitoring using an online monitoring system for wastewater discharged from alcohol factories. Local and regional offices of ECD are tasked with regular monitoring of effluent quality, and ECD headquarters is directly involved in effluent monitoring upon notification of major environment pollution issues.

Measures against non-compliance

When violations of effluent standards are found, a written warning is sent to industries to correct current activities to comply with the relevant laws and effluent guidelines. If this fails to solve the pollution issue, an operation suspension notice is issued.

5.5 Major Policies on Water Environmental Management

The Myanmar Sustainable Development Plan (MSDP) 2018–2030 is a document laying out a vision for the country toward sustainable development, and Goal 5 emphasizes sound management of natural resources and environment for prosperity of the nation. The National Environmental policy of Myanmar (2019) sets a vision for a clean environment with a healthy and functioning ecosystem to ensure inclusive development and wellbeing for all people in Myanmar. Myanmar National Water Policy (NWP) sets its vision as, "in 2040 Myanmar will become water efficient nation with well-developed and sustainable water resources based on a fully-functional integrated water resources management system". The objectives of the NWP are to establish an Apex body for strengthening inter-ministerial coordination for water management, invest in water sector infrastructures, institutions and capacity building, improve efficiency on the water supply and demand sides, and enhance water information, knowledge, technology and cooperation.

6 | Recent Developments in Water Environmental Management

There are several developments in government policies that will have significant impacts on water environment management, as follows:

i. Drafting of the national surface water quality standard. ECD aims to finalize and complete the approval process of the draft national surface water quality standard in 2021.

ii. Implementation of Project on Capacity Development in Enforcement and Promotion of Environmental Compliance.

iii. Ongoing project for establishing a National Water Quality Monitoring System and Building the National Laboratory to Improve the National Capacity for Water Quality Management in Myanmar.

iv. Implementation "Integrated Water Resources Management – Institutional building and trainings" project by Forestry Department, with specific outcomes of (1) ecological water quality status assessment; (2) functioning Myanmar National Water Quality Laboratory; (3) database and data user interface tools, for communication of environmental status by FD; (4) implementation of the Myanmar National Water Framework Directive - in selected Myanmar sub-basins; (5) development of monitoring and risk assessment plans in areas of mining activities.

7 | Challenges and Future Plans

Based on the current state of water quality management in Myanmar, some key management challenges are identified as follows:

	Description	Actions to be taken
Institutional challenge	i. Formulation of environmental water quality standards, monitoring and inspection of water and effluent quality	i. Organize monitoring and inspection teams at national, state, regional, city and township levels, including relevant departments.
Enforcement challenges	i. Lack of human resources and capacity of regional offices ii. Lack of incentive policies	i. Recruit new human resources and arrange capacity building training. ii. Formulate incentive policy for enforcement of environmental pollution.
Resource and financial challenges	i. Lack of financial capacity for establishing laboratory and technical training	i. Enhance cooperation with development partners to establish laboratory and capacity development training program on water and effluent quality monitoring.

2.9 Nepal

1 | Country Information

Table 2.9.1 Basic indicators

Land Area (km^2)		147,181*
Total Population		30.16 million**
GDP (current USD)		31.83 billion (2020)***
GDP per capita (current USD)		1,085 (2020)***
Average Precipitation (mm/year)		1,530 (2014)
Total Renewable Water Resources (km^3)		210.2 (2014)
Total Annual Freshwater Withdrawals (billion m^3)		29.31 (2017)
Annual Freshwater Withdrawals by Sector	Agriculture	98.26% (2017)
	Industry	1.7% (2017)
	Municipal (including domestic)	0.03% (2017)

* The country's official land area is being updated with reference to the new country map approved by the parliament in 2020
(Source: **NPC 2020 (2020 projection), ***GoN 2019, WEPA 2018)

Figure 2.9.1 Trishuli River in Nepal

2 | State of Water Resources

Nepal has abundant water resources. Average annual precipitation is around 1,500 mm, ranging from over 6,000 mm along the southern slopes of the Annapurna Range in central Nepal to less than 250 mm in the north-central portion near the Tibetan plateau. About 10% of total precipitation in Nepal falls as snow, mostly in the 23% of Nepal's total area that lies above the permanent snowline of 5,000 m. There are 3,252 glaciers covering an area of 5,323 km^2 (or 3.6% of Nepal's total area), with an estimated ice reserve of 481 km^3, and 2,323 glacial lakes, covering an area of 75 km^2. The snow-capped Himalayas is the main source of rivers in the country, especially during the dry season.

There are about 6,000 rivers in Nepal, with a total drainage area of 191,000 km^2, 74% of which lies in Nepal. Three categories of river systems predominate, based on their origin. The first comprises four main river systems from east to west, respectively: Koshi, Gandaki, Karnali, and Mahakali river systems, all of which originate from glaciers or snow-fed lakes in the Himalayas. River systems in the second category originate in the Mahabharat range in the mid-hills, and include Babai, West Rapti, Bagmati, Kamala, Kankai and Mechi river systems. River systems in the third category include streams or rivulets from the Chure hills bordering the Terai plain region in south Nepal, the streams and rivulets of which generally cause flash-flood during monsoon rains and remain dry or with very low flow during the dry season.

An assessment has identified 5,358 wetlands in Nepal including high altitude glacier lakes in the Himalayas, natural lakes as well as ponds, dams and other small wetlands (NLCDC 2009). Of these, 329 lakes (including ponds, small wetlands) up to 3,000 m elevation are roughly evenly distributed across seven provinces of Nepal, except in the far west where there are only 21 lakes (Table 2.9.2) (NLCDC 2018).

Table2.9.2 Distribution of lakes in seven provinces in Nepal

Province	Total Lakes
Province No. 1	73
Province No. 2	86
Bagmati Province	36
Gandaki Province	61
Lumbini Province	52
Karnali Province	14
Sudurpashim Province	7
Total	**329**

(Source: NLCDC 2018)

The annual rechargeable groundwater reserve is 8.8 billion m^3, of which less than 2 billion m^3 is currently extracted, mostly for groundwater irrigation in the southern Terai region (WECS 2011). Usually, people living in the Terai (lowland), inner valleys in the hills and mountains extract groundwater for domestic as well as industrial uses.

3 | State of Ambient Water Quality

Water quality of public water bodies is generally considered good. However, urban areas, especially

Kathmandu Valley and Pokhara, suffer from degradation due to direct disposal of huge volumes of untreated or insufficiently treated domestic and industrial wastewater. Solid waste dumped directly into rivers and lakes also negatively contribute to state of water environment.

Increased use of fertilizers and pesticides also impact water quality of surface and groundwater, especially, in peri-urban areas where commercial farming (such as vegetables) is extensive. During the rainy season there are increased incidences of water borne diseases due to unsafe drinking water and sanitation, especially, in rural areas.

3.1 Rivers

Table 2.9.3 and 2.9.4 summarizes the state of water quality in some key locations. Pollution of rivers in urban areas, soil erosion in rural areas, mining of sand and rocks are the three main factors impacting river water quality. Sedimentation in rivers is prominent in the rainy season due to soil erosion and runoff. Development activities such as sand mining, encroachment of river banks and improper river bank protection works have also caused serious sedimentation issues. Over the last decade increased mining of sands, stones by small and medium-sized crusher enterprises have resulted in increased sedimentation in the rivers, with serious turbidity and ecological impacts (such as changing courses of rivers and river bank erosion).

Table 2.9.4 State of water quality in selected river system

Location / River	pH	TDS (mg/L)	DO (mg/L)	BOD (mg/L)
Mechi	8.3	30	8.9	1.8
Kankai	7.7	60	8.7	2
Arun	6.2	200	9.1	2.1
East Rapti (Sauraha)	7.8	213	8.7	2.5
Seti (Ramghat)	8.2	222	9.3	2
Bheri (Chatagaon)	7.8	208	9.3	1.1
Karnali (Chisapani)	7.8	264	10.5	1.5
Mahakali (Pancheswor)	8.8	110	5	2
Desired value	*6.5–8.5**	*<1000**	*>5.0*	*<30*

* NDWQS : National Drinking Water Standard

(Source: Department of Hydrology and Meteorology 2018)

Table 2.9.3 State of water quality in selected rivers across Nepal shown for upstream-downstream sections (2016)

	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	EC (μS/cm)	NH_3-N (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	TOC (mg/L)	TH (mg/L)	Mg (mg/L)	Fe (mg/L)	TC (MPN/ 100ml)	E-coli (MPN/ 100ml)
Desired Value	6.5–8.5*	>5	<30	<250	<1000*	<1500*	<1.5*	<50*	-	-	<500*	<100*	<0.3*	0*	0*
Bagmati (Sundarijal-Khokana**)	6.6–7.4**	14.8–1.2	9.6–90.5	24.8–192	380–810	460–970	10–70	0.1–0.3	0.1–0.1	6.8–30	140–90	21.1–10.6	0.5–3.9	500–900	40–50
Bishnumati (Budhanilkantha-Teku Dovan)	7–7.5	12.5–0.9	15.4–167	36.7–178	120–920	187–1360	90–90	0.5–0.5	0.2–0.1	22.6–34.6	160–130	24.5–43.7	0.5–5.7	900–1600	110–170
Nakhu- Saibu	8–8.1	2.1–7.1	40.5–5.4	78–15.9	120–920	650–300	90–30	0.5–0.2	0.13–<0.1	12.1–3.6	100–120	12.3–24.7	4.2 –2.8	1600–900	110–70
Hanumante (Sallaghari-Thimi)	8.5–7.3	1.8–15.1	33.0–48.9	120–90.7	1530–1290	1800–1600	160–180	2.4–2.7	0.2–0.1	45.6–26.7	80–120	9.8–10.2	6.4–6.5	1600–1600	120–90
Manahara (Pepsikola-Balkumari)	7.4–7.6	7.0–3.9	14.5–23.8	23.7–40.5	620–980	870–1450	60–60	2.3–2.0	0.2–0.2	4.5–12.8	60–80	7.8–11.8	4.9–6.1	1600–500	140–40
Seti Pokhara (Mardi- Dobila)	7.4–7.6	8.1–8.7	1.2–1.3	2.4–2.6	110–150	130–170	1.5–2.8	0.13–0.1	0.05–0.01	2.0–2.0	120–170	9.8–6.9	0.3–3.8	500–500	50–40
Narayani (Bridge-Devghat mixed)	7.3–7.1	11.2–9.7	0.88–1.5	2.5–3.5	170–160	200–180	2.0–1.1	3.5–3.9	0.1 –0.1	2.0–5.0	340–180	25.6–22.9	0.2–0.3	900–900	60–70
Sirsiya (Parwanipur - Ghadiharwa Pokhara)	6.5–6.6	1.1–1.1	87.3–88.6	123.1–78	390–750	410–710	80.0–90.0	8.9–3.6	0.1 –0.2	23.0–33.0	300–240	24.6–25.9	3.9–3.7	1600–900	170–110
Tinau (Jhumsa bridge-Radhakrishna Tole)	7.2–7.5	10.4–9.5	1.6–1.5	2.6–3.9	200–220	220–220	0.9–1.0	0.5–0.5	0.02–0.01	4.0–4.0	200–200	14.5–9.8	0.1–0.1	900–500	70–30

* NDWQS : National Drinking Water Standard
** corresponds to upstream and downstream sections of the rivers shown in the table.

(Source: GoN 2016)

3.2 Lakes and Reservoirs

Lake water in the country is generally good. However, some lakes are under pressure from economic development, tourism activities, and population. Table 2.9.5 shows the state of water quality in two lakes, one in Kathmandu and the other in Pokhara. In the Phewa Lake, which a major tourist attraction in Pokhara, there are several hotels and residents established along the lake. Disposal of wastewater into the lake often causes eutrophication and algal bloom at several locations.

Table 2.9.5 State of water quality in the Phewa Lake (Pokhara) and Taudaha (Kathmandu) (2016)

	pH	DO (mg/L)	BOD (mg/L)	COD (mg/L	TDS (mg/L)	EC (µS/cm)	NH_3-N (mg/L)	NO_3-N (mg/L)	NO_2-N (mg/L)	TOC (mg/L)	TH (mg/L)	Mg (mg/L)	Fe (mg/L)	TC (MPN/ 100m)	E-coli (MPN/ 100m)
Desired Value	6.5–8.5*	>5	<30	<250	<1000*	<1500*	<1.5*	<50*	-	-	<500*	<100*	<0.3*	0*	0*
Phewa Lake (Halanchowk - Dam site), Pokhara	7.5–7.6	7.9–8.0	2.5–2.1	5.7–5.7	50–50	50–60	1.6–1.6	0.11–0.16	0.07–0.07	5–4	120–120	6.7–11.1	0.1–0.1	900–900	70–70
Taudaha (Locations 1-3), Kathmandu	8.2–8.1	8.9–8.9	17.1–25.9	24.5–33.8	90–85	175–167	50–37.8	0.3–1.0	0.1–0.1	10.1–13.8	160–130	12.8–19.4	0.9–0.8	900–500	70–40

* NDWQS : National Drinking Water Standard (Source: GoN 2016)

3.3 Groundwater

Groundwater contamination in Nepal is caused by pathogenic bacteria, pesticides, nitrate and effluents from industrial and domestic sources. Unplanned urban development and insufficient waste management facilities are the main causes of groundwater pollution in rural areas. In Kathmandu Valley, long-term deterioration of groundwater quality is continuously being reported such as nitrogen contamination in shallow wells (Shakya et al. 2019). Table 2.9.6 shows groundwater quality at key locations.

Table 2.9.6 State of groundwater quality in selected locations

		Temp. (°C)	pH	EC (µS/cm)	Turbidity (NTU)	Hardness (mg/L)	Cl (mg/L)	Total Alkalinity (mg/L)	Fe (mg/L)	As (mg/L)	F (mg/L)
Desired value		-	6.5–8.5*	<1500*	<5*	<500*	<500*	-	<0.3*	<0.05*	0.5–1.5*
Kathmandu Valley	Shallow Well	18.6	7.1	874.5	45.9	230.7	81.8	366.0	1.47	0.004	0.43
	Tube Well	17.9	7.0	576.8	54.8	218.8	61.1	258.0	1.90	0.003	0.27
	Deep Tube Well	20.3	7.0	704.2	33.2	251.2	59.0	302.7	1.80	0.009	0.74
East Terai (Jhapa, Morang and Sunsari) (2018)**	Groundwater	27	6.9	445	12.7	191.6	17	197.6	1.83	0.005	0.235
Far west Terai (Kailali) (2014)***	Groundwater	25.6	6.96	838.25	22.13	323	24.88	-	2.01	0.01	0.25

* NDWQS : National Drinking Water Standard (Source: **Mahato et al. 2018, ***Gurung et al. 2015)

4 | State of Wastewater Treatment

Discharge of untreated wastewaters and dumping of septic sludge from on-site sanitation systems into rivers is common due to lack of adequate facilities to treat wastewater. An estimated 876 million liters per day (MLD) of domestic wastewater is generated in Nepal, as shown in Figure 2.9.2 About 70% of this comes from on-site sanitation (faecal sludge) and only 30% of wastewater is collected through sewer networks. However, of the collected wastewater, only around 7% is treated while 93% (i.e. 268 MLD) is disposed of untreated. An estimated 20.1 MLD of wastewater is treated either in centralized WWTP or DEWATS systems.

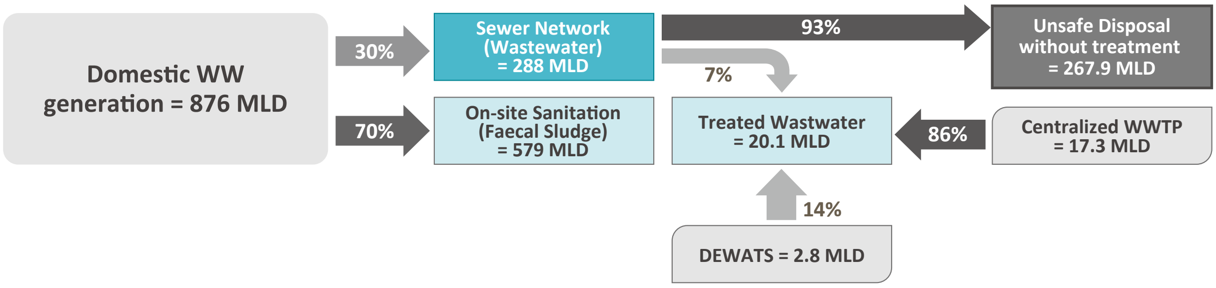


Figure 2.9.2 Domestic wastewater (WW) management in Nepal as of 2017 (Source: GoN 2018)

Septic tanks and pit latrines in urban localities have posed the risk of ground water pollution. Rapid, unplanned urban growth and the lack of adequate investment are responsible for the current poor state of wastewater management in Nepal, especially Kathmandu Valley.

Management of industrial wastewater is largely unknown due to lack of reported data, while the Department of Environment lacks the resources and capacity (human resources for monitoring/sampling and analysis labs) to enforce compliance with existing effluent standards. Industries, especially small and medium-sized enterprises, are unable to invest in costly treatment facilities as relevant acts and regulations on effluent discharge came into effect several years after these industries were established.

The tariff for wastewater in Nepal is based on water consumption either metered (block tariffs) or unmetered (flat rate) according to pipe size. Kathmandu Upatyaka Khanepani Limited (KUKL) tariff for sewer connection (and wastewater treatment, if available) is 50% of the water consumption fee (KUKL 2021).

5 | Frameworks for Water Environmental Management

5.1 Legislation

Nepal has enacted various acts and regulations related to the environment and water since the 1980s such as the Water Resource Act (1992), Drinking Water Rules (1998), Water Resource Strategy (2002), Drinking Water Quality Standards (2005). After Nepal become a federal republic comprising three layers of government (local, provincial and state), the new Constitution of Nepal 2015 (2072 BS) guaranteed the rights to a clean environment, healthcare and conservation, management and use of natural resources. The constitution also ensures the right of access to basic clean drinking water and sanitation services. Several articles of the constitution have provisions on water and the environment, while the government is either revising or in the process of finalizing new acts and regulations as part of legal or institutional reform under the new federal administration (Table 2.9.7). The Environment Protection Act (2019),

Table 2.9.7 Key provisions related to water environment in the new constitution and recent acts and policy documents

Name	Category	Year	Purpose/arrangements
Constitution of Nepal	Constitution	2015	Every citizen shall have the right to live in a clean and healthy environment; victims of environmental pollution shall be entitled the right to compensation from the polluter; right of access to basic clean drinking water and sanitation services; conservation and multiple uses of water resources; use of forests and water resources and management of environment
Environment Protection Act	Act	2019	The umbrella Act governing over all environmental protection issues of the country.
Forest Act	Act	2019	This Act governs all forest and related resources focusing on forest management, while contributing to the conservation of wildlife, environment, and water resources.
National Climate Change Policy, 2019	Policy	2019	Utilizes opportunities for various types of assistance through the framework of conventions for the purpose of climate change management in line with the national priority and local needs while complying with international provisions.
National Environment Policy 2019	Policy	2019	Guides the implementation of environment related laws and other thematic laws, realizes international commitments and enables collaboration between all concerned government agencies and non-government organizations on environmental management actions.
National Water Resources Policy	Policy	2020	The policy aims to cover all aspects of water resources development and management based on the Integrated Water Resources Management (IWRM) principle and newly restructured three tiers of government.
Environment Protection Rules	Rule	2020	This Rule is based on the new Environment Protection Act 2019.
Water Supply and Sanitation Act	Act	Under Parliament	This Act governs all water supply and sanitation protection of the country.
Water Resources Act (Draft)	Act	Under drafting	The draft Act will be the new water resources act for the execution of new policy which covers all aspects of water resources development and management.

National Environment Policy (2019), National Climate Change Policy (2019), and Integrated National Water Resources Policy (2020) are prominent acts/policies issued since adoption of the new constitution. The Water Supply and Sanitation Act is currently awaiting approval in the parliament while the Integrated National Water Resources Act is in the final stage of drafting.

5.2 Institutional Arrangement

The Ministry of Forests and Environment is responsible for environmental protection through managing and coordinating the country's environmental protection policies and measures. The Department of Hydrology and Meteorology (DHM) under Ministry of Energy, Water Resources and Irrigation (MOEWRI) implements and coordinates the monitoring of river hydrology, climate, agro-meteorology, sediment, air quality, water quality, limnology, snow hydrology, glaciology, and wind and solar energy. The Groundwater Resources Development Board monitors the quality of underground as well as surface water. The Water and Energy Commission Secretariat (WECS) has assumed the role of apex body for national planning related to water and energy through the formulation and provision of assistance to water and energy-related policy and strategy development. WECS is also mandated to ensure sustainability by integrating environmental agenda into development policies. Various ministries and line agencies at the national level promote water and environmental management, requiring these ministries to coordinate the work between them (Table 2.9.8).

Table 2.9.8 Key institutions and mandated areas relevant to water environment

Name of the Institution	Level	Mandated Working Area
Ministry of Energy, Water Resources and Irrigation (MOEWRI)	Central	Overall Energy, Hydropower, Irrigation and Water Resources development of the country.
Department of Water Resources and Irrigation	Central	Department of Water Resources and Irrigation is responsible for planning, developing, implementing and monitoring of various central level surface and groundwater irrigation systems by utilizing available surface and ground water resources.
Department of Hydrology and Meteorology (DHM)	Central	DHM is responsible for collecting, processing, publishing and disseminating hydrological and meteorological data and monitoring river hydrology, water quality, sediment, limnology, snow hydrology, glaciology, weather, climate, agro-meteorology, air quality and solar energy in the country.
Water and Energy Commission Secretariat (WECS)	Central	Policy and planning regarding energy and water resources development and management covering all sectors. Advisory role on critical issues related to large water resources projects.
Ministry of Water Supply (MWS)	Central	Water supply, sanitation and hygiene development and management of the country.
Department of Water Supply and Sewerage Management (DWSSM)	Central	The Department of Water Supply and Sewerage Management (DWSSM) is responsible for planning, implementing, operating and maintenance of water supply and sanitation systems throughout the country.
Nepal Water Supply Corporation (NWSC)	National Corporation	NWSC is a public utility organization and autonomous government body, and provides drinking water supply services to the 20 cities within the country.
Ministry of Forests and Environment (MOFE)	Central	Forest resources and environmental development, with a mandate covering environmental management and enforcement.
Department of Environment	Central	Responsible for the implementation and compliance of Environmental Protection Act, and Rule (EPR), and pollution control standard as promulgated by the Government of Nepal.
Ministry of Urban Development	Central	Overall urban planning, development and Management for the development of municipalities in the country.
Ministry of Physical Infrastructure Development	Provincial	Provincial level policy planning formulation and development of various physical infrastructure, and their environmental management.
Ministries of Industry, Tourism, and Forests and Environment	Provincial	Provincial level policy planning formulation and development related to forests, environment, conservation of biodiversity, adaptation to climate change and science and technology.
Kathmandu Upatyaka Khanepani Limited (KUKL)	Kathmandu Valley	KUKL is responsible for the operation and management of water and wastewater services in the Valley, and will assume responsibility for infrastructure built by the Melamchi Water Supply Project.
Local Units	Local	Local level planning and development in close coordination with the province.

5.3 Water Quality Standards

Ambient water quality standards

There are separate standards and guidelines for different uses (drinking water, irrigation, aquaculture, livestock, and recreation) in addition to Nepal Water Quality Guidelines for the Protection of Aquatic Ecosystem (2008).

Monitoring framework

Systematic ambient water quality monitoring is not yet conducted in public water bodies in the country, although water quality is monitored by different ministries and agencies for different purposes. For instance, regular monitoring of the water quality of the Bagmati River in the Kathmandu Valley area is conducted by the High Powered Committee for the Integrated Development of the Baghmati Civilization, which started publishing data for the general public in February 2014. Department of Hydrology and Meteorology under the MOEWRI monitors river and lake water quality. For drinking water, water supply providers are required to monitor different water quality parameters under the surveillance of concerned agencies under the Ministry of Population and Health (Table 2.9.9). Figure 2.9.3 shows the institutional framework of Water Quality Surveillance.

Table 2.9.9 Drinking water quality parameters used in monitoring

No.	Category	Parameters	Monitoring Frequency	Monitoring Institution	Surveillance Agency
1	Physical	Turbidity, pH, Colour, Taste and Odour	Daily	Water Supply Providers	Ministry of Population and Health and its line agencies
2		EC	Monthly		
3		TDS	Quarterly		
4	Chemical	Residual Chlorine	Daily		
5		Ammonia, Chloride, Nitrate, Total Hardness, Calcium	Monthly		
6		Iron, Manganese, Sulphate, Arsenic, Cadmium, Copper, Fluoride, Cyanide, Lead, Chromium, Zinc, Mercury, Aluminum	Yearly		
7	Microbiological	E. coli, Total coliform	Monthly		

(Source: GoN/MoHP 2018)

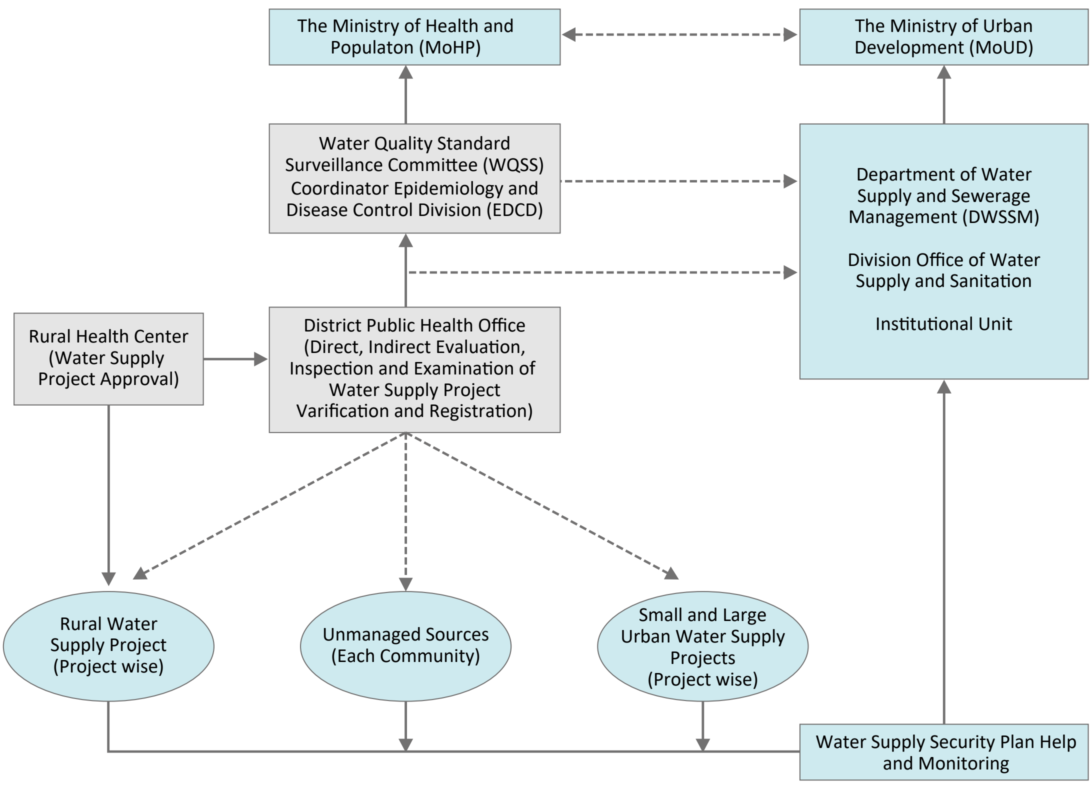


Figure 2.9.3 Institutional framework of national drinking water quality surveillance (Source: GoN/MoHP 2018)

5.4 Effluent Standards

Effluent standards

Effluent standards for different pollution sources are also set up under the EPA as follows:

- Tolerance limits for industrial effluent discharged into inland surface waters (generic)
- Tolerance limits for specific industrial effluent discharged into inland surface waters (tanning, wool processing, fermentation, vegetable ghee and oil, paper and pulp, dairy products, sugar milling, cotton textiles, non-alcoholic beverages, pharmaceuticals, soap, paints, etc.)
- Tolerance limits for industrial effluent discharged into public sewers
- Tolerance limits for wastewater discharged into inland surface waters from combined wastewater treatment plants

Effluent inspection procedure

Inspection mechanisms and procedures are guided by the water quality monitoring framework, guidelines and responsibilities under relevant line ministries or departments dealing with drinking water, industry, and agro-farms.

Measures against non-compliance

Penalties are imposed for non-compliance, although enforcement is sporadic due to gaps in monitoring capacity of the concerned agencies. Instances of enforcement have taken place, such as the MOFE decision in 2019 requesting penalties for non-complying medical institutes.

6 | Recent Developments in Water Environmental Management

The government has substantially strengthened environment-related legislations, acts, policies, and guidelines related to the water environment. Under its federal structure, the government is also revising or drafting acts and legislations and establishing new institutional structures at federal, provincial, and local levels. The establishment of Ministry of Water Supply reflects the government's national and international commitments and increasing prioritization of the water, sanitation and hygiene (WASH) sector together with relevant goals and targets, especially the Sustainable Development Goal on water and sanitation. Nepal has set its national indicators for WASH-related targets, such as ensuring access to piped water supply and improved sanitation by 2030 for 95% of the population.

7 | Challenges and Future Plans

A major challenge for water environment governance in Nepal is the actual implementation of acts, policies, and guidelines to ensure effective monitoring and enforcement at federal, provincial, and local levels. Coordination among line institutes such as water resources (MOEWRI), water supply (MWS), and environment (MOFE) at different levels is a big challenge due to overlapping mandates, resource constraints, multiple sector priorities, and lack of technical expertise or capacity. Although the federal structure grants autonomy regarding power and decision making down to local levels, institutional establishment, allocation of trained staffs, and establishment of monitoring and assessment facilities are still in their infancy.

Nepal is aiming to rapidly develop and transition from Least Developed to Developed status such as through investments in industrialization, construction, tourism, and modernization of agriculture. For instance, rivers in Nepal are under pressure from mining industries (formal and informal), contributing to high levels of sedimentation due to high demand for construction materials. It is thus evident that the water environment will come under greater pressures going forward, meaning the level of water governance capacity of the concerned agencies as well as stakeholders needs to be substantially improved.

2.10 Philippines

1 | Country Information

Table 2.10.1 Basic indicators

Land Area (km²)		300,000 (2020)*
Total Population		104.9 million (2017)*
GDP (current USD)		376.8 billion (2019)**
GDP per capita (current USD)		3,512 (2019)**
Average Precipitation (mm/year)		2,348 (2017)***
Total Renewable Water Resources (km^3)		479 (2017)***
Total Annual Freshwater Withdrawals (billion m^3)		92.75 (2017)***
Annual Freshwater Withdrawals by Sector	Agriculture	73.28% (2017)***
	Industry	17.09% (2017)***
	Municipal (including domestic)	9.63% (2017)***

*Estimated (Sources: **BSP 2020, ***FAO AQUASTAT 2020)

Figure 2.10.1 Anilao River in Ormoc City, Philippines

2 | State of Water Resources

The Philippines is an archipelagic country with a tropical and monsoon climate endowed with coastal bays, rivers, lakes, and groundwater. It has abundant water resources with water availability of 5,302 m^3/year/capita, which varies according to topography and season. River basins are classified according to size, by the National Water Resources Board (NWRB). Around 421 have catchment areas of over 40 km^2. There are 18 with areas over 1,400 km^2 (typologically classified as major river basins), occupying over a third (i.e., 108,923 km^2) of total land area, as shown in Table 2.10.2. Owing to their significance for water sources for industry, agriculture and domestic uses, and ecological stability, the government considers protection and conservation of these rivers a high priority for overall socio-economic development and sustainability.

Table 2.10.2 Major River basins in the Philippines

Name of River Basin	Catchment Area (km^2)	River Length (km)
Cagayan	25,649	505
Mindanao	23,169	373
Agusan	10,921	350
Pampanga	9,759	260
Agno	5,952	206
Abra	5,125	178
Pasig-Laguna de Bay	4,678	78
Bicol	3,771	136
Abulug	3,372	175
Tagum-Libuganon	3,064	89
Ilog-Hilabangan	1,945	124
Panay	1,843	132
Agus	1,890	36
Tagoloan	1,704	106
Davao	1,623	150
Cagayan de Oro	1,521	90
Jalaur	1,503	123
Buayan-Malungon	1,434	60
Total	**108,923**	

(Source: NWRB)

According to a report from the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture (DA), there are 79 natural lakes in the Philippines, which are utilized for fish production. Ten of the lakes are considered as major hosts for aquaculture production, including the Laguna Lake (Laguna de Bay), which the largest inland freshwater body in the Philippines. Since the country consists of numerous islands, the marine waters cover an area of about 266,000 km^2, with a coastline length of 36,289 km. Around 70% of municipalities are located in coastal areas.

Surface water is the main water source for the country. Another important source of water for domestic supply, irrigation, and industrial uses is in the form of an extensive groundwater reservoir.

3 | State of Ambient Water Quality

The rapid increase in population, urbanization, and industrial development has led to water quality degradation and deterioration. Figure 2.10.2 shows the four key sources of water pollution. Water classification or reclassification based on the water quality criteria serves as the benchmark for maintaining or improving the state of water quality management in the Philippines. In 2019, the Environmental Management Bureau (EMB) completed its classification of 898 water bodies based on the uses (such as public water supply, agricultural, aquacultural, commercial, industrial, navigational, recreational, wildlife conservation and aesthetic purposes) and water quality to be maintained (EMB 2019).

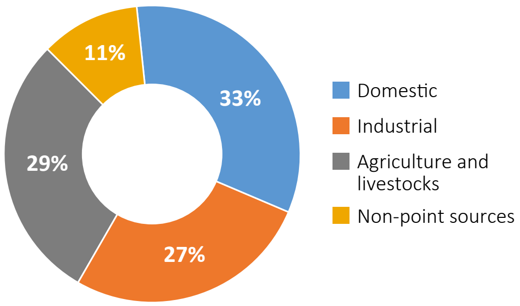


Figure 2.10.2 Major sources of water pollution in the Philippines based on BOD loading (Source: EMB 2014)

3.1 Rivers

There are 321 classified principal rivers with drainage areas of 40 km^2 or more for monitoring, accounting for 76% of the country's 421 Principal Rivers identified by NWRB (EMB 2019). The objective of monitoring principal rivers is to improve water quality and comply with the DENR Administrative Order No. 2016-08 or the Water Quality Guidelines and General Effluent Standards of 2016. Of the 421 Principal Rivers, 180 suffer from water pollution, mainly due to domestic wastes (fecal coliform) and industrial and agricultural wastes. Monthly water quality monitoring conducted in 46 Priority Rivers during 2019 found that 34 rivers were within the BOD criteria and 37 were within the DO criteria. An additional 180 rivers were monitored throughout the Philippines for DO, of which 82% were within the water quality guideline value.

With the intention of reducing floating garbage, which is noticeable in some waterways and creeks, the country implemented the Adopt-an-Estero Waterbody Program. The measures implemented include increased frequency of dredging and de-clogging activities, improved waste collection efficiency, faster flooding abatement, complementary local policies and programs and employment for some communities along the adopted waterbodies. After an extensive clean-up carried out by 29,391 individuals from partner adopters, LGUs and communities within the adopted waterbodies, 2,065.3 tons of mixed solid waste were recovered. Of the 407 esteros or waterbodies monitored in 2019, 153 exhibited significant improvement in BOD and 147 showed improvements in DO level.

3.2 Lakes and Reservoirs

Deterioration of water quality is one of the core management issues regarding the Laguna Lake (Laguna de Bay). Pollution of the lake mainly derives from domestic (77%), agriculture (11%), industry (11%) and forestry (1%) sources. Table 2.10.3 summarizes the water quality from lakes and of tributaries feeding into the Laguna Lake (Laguna de Bay). While there have been improvements in the water quality of the lake for several parameters, that of the tributaries is of Class D or Failed status.

Table 2.10.3 Observed water quality in the Laguna Lake (Laguna de Bay) and its tributaries in 2018

		Class A	Class B	Class C	Class D	Failed
DO	mg/L	>5	>5	>5	2–5	<2
	% of monitoring points	100% (43%)*			(19%)	(38%)
BOD	mg/L	<3	3–5	5–7	7–15	>15
	% of monitoring points	100% (24%)	(19%)	(11%)	(3%)	(43%)
NO_3^-	mg/L	≤7	≤7	≤7	7–15	>15
	% of monitoring points	100% (100%)				
PO_4^{3-}	mg/L	≤0.5	≤0.5	≤0.5	0.5–5	>5
	% of monitoring points	100% (47%)			(50%)	(3%)
Fecal coliform	MPN/100 ml	<1.1	1.1–100	100–200	200–400	>400
	% of monitoring points	(N/A)	100% (N/A)	(N/A)	(N/A)	(N/A)

Note: There were a total of nine monitoring points in the lake and 35 along the tributaries; *figures in parentheses refer to tributaries

(Source: LLDA 2018)

3.3 Coastal Water

In 2019 the EMB monitored 39 priority recreational waters (bathing beaches) for Fecal Coliform and found that 64% of beaches were within the water quality guideline value. Similarly, pH was monitored in 33 recreational waters, 97% of which had values within the criteria. In addition to priority bathing beaches, 174 bathing beaches were monitored for Fecal Coliform and 157 for pH, 97 of which passed the water quality criteria for Class SB waters for Fecal Coliform and 151 passed the water quality standard for pH. Table 2.10.4 shows the water quality state in the Manila Bay bathing beaches.

Table 2.10.4 Average Dissolved Oxygen (DO), Phosphate (PO_4^{3-}), and Nitrate (NO_3^-) in the Manila Bay Beaches (National Capital Region), 2018

Manila Bay Bathing Beaches Monitoring Station	DO	Phosphate (PO_4^{3-})	Nitrate (NO_3^-)
Navotas	2.59	0.2	0.33
Luneta	3.9	0.16	0.38
Cultural Center of the Philippines (CCP)	2.8	0.33	0.36
Mall of Asia (MOA)	0.9	0.51	0.33
PEATC	4.9	0.25	0.33
Water Quality Guidelines Class "SB" DAO 2016–08	*6*	*0.5*	*10*

(Source: EMB 2019)

3.4 Groundwater

The status of groundwater quality is assessed through the Philippine National Standard for Drinking Water under the Tap Watch Program of the EMB, which monitors 88 shallow wells in the country. Under the program, it was found that nearly 58% of groundwater samples in selected sampling sites were contaminated with coliform, meaning treatment is required. The increased level of salinity in groundwater is another concern, especially near coastal areas of major cities such as Metro Manila and Metro Cebu, the cause of which is assumed to be over-abstraction of groundwater.

4 | State of Wastewater Treatment

Domestic wastewater

Only 10% of domestic wastewater is treated, while only 5% of the total population is connected to a sewer network. Those not connected rely on septic tanks, pit latrines, or practice open defecation, while the vast majority use flush toilets connected to septic tanks while.

In Metro Manila, 43 sewage treatment plants (STPs) and septage treatment plants (SpTPs) serve over a million residents (around 9%) of the population. An average 9.4 million kg of BOD was removed per year over the most recent four-year period. The highest pollution load reduction was attained in 2012 with 9.5 million kg of BOD removed.

There are ongoing and planned wastewater treatment projects to treat domestic wastewater in major cities or under certain housing schemes.

Industrial wastewater

As of October 2017, there were 379 operating special economic zones in the Philippines; 261 Information Technology Parks, 74 Manufacturing Economic Zones, 22 Agro-Industrial Economic Zones, 20 Tourism Economic Zones and 2 Medical Tourism Centers. Four zones are owned by the Philippine Economic Zone Authority (PEZA) while the remaining are privately owned. The majority of manufacturing industries in the Philippines are located in the National Capital Region (30%), Region 4A- Calabarzon (17%), and Region 3- Central Luzon (11%).

Industries that are known to generate large amounts of wastewater are food and dairy manufacturing, pulp and paper, and textiles, though very little related data exists. Volumes generated by each industry depend mainly on the level of technical processing and production rates, as shown in Table 2.10.5.

Table 2.10.5 Estimated wastewater generation rates of selected industry types in the Philippines

Industry	Wastewater volume from industrial use ('process wastewater')(m^3/day)
Poultry processing plant	1,750
Meat and meat products	75–380
Mining	67,500
Pharmaceuticals manufacturing	50–200
Milk manufacturing	960
Ethanol manufacturing	3,100
Sugarcane milling	100,000
Beverage manufacturing	13,000
Packaging	60
Food processing	500
Pineapple processing	6,540

(Source: ARCOWA 2018)

Industrial wastewater generally contains high BOD loads and other kinds of pollutants, depending on the type of manufacturing process. Table 2.10.6 shows the indicative wastewater quality of selected industry types.

Individual companies have obligations to manage their wastewater either as stand-alone entities or as part

Table 2.10.6 Indicative wastewater quality of selected industry types in the Philippines

Industry	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	Temp. (˚C)	pH
Sugarcane milling	2,000–3,500	6,000	800–1,000	–	6.5–8.0
Ethanol manufacturing	60,000	110,000	6,000	48–50	4–4.5
Fish product canning	30,000	45000	10,700	25	6.5–7.5
Beverage manufacturing	900	1,500	250	25	44,147
Meat processing	1,000–1,500	2,000	250	-	7
Copper cathode	-	-	43	30.4	8.15
Swine farms	2,000–4,200	4,000–5,429	1,600–5,380	-	-
Bottling services	400	1,647.05	90	32.2	8.35
Desiccated coconut manufacturing	6,000–10,000	17,000–20,000	2,000–4,000	-	5.0–6.3
Pineapple processing	10,200	20,000	585	40–50	4.5–6.5

(Source: ARCOWA 2018)

of an industrial park. Ideally, the process wastewater and other non-domestic wastewater are pre-treated by industries before discharging the effluent into the sewerage system of the industrial park. Many industrial parks operate their own, however, these are still required to comply with pre-treatment effluent standards established by the industrial park before discharge into the centralized wastewater treatment facility (CWTF) of the park. The CWTF within the industrial park shall further treat the effluent from industries before discharging it into bodies of water or reuse for landscaping, irrigation or other purposes. Recent regulations on nutrients have been a challenge for CWTF operators as existing treatment systems are not designed to remove nutrients such as nitrates and phosphates to the levels required.

For industries not located within an industrial park, effluent must comply with the Philippine Effluent Standards, DAO 2016-08. However, some industries find managing wastewater challenging as they have to develop their own expertise to comply with effluent standards set either by the special economic zone or with general effluent standards.

Individual companies generally collect and report their wastewater volume data as required by the regulations, though there is no national database collating all these data. Individual industrial facilities, outside of special economic zones, need to acquire a wastewater discharge permit and are responsible for the quality of their discharge to surface waters. From the monitoring conducted by the EMB, rivers of the regions had “unsatisfactory ratings” for their water quality criteria. In areas of regulation, in the Manila Bay Area alone, 5,228 out of 10,168 industries were served with Notices of Violation (NOV) for failure to acquire permits to discharge treated wastewater.

The wastewater charge formula was established in 2005 (DAO 2005-10) on the basis of payment to the government for discharging wastewater into water bodies in all water management areas. The concept behind this was to incentivize those who discharge pollutants to reduce their pollution loads, such as through improved production processes and investment in pollution control technologies. DENR also issues discharge permits for wastewater, which include the allowable values of both quantity and quality of effluents, compliance schedule and monitoring requirements.

5 | Frameworks for Water Environmental Management

5.1 Legislation

The Philippines has an extensive body of water-related legislation that provides the legal basis for policies and regulations concerning water resource management of the country. The Philippine Clean Water Act of 2004 (Republic Act No. 9275 (RA 9275)) provides a comprehensive and Integrated strategy to prevent and minimize pollution through a multi-sectoral and participatory approach involving all the stakeholders. The Act aims to protect the country's water bodies from pollution from land-based sources (industries and commercial establishments, agriculture, and community/household activities). The Act applies to water quality management in all water bodies, abatement and control of pollution from land-based sources, and enforcement of water quality standards, regulations and penalties.

Under Section 5 of RA 9275, Department of Environment and Natural Resources (DENR) in coordination with the National Water Resources Board (NWRB) designates Water Quality Management Areas (WQMA) using appropriate physiographic units such as watershed, river basins or water resources regions. As such, WQMA have similar hydrological, hydrogeological, meteorological or geographic conditions which affect the physiochemical, biological and bacteriological reactions and diffusions of pollutants in the water bodies or otherwise share common interest or face similar development programs, prospects or problems. Governing boards, composed of relevant stakeholders in each WQMA and chaired by DENR regional offices, are responsible for the development of strategies to coordinate policies, regulations/local legislation, and other measures necessary to effectively implement the Clean Water Act.

The Water Quality Guidelines and General Effluent Standards of 2016 (DAO 2016-08) provide guidelines for the classification of water bodies in the country, determination of time trends and the evaluation of stages of deterioration/enhancement in water quality, and evaluation of the need for taking actions in preventing, controlling, or abating water pollution.

Other legislations related to water environmental conservation are the Philippines Environmental Policy (PD 1151) and the Solid Waste Management Act (RA 9003). EMB is the governmental agency responsible for water conservation and protection.

5.2 Institutional Arrangement

The lead agency for water resource management is the Department of Environment and Natural Resources (DENR). Its mandates are to formulate, integrate, coordinate, supervise, and implement all policies, plans, programs, projects and activities relative to the prevention and control of pollution as well as management and enhancement of environment. The responsibility for planning and managing water resources in the Philippines is shared among several government departments, bureaus and agencies (Table 2.10.7). In addition, local government units (LGUs) are required to provide water supply systems, communal irrigation facilities, implement social forestry and local flood control projects under the supervision and control of DENR (SEPO 2011). A number of institutions and agencies are involved in overseeing water governance at all levels.

5.3 Ambient Water Quality Standards

Ambient water quality standards

The Philippines uses its Water Quality Guidelines and General Effluent Standards (GES) of 2016 by DENR Administrative Order No. 2016-08 (DAO 2016-08) (an amendment of DAO 1990-35). DAO 2016-08 has a provision for the water classification of water bodies for the purpose of maintaining the quality of water based on beneficial usage (Table 2.10.8).

The water quality guidelines (WQG) are to be maintained for each water body classification, the parameters of which are categorized as primary or secondary. Primary parameters are the required minimum water quality parameters to be monitored for each water body. Secondary parameters are those used in baseline assessments as part of an environmental impact assessment or other water quality monitoring purposes.

Water quality monitoring framework

Regional offices of EMB conduct regular water quality monitoring throughout the country based on the parameters indicated in DAO 2016-08. From 2001 to 2016, 238 water bodies were monitored either for classification or for regular water quality monitoring, and depending on the resources, monitoring is carried out monthly or quarterly in accordance with the DENR-EMB Water Quality Monitoring manual (2009).

5.4 Effluent Standards

Effluent standards

DAO 2016-08 states that discharges from any point source shall at all times meet the effluent standards, and Section 7 of the same states that discharges from any point sources shall at all times meet the effluent standards set forth to maintain the required water quality per water body classification. The GES is to be used regardless of the industry category and volume of discharge. Effluent used for agricultural purposes shall conform to DAO 2007-26 and shall at all times meet the effluent standards.

Effluent inspection procedure

Monitoring in the industry is conducted at different levels (Table 2.10.9), and can only be carried out by the subjects needing to comply with effluent standards themselves, in principle. The documents to be submitted include monitoring reports (self-monitoring), plans, required permits (discharge permits) or other proof of compliance or implementation. Field monitoring for verification involves actual plant inspection, effluent sampling and validation of submitted reports.

Table 2.10.7 Key institutions involved in water governance in the Philippines

Name of the agency	Mandates of the agency
Department of Environment and Natural Resources (DENR)	The primary government agency responsible for the conservation, management, development, and proper use of the country's environment and natural resources.
National Water Resources Board (NWRB)	To administer/enforce the Water code and serve as the lead coordinator for water resources management programs.
Environmental Management Bureau (EMB)	To formulate, integrate, coordinate, supervise, and implement all policies, plans, programs, projects, and activities related to the prevention and control of pollution as well as management and enhancement of the environment.
Forest Management Bureau (FMB)	To formulate/implement policies and programs for the protection, development, occupancy management, and conservation of forest lands and watershed areas.
Department of Agriculture	
National Irrigation Administration (NIA)	To undertake water resource projects for agricultural irrigation and other purposes, such as flood control and drainage.
Bureau of Soil and Water Management (BSWM)	To formulate/implement policies and programs for the protection of existing and potential sources of soil and water for agricultural development.
Bureau of Fisheries and Aquatic Resources (BFAR)	To establish plans for the proper protection and management of the country's fisheries and aquatics resources.
Department of Health (DOH)	Administers compliance of the country's National Standard for Drinking Water Program.
Department of Interior and Local Government (DILG)	Administers implementation of the country's National Water Supply and Sanitation Program; mandated to oversee attainment of the country's SDG goal on access to safe drinking water by all.
Water Supply and Sanitation Unit	To provide capacity building programs for Local; Government Units (LGUs) in preparing local water supply and sanitation plans as well as providing information on available sector programs, and facilitating access to financing for water supply and sanitation projects.
Department of Public Works and Highways (DPWH)	Primary agency for implementing the country's national Sewerage and Septage Management.
National Economic and Development Authority (NEDA)	To coordinate the preparation of national/regional/sectorial development policies and investment programs, including those on sanitation.
National Power Corporation (NPC)	To develop and manage electric generation facilities including (but not limited to) hydroelectric dams and undertakes other activities related to watershed management.
Metro Manila Development Authority (MMDA)	Administers governance of MM area development such as infrastructure development, law enforcement of environmental laws - solid waste management, Clean Water Act, Water Code of the Philippines, Clean Air Act, etc.
Metropolitan Waterworks and Sewerage System (MWSS)	To regulate water concessionaires' rates and services standards in Metro Manila and maintain existing assets and infrastructures.
Pasig River Rehabilitation Commission (PRRC)	Coordinate and integrate, and monitor the implementation of all Government Agencies plans, and programs for the rehabilitation of Pasig river.
Laguna Lake Development Authority (LLDA)	To formulate, regulate and implement all policies, plans, programs, projects and activities related to the prevention and control of pollution as well as management and enhancement of environment in the Laguna Lake Region.
Local Water Utilities Administration (LWUA)	To promote, finance, and regulate the operation and construction of local water utilities outside Metro Manila.
Local Government Units (LGUs)	Administration/management of rivers within the jurisdiction of the LGUs and implementation of Ecological Solid Waste Management Act within its area of political and jurisdictional responsibility.

Table 2.10.8 Classification of water bodies according to intended beneficial use

Classification	Intended Beneficial Use
Class AA	Public Water Supply Class I – Intended primarily for waters having watersheds, which are uninhabited and otherwise protected, and which require only approved disinfection to meet the Philippine National Standards for Drinking Water (PNSDW)
Class A	Public Water Supply Class II – For sources of water supply requiring conventional treatment (coagulation, sedimentation, filtration and disinfection) to meet the latest PNSDW
Class B	Recreational Water Class I – Intended for primary contact recreation (bathing, swimming, skin diving, etc.)
Class C	Fishery Water for the propagation and growth of fish and other aquatic resources. Recreational Water Class II (Boating, fishing or similar activities). For agriculture, irrigation, and livestock watering)

Table 2.10.9 Monitoring of industries

Level	Responsible Person/Office	Report Requirement
Project Proponent/Company	Pollution Control Officer	Self-Monitoring Report (SMR) and/or (CMR) Compliance Monitoring Report
Multi-Partite Monitoring (MMT) or Third Party Monitoring	Team headed by the company composed of various Stakeholders (LGUs, Non-Government Organizations (NGOs) and other sectors)	Audit Report/CMR
Regulating body	EMB Central Office/EMB-Regional Offices	Compliance Evaluation Report

Measures against non-compliance

The Clean Water Act requires owners or operators of facilities that discharge regulated effluents to obtain a discharge permit, which is a legal authorization granted by the DENR to discharge wastewater. The permit specifies items such as quantity and quality of effluent, compliance schedule and monitoring requirements, and can be suspended or revoked if business entities fall out of compliance with the rules and regulations and/or permit conditions.

A number of industries and commercial establishments are still unable to comply with the effluent standards despite the availability of technology to treat wastewater. As shown in Table 2.10.10, about 54% or 4,930 of the 9,060 monitored firms nationwide were found to have violated effluent standards in 2019. There are still micro-, small and medium-sized enterprises which do not invest in facilities to treat their wastewater prior to discharge to water bodies resulting in the degradation of rivers, lakes and marine waters.

Table 2.10.10 Percentage of compliance of firms in 2018 and 2019

Details	2018	2019
Discharge permits issued	6,010	5,929
Monitored firms	9,554	9,060
Notices of violation issued	4,959	4,930
Percentage of compliance	48%	46%

(Source: EMB 2019)

Those who violate the GES are referred to the Pollution Adjudication Board (PAB) for issuance of a "Cease and Desist Order" (CDO). Upon recommendation of the PAB, anyone who commits any of the prohibited acts or violates any of the provisions of this Act and its Implementing Rules and Regulations (IRR) may be fined not less than 10,000 PHP but not more than 200,000 PHP for every day of violation. Failure to undertake clean-up operations, willfully or through gross negligence, can lead to imprisonment of not less than two but not more than four years, in addition to a fine of not less than 50,000 PHP but not more than 100,000 PHP per day of violation. In cases where such failure or refusal to clean-up results in serious injury or loss of life or irreversible water contamination, imprisonment of not less than six years (but not more than 12 years) and a fine of 500,000 PHP per day for each violation will be applied.

On the other hand, rewards are provided to individuals, private organizations and other entities from the National Water Quality Management Fund for outstanding and innovative projects, technologies, processes and techniques, and activities. Incentives for industries are also provided, such as tax and duty exemptions for industrial wastewater treatment/collection facilities.

6 | Recent Developments in Water Environmental Management

One development is DAO 2019-15, which has designated the Boracay Island Water Quality Management and Conservation Area (WQMACA) as well as creation of its Governing Board, the objective of which is to protect and continuously improve water quality and sustain livelihood opportunities in the island. Under a clean-up initiative of Boracay Beach areas, several notices of violation (NOVs) and cease and desist orders (CDOs) have been issued to various commercial establishments in Boracay Beach areas (prime tourist destination), Province of Aklan, regarding violations of the Clean Water Act. Various establishments were also demolished, due to violations of the easement rule under the Water Code of the Philippines.

Another is DAO 2018-12, which has designated two Water Quality Management Areas and their Governing Boards, for the Upper and Lower Amburayan River System (UARS/LARS). This DAO aims to ensure water quality of the UARS and its tributaries to make it a sustainable resource for the people of the municipalities of Atok, Bakun, Buguias, Kapangan, Kibungan and Tublay and their communities. In LARS, improvement in water quality is expected to contribute to enhancement as a source of water irrigation and other agricultural uses in the Provinces of La Union and Ilocos Sur.

Regarding Manila Bay, an ongoing large-scale ground inspection/rehabilitation is underway, involving issuance of NOVs and CDOs to violating commercial establishments/hotels for failure to establish STPs/wastewater treatment plants. Part of the clean-up activities of the bay area and its tributaries undertaken by the DENR-NCR MBSCMO under KRA 2 include Installation of trash traps at Baseco Lagoon, fabrication of two trash collector rafts with capacity of 552 kg loads, inspection of rivers and esteros, coordination meetings with concerned stakeholders, and launching of the Manila Bay Watch Bike Patrollers. Over 1.2 million kg of solid wastes were collected and removed from Manila Bay area and its tributaries.

Clean-up drives are also active in other major beach areas of prime tourist destinations in the Mimaropa region, namely: Coron, El Nido and San Vicente, in Palawan, and Puerto Galera in Oriental Mindoro, San

Jose in Occidental Mindoro; Panglao, Bohol and Siargao, Agusan Del Norte. NOVs and CDOs have been issued to various commercial establishments in violation of the Clean Water Act, and various establishments were demolished in violation of the easement rule under the Water Code of the Philippines.

7 | Challenges and Future Plans

With the foundation for sustainable water quality management already laid out, the main challenge now lies in the continuation of existing water quality management policies and programs to rehabilitate and preserve the quality of the country's water bodies, and ultimately, achieve and sustain quality of life for future generations. Weak water use regulations and fragmentation in the water agencies cause coordination issues and weak enforcement. Other challenges include maintaining water quality against drivers and pressures, such as high water demand and limited supply, indiscriminate land use and development, increasing volumes of solid wastes, pollutants, and hazardous wastes, and inadequate treatment facilities. Science-based data and information is needed for efficient and effective planning and decision making to improve water quality governance. For that, it is important to increase access to the new knowledge and technologies generated from international R&D standards.

The major responses planned or undertaken to overcome the challenges include:

- Meetings with concerned agencies to tackle issues and concerns as well as take appropriate actions
- Review, reorganize, reevaluate, and update legal and institutional framework for effective and proper handling of water management
- Study and implementation of participatory water governance model
- Improve planning and decision-making processes
- Create a cost-effective long-term plan/framework to help address issues in water management, especially in reducing long-term costs, potential increases in waste, and implications resulting from the lack of available clean water
- Conduct trainings and seminars to inform, educate and properly disseminate information regarding water management and water environment governance
- Conduct workshops on various technologies used in water resources management

2.11 Sri Lanka

1 | Country Information

Table 2.11.1 Basic indicators

Land Area (km^2)		62,705 (2019)
Total Population		21.8 million (2019)
GDP (current USD)		84 billion (2019)
GDP per capita (current USD)		3,852 (2019)
Average Precipitation (mm/year)		1,712 (2017)
Total Renewable Water Resources (km^3)		52.8 (2017)
Total Annual Freshwater Withdrawals (billion m^3)		13 (2005)
Annual Freshwater Withdrawals by Sector	Agriculture	87.3% (2005)
	Industry	6.4% (2005)
	Municipal (including domestic)	6.2% (2005)

(Source: CB 2019, FAO 2020)

Figure 2.11.1 Kandy Lake in Kandy, Sri Lanka

2 | State of Water Resources

Sri Lanka is a tropical island country with an average annual rainfall of 900–5,000 mm (Figure 2.11.2), which provides 131,230 million m^3 of freshwater annually. Zones in its southwest are the wettest, receiving over 2,000 mm/year, while northern (and some southeast) areas are considered dry zones with under 1,500 mm/year. There are 103 river basins, and the largest river is the 335 km Mahaweli River, covering an area of 10,448 km^2 (MENR and UNEP 2009). Rivers in the wet zones contribute over 50% of the runoff despite covering only about one third of the land area. There are over 3,400 wetlands, which include ancient irrigation reservoirs, recently constructed multipurpose reservoirs, tanks and lakes.

Groundwater resources in the country are estimated at 7,253 million m^3 and represent the major source of water especially in rural areas, where around 72% of the rural population relies on it for domestic uses.

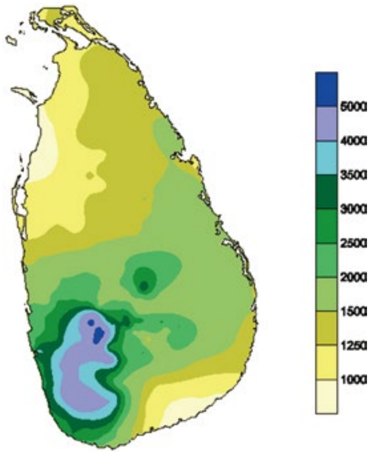


Figure 2.11.2 Annual precipitation distribution (in mm) in Sri Lanka

3 | State of Ambient Water Quality

Pollution by domestic and industrial wastewater as well as leachate from garbage continues to be a problem for surface water and groundwater resources in Sri Lanka. Central wastewater treatment facilities cover less than 5% of the population, and commonly comprise onsite septic tanks among urban dwellings. High use of synthetic fertilizers on farms and resultant runoff and leaching of nutrients is another cause of nutrient pollution in the surface and groundwater.

3.1 Rivers

Water quality in main water courses is still within the limits of the ambient water quality standard. However, untreated or insufficiently treated wastewater in urban areas is the main cause of river pollution. For instance, the Kelani River, the second largest river basin in Sri Lanka, is one of the most polluted due to the rapid growth of industry and high population density along the river.

Illegal dumping of solid wastes into waterways is also a serious concern. Expansion of sand mining activities also affects the river water quality, such as with increased turbidity, decreased water flow and accelerated saltwater intrusion. Table 2.11.2 shows the recent state of water quality in certain rivers.

Table 2.11.2 State of river water quality

River	Year	BOD (mg/L)	COD (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)
Nilwala River	2019	1	5.6	0.9	<0.01
Deduru oya	2019	20.1	3.23	1.47	<0.01
	2020	2.95	26.06	9.97	<0.01
Attanagalu oya	2019	3.71	16.83	<0.01	<0.01
Menik River	2019	1.67	14.63	0.15	<0.1
	2020	1.78	12.92	0.15	<0.1
Mahaweli River	2020	5.0	7.75	0.03	<0.01
Malwathu oya	2020	1.70	23.70	0.02	0.1
Badulu oya	2018	1.37	12.41	0.43	<0.1
	2019	9	66.29	2.87	<0.1
	2020	1.4	11.0	0.50	<0.1
Diyawanna oya	2017	3.87	22.43	0.99	<0.01
	2018	1.75	15.75	1.87	<0.15
	2019	2.75	10.5	1.06	0.05

(Source: CEA 2021)

3.2 Lakes and Reservoirs

In general, the water quality of lakes and reservoirs is considered good. Table 2.11.3 summarises water quality status of select reservoirs.

Table 2.11.3 Water quality of certain reservoirs

Reservoir	Year	BOD (mg/L)	COD (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)
Kurunegala tank	2019	7.43	25.06	1.10	0.03
	2020	3.10	29.7	1.40	<0.01
Gregory Lake	2019	8.42	31.0	1.53	0.04
Wennaruwa wewa	2019	12.85	3.18	1.69	0.054
Nuwara wewa	2019	2.53	28.27	NA	0.06
	2020	5.81	18.91	NA	0.03
Tissa wewa	2019	3	35	NA	0.04
	2020	3.56	23.92	NA	0.02

(Source: CEA 2021)

3.3 Coastal Water

Water pollution in coastal water bodies has grown over the past few decades due to rapid development activities and human settlements both in and outside coastal areas, establishment of new industries and tourism. Over 60% of industrial establishments are located along Sri Lanka's coastal zone, such as coastal districts of Colombo and Gampaha. Organic pollution in coastal areas, such as Beruwala and Unawatuna areas, has led to high levels of BOD.

3.4 Groundwater

A common groundwater quality problem in the country is microbial contamination and nutrients (such as nitrate) caused by leachate from on-site sanitation systems such as pit latrines (Table 2.11.4). Excessive fertilizer use and untreated wastewater are other factors responsible for high nitrate levels in the groundwater. In coastal areas, salinity is a prominent issue and is caused by a combination of factors such as excessive groundwater use and sea waves encroaching inland.

Table 2.11.4 Variation in groundwater quality across different areas (2014–2018)*

Sampling area	TDS (mg/L)	E.coli (cfu/ 100 ml)	COD (mg/L)	TSS (mg/L)	PO_4^{3-} (mg/L)	NO_3^- (mg/L)
Farmland	160–172	22–40	10–13	140–155	0.3–0.6	0.3–0.5
Solid Waste Dumping Site	270–296	10–790	12–20	13–93	0.2–0.5	3.1–6.2
City	80–105	4–608	16–20	6–58	0.2–0.4	0.3–7.4

*Based on research by University of Peradeniya & National Water Supply & Drainage Board (Source: CEA 2019)

Industry is another source of groundwater contamination in Sri Lanka. A study conducted under the WEPA Action Program found higher COD, Nitrate, and EC in groundwater samples collected nearby some industries.

4 | State of Wastewater Treatment

Domestic wastewater

National sewerage coverage is limited to less than 3%, while the rest of the country relies on on-site sanitation such as septic tanks, Ventilated Improved Pit Latrines (VIPs), and unimproved sources (pit latrines and unknown types). There are ongoing and planned wastewater treatment projects to treat domestic wastewater in major cities or under certain housing schemes. Tables 2.11.5 and 2.11.6 show the state of existing wastewater treatment facilities.

Table 2.11.5 Existing wastewater treatment facilities in major cities

Sewerage System	Treatment Capacity (m³/day)	Beneficiaries
Colombo (CMC)	Sea outfall	331,500
Dehiwala/Mt. Laviniya	CMC sea outfall	65,000
Kolonnawa	CMC sea outfall	60,000
Kataragama	3,000	20,000
Hikkaduwa	1,040	500 + Commercial (60 Nos.)
Rathmalana	17,000	20,000
Ja Ela	7,500	10,500
Kurunegala	4,500	43,000
Kandy	14,000	55,000 + 150,000 (floating)

(Source: CEA 2021)

Table 2.11.6 Wastewater treatment in major housing schemes

Housing Scheme	No. of Connections	Treatment capacity (m^3/d)	Beneficiaries
Mattegoda	1,154	600	4,850
Jayawadanagama	669	NA	2,810
Maddumagewatta	315	NA	1,320
Raddolugama	2,045	6,000	8,590
Kuruminiyawatta	202	NA	850
Royal Park	249	NA	1,045
Hantana	394	550	1,650

(Source: CEA 2021)

Industrial wastewater

In Sri Lanka industries are categorised into three broad groups, namely Type A, B and C by the Central Environment Authority (CEA) depending upon the severity of pollution potential and to guide the siting of such industries. A total of 15,404 highly polluting industry units (Type A), 10,631 medium polluting industrial units (Type B) and 26,622 low polluting industrial units (Type C) operate within Sri Lanka. Most industrial zones have own wastewater treatment systems for treating wastewater from factories operating within their boundaries. There is little or no data on the state of wastewater generation and treatment from small and medium-sized industries. Table 2.11.7 shows the state of wastewater treatment in some export processing zones.

Table 2.11.7 Wastewater treatment in certain export processing zones

Export Processing Zone	Treatment capacity (m^3/d)
Biyagama	21,000
Seetawaka	9,900
Koggala	675
Katunayaka	3,000
Mirigama	400
Wathupitiwala	900
Polgahawela	450
Mawathagama	500
Horana	1,000
Malwatta	450

(Source: CEA 2021)

According to the National Water Supply and Drainage Board Law, No. 02 of 1974, different tariff structures apply for domestic and industrial sewer services based on total amounts of water consumption from all water supply sources for each billing month. The domestic sewer service provided for commercial purpose charges a flat rate of 40 LKR per cubic meter, while for residential purpose the tariff rate varies according to water consumption. For residential purpose, an additional service charge of 200 LKR also applies. For industrial purpose, a flat rate of 65 LKR per cubic meter applies.

5 | Frameworks for Water Environmental Management

The Constitution of Sri Lanka states that protection, preservation, and improvement of the environment for the benefit of the community is the responsibility of the state (Article 27/14) and that every person in the country has a duty to “protect nature and conserve its riches” (Article28). Surface water resources – rivers, streams and lakes – are controlled by the government, under the Crown Lands Ordinance and the Constitution. Vistas of Prosperity & Splendour" Manifesto of President Gotabaya Rajapakse Among ten (10) key policies addressed in the manifesto of the President Gotabaya Rajapakse, the 8th chapter describes about the Sustainable Environmental policy to strengthen and protect the forest cover, rivers, streams and wildlife. The Haritha Lanka Program, approved in June 2008, is the current basic national policy document for environmental conservation, and aims to promote sound environmental management in Sri Lanka by balancing the needs of social and economic development and environmental integrity. The “National Action Plan for Haritha Lanka Program” was prepared in the same year, based on the above program, and includes steps to be implemented during 2009–2016 under the supervision of the National Council for Sustainable Development (NCSD). The plan’s proposed strategies and actions represent a concerted effort of all relevant ministries and stakeholder institutions. As regards environment pollution control, the CEA prepares five-year action plans.

5.1 Legislation

The National Environmental Act (NEA) No. 47 of 1980 (amended as Act No. 53 of 2000) forms the basis of the country’s law, and aims “for the protection, management and enhancement of the environment, for the regulation, maintenance and control of the quality of the environment; for the prevention, abatement and control of pollution”. According to the act, discharges, deposits or emission of waste into the environment cannot be carried out without a license and must comply with standards and criteria prescribed. Other acts and ordinances related to water environmental management are illustrated in Figure 2.11.3.

Environmental Conservation (Overall)

- ◆Constitution of the Democratic Socialist Republic of Sri Lanka
- ◆National Environment Act No.47 of 1980 as amended by No. 56 of 1988 and No. 53 of 2000
  - Effluents discharge standards Gazette No. 1534/18 and the prescribed activities for which a license is required in Gazette No. 1533/16
  - Prescribed projects in Gazette No. 772/22 which apply the EIA process
  - EPA - Environment Protection Areas declared under the sections 24C and 24D of the National Environmental Act No. 47 of 1980
- ◆Local Authorities Act (for municipal and urban councils and Pradeshiya Sabah)

Management of specific areas

- Mahaweli Authority Act No. 23 of 1979
- North Western Provincial Environmental Statute No. 12 of 1990

Marine and costal water quality

- ◆Marine Pollution Prevention Act of No. 35 of 2008
- ◆Coast Conservation Act No.57 of 1984 as amended by Act No. 64 of 1988

Water resource development/management

- ◆Irrigation Ordinance Chapter 453
- ◆National Water Supply & Drainage Board Act No.2 of 1974
- ◆Water Resources Board Act No. 29 of 1964

Other acts related to water environmental management

- ◆Urban Development Authority Act No. 41 of 1978 as amended from time to time
- ◆Greater Colombo Economic Commission Law No. 4 of 1978 as amended by Act No. 49 of 1992

Figure 2.11.3 Laws and regulations related to water environmental management (Source: created based on information from CEA)

5.2 Institutional Arrangement

Different governmental agencies control different areas of water environment management in Sri Lanka, as summarized in Table 2.11.8. The Ministry of Environment, established in 2001, is the national authority for formulating policies and guidelines for conservation of the environment and natural resources. Under the ministry, the CEA is responsible for implementation of policies and regulations pertaining to environmental pollution control and management. The CEA was established in 1981 as the authority with regulatory powers to control, manage and enhance the environment.

Marine Environment Protection Authority (MEPA) has the regulatory powers over the marine pollution prevention and other governmental organizations that are related to construction, engineering services, housing and common amenities such as the Condominium Management Authority, National Housing Development Authority, and the Board of Investment (BOI) of Sri Lanka are indirectly related to water environment as their activities significantly affect the condition of water quality. Local governments are also playing an important role in water environmental management in regulating low-impact industries and activities prescribed by orders issued under the NEA. Public health inspectors at the local level control on-site sanitation systems such as pit latrines and septic tanks.

Table 2.11.8 Key agencies involved in the management of water environment

Name of the agency	Mandates of the agency
Ministry of Environment (MOE)	Overall management of the environment and natural resources of the country. Formulating key policies, strategies, and guidelines for environmental management.
Central Environmental Authority	Overall responsibility for protecting the environment including water environment
Water Resources Board	Scientific characterization, mapping, and preparation of comprehensive and integrated plans for the conservation, utilization, control, and development of groundwater resources.
National Water Supply & Drainage Board	Operational development and installation of public and private water supply schemes based on groundwater and coordinate sewerage systems.
Department of Irrigation	Regulation and control of inland waters
Mahaweli Authority	Maintenance of Mahaweli River and its reservoirs for development of lands for agriculture.
Coast Conservation & Coastal Resources Management Department	Conservation of the coastal zone and management of its resources.
Marine Environment Protection Authority (MEPA)	Protection of the marine environment from ship- and shore-based maritime related activities.

(Source: created based on information from CEA)

5.3 Ambient Water Quality Standards

Ambient water quality standards

Table 2.11.9 shows the ambient water quality standards (AWQS) under the National Environmental (Ambient Water Quality) Regulations, No. 01 of 2019. According to this standard, no person shall discharge, deposit or

Table 2.11.9 Sri Lanka's Ambient Water Quality Standards (2019)

	No.	Parameter	Unit	Category A	Category B	Category C	Category D	Category E	Category F
General	1	Colour	Pt mg/L, max	20	-	-	100	-	-
	2	Electrical Conductivity	µS/cm, max	-	-	-	-	700	-
	3	Turbidty	NTU, max	5	-	-	-	-	-
	4	TSS	mg/L, max	25	-	40	1,500	2,100	-
	5	Total Hardness (as $CaCO_3$)	mg/L	250 des 600 max	-	-	-	-	-
	6	pH	-	6.0–8.5	6.0–9.0	6.0–8.5	6.0–9.0	6.0–8.5	5.5–9.0
	7	DO at 25°C	mg/L, minimum	6	5	5	4	3	3
	8	BOD_5 at 20°C	mg/L, max	3	4	4	5	12	15
	9	COD	mg/L, max	10	10	15	30	-	40
Nutrient	10	NO_3-N	mg/L, max	10	10	10	10	-	10
	11	NH_3-N pH < 7.5		-	-	0.94	-	-	9.1
		7.5 ≤ pH < 8.5	mg/L, max	-	-	0.59	-	-	4.9
		8.5 ≤ pH		-	-	0.22	-	-	1.6
	12	PO_4-P	mg/L, max	0.7	0.7	0.4	0.7	-	-
Other	13	Chloride (Cl)	mg/L, max	250	-	-	250	600	-
	14	CN	mg/L, max	0.05	0.05	0.05	0.05	0.05	0.05
	15	F	mg/L, max	1.5	-	-	1.5	-	-
	16	SO_4^{2-}	mg/L, max	250	-	-	250	1,000	-
Metal	17	Cd, total	µg/L, max	5	-	5	5	-	5
	18	Cr, total	µg/L, max	50	-	20	50	-	50
	19	Cu, total	µg/L, max	-	-	100	-	-	100
	20	Fe, total	µg/L	300 des 1,000 max	-	-	2,000	-	-
	21	Pb, total Hardness < 120				2			
		120 ≤ Hardness < 180	µg/L, max	50	-	3	50	-	-
		180 ≤ Hardness				4			
	22	Mn, total	µg/L, max	1,000	1,000	1,000	1,000	1,000	1,000
	23	Hg, total	µg/L, max	1	1	1	1	2	2
	24	Ni, total	µg/L, max	70	100	100	100	200	100
	25	Se, total	µg/L, max	10	10	5	10	-	-
	26	Zn, total	µg/L, max	1,000	-	1,000	1,000	2,000	24,000
	27	B, total	µg/L, max	-	-	-	-	500	-
	28	As, total	µg/L, max	50	50	50	50	50	50
	29	Al, total	µg/L, max	200	-	-	-	5,000	5,000
Organic Micro Pollutant	30	Phenolic compounds	µg/L, max	2	5	2	5	5	5
	31	Oil/Grease	µg/L, max	100	-	100	100	-	300
	32	Anionic surfactants as MBAS	µg/L, max	1,000	1,000	1,000	1,000	1,000	1,000
	33	MCPA	µg/L, max	2	-	-	20	-	-
	34	Pendimethalin	µg/L, max	2	-	-	20	-	-
Microbes	35	Total Coliform	MPN/100ml, max	10,000	10,000	-	10,000	-	-
	36	Fecal Coliform	MPN/100ml	500 des 1,000 max	500 des 1,000 max	-	-	-	-

Note: 'des' means desirable and 'max' means maximum

(Source: Government of Sri Lanka 2019)

emit any pollutant into inland surface waters exceeding AWQS. There are six categories under AWQS, classified by suitability for different uses/purposes:

1. Category A: water sources requiring simple treatment for drinking
2. Category B: water sources suitable for bathing and contact recreation
3. Category C: water sources suitable for aquatic life
4. Category D: water sources that require general treatment process for drinking
5. Category E: water sources suitable for irrigation and agricultural activities
6. Category F: water sources of minimum quality outside of categories A to E

Water quality monitoring framework

The CEA is authorized to conduct water quality monitoring, which is carried out by environmental pollution control unit and water quality monitoring laboratory. The CEA possesses a main laboratory at the Head Office and 9 Provincial and District laboratories and private laboratories are also registered once in two years to cater the environmental monitoring needs. The National Water Supply and Drainage Board (NWSDB) conducts water quality monitoring at water intake points for drinking water purification – in total 340, including 70 groundwater intake points. CEA conducts regular water quality monitoring in 12 main water bodies, with additional or random monitoring in other areas conducted on an as-needed basis, and has ambient water quality monitoring projects for different river basins, as shown in Table 2.11.10. The first water sampling took place in the Kelani River, which is a major source of water supply, in 2013. Online water quality monitoring commenced in 2017. In the same year, monitoring expanded to 16 water bodies (rivers, tanks, reservoirs), and in 2020 is now conducted on a comprehensive basis.

Table 2.11.10 Water quality monitoring in major water bodies

Water body	Monitoring points	Frequency	Parameters
Kelani River	17	Once a month	BOD, COD, TSS, pH, Coliform, Phosphate, Nitrate, Heavy metals
Mahaweli River	12	Once a month	
Dadugam Oya	12	Once a month	
Benthota River	12	Once a month	
Mahaoya	12	Once a month	
Kandy Lake	10	Every three months	
Kurunegala Tank	12	Once a month	
Gregory Lake Nuwara Eliya	12	Once a month	
Nuwara Wewa Anuradhapura	12	Once a month	

(Source: CEA 2019)

The Sri Lanka Land Reclamation & Development Agency carries out canal water quality monitoring in the Colombo area at 23 locations, while agencies such as the Water Resources Board and International Water Management Institute are also involved in groundwater monitoring.

5.4 Effluent Standards

Effluent discharge standards

The standards for discharge of wastewater into the environment were published in Gazette Notification No. 1534/18, dated 01/02/2008, and termed as the National Environmental (Protection & Quality) Regulations No. 01 of 2008 Wastewater Discharge Standards. Proposed effluent discharge standards are based on the point of discharge and the type of effluent identified by the Environmental Pollution Control Unit of EPC Division. Tolerance limits and values exist for industrial and domestic wastewater as well as effluent based on the mode of discharge into coastal or marine waters, inland surface water, land for irrigation purpose and so on. Further, specific tolerance limits and values are prescribed for activities related to rubber manufacturing, processing or modifying industries, textile and apparel sector industries, tanning industries and public sewer systems. In the proposed regulation sea out falls (long & short) and near shore, more stringent standards can be imposed if possible regarding the need to protect the water environment from hazardous waste landfills.

Effluent inspection procedure

In principle, effluent quality is self-monitored by the discharging industry concerned or laboratory assigned by the CEA. Effluent quality reports may be submitted at least once a year, to the actual monitoring body concerned decided by the CEA. Industries also submit effluent quality reports from third party laboratories recognized by the CEA. However, not all industries have monitoring facilities and the CEA occasionally monitors/inspects effluents discharged from such biannually or annually, as well as investigates suspected cases of non-compliance such as those based on complaints received from the general public.

Measures against non-compliance

There are several enforcement instruments for water environment, such as Environmental Impact Assessment (EIA), Environmental Protection Licensing (EPL), Scheduled Waste Management License (SWML), Environmental Protected Areas, Directives to Local

Government Authority on Solid Waste Management, Environmental Recommendations (ER). The EPL scheme, which started in 1990, is required for all entities in the country that discharge wastes into the environment, as prescribed by a regulation published under the NEA, and licenses vary according to the pollution potential of an industry (Type A, B and C). Additional enforcement arrangements are made by other agencies, such as the Water Resource Board, which grants approval for groundwater withdrawals for commercial uses, MEPA, which requires discharge permits for discharging wastewater to the sea, and Mahweli Authority, which protects reservoirs coming under their purview.

Non-compliance or violation results in suspension or cancellation of licences and filing of cases, as well as minimum fines of 10,000 LKR, imprisonment or both, as determined by the NEA.

6 | Recent Developments in Water Environmental Management

In 2020, a comprehensive river water monitoring program was started to strengthen the ongoing river monitoring program. It is being implemented along 25 main rivers at monitoring points determined based on physical factors and pollution sources. Monitoring is to be carried out by central and provincial labs of the CEA. Further, to avoid duplicity, NWSD will share water quality data from its intake points. This overall monitoring process is to form the basis of the master plan for river monitoring. After analysis of the data, monitoring will be further strengthened to cover industries and implement pollution control measures.

In 2020, implementation of a program to protect the Kelani River was initiated. The river is nationally important as a water resource supporting fisheries, hydro-electricity generation, sand mining, and main water supply source for Colombo. Around 10,000 industrial activities are located along the river. Pollution in upstream areas results from agricultural run-off from tea plantations, whereas downstream areas are affected by high contamination due to urban run-off, industrial discharge, and leachates of haphazardly disposed solid waste. The program aims to maintain and improve water quality by undertaking server activities planned for the short, medium and long term. In the short term (early 2020), it plans to conduct GIS mapping, locate and identify pollution sources, monitor industrial activities through a monitoring team, and carry out water quality monitoring (including establishing online monitoring stations) and awareness programs. In the medium term (by 2020), activities are to include investigation of industrial and domestic waste dumping, analysis of waste loads, initiation of legal action against unauthorized industries, and implementation of the second phase of online monitoring. After 2020, the program plans to install CCTV linked to CEA to observe effluent discharge from large industries, continue establishing online monitoring stations, and develop a comprehensive database to analyse trends in water quality.

Surakimu Ganga National Environmental Programme was started in 2021, as a national river protection programme based on the Sustainable Environmental Management which emphasized in the 8th chapter of the manifesto “A vision for a Resurgent, Prosperous Country” released by the Hon President of Sri Lanka. The ministry of Environment, the CEA and stakeholder agencies including local government are working together in this programme to protect the 103 riverine systems in Sri Lanka. The ultimate goal is to control water pollution, restore, manage eco system functions and get the maximum beneficial use from such rivers.

The programme is implemented through inter-ministerial coordinating committee, District Committees and Divisional Committees island wide. Initially 27 perennial rivers were selected for thorough investigation of issues and to take remedial measures to overcome the river water pollution. The ongoing water quality monitoring programmes and other actions taken so far by the stakeholder agencies will be coordinated and networked through “Surakimu Ganga” programme.

In the proposed NEA amendments new regulations on environmental damage compensation, introduction of the polluter pays principle, legalization of environmental clearance, and control over groundwater pollution are included.

7 | Challenges and Future Plans

The lack of proper institutional coordination is a major challenge since water sector management is divided into several sections under different ministries or agencies. Similarly, different sections of water management are spread across several laws and regulations, meaning compliance monitoring and enforcement thereof remain an ongoing challenge. There is also a need for considerable improvement as regards resources allocation from the national budget, such as for hiring staff for field monitoring and inspection and laboratory analysis. The lack of baseline data as well as limited sharing of available data are further barriers to improvements in water environmental governance. The lack of financial and technical resources often hampers regular monitoring as well as the establishment of new monitoring stations. Failure to self-report by industry is another prominent challenge as some industries lack the resources and capacity to monitor and report their compliances. Industries, in particular SMEs, lack the financial resources such as for treating wastewater. Further, the high costs of construction and operation of centralized WWTP as well as public resentment and protests over WWTP establishment remain as challenges for wastewater treatment in cities.

2.12 Thailand

1 | Country Information

Table 2.12.1 Basic indicators

Land Area (km²)		510,890 (2016)
Total Population		69.625 million (2019)
GDP (current USD)		543.65 billion (2019)
GDP per capita (current USD)		7,260 (2019)
Average Precipitation (mm/year)		1,718.1 (2016)*
Total Renewable Water Resources (km³)		438.7 (2017)**
Total Annual Freshwater Withdrawals (billion m³)		57.3 (2014)
Annual Freshwater Withdrawals by Sector	Agriculture	90% (2014)
	Industry	5% (2014)
	Municipal (including domestic)	5% (2014)

(Source: World Bank 2020, *Thai Meteorological Department 2016, **World Data Atlas 2017)

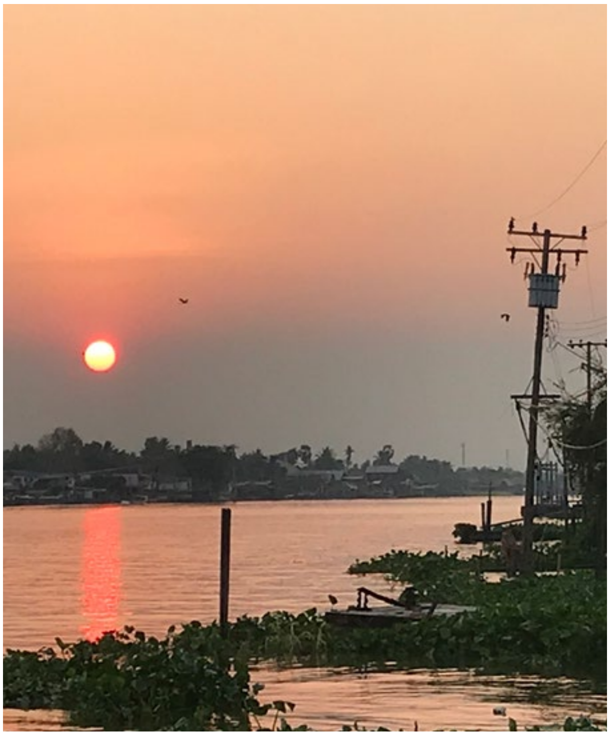


Figure 2.12.1 Chao Phraya River in Thailand

2 | State of Water Resources

Based on geographical characteristics, Thailand can be divided into 25 river basins. The total volume of water from rainfall in all river basins is estimated at more than 800,000 million m³, of which 75% is lost through evaporation, evapotranspiration and infiltration, and the remaining 25% constitutes the runoff that flows into the rivers and streams. The available water quantity is about 3,300 m³/capita/year (Office of National Water Resources Committee 2000).

According to ADB (2013), Thailand has abundant water resources with an estimated 126 billion cubic meters (m³)/annum exploitable, considerably more than the reported national demand for water of 50–56 billion/m³/annum (excluding navigation and ecosystem requirements). Of these water resources, groundwater is important as it supplies 20% of public water supply and 75% of domestic water. The groundwater system is mainly recharged by rainfall of about 40,000 million m³ and seepage from rivers. It was estimated from previous hydrological balance studies that about 12.5 to 18% of rainfall reaches aquifers. Both the government and the private sector have undertaken more than 200,000 groundwater well projects with a total capacity of about 7.55 million m³/day (information from the WEPA focal person in 2012).

3 | State of Ambient Water Quality

3.1 Surface Water

According to the 2019 water quality monitoring results published by the Pollution Control Department of Thailand in 2020, of the 65 major water sources across the country, in terms of water quality, 2% were found to be very good (excellent), 34% were good, 46% were fair, and 18% were poor. The 'very good' water source was the Upper Tapi River. Surface water quality in the northern, central, north-eastern, and eastern regions was worse than in the previous year, and water quality in the central region was worse than other regions. When compared to the surface water classification criteria, only three sources, representing 5% of water sources, met the water quality. The majority of water sources over the past decade (2010–2019) tended to be stable, with water quality ranging from fair to good.

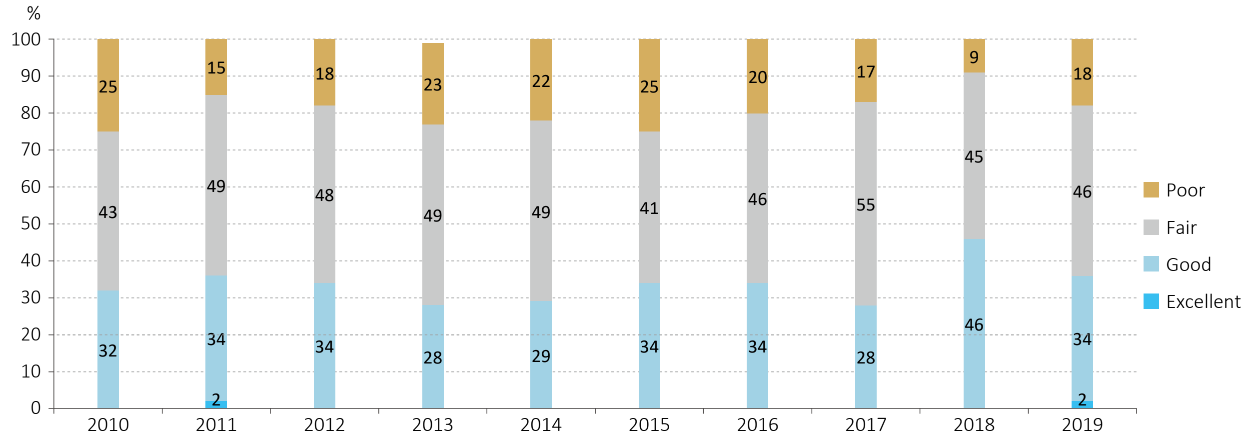


Figure 2.12.2 State of surface water quality across the country during 2010–2019 (Source: PCD 2020)

From the analysis of surface water quality data, it was found that main parameters such as DO, BOD, Total Coliform Bacteria (TCB), Faecal Coliform Bacteria (FCB), Ammonia-Nitrogen (NH_3-N) and Heavy Metals (HMs), did not meet the required standard for surface water sources classification during 2010–2019. More specifically, the percentage of heavy metal values that exceeded the surface water source classification ranges from 0.2–1.5%; meanwhile, for BOD and DO values, they range from 19–36% and 19–31%, respectively, with a slight downward trend.

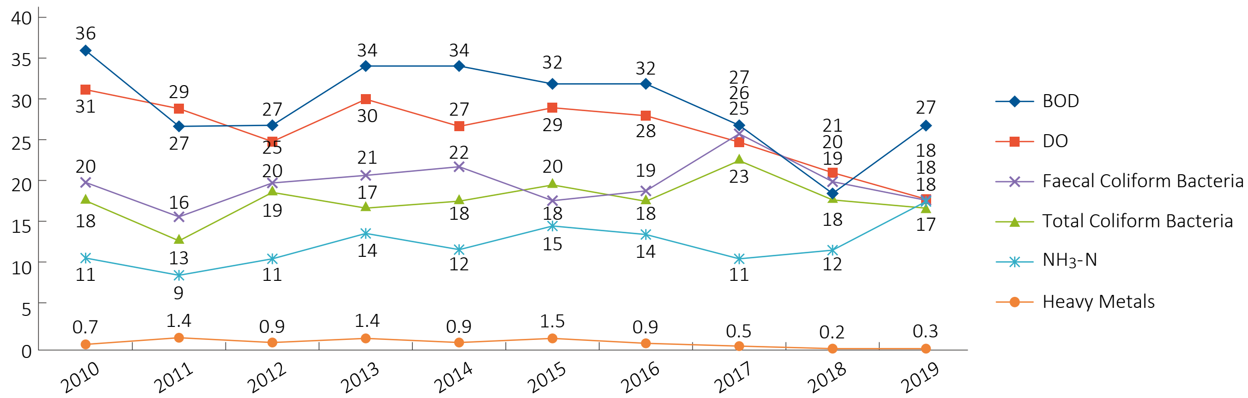


Figure 2.12.3 Percentage of parameters that do not meet the surface water sources classification during 2010–2019 (Source: PCD 2020)

When assessed using the water quality index, that the water sources of highest quality were 1) the upper Tapi River, 2) the Kwai Noi and Kok River, 3) the upper Phetchaburi River, 4) the Lee and Kwai Yai Rivers, and 5) the Tradd River. The most deteriorated water sources were 1) the lower Ram Tahong River, 2) the lower Chao Phraya River, 3) the lower Tha Chin River and the upper Panglad River, 4) the lower Rayong River and the Lopburi River, and 5) the Sakae Klang River. The causes of poor water quality were municipal wastewater, industrial sewage, and agricultural and livestock runoff discharging into major water sources, as well as inefficient wastewater treatment systems and inadequate wastewater collection and treatment (PCD 2020).

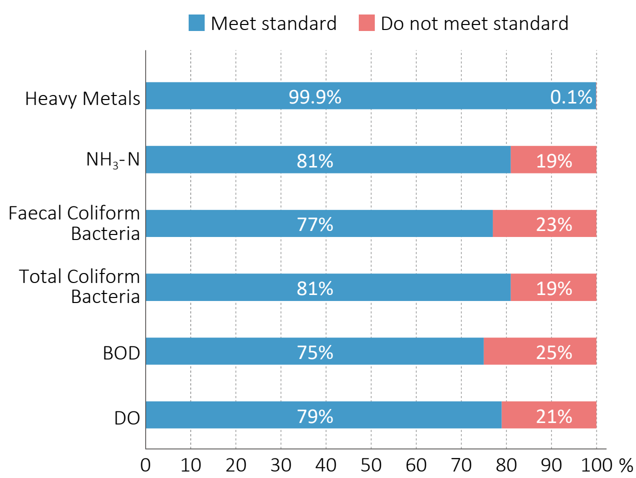


Figure 2.12.4 Results of surface water quality monitoring in the Central region compared to the surface water quality standard - Class 3 (Source: PCD 2020)

Over the past 11 years (2009–2019), the water quality of most water sources was fair. None have been found to be of very poor quality since 2009, and water sources in general are undergoing a transformation towards good water quality. Sources that have consistently retained 'good' status are Upper Tapi, Khwae Noi, and Lum Chee. Conversely, some sources tend to be of consistently poor quality, requiring close monitoring and problem solving, which are the Lower Chao Phraya, Lower Tha Chin, Lop Buri and Lower Lumtakong.

For the purposes of water quality monitoring and evaluation, water samples are collected four times a year, and analysed in accordance with surface water quality standards issued under the Enhancement and Conservation of Natural Environmental Quality Act 1992. The 23 parameters analysed include temperature, Acidity/Alkalinity (pH), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Coliform Bacteria (TCB), Faecal Coliform Bacteria (FCB), Nitrate-Nitrogen (NO_3^--N), Ammonia-Nitrogen (NH_3-N), heavy metal group such as Copper (Cu), Nickel (Ni), Manganese (Mn), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Lead (Pb), Mercury (Hg), Arsenic (As), and chlorinated pesticides such as DDT, Alpha-BHC, Dieldrin, Aldrin, Endrin, and Heptachlor Epoxide (PCD 2014).

3.2 Coastal Water

According to the Thailand State of Pollution Report 2019, the coastal water quality is generally fair to good. While tourist beaches have excellent coastal water quality, some coastal areas are consistently defined as poor, especially in the Inner Gulf of Thailand.

In 2019, the coastal water quality monitoring results showed that 2% of samples were of very good quality, 59% were of good quality, 34% were fair, 3% were poor, and 2% very poor. Coastal water quality over the past 10 years has tended to improve since 2016 and remained stable through 2019. 'Very good' coastal waters were Koh Lann, Phrao Bay (Samet Island), Ban Son Bay, and Koh Phangan; however, the Gulf of Thailand at the mouths of the Bang Pakong, Chao Phraya, and Tha Chin rivers continued to have poor to very poor water quality. There were 26 red tide events (over four times the amount in the previous year), presumably caused by factors such as municipal wastewater discharge, industrial and agricultural drainage, oil spills from drilling, oil transport, navigation, and rapid phytoplankton production (PCD 2020).

The trend of coastal water quality in the period of 2010–2019 also showed that, in general, most of the coastal water quality has been at a fair to good level, the percentage of coastal water locations with poor and very poor quality have reduced, and the percentage of coastal water locations with fair and good quality has increased, especially after 2015.

Coastal water samples have been collected twice a year and evaluated using the Marine Water Quality Index (MWQI). This tool was developed by the Pollution Control Department for assessing marine water quality in a range of 0–100 (0–25: very poor; 25–50: poor; 50–80: fair; 80–90: good; 90–100: excellent). The MWQI is calculated from the coastal water quality data across eight parameters: Dissolved Oxygen (DO), Total Coliform Bacteria (TCB), Phosphate - Phosphorus (PO_4^{3-}-P), Nitrate - Nitrogen (NO_3^--N), Temperature (Temp.), Suspended Solids (SS), Acidity - Alkalinity (pH) and Ammonia - Nitrogen (NH_3-N). However, if levels of pesticides and toxic elements such as Mercury (Hg), Cadmium (Cd), Total Chromium (Total Cr), Chromium Hexavalent (Cr^{6+}), Lead (Pb), Copper (Cu), Cyanide (CN^-) and PCBs are found to exceed the Marine Water Quality Standards, the MWQI is recorded as "0" by default (PCD 2017). In general, the main parameters indicating coastal water quality problems are bacteria (Total Coliform Bacteria, Faecal Coliform Bacteria and Enterococci), as well as chemical contaminants, i.e., phosphates (phosphorus)

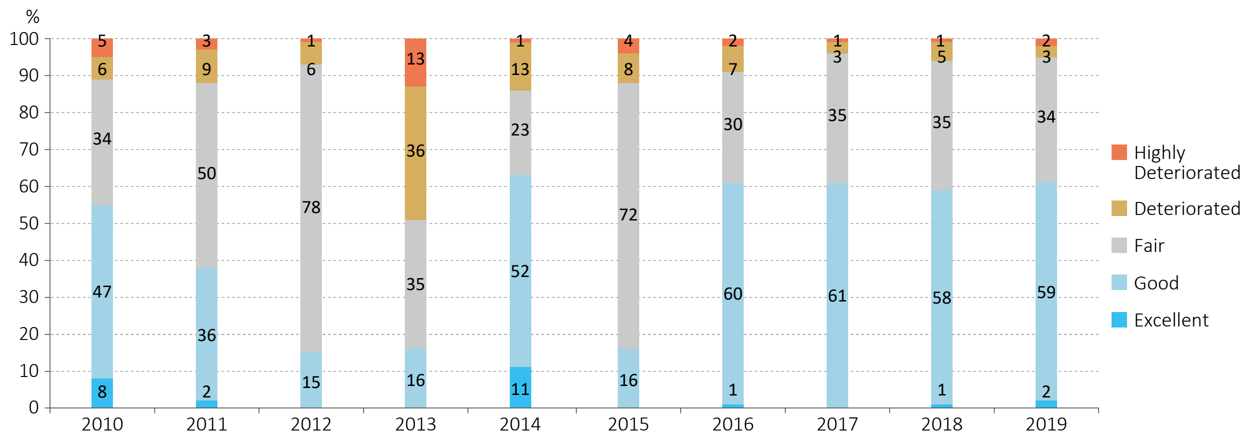


Figure 2.12.5 State of coastal water quality across the country over 2010–2019 (Source: PCD 2020)

and nitrates (nitrogen), mostly from communal and tourist areas, and agricultural and industrial activities. Areas where water quality was found to be of poor to very poor quality are areas of the Inner Gulf of Thailand and estuaries of the Bang Pakong River, the Chao Phraya River, the Tha Chin River, and the Mae Klong River (PCD 2015, PCD 2017).

3.3 Groundwater

In 2019, groundwater quality and groundwater level changes were monitored from 1,162 observation wells at 2,098 sites distributed across 27 basins/watersheds. The results showed that groundwater was generally of good quality and within the standard, according to the Groundwater Act B.E.2520. However, in some areas, concentrations of iron and manganese exceeded the standard due to geographical or hydrological conditions. Also, in the Gulf of Thailand and areas along Lake Songkhla, the salinity level of groundwater has increased. Heavy Metals (HMs) and volatile organic compounds (VOCs) exceeding the required standard for groundwater

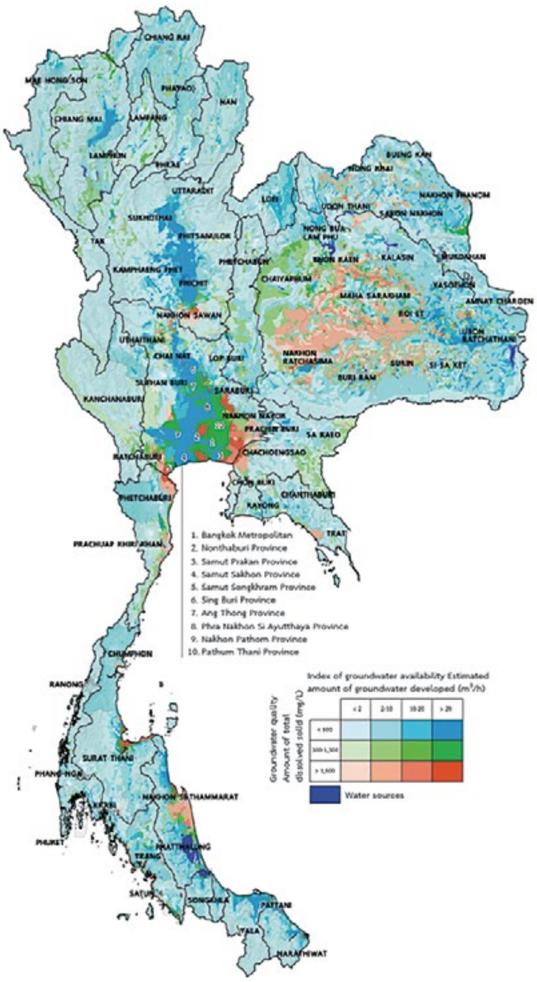


Figure 2.12.6 State of groundwater quality in Thailand
(Source: Department of Groundwater Resources 2019, PCD 2020)

have been detected in samples at some waste disposal sites, industrial waste disposal sites, and industrial parks (PCD 2020). Therefore, groundwater use needs to be carefully monitored for possible contamination.

4 | State of Wastewater Treatment

Rapid population growth and the lack of proper collection, treatment, and management of domestic wastewater are the main causes of water quality degradation in surface and coastal waters. In 2019, the total population increased from 66.41 million (2018) to 69.63 million, and numbers of foreign tourists entering the country increased from 25.83 million (2018) to 26.56 million (PCD 2020). Consequently, the total amount of generated wastewater has also increased. Meanwhile, wastewater is discharged into water resources from various sources, including local businesses, factories, and agricultural activities, often exceeding the carrying capacity of the concerned water source, especially in some important river basin areas, major waterways, and tourist destinations. Activities such as related to industry, ports, tourist attractions, and aquaculture are also increasing each year.

Although both surface and groundwater pollution derive from various sources, the main sources of water pollution can be divided into three types: domestic wastewater with a total generated amount of about 9.7 million m^3/day, industrial wastewater with a total volume of 17.8 million m^3/day, and agricultural wastewater with a discharged volume of 4.9 million m^3/day (only for pig farms and aquaculture operation) (Chaiyo 2019).

Domestic wastewater

Every day it is estimated that 9.7 million cubic meters of domestic wastewater is generated across the country, which is managed by 105 centralised municipal wastewater treatment plants operated by local government agencies and wastewater management authorities. Currently, 95 treatment plants are in operation, with a treatment capacity of 2.6 million cubic meters per day (27% of total wastewater volume). In big cities like Bangkok, ratios of treated wastewater are higher, estimated at 45% (PCD 2020). The main reason for the low ratios of treated domestic wastewater across the country is the lack of budget to cover investment as well as operation and maintenance system expenditure at the local administrative organization level. The treatment technology used for wastewater mainly comprises stabilization ponds, aerated lagoons, and activated sludge systems.

Houses and all other buildings are required to install wastewater treatment systems for primary treatment to reduce the contamination of wastewater before it is discharged into water sources.

Large buildings such as hotels, condominiums, hospitals, department stores, markets, restaurants, schools, dormitories and office buildings are required to install wastewater treatment systems and treat wastewater according to standards. Monitoring and law enforcement are regularly implemented to manage wastewater treatment, especially in important river basin areas, major canals, and attractive beaches. Survey results revealed that 62% of large buildings are in compliance with the law (PCD 2020).

Industrial wastewater

Industries discharge processed wastes including by-products from industrial operations as wastewater. At present, many industries are located in areas of high population density or within residential areas in cities. Across the country there are more than 120,000 industrial establishments of various sizes in 77 provinces, carrying out a wide range of activities, located within the Inner Gulf. Meanwhile, there are approximately 87,000 small or community factories in Thailand, contributing 6% of the BOD load in main rivers (Wangcharoenrung 2017). The total amount of generated industrial wastewater was estimated at 17.8 million m^3/day (Chaiyo 2019). Laws and regulations are being strictly enforced for small/community, medium-sized and large factories, industrial plants and industrial estates, which were all required to have wastewater systems complying with the effluent standards set by the Government of Thailand.

General standards for controlling effluent from industry, industrial parks, industrial zones and specific standards for producing fresh water from seawater reverse osmosis plants, leather mills, pulp and paper mills have been issued.

Many industries, such as dyeing, textiles, pulp and paper, tea, coffee and beverage industries, small and medium-sized enterprises (SMEs), have transferred to using clean technologies to reduce waste, water and raw material use, energy, greenhouse gas and CO_2 emissions, and have achieved effluent standards in both production processes and discharge lines. During 2011–2018, about 34,000 plants were certified as green industrial plants.

Industries that generate large volumes of wastewater are obliged to install equipment and tools to measure Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) parameters, and report such to local authorities via computer networks to ensure their treated wastewater meets the standards.

Agricultural wastewater

Agricultural activities such as the use of chemical fertilizers, pesticides and animal wastes from livestock farms (e.g., pig farms) all produce wastewater. A large portion of the fertilizer used for rice paddy fields is washed away by irrigation water and flows into rivers, estuaries, or other bodies of water, which causes eutrophication and encourages water hyacinth growth. This unwanted plant grows very quickly, and smothers major areas of water bodies.

Standards for controlling water discharge from pig farms and aquaculture have been formulated, and monitoring systems are in place to ensure wastewater treatment plants operate within the standards. Farmers are assisted in managing wastewater efficiently and produce in an environmentally friendly manner. Currently, there are 18,118 aquaculture farms, which are GAP (Good Aquaculture Practice) certified (PCD 2020).

To both raise awareness and develop environmental management of pig farms, including of waste treatment and recycling in order to reduce the impact of odour and polluted water problems, a project named “Farm Rak Sing Waed Lom” (Environmentally Friendly Farm) was launched, aimed at farmers.

5 | Frameworks for Water Environmental Management

5.1 Legislation

The Constitution of Thailand (RTG 2017) stipulates that the Thai people have the duty to cooperate in and support the conservation and protection of the environment, natural resources, biodiversity, and cultural heritage (chapter IV, section 50-8). Meanwhile, the State has the responsibility to “conserve, protect, maintain, restore, manage, and utilize or arrange for utilization of natural resources, environment, and biodiversity to attain benefits in a balanced and sustainable manner and shall allow the people and communities in the concerned localities to participate in and benefit from the implementation herein described as required by the law” (chapter V, section 57-2). The Constitution also stipulates that the Thai people have a right to use the environment, but that they also have a duty to conserve and protect the environment.

Meanwhile, the Enhancement and Conservation of the National Environmental Quality Act (NEQA) of 1992 is the basic law for environmental conservation in the country and defines the authorities and responsibilities regarding environmental protection. Some key features of NEQA are as follows:

- Establishment of the Environmental Fund, from which resources will be drawn to solve environmental problems in priority areas.
- Formulation of a National Environmental Management Plan, executing duties of government agencies to implement the plan and for provinces to prepare action plans.
- Provision for the National Environmental Board (NEB) to declare Pollution Control Areas (PCAs) or Conservation and Environmentally Protected Areas when justified from an environmental point of view.
- Establishment of a multi-agency Pollution Control Committee for pollution control matters, including enactment of discharge standards.
- Recognition of the Polluter Pays Principle.

In terms of control and management of water quality issues in Thailand, the regulations can be grouped into three categories as follows:

- The application of the environmental impact assessment (EIA) to determine the impact and mitigation plan for development projects of various types and sizes such as dams with a storage volume of 100 million m^3 or more, irrigation projects of 12,800 ha or more, hotels or resorts with 80 rooms or more, thermal power plants with capacities of 10 MW or more, and mining projects of all scales.
- The establishment and application of effluent standards such as industrial effluent standards, domestic effluent standards, and effluent standards for pig farms and fish/shrimp farms.
- The ambient water quality standards and classification based on the state of water quality, socio-economic aspects and availability of treatment technologies.

An overview of the legislation related to water environmental management in Thailand is shown in Figure 2.12.7.

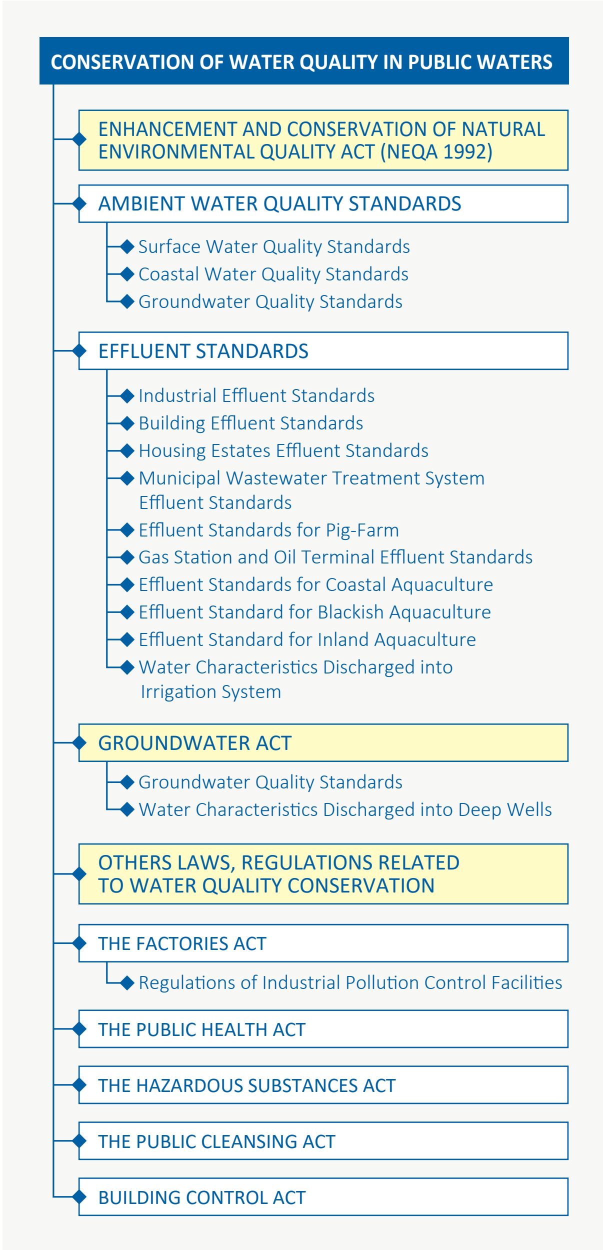


Figure 2.12.7 Legislative chart for water quality management
(Figure was prepared by IGES based on information from the official website of Thailand Pollution Control Department: http://www.pcd.go.th/about/en_ab_mission.html)

5.2 Institutional Arrangement

According to NEQA, PCD and the Office of Natural Resources and Environmental Policy and Planning (ONEP) under MoNRE are responsible for wastewater management through conducting national and regional water quality management planning as well as facilitating local authorities in their responsibilities for wastewater management. Under the EQA, the PCD establishes effluent standards for pollution control from point sources in order to meet ambient environmental quality standards.

5.3 Ambient Water Quality Standards

Surface water quality standards

The first standard for ambient water quality was established in 1994, and comprised 28 items under five categories of water bodies, designated according to water usage as shown in Table 2.12.2. The General Water Quality Index was established as an indicator to promote people's understanding of water quality, which was calculated with the values of eight parameters (pH, DO, BOD, TS, FCB, NO_3 , TP, SS). These standards are the national minimum standards.

Table 2.12.2 Surface water quality standard classification

Class	Description/Condition	Beneficial Use
Class 1	Natural water resources without wastewater from any activities	Water is safe for consumption, sanitized, and appropriate for propagation and ecosystem conservation.
Class 2	Very clean fresh surface water resources	Water resources for conservation, fishery, swimming, water recreation and consumption (with basic treatment).
Class 3	Medium clean fresh surface water resources	Water resources for agriculture and consumption (with general treatment).
Class 4	Fairly clean fresh surface water resources	Water resources for industrial work and consumption (with special treatment).
Class 5	Sources which are not classified into classes 1-4	Water resources for transportation.

(Source: PCD 2015)

Coastal water quality standards

The coastal water quality standards comprise 30 parameters designated in six classes, determined according to usage (six classifications). Different classifications are applied for the west coast of Phuket Island.

Groundwater quality standards

The parameters included in groundwater quality standards are divided into four groups: volatile organic compounds (15 parameters), heavy metals (10 parameters), pesticides (nine parameters) and others (four parameters).

Water quality monitoring framework

Under the EQA, the government conducts monitoring of the receiving water quality to maintain quality. The Water Quality Management Division under the Pollution Control Department - Ministry of Natural Resources and Environment (MONRE) is responsible for regular monitoring of both inland (surface and groundwater) and marine water. There are 368 general and 75 automatic monitoring stations across 48 main rivers and six standing surface water resources (lakes) within the country. Water quality samples from general monitoring stations are taken four times/year during the wet and dry seasons (Chaiyo 2020), and the methods used should follow the Standard Method for the Examination of Water and Wastewater (1998) (Yolthantham 2011). Monitoring results of ambient water quality, conducted by the Pollution Control Department, are summarized and made available to the public through online publications annually (e.g., Thailand State of Pollution Report).

5.4 Effluent Standards

Based on the NEQA (Section 32), a series of effluent standards have been set up as follows:

a. Industry

Industrial effluent standards

Standards are applied to factory Group II and III categories and all industrial estates under the Factory Act B.E. 2535 (1992). Standard values are designated for 15 parameters and 12 heavy metals. This standard has been used since 3 January 1996. The standard also provides some exemptions for certain industries such as related to chemicals, starch, and animal foods. Recently, a new Decree on Industrial Effluent Control Standard B.E. 2559 (2016) was announced by the Ministry of Natural Resources and Environment of Thailand, on 6 June 2016, to take effect from 6 June 2017. Under the new standard, no exemptions are permitted. The standard is comprised of two parts – a general effluent standard (consisting of 15 parameters and 16 heavy metals), and type-specific effluent standards.

Regarding effluent quality control, the Regulations of Industrial Pollution Control Facilities (1982) stipulates that specific industrial plants are obligated to have supervisors and machine operators responsible for pollution prevention. Such industrial plants include those using heavy metals in production processes and discharging wastewater in quantities above 50 m^3/day containing designated quantities of heavy metals.

b. Domestic and commercial

Building effluent standards

Effluents from each type of building, namely apartments, hotels, hospitals, schools and academic buildings, public and private offices, department stores, fresh markets and restaurants, are regulated under these standards. Regulated parameters, depending on building size, include pH, BOD, suspended solids, sulfide, TKN, and fat, oil, and grease.

Housing estate effluent standards

These standards regulate effluent from housing estates, which are classified into two types: those with over 100 but less than 500 units, and those over 500 units. Regulated parameters include pH, BOD, suspended solids, settleable solids, total dissolved solids, sulfide, TKN and fat, oil, and grease.

Municipal wastewater treatment system effluent standards

This is a new standard, established in 2010, and contains six parameters, namely pH, BOD, SS, TN, TP and fat, oil, and grease.

Gas station effluent standards and oil terminal effluent standards

There are four parameters in these standards, namely pH, COD, SS, and fat, oil, and grease.

c. Agriculture

Effluent standards for pig farms

In consideration of the contribution of pig farms to water pollution such as in the Tha Chin River and Bang Pakong River, standards were established in 2001. Parameters designed by the standards include pH, BOD, COD, SS, and TKN and different values are applied to Type A (more than 600 livestock units) and Type B (60–600 livestock units).

d. Others

Effluent standards for coastal aquaculture and others

There are several effluent standards for aquaculture and others as follows:

- Effluent Standards for Brackish Aquaculture
- Effluent Standards for Inland Aquaculture
- Water Characteristics Discharged into Irrigation System
- Water Characteristics Discharged into Deep Wells

Effluent inspection procedures

Around 10 years ago, under the Environmental Army Project (2005–2007), over 25 universities across Thailand took part in a large-scale survey to support the inspection of about 120,000 factories in the country, which was aimed at building a wastewater database for better planning and management of industrial wastewater in the future. The data collected includes: (i) Contact address; (ii) GPS Coordinates; (iii) Photos of front door and effluent points; (iv) Boiler's exhaust opacity with Ringelmann Scale; (v) Effluent wastewater quality.

According to Wangcharoenrung (2017), under a survey carried out by the Environmental Army Project 10 years ago targeting factories, the results showed that compliance statistic was almost the same after 10 years. In addition, a number of challenges in monitoring have also been pointed out, including:

- Limited human resources: Approximately 120,000 factories in 77 provinces but only three inspection officers per province for Ministry of Industry and 40 officers for Pollution Control Department.
- Insufficient monitoring tools: lack of equipment and laboratory facilities for monitoring and analysis.
- Data exchanges between government agencies is not common thus much duplication exists.
- Lack of environmental awareness/honesty of factories; profit is considered paramount.

Problematic industries, which often fail to comply with the effluent standard are classified into three types (Wangcharoenrung 2017):

- High Risk Industry Group (1): Those with frequent accidents, such as in the petrochemical industry, ethanol industry, sugar industry and cold storage industry. Possible reasons: (i) lack of qualified/well-trained safety and environmental officers; (ii) lack of accident prevention training.
- High Pollution Industry Group (2): Those finding it challenging to comply with the effluent standard, such as the starch industry, textile, pulp and paper industry and leather tanning industry. Possible reasons: (i) one general effluent standard cannot fit all types of factories; (ii) only concentration-based standard exists; (iii) lack of knowledgeable persons for wastewater treatment plant operation.
- Low Capacity for Environmental Management Group: Those which do not treat wastewater, such as SMEs and community factories. The survey conducted in 2014 showed there are approximately 87,000 small and community factories, contributing 6% of the BOD load of main rivers in Thailand. Possible reasons: (i) factories lack funding and

knowhow for wastewater treatment; (ii) small site inspections are impossible or too challenging.

In 2016, statistics related to pollution complaints from various responsible offices showed that there were 10,422 complaints, a drop of 9% from the previous year. The types of pollution problems included air pollution (foul odours, dust and smoke), noise levels and vibration. However, most of the complaints received by the Public Service Center, Office of the Permanent Secretary, Prime Minister Office concerned municipal solid wastes, sewage wastes, and hazardous wastes (PCD 2016).

Effluent monitoring

The NEQA requires the owner or possessor of point sources of pollution designated under the act to monitor the quality of effluent and collect statistics and data, as well as submit notes and reports (Section 70 and 80). The types of effluent to be monitored are categorized into four groups: sewage-swine farms; land development, industrial estates and industrial zones, and Class A buildings (hotels, hospitals, condominiums, department stores, markets and restaurants). The point sources of water pollution were also monitored in three river basins: the Chao Phraya, Tha Chin, and Bang Pakong.

If the capability to treat or dispose of wastewater fails to meet applicable standards, the owner has a duty to make modifications or improvements to reach conformity with the pollution control official's directions. Fees, fines and civil liability and penal provisions are applied if violations are found or the owners refuse to comply. It is a promising trend that all sectors are willing to comply with the standards, and it can be advantageous for securing business agreements as well as lead to improved quality of the environmental and by extension quality of life.

Meanwhile, the Pollution Control Department has the authority as pollution control office under the National Environmental Quality Act B.E. 2535 (1992) to investigate wastewater effluent from various pollution sources. According to the PCD (2015) in 2015, 1,392 pollution sources consisting of industrial factories, industrial estates, certain types and sizes of buildings, gas service stations, swine farms, municipal wastewater treatment systems and allocated lands were under investigation, of which 404 sources did not meet the standards. While notification to officers in the Factory Act was required for industrial factory and industrial estate sources, administrative orders were issued to pollution contributors or possessors other than industrial factories and industrial estates to make changes, corrections, or improvements to their pollution treatment systems to meet the required standards within designated time durations.

5.5 Other Policies on Water Environmental Management

The Government of Thailand has, over time, invested over 83 billion THB in constructing centralized wastewater treatment facilities. As per Section 23 and Section 24 of the Decentralization Act, 1999, Provincial Administrative Organizations, Municipalities, Tamboon (sub-district) Administrative Organizations and the City of Pattaya may receive income from fees collected from users for the public services provided in order to operate and maintain the facilities (Bao et al. 2020).

Similarly, under the National Environmental Quality Improvement and Conservation Act of 1992, local governments may collect fees from service areas where centralized wastewater treatment facilities were built and operated as public works using government funds. On 4 December, 2006, the National Environmental Board (NEB) agreed to collect wastewater management fees based on the "Polluter Pays Principle" and the type of wastewater treatment system. According to a recent study, only around 17 local government agencies have adopted user fees for wastewater collection across the country (Bao et al. 2020). For various reasons, most local government agencies do not impose user fees or service charges for wastewater collection and treatment, which has resulted in insufficient funds to operate and maintain existing treatment plants.

Despite the many economic tools or instruments available, which have also been successfully applied in other countries, none have been successfully applied in Thailand. As a basic guiding rule, to effectively address the issues surrounding water pollution, the principle of 'polluters pay principal' should therefore be adopted nationwide. It should be noted that, based on the lessons learned from other ASEAN countries, economic instruments can be successfully implemented when combined with other measures, such as stricter environmental standards, guidelines on alternative technologies, and environmental awareness raising measures.

6 | Recent Developments in Water Environmental Management

The 12th National Economic and Social Development Plan

On 13 September 2016, the 12th National Economic and Social Development Plan was approved by the Cabinet, which contains 10 strategies, two of which focus on pollution management: (1) a strategy on an "environmentally-friendly growth for sustainable development", and (2), strategy on "the development of the various regions, the cities, and economic areas, with the goal of conserving and restoring natural resources and the environment in order to sustain an environmentally-friendly growth and the people's good quality of life".

Pollution Management Plan for 2017–2021 period

Also occurring in September 2016 was the National Environmental Board's approval of the Pollution Management Plan for the 2017–2021 period, prepared by the Ministry of Natural Resources and the Environment (MONRE), which contains four strategies, two of which cover pollution management. One is a strategy for managing the quality of the environment in a good state, i.e., such that it is protected, rehabilitated and restored. The other focuses on increasing the efficiency of usage of natural resources in a worthy and sustainable manner, which can be used to gauge whether all stakeholders are aware of the value of natural resources, utilize them efficiently, as well as mitigate any potential environmental impact and thus enabling economic development on the bases of sustainable bio-resources.

20-Year Pollution Management Strategy

On 28 December 2016, the National Environmental Board gave its approval for the 20-Year Pollution Management Strategy prepared by MONRE, with goals in three phases: (i) Phase 1: in the first five years, improve the pollution management system; (ii) Phase 2: in years 10–15, produce and consume environmentally-friendly products on a daily-life basis; and (iii) Phase 3: within 20 years, gear the country towards becoming a low carbon and zero waste society.

Maintenance of the Cleanliness and Orderliness of the Country Act (No. 2) B.E. 2560 (2017)

Also taking place in 2016 was the Ministry of Interior's drafting of the Maintenance of the Cleanliness and Orderliness of the Country Act (No. 2) B.E. 2560 (2017), which was approved by the Cabinet on January 12th, 2016. It states that local administrative offices in each area are to be responsible for the collection and disposal of sewage waste and municipal solid waste. The Minister of Interior is to issue a ministerial regulation as follows: (i) set up a specific fee for sewage and municipal solid waste management, (ii) assign the responsibility and authority to Local Administrative Organizations concerning waste collection, transport and disposal, (iii) those who wish to conduct businesses around sewage and waste collection, transportation and disposal must apply for a license from the local administrator, (iv) the Department of Local Administration has the duty to propose, advise and support the Local Administrative Organizations to conduct plans for the Waste Management Project to be in-line with the provincial development plan, prepare a budget for local administrative organizations requiring budgetary support drawn from the National Budget, state the penalties under criminal law for those conducting unauthorized business operations around waste collection, transportation and disposal, as well as for those who infringe local laws. This Act was announced in the Royal Thai Government Gazette No. 134 Section 5A on 15 January B.E. 2560 (2017), and went into effect on 16 January B.E. 2560 (2017) (PCD 2016).

Strategy for Water Resource Management Act B.E. 2558–2569 (2015–2036)

MONRE in cooperation with Ministry of Agriculture and Cooperatives drafted the Strategy for Water Resource Management Act B.E. 2558–2569 (2015–2036) which was approved by the Cabinet on 7 May, 2015. The strategy set a policy framework for unified and integrated prevention of and solutions to water resource problems, including the scarcity of water, flooding and water quality issues. The vision of the strategy states that "Every single village has clean water for household consumption as well as for stable production. Damages from flooding are mitigated. Water quality meets the standard. Water resources are sustainably managed with balanced development and participation of all sectors". This Strategy consists of six sub-strategies, each focusing on a different target area: (i) Strategy for Water Management for Household Consumption, (ii) Strategy for Creation of the Stable Water Supply in Production Sector (both agricultural and industrial sectors), (iii) Strategy for Flooding Management, (iv) Strategy for Water Quality Management, (v) Strategy for Conservation and Mitigation of Impaired Watershed Forest and Prevention of Soil Erosion, and (vi), Strategy for Management.

7 | Challenges and Future Plans

The water environmental management in Thailand has historically been a priority for the country, especially since 1992. Legislative frameworks have since been developed and improved to promote implementation, and over the last 25 years, the overall picture of the country's state of pollution shows some improvements, due to the cooperation of various stakeholders, including governmental and non-government actors. However, many issues still need to be addressed, such as the steady degradation of water quality in many cities and areas due to rapid development of communities, especially those living next to waterways, and impacts from agricultural and industrial activities. Many cities also still lack appropriate sewage collection and treatment systems.

Based on the current challenges and above discussion, it is recommended that the following measures be considered to further improve water quality and more effectively control water pollution in Thailand in the coming years:

- Effective implementation and enforcement of relevant laws and strategies on water pollution prevention and protection of water resources, including National Water Quality Management Plan under the 20-year Pollution Management Strategies, Strategy for Water Resource Management (2015–2036); 20-year Marine and Coastal Resources Management Master Plan (2017–2036), the National Water Quality Master Plan (2018–2037), and the 20-year Groundwater Resources Management Strategy (2017–2036).
- Effective application of economic measures in the pollution permitting system to reduce discharges to water sources and maintain acceptable water quality level.
- Establishing specific effluent standards, taking into account the sensitivity of the surrounding area and the assimilative capacity of the receiving water body.
- Regular monitoring of ambient water quality, investigation of water quality changes, and inventory of pollution sources, which play an important role in strategies for effective water quality protection and management.
- Use of less capital-intensive solutions, to avoid constructing costly centralized wastewater treatment plants and raise the ratio of wastewater treatment. Decentralized wastewater treatment systems can be integrated as an effective means to supplement centralized systems, due to their competitive advantages of cost, area availability and just-in-time nature, thereby improving wastewater management, especially in urban and peri-urban settings. There should be zoning of areas for different sanitation system schemes, i.e., on-site/decentralized/centralized or combinations thereof, considering various local factors such as population density and land availability.
- Development of appropriate guidelines and procedures for the collection of water protection fees, to ensure that the full cost of operating and maintaining the wastewater treatment system is recovered.
- Promotion of environmental awareness, by collecting wastewater treatment fees in the service areas of water quality management facilities so that the citizens benefitting from these facilities can participate in a holistic and sustainable solution to the problem, based on the polluter pays principle (PPP).
- Replication of knowledge dissemination and awareness programs on environmental measures across the country for all polluting sectors, especially agriculture and aquaculture. Environmentally friendly agricultural practices for farmers should be further strengthened to reduce the impact of environmental problems such as odours and wastewater.
- Creation (by government) of an enabling environment for private investment in the water and wastewater sector, ensuring good returns, while further encouraging private sector involvement in corporate social responsibility.

2.13 Viet Nam

1 | Country Information

Table 2.13.1 Basic indicators

Land Area (km²)		310,070 (2016)
Total Population		96.46 million (2019)*
GDP (current USD)		261.9 billion (2019)*
GDP per capita (current USD)		2,715 (2019)*
Average Precipitation (mm/year)		1,950 (2017)**
Total Renewable Water Resources (km³)		884 (2017)
Total Annual Freshwater Withdrawals (billion m³)		82 (2014)
Annual Freshwater Withdrawals by Sector	Agriculture	80.6% (2018)
	Industry	15.0% (2018)
	Services	1.7% (2018)
	Municipal (including domestic)	2.7% (2014)

(Source: *World Bank 2020, **2030 WRG 2017)

Figure 2.13.1 Han River in Da Nang, Viet Nam

2 | State of Water Resources

Viet Nam has a large river and canal network, including over 3,450 rivers and streams with lengths exceeding 10 km. There are 13 large rivers and 310 inter-provincial rivers belonging to eight large river basins, with an area of about 270,000 km² (accounting for 80% of the total area of the river basin). Of these, many rivers cross borders with other countries, such as the Mekong river systems (Mekong River), Red River, Bang Giang - Ky Cung River, Ma River, Ca River, and Dong Nai River. As a result, the country has an abundance of surface water resources. The total volume of the country's river basins is about 830–840 km³/year, but only about 310 km³ (37%) is within the country, while the remaining 63% is generated from neighboring countries (MONRE 2018).

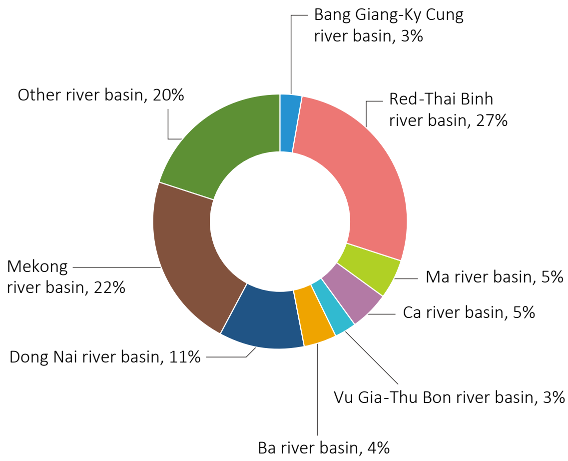


Figure 2.13.2 River basin area as percentage of total area

(Source: MONRE 2018)

Although Viet Nam enjoys abundant surface water resources in general, they are unevenly distributed across the country due partly to uneven rainfall distribution. The total volume of water being exploited is about 80.6 billion m³ (approx. 10% of total national water volume), of which over 80% is used for agricultural purposes (about 65 billion m³ /year). Water is also used for energy production, daily life, aquaculture and industrial production, tourism and services. There is a trend of rising water use in industry, fisheries and living. Water use for agricultural production is highest in the Mekong Delta and Red River Delta, accounting for 70% of water use. The catchment area with the highest industrial water use rate is Hong- Thai Binh, accounting for nearly half of the total water use for Vietnam's industry (MONRE 2015). The structure of water use is expected to change by 2030, with 75% going to agriculture, 16% to industry, and 9% to domestic uses (MONRE 2018). In addition, Rapid urbanisation and the prolonged dry season due to the impacts of climate change is causing serious water shortages in many areas of the country, especially in the areas around Mekong river basin in Vietnam.

Table 2.13.2 River basins in Viet Nam

Major river basins	Catchment area (km^2)	Total annual flow (km^3)
Red and Thai Binh	169,020	135
Bang Giang-Ky Cung	13,260	9.4
Ma	28,400	18
Ca	29,930	23.5
Gianh	4,680	8.14
Thach Han	2,550	4.68
Huong	3,300	5.64
Vu Gia-Thu Bon	10,350	20.1
Tra Khuc-Ve-Tra Bong	5,200	6.19
Kon-Ha Thanh- La Tinh	3,640	2.58
Sesan	11,450	12.9
Srepok	18,200	13.5
Ba	13,900	9.5
Dong Nai-Sai Gon	40,294	37
Mekong (or Cuu Long)	761,417	475
Group of river basins in southeast region	15,760	9.16

(Source: MONRE 2014)

It is predicted that Viet Nam will become one of the countries most vulnerable to climate change and is likely to face significant impacts, especially in its water resources, surface water resources in particular. Impacts from climate change will vary according to region, and in recent years the northern delta and central coastal regions have already been affected by longer dry periods and torrential rains, resulting in droughts and flooding, as well as rising sea levels, storms, flooding and coastal erosion. The southern region is relatively flat and geologically weak, and is prone to flooding and saltwater intrusion as a result of sea level rise, with about 45% of the region projected to be at risk by 2030 (MONRE 2018).

In addition to surface water, groundwater is also an important water supply source for domestic, industrial and agricultural activities. According to MONRE (2015), groundwater in Viet Nam is relatively plentiful due to the abundant rainfall which is distributed widely across the country. Reserves are estimated at about 172.6 million m^3/day. The total volume of groundwater exploitation is about 10.53 million m^3/day, of which the Northern and Southern delta are the two most exploited areas with total capacities of about 5.87 million m^3/day, accounting for 55.7% of the country's exploitation. Recently, due to overexploitation of groundwater in areas such as Hanoi and the Mekong delta, problems of falling water tables, associated land subsidence and salinity intrusion have been reported.

3 | State of Ambient Water Quality

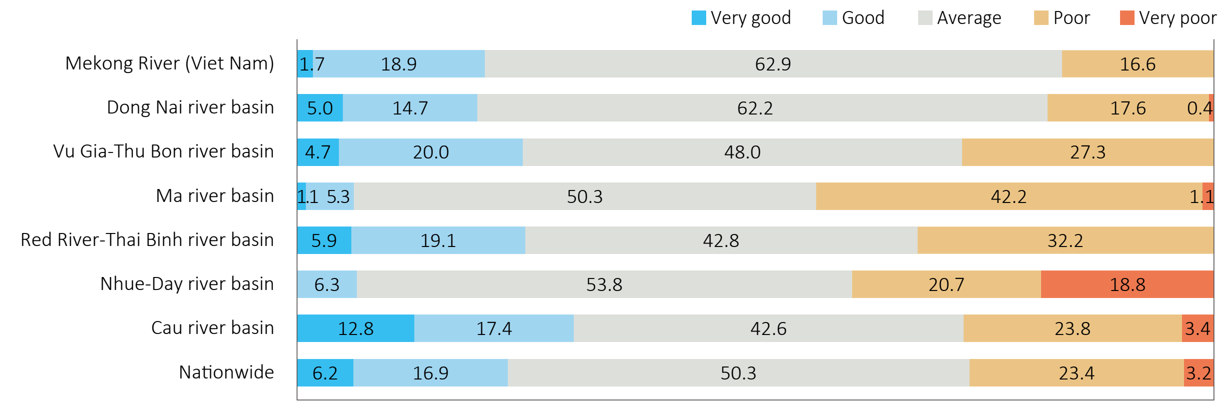
Water pollution of river basins across the country results from different sources, but is mainly due to the discharge of untreated or partly treated domestic, industrial and agricultural wastewater, as well as wastewater from craft villages and hospitals. According to MONRE (2018), domestic wastewater accounts for more than 30% of the total wastewater discharged directly to rivers, lakes, or canals leading to rivers, and is often characterized by high levels of organic compounds, nutrients, suspended solids, and large amounts of coliforms.

3.1 Surface Water

In general, the surface water quality in some major river basins has seen a slight improvement due to more efficient control over rising pollution loads. The Red-Thai Binh, Ma, Vu Gia-Thu Bon and Mekong river basins have relatively good water quality, and many segments of these rivers are used as raw sources for domestic water treatment plants. However, some river basins are still severely polluted and of relatively low quality, such as Nhue-Day river basin. Most river basins in Viet Nam's territory have high TSS values and turbidity, often exceeding QCVN 08- MT: 2015/BTNMT (A2), as well as the B1 level (see Table 2.13.3) during the flood season.

Major pollutants in the contaminated areas are included in organic pollution and micro-organism. Local pollution of oil, grease and heavy metals also occurs, especially in areas affected by waterborne traffic, industrial production, and mineral exploitation.

Water Quality Index values calculated based on the 2014–2018 water quality monitoring results of seven river basins showed that the ratio of river basins, which have been classified as "Average" quality, account the highest percentage in all river basins. The river basins with good and very good water quality (higher than the national average) are the Red river -Thai Binh river basin, Mekong river basin, and Cau river basin. The Nhue-Day river basin still has the poorest water quality with a ratio of 18.8%. In the Ma river basin, Red River-Thai Binh river basin, and Dong Nai River basin, the ratio of average to poor water quality is very high, mainly due to the high amount of suspended solids (especially during the rainy season) (MONRE 2018).



WQI Value	*Suitability for the following purposes*
91–100	Used for domestic water supply purposes
76–90	Used for domestic water supply purposes, but requires appropriate treatment measures
51–75	Used for irrigation and other similar purposes
26–50	Used for navigation and other similar purposes
0–25	Heavily polluted water source, this is a need for appropriate treatment measures in the future

Figure 2.13.3 Changes of WQI values of rivers belonging to Red River-Thai Binh river basin during 2014–2018
NOTE: Water Quality Index (WQI) is calculated according to "Decision No. 879/QD-TCMT dated 1 July 2011" (Source: MONRE 2018)

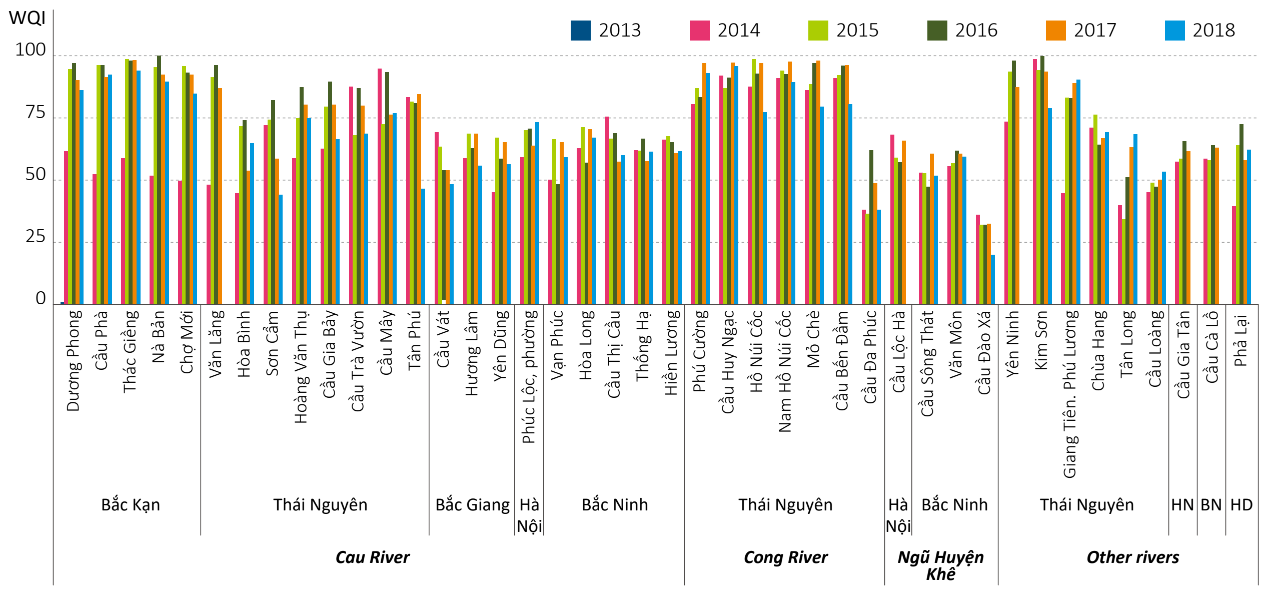


Figure 2.13.4 Changes of WQI values of rivers belonging Cau river basin during 2014–2018 (Source: MONRE 2018)

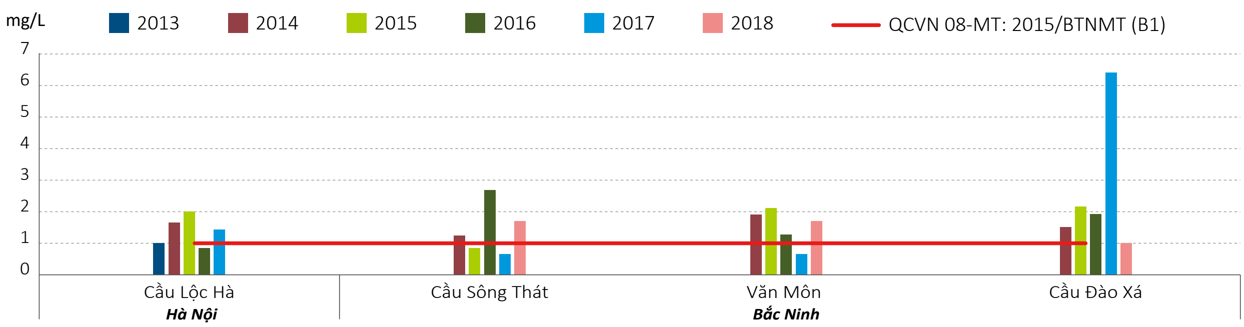


Figure 2.13.5 Changes of ammonium content in Ngu Huyen Khe river water during 2014–2018 (Source: MONRE 2018)

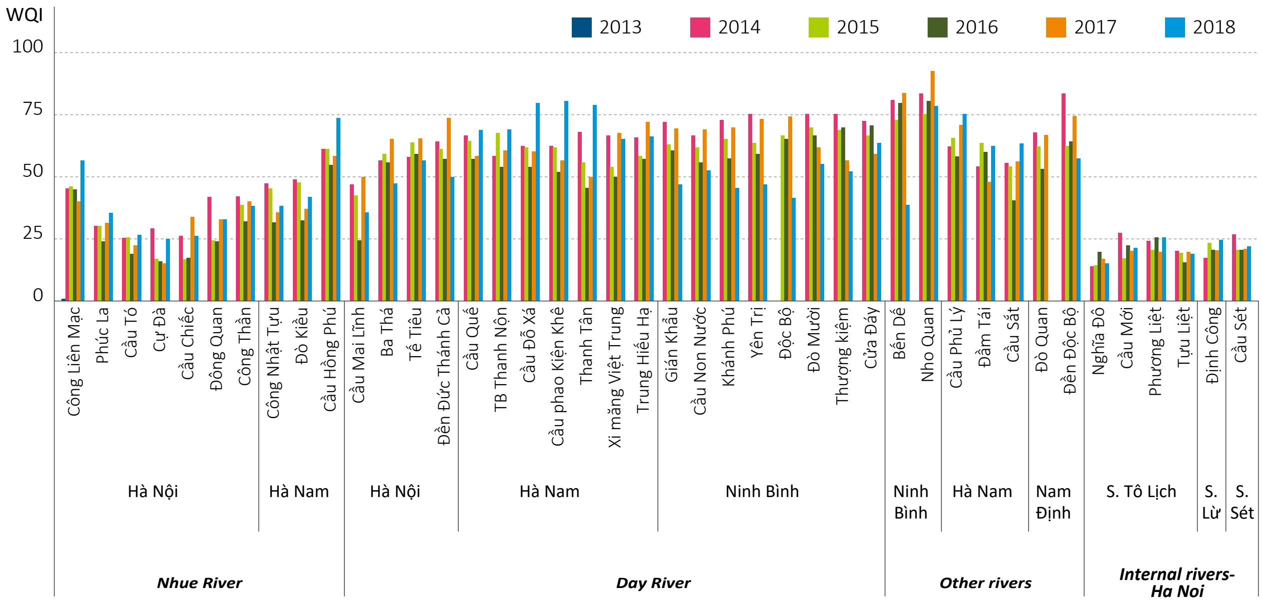


Figure 2.13.6 Changes of WQI values of rivers belonging to Nhue - Day river basin during 2014–2018 (Source: MONRE 2018)

Nhue-Day river basin is part of the Red-Thai Binh river basin, which expands over six provinces and cities in the Red River Delta region. During 2014–2018, river segments flowing through urban and production-intensive areas continued to be polluted by organic matter, nutrients, and microorganisms, and river water quality in 2016 dropped compared to previous years. Conversely, 2017 to 2018 saw water quality rise in some areas.

Meanwhile, water quality of the part of Nhue River flowing through Hanoi city has always showed low (low WQI value), mainly due to the significant impact of water pollution in the downstream area, especially during the dry season. Further, most of the rivers flowing through Hanoi have always been heavily polluted (with WQI less than 25), with no improvement from year to year. Other smaller rivers such as Lu river, Set river, and Kim Nguu river are also in the same condition, according to MONRE (2018).

Table 2.13.3 Classes of surface water quality standards

Class	Objective of use
A1	Good for domestic water supply and other purposes in A2
A2	Good for domestic water supply, but suitable treatment technology must be applied; conservation of aquatic life or other purposes in B1 and B2
B1	Good for irrigation and other purposes with demand for similar quality water and other purposes in B2
B2	Good for water transportation and other purposes with demand for low-quality water

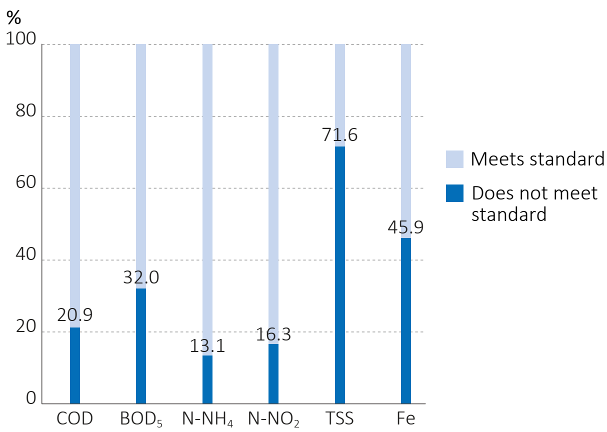


Figure 2.13.7 Ratio of values exceeding QCVN 08-MT: 2015/BTNMT (A2) of some selected parameters on Ca river basin during 2014–2018 (Source: MONRE 2018)

3.2 Coastal Water

In general, coastal water quality in Vietnam is relatively good and most monitoring parameters are within the limits set by National Technical Regulation on Coastal Water Quality QCVN 10-MT: 2015/BTNMT). In most monitored areas QCVN 10-MT: 2015/BTNMT (aquaculture and bathing) limits were even bettered in terms of COD, NH_4^+ during 2011–2015, especially in northern and southern coastal areas. However, cases of organic pollution are rising due to increased discharge of untreated wastewater and solid waste directly into the sea in coastal provinces, and levels of organic pollution in the northern coastal areas is higher than in the central and southern regions, but showed a falling tendency during 2011–2015. Tho Quang boat (Da Nang) has become one of the hotspots of marine pollution in recent years.

3.3 Groundwater

According to MONRE (2015), although groundwater quality may vary geographically, it is generally considered relatively good. Normally, groundwater has a pH value arranging from 6.0–8.0, is termed as soft water (hardness <1.5 mg/l), and concentrations of organic compounds, microorganisms and heavy metals are often within permissible levels, i.e., National Technical Regulation on Groundwater Quality QCVN 09-MT:2015/BTNMT.

However, cases of groundwater pollution are occurring in certain areas, especially the Northern Delta (e.g., Red River Delta). Major pollutants exceeding permissible levels include Total Dissolved Solids (TDS), ammonium, heavy metals (Mn, As, Cd, Pb) and salt intrusion. Saltwater intrusion has been reported in some areas, especially in the three most vulnerable – coastal central provinces, lower basin of Dong Nai river, and coastal provinces of the Mekong delta. Ammonium content in groundwater has also frequently exceeded the limits of quality standards in some points of regions across the country, the highest being in the Northern Delta (VEA 2015).

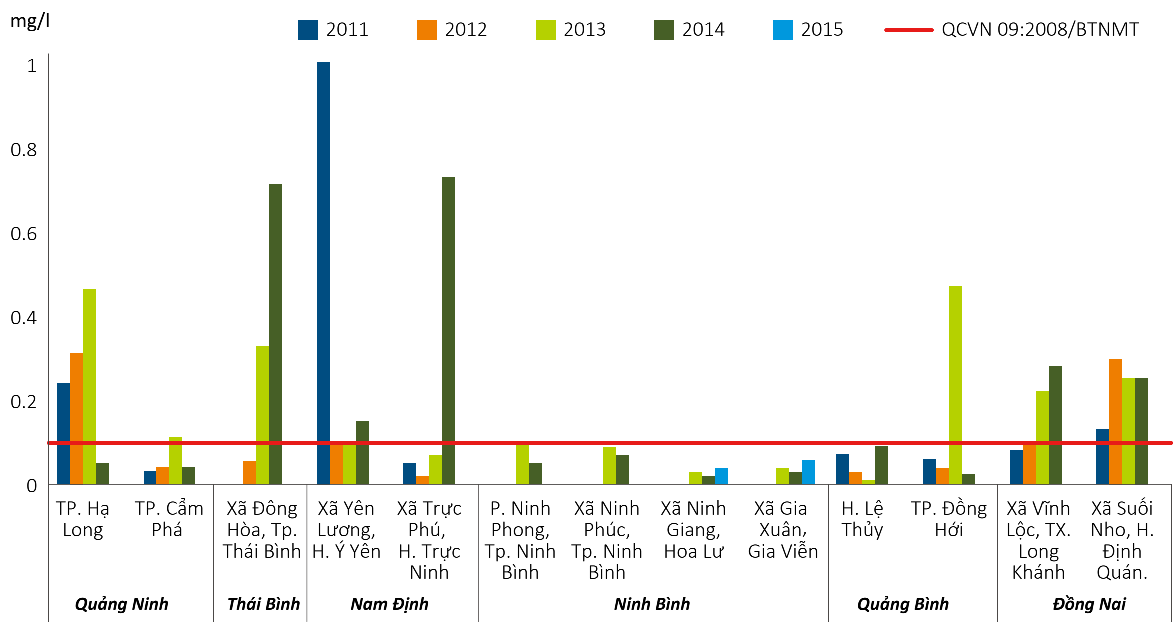


Figure 2.13.8 Ratio of ammonium content in underground water in some localities in the period 2011–2015 (Source: VEA 2015)

4 | State of Wastewater Treatment

Domestic wastewater

Domestic wastewater includes wastewater sources from household activities, businesses and service industries (restaurants, hotels, resorts, etc.). The percentage of domestic wastewater of total wastewater discharged directly into rivers, lakes and canals is very high, exceeding 30%. Based on the data, the southeast region and Red River Delta (especially in big cities like Hanoi and Ho Chi Minh) areas exhibit the highest amounts of domestic wastewater discharge into receiving water bodies. The estimated ratio of domestic wastewater collected and properly treated in Class IV urban areas (or higher) is about 12.5%, an increase of 5% compared to 2011–2015, with 45 centralized wastewater treatment plants across the country with approx. 926,000 m^3/day total capacity. In big cities such as Hanoi, only about 20.62% of the city's total generated domestic wastewater is treated, which drops to 10% or higher in Ho Chi Minh city. Currently, construction is planned for about 80 additional centralized wastewater treatment systems under ongoing projects, with a total design capacity of about 2.4 million m^3/day (MONRE 2018).

Industrial wastewater

In addition to domestic wastewater, other sources of wastewater discharges such as from industry, services, craft villages also affect the urban water environment. In the inner parts of some cities like Hanoi, there are still some small-scale production units and craft villages (e.g., food processing, slaughtering cattle), mainly comprised of households, which have not invested in waste and wastewater treatment systems. The southeast region, where a large number of industrial zones are concentrated, is considered to produce the largest volume of industrial wastewater generation, followed by the Red River Delta, which also has a large number of industrial zones and industrial production establishments in operation.

In Vietnam, industrial wastewater has been carefully controlled and treated, especially industrial wastewater generated from industrial zones; however, percentages of properly treated wastewater meeting national effluent standards varies. As of early 2020, 274 industrial zones operated nationwide, of which 244 had centralized wastewater treatment systems, accounting for 89%. Provinces with large numbers of industrial zones/parks are those such as Ho Chi Minh City, Hanoi, Binh Duong, Ba Ria - Vung Tau, Dong Nai, Long An, Quang Ninh, Bac Ninh. There are 191/244 industrial parks with automatic water quality monitoring stations, accounting for 78.3%. According to Decree 38/2015/ND-CP on Waste and Scrap Management, all factories, production, business and service establishments located outside industrial zones/parks and which discharge large amounts of wastewater (1,000 m^3/day or higher) must install automatic continuous wastewater monitoring systems, and transmit all real time data directly to the Department of Natural Resources and Environment as regulated.

Wastewater pollution from agricultural activities

Currently, agricultural wastewater is also a matter of great concern as it represents one of the main factors influencing water resources in areas with thriving agricultural economies, such as Mekong Delta and Red River Delta. Wastewater from agricultural activities often contains pesticides and fertilizers, which are toxic to the environment and human health. It is estimated that each year about 70,000 kg (solid form) and over 40,000 liters of pesticides (liquid form), as well as about 70,000 kg of untreated chemical bags enter the environment, increasing the level of pollution of surface water and groundwater (World Bank 2017). In addition, wastewater from livestock production also significantly contributes to environmental burdens due to its volume – the total for 2018 was estimated at approx. 6.66 million m^3/day (MONRE 2018) – as well as contents, comprising large amounts of suspended solids, organic substances, nutrients and microorganisms.

5 | Frameworks for Water Environmental Management

5.1 Legislation

Article 53 of the new Constitution 2013 states that "The land, water resources, mineral resources, wealth lying underground or coming from the sea and the air, other natural resources, and property invested and managed by the State are public properties, coming under ownership by the entire people represented and uniformly managed by the State." The Constitution is the basis of environmental and water resources protection in the country.

The Law on Water Resources 2012 (Decree No. 17/2012/QH13) also highlights issues relating to the protection of water resources, including responsibilities for the prevention of water deterioration and depletion, and control of water quality. In addition, the Law on Environmental Protection 2014 (No. 55/2014/QH13) provides statutory provisions on environmental protection activities; measures and resources used for the purpose of environmental protection, including river water environmental protection; and rights, powers, duties and obligations of regulatory bodies, agencies, organizations, households and individuals who are tasked with environmental protection.

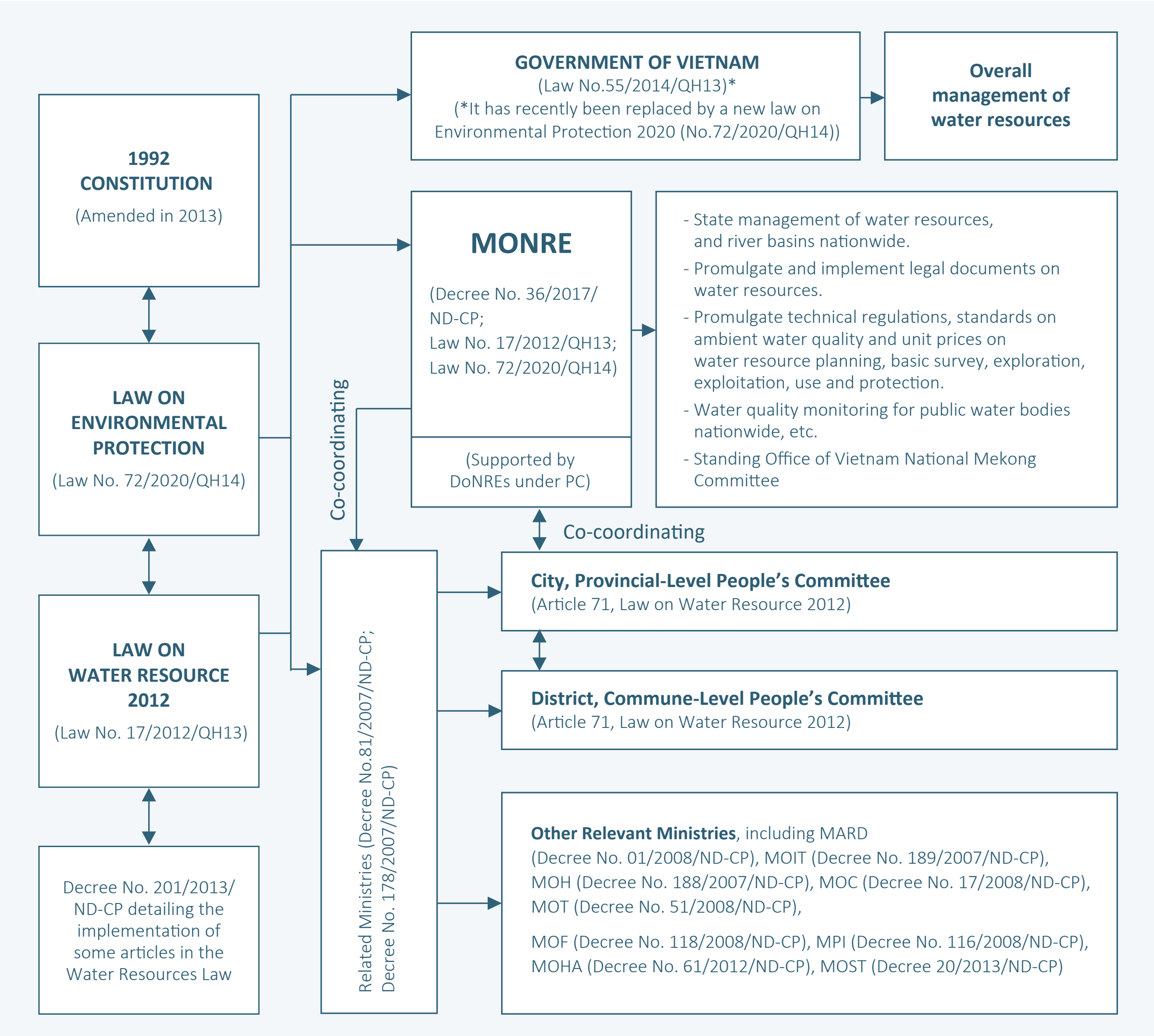
Several other relevant laws, such as the Mineral Law, Land Law and Biodiversity Law, and decrees, decisions, circulars and strategies on water resources management have also been promulgated to complete the national legislation related to water environmental management in Viet Nam.

5.2 Institutional Arrangement

State responsibilities for water resources management of the government, ministries and ministerial-level agencies, city and the provincial people's committee, district and commune people's committee are clearly stated in the Law on Water Resources 2012 and Law on Environmental Protection 2014, which has recently been replaced by a revised Law on Environmental Protection 2020 (No. 72/2020/QH14), which set out how the government is to perform uniform or overall state management of water resources.

The Ministry of Natural Resources and Environment (MONRE) is the main ministry responsible for overall state management of water resources, including the planning for environmental protection, verification of reports on strategic environmental assessments, assisting the government in designing, implementing and providing guidelines for responses to climate change, providing instructions on environmental remediation and improvement, implementation of national environmental monitoring, promulgation of technical regulations, standards on water quality and obligation for water quality monitoring of public water bodies, and management of river basins nationwide (Figure 2.13.9).

Other ministries that may influence or affect water resources management include the Ministry of Agriculture and Rural Development, Ministry of Industry and Trade, Ministry of Health, Ministry of Science and Technology,Ministry of Construction, Ministry of Transport, and Ministry of Finance, Ministry of Planning



Note: MONRE: Ministry of Natural Resources and Environment; MARD: Ministry of Agriculture and Rural Development; MOC: Ministry of Construction; MOHA: Ministry of Home Affairs; MOH: Ministry of Health; MOST: Ministry of Science and Technology; MPI: Ministry of Planning and Investment; MOF: Ministry of Finance; MOIT: Ministry of Industry and Trade; MOT: Ministry of Transport; PC: City or Provincial People's Committee.

Figure 2.13.9 State responsibilities for water resources management in Viet Nam

(Source: Prepared by IGES based on information from the relevant decrees) and Investment, and Ministry of Home Affairs (Table 2.13.4). In implementation, local governments play an important role in environmental management. The Department of Natural Resources and Environment (DoNRE) under the city or provincial people's committee takes a leading role in the promotion of environmental conservation activities through implementing environmental regulations and providing guidance.

Table 2.13.4 Responsibilities of other relevant ministries for water resources management

Relevant Ministries	Responsibilities
Ministry of Agriculture and Rural Development (MARD)	Manages rural water supply and sanitation; manages water for irrigation and aquatic production; flood, storm and disaster prevention; fishery, cultivation land management; management of hydraulic engineering and dikes.
Ministry of Construction (MOC)	Manages urban public works; design and construction of urban water supply, drainage and urban wastewater works.
Ministry of Health (MOH)	Manages drinking water quality; responsible for preparing and supervising water quality standards and regulations (drinking and domestic).
Ministry of Science and Technology (MOST)	Appraises the draft and publicizes the water quality standards prepared by MONRE.
Ministry of Finance (MOF)	Prepares policies on taxes and fees for water resources; allocates state budget.
Ministry of Planning and Investment (MPI)	Checks and provides instructions to other ministries and sectors on the preparation and implementation of the strategies on socio-economic development; allocates, plans and invests; coordinates international relations.
Ministry of Tansport (MOT)	Manages and develops transportation on water; manages aquatic engineering and port systems.
Ministry of Industry and Trade (MOIT)	Develops hydropower via the Viet Nam Electricity Corporation (EVN).

(Source: Prepared by IGES based on information from the relevant decrees defining functions and responsibilities of each relevant ministry)

5.3 Ambient Water Quality Standards

Ambient water quality standards

Ambient water quality standards are established for surface water, coastal water and groundwater. The Center for Environmental Monitoring (CEM) under the Viet Nam Environment Administration (VEA), was established under Decision No. 188/QD-IDU on 23/3/2010 of the VEA, and assists the VEA in organising, implementing tasks of national environmental monitoring, construction and environmental data management, applications for information technology in environmental monitoring, and building reporting on environmental quality in the functional framework of the VEA. The CEM is a leading center in the national environmental monitoring network. Since 2005, a number of regular monitoring programs have been carried out by the Center for Environmental Monitoring. In order to improve efficacy in managing monitoring data, from 2003, CEM started developing software dedicated to this task, and in 2009–2011, under the framework of an investment project to build an information network system, the software was developed into a new system and modified to handle additional requirements.

Water quality monitoring framework

At the national level, according to MONRE, the periodic surface water monitoring program continues to operate. It involves around 360 monitoring points for monitoring a number of the river basins, including Cau, Nhue – Day, Red River-Thai Binh, Ma, Ca, Vu Gia - Thu Bon, and Dong Nai river basin about 4–5 times a year. Other ministries also maintain their own annual environmental quality monitoring programs, with approximately 100 monitoring points of surface water in urban areas, areas affected by industrial production activities, with a monitoring frequency of 3–6 times/year.

At the local level, most provinces and cities have approved environmental monitoring network planning or the environmental monitoring plan in their areas, with numbers of monitoring points and annual monitoring frequency varying greatly (5–30 points; 2–6 times/year) among localities according to local conditions and requirements, as well as state of funding approval.

In addition to periodic monitoring activities, investment and expansion of automatic continuous monitoring systems have also taken place at both central and local levels. According to statistics, there are currently 23 continuous automatic surface water environmental monitoring stations at the central level and over 80 at the local level.

Monitoring data is used to review and revise policies and countermeasures for improving water quality and conservation measures. MONRE issues the National State of the Environment Report annually, in which major data is made public.

5.4 Effluent Standards

Effluent standards

There are various effluent standards in Viet Nam as shown in Figure 2.13.10, including for domestic, industrial and medical wastewater. In general, industries are required to carry out environmental impact assessments (EIA) and have to commit to self-monitoring four times a year, in accordance with a circular issued by the national government. Twice a year MONRE, VEA or/and DoNRE conduct inspections of compliance with industrial effluent standards, which are carried out based on prior announcement and not more than twice a year. If a violation is suspected, “environmental police” from the Ministry of Public Security are authorized to conduct compulsory investigations without prior notice, and therefore have more opportunities to identify possible non-compliance. As mentioned earlier, currently 191 out of 244 industrial parks are equipped with automatic water quality monitoring stations, accounting for 78.3%. Meanwhile, no automatic monitoring systems are available in small-scale industrial clusters or craft villages.

Effluent inspection procedures

Wastewater discharge activities from production, business, service establishments and industrial parks must be periodically monitored, according to the approved environmental impact assessment report, for which environmental protection plans have been determined. Meanwhile, industrial zones and parks must install automatic continuous wastewater monitoring systems and transmit data directly to the local Department of Natural Resources and Environment.

According to Decision No. 1620/QD-BTNMT of 21st July 2016, on approval of inspection plans for projects, factories or business establishments with wastewater discharges, those organizations engaged in production

CONSERVATION OF WATER QUALITY

- **LAW ON ENVIRONMENTAL PROTECTION 2014**
- **LAW ON WATER RESOURCES 2012**
- **AMBIENT WATER QUALITY STANDARDS**
  - QCVN 08-MT:2015/BTNMT – National Technical Regulation on Surface Water Quality
  - QCVN 09-MT:2015/BTNMT – National Technical Regulation on Groundwater Quality
  - QCVN 10-MT:2015/BTNMT – National Technical Regulation on Coastal Water Quality
  - QCVN 38:2011/BTNMT – National Technical Regulation on Surface Water Quality for Protection of Aquatic Lives
  - QCVN 39:2011/BTNMT – National Technical Regulation on Water Quality for Irrigated Agriculture
  - QCVN 44:2012/BTNMT – National Technical Regulation on Off-Shore Water Quality
- **EFFLUENT STANDARDS**
  - QCVN 01-MT:2015/BTNMT – National Technical Regulation on the Effluent of Natural Rubber Processing Industry
  - QCVN 11-MT:2015/BTNMT – National Technical Regulation on the Effluent of Aquatic Products Processing Industry
  - QCVN 12-MT:2015/BTNMT – National Technical Regulation on the Effluent of Pulp and Paper Mills
  - QCVN 13-MT:2015/BTNMT – National Technical Regulation on the Effluent of Textile Industry
  - QCVN 14:2008/BTNMT – National Technical Regulation on Domestic Wastewater
  - QCVN 25:2009/BTNMT – National Technical Regulation on Wastewater of Solid Waste Landfill Sites
  - QCVN 28:2010/BTNMT – National Technical Regulation on Health Care Wastewater
  - QCVN 29:2010/BTNMT – National Technical Regulation on the Effluent of Petroleum Terminal and Stations
  - QCVN 35:2010/BTNMT – National Technical Regulation on Discharged Produced Water for Offshore Oil and Gas Facilities
  - QCVN 38:2011/BTNMT – National Technical Regulation on Surface Water Quality for Protection of Aquatic Lives
  - QCVN 39:2011/BTNMT – National Technical Regulation on Water Quality for Irrigated Agriculture
  - QCVN 40:2011/BTNMT – National Technical Regulation on Industrial Wastewater
  - QCVN 52:2013/BTNMT – National Technical Regulation on Wastewater of Steel Industry
  - QCVN 60-MT:2015/BTNMT – National Technical Regulation on the Effluent of Bioethanol Processing
  - QCVN 62-MT:2016/BTNMT – National Technical Regulation on the Effluent of Livestock
  - QCVN 63:2007/BTNMT – National Technical Regulation on Effluent Discharged from the Cassava Starch Processing Factories
- **OTHER RELEVANT LAWS, DECISIONS, DECREES, CIRCULARS, ETC.**

Figure 2.13.10 Relevant laws, standards for conservation of water quality in Viet Nam

(Source: Prepared by IGES based on information from the relevant Laws, Standards, Decisions, Decrees, Circulars, etc.)

and business activities that discharge wastewater into the receiving environment (industrial establishments with wastewater discharge flowrates of 200 m^3/day or more and at risk of causing environmental pollution in sea or river basins) must be regularly inspected by both central and local authorities. Further, according to Article 37 of Circular 25/2019/TT-BTNMT of December 31, 2019 (MONRE), project owners, or production, business or service facility owners are responsible for preparing regular annual environmental monitoring and protection reports (covering work activities, environmental protection measures, environmental monitoring, solid waste and hazardous waste management, and management situation of scrap imported under the guidance in Appendix IV of the Circular). These annual reports (January 1 to end of December 31) must be sent to the competent agency/authority (Ministry of Natural Resources and Environment) before January 31 of the following year. Concurrently, establishment owners or enterprises must maintain all related documents for sharing with competent state agencies when they visit for inspections and examination.

During 2014–2018, the Ministry of Natural Resources and Environment presided over and coordinated with other ministries and localities in carrying out inspections and examinations of over 3,000 establishments, industrial parks and industrial complexes nationwide. Sanctions were issued for 1,400 violating organizations, with fines exceeding 200 billion VND (MONRE 2018).

5.5 Other Policies on Water Environmental Management

In recent years, environmental management in Vietnam has focused more on the use of economic tools, including taxes, environmental fees or other forms of sanctions or compensation as measures to complement other conventional standard-based approaches.

Tax policy related to the water environment

The current tax policy is based on the viewpoint of limiting activities that adversely affect the environment in general and the water environment in particular, as well as activities having a direct or indirect impact on environmental protection. The 2009 Law on Natural Resources Tax stipulates that "natural water, including surface water and underground water, except natural water used for agriculture, forestry, fisheries, and salt production" is subject to natural resources tax. The law also stipulates that "natural water used for agriculture, forestry, fishery and salt production" is not subject to tax; and that "Natural water used for hydropower production by households and individuals to produce for domestic use and Natural water exploited by households and individuals for domestic use" are subject to natural resource tax exemption. Implementing a natural resources tax on natural water contributes to encouraging exploitation and rational use of natural resources in order to help better protect natural resources.

Environmental protection fee for wastewater

The environmental protection fee for wastewater has been regulated by the Government of Vietnam and implemented since 2003, and regulations on such fees have undergone two changes to date. According to Decree No. 154/2016/ND-CP, the environmental protection fee for wastewater continues to apply to domestic and industrial wastewater. Collection of the fees has been assigned to local authorities, with the Department of Natural Resources and Environment collecting the fees for industrial wastewater, and clean water service providers (i.e., People's Committees of communes, wards and towns) collecting the fees for domestic wastewater.

Sanctioning of administrative violations in the field of environmental protection and water resources

Administrative violations related to water environment are specified in two documents: Decree No. 155/2016/ND-CP, related to environmental protection, and Decree No. 33/2017/ND-CP, related to water resources and minerals.

6 | Recent Developments in Water Environmental Management

The revised Law on Environmental Protection 2020, which has recently been approved by the National Assembly on 17th November 2020, consisting of 16 chapters with 171 articles regulating environmental protection activities and stipulating the rights, duties and responsibilities of agencies, organizations, resident communities, households and individuals in environmental protection activities. This Law will come into effect from January 1, 2022.

In addition, one of the most recent development in water environment management is Decision No. 622/QD-TTg on10th May 2017 by the Prime Minister, related to the issuance of the National Action Plan for

Implementation of the 2030 Sustainable Development Agenda. Viet Nam's sustainable development goal to 2030 consists of 17 goals and 115 targets, corresponding to the global SDGs elaborated in the document "Transforming our world: The 2030 Agenda for Sustainable Development" adopted by the United Nations General Assembly in September 2015. These targets cover all the UN SDGs targets with several modifications and adjustments suitable in the context of Viet Nam. Concerning the water and sanitation related goal, SDG 6, MONRE, MARD, MoC and MoF have been assigned as lead organizations in implementing the related targets – specifically, MONRE is responsible for targets 6.1d, 6.3b, 6.4, 6.5, and 6.6; MoC for 6.1a, 6.2, and 6.3a; MARD for 6.1b; and MoF for 6.1c, 6.3c.

7 | Challenges and Future Plans

Over the last 2 decades, a number of efforts made have been made by both central and local governments as well as donor agencies to improve the water quality and environmental landscape of lakes and rivers, especially in big cities and provinces such as Hanoi, Da Nang and Ho Chi Minh City, but despite this, the issue of surface water pollution in lakes, rivers and canals remains. Surface water quality in many cities continues to decline, due to contamination from organic substances, nutrients and microbial contamination, as these areas receive large amounts of untreated or improperly treated wastewater from both domestic and industrial sources.

Below gives a list of the challenges that remain as well as recommended necessary actions to be considered:

Remaining challenges	Necessary actions proposed
Institutional challenges	i. Reviewing, supplementing and completing legal policies on water environmental protection ii. Assignment and consolidation of state management system for water environment protection iii. Develop and promote the implementation of river basin planning, zoning planning, water exploitation and use
Enforcement challenges	i. Strengthen activities of water pollution control, inspection, examination and enforcement of compliance with the law on water environment protection ii. Apply economic tools, scientific and technological solutions in water environment protection iii. Effective investment to thoroughly solve hotspots of water pollution in river basins; waste source control; effective prevention and control to minimize contamination of the water environment iv. Raising awareness and enhancing community participation and responsibility in water environmental management and protection v. Promote international cooperation activities in water environmental management and protection, especially transboundary issues
Resource and financial challenges	i. Promote international cooperation activities ii. Attract private investment
Technical challenges	i. Promote international cooperation activities ii. Screen production types and production technologies in attracting investment, ensuring not to attract outdated production technologies into Vietnam; choose environmentally friendly technologies for hazardous waste and organic matter pollution

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Chapter 2

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Ministry of the Environment, Japan
Water Environment Division
Environmental Management Bureau

1-2-2 Kasumigaseki, Chiyoda-ku, Tokyo 100-8975 Japan
TEL: +81 3 3581 3351 | FAX: +81 3 3593 1438
URL: http://www.env.go.jp/en/

Institute for Global Environmental Strategies (IGES)
WEPA Secretariat

2108-11 Kamiyamaguchi, Hayama, Kanagawa 240-0115 Japan
TEL: +81 46 855 3700 | FAX: +81 46 855 3709
E-mail: contact@wepa-db.net | URL: http://www.iges.or.jp/

www.wepa-db.net