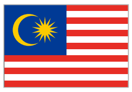
2.7 Malaysia



1 | Country Information

Table 2.7.1 Basic indicators

Land area (km^2)		330,876.50 (2023)*
Total population		34.0 million (2024)**
GDP (current USD)		407.03 billion (2022)***
Per capita GDP (current USD)		11,993.19 (2022)****
Average annual rainfall (mm/year)		2,875 (2020)*****
Total renewable water resources (km^3)		580.0 (2020)*****
Total annual freshwater withdrawals (billion m^3)		7.25 (2023)*
Annual freshwater withdrawal by sector	Agriculture	45.65% (2020)*****
	Industry	29.90% (2020)*****
	Municipal (including domestic)	24.45% (2020)****

(Source: *DOSM 2023, **DOSM 2024, ***World Bank 2024a, ****World Bank 2024b, *****World Data Atlas 2024)

Figure 2.7.1 Ampang Hilir Lake in Kuala Lumpur, Malaysia

2 | State of Water Resources

Malaysia is a rich water resource country thanks to its high rainfall. In 2022, the highest annual rainfall recorded to date, 6,172.8 mm, was recorded at Mulu station, 807.0 mm higher than in 2021, and the lowest, 1,943.0 mm, was recorded at Sitiawan station (DOSM 2023). In terms of volume, Malaysia's annual rainfall equates to 972.8 billion m^3. Of this, 495.71 billion m^3 is surface runoff, 64 billion m^3 goes to groundwater and the remainder returns to the atmosphere through evapotranspiration (ASM 2014). Malaysia's weather 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 constitutes 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 About 80% of the water withdrawn from river systems is used for irrigation. Percentages of water withdrawn from surface water sources for domestic and industrial uses are expected to rise in the future.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 in a few isolated spots, where physical or geographical factors make it too challenging, 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. This is expected to increase by about 5% annually, 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 due to the rapidly rising population and industrial growth. 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

(1) Rivers

There are 2,986 river basins in Malaysia, 189 of which are major river basins (exceeding 80 km^2). Of the major river basins, 144 are monitored for river water quality status (DOSM 2023). In 2022, 8,163 samplings were conducted by Department of Environment Malaysia (DOE) from 672 rivers, based on 1,353 manual and 55 upstream water intake water quality monitoring stations. Continuous river water quality monitoring was also conducted for 26 rivers based on 30 monitoring stations (DOE 2022). Regarding the five-year period from 2018 to 2022, results for river water quality are as shown in Fig. 2.7.2, whereas Figs. 2.7.3, 2.7.4 and 2.7.5 specifically show the trends of river water quality based on BOD, NH_3-N and SS sub-indexes.

From Fig. 2.7.2, it can be seen that clean rivers exhibited an improving trend from 56% in 2018 to 74% in 2022. Slightly polluted rivers decreased from 36% in 2018 to 22% in 2022. However, polluted rivers increased from 3% in 2021 to 4% in 2022, indicating the need for a stricter and more efficient approach to combating river water pollution. From Fig. 2.7.3, out of a total of 1,353 river stations, 1,060 (78.3%) indicated clean rivers in 2022—an increase of 11 compared to 2021 (1,049). Further, the number of stations indicating slightly polluted rivers also dropped, from 609 (45%) in 2018 to 149 (11%) in 2022, showing an improvement. For stations reporting polluted river water, while the number showed a large drop from 528 (39%) in 2018 to 122 (9%) in 2021, indicating a trend of improving river water quality, it then rebounded to 149 (11%) in 2022, indicating a worsening status, suggesting wastewater containing high organic matter (BOD) was being discharged into those rivers.

Figure 2.7.4 shows the trend of river water quality based on NH_3-N from 2018 to 2021 as indicated by stations. While the number of clean river indications from stations increased from 406 (30%) in 2018 to 685 (51%) in 2021, it then declined to 641 (47%) in 2022. On the other hand, the number of indications of polluted rivers decreased from 500 (37%) in 2018 to 389 (29%) in 2022. In terms of suspended solids (SS) (Fig. 2.7.5), the number of clean river indications from stations decreased from 1,037 (77%) in 2021 to 1,028 (76%) in 2022, and the number of polluted river indications from stations increased from 191 (14%) in 2021 to 207 (15%) in 2022. Most river water quality monitoring stations showed a significant deterioration in water quality in 2022 compared to 2021. Resumption of industrial activities since the rescindment of the Movement Control Order (MCO; imposed in 2021) is one of the contributing factors cited in increasing pollutant loads and thus deterioration in water quality at river stations located in areas close to industries (DOE 2022).

In 2022, the Department of Environment (DOE) analyzed 8,136 water quality samples from 1,353 manual river water quality stations to monitor heavy metal concentrations, including mercury (Hg), arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), and zinc (Zn). In terms of compliance with the National Water Quality Standards (NWQS), all river station results indicated standards were fully met for mercury and zinc. For arsenic, cadmium, chromium, and lead, compliance ranged from 99.2% to 100%, indicating that almost all samples were within acceptable limits (DOE 2022).

In 2022, the DOE assessed 55 upstream water intake stations based on the water quality index, 52 (94.5%) of which indicated clean water, while three (5.5%) indicated slightly polluted water. Based on the water quality index (WQI), 28 (50.9%) stations indicated Class I, 25 (45.5%) indicated Class II, and two (3.6%) indicated Class III (DOE 2022). For the BOD sub-index, 54 (98.2%) stations indicated Class II, and one (1.8%) indicated Class III. In terms of the NH_3-N sub-index, 43 (78.3%) stations indicated Class I, 11 (20.0%) indicated Class II, and one (1.8%) indicated Class III. Regarding the suspended solids (SS) sub-index, 36 (65.5%) stations indicated Class I, 13 (23.6%) indicated Class II, four (7.3%) indicated Class III, and two (3.6%) indicated Class IV (DOE 2022).

River pollution is still a major issue in Malaysia, despite substantial investment in and efforts taken to improve and maintain river quality. Both point-source and nonpoint-source pollution 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 main sources of NH_3-N were assumed to be animal farming and domestic sewage, and sources of SS were attributed to improper earthworks and land clearing activities. Future scenario predictions indicate an even more challenging management environment for 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.

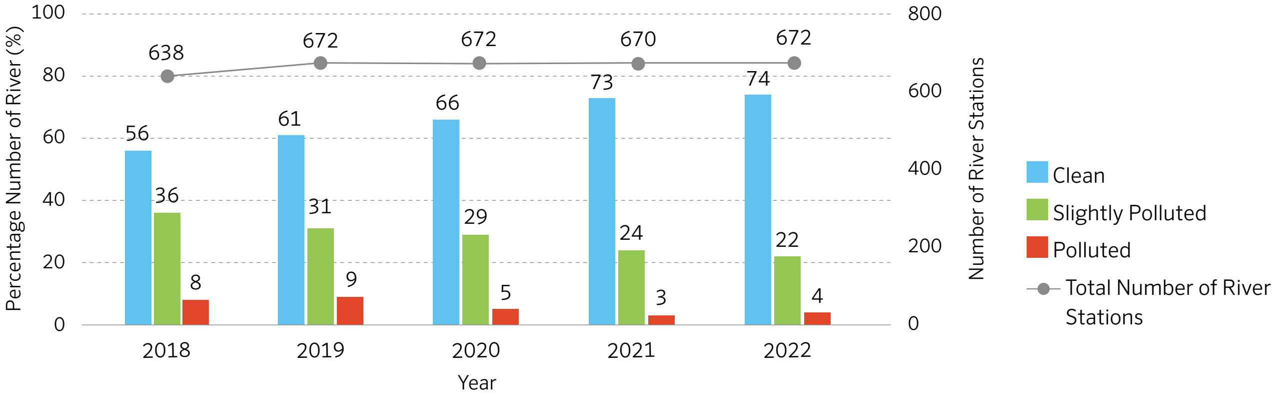


Figure 2.7.2 Trend in river water quality in Malaysia (2018-2022) (Source: DOE 2022)

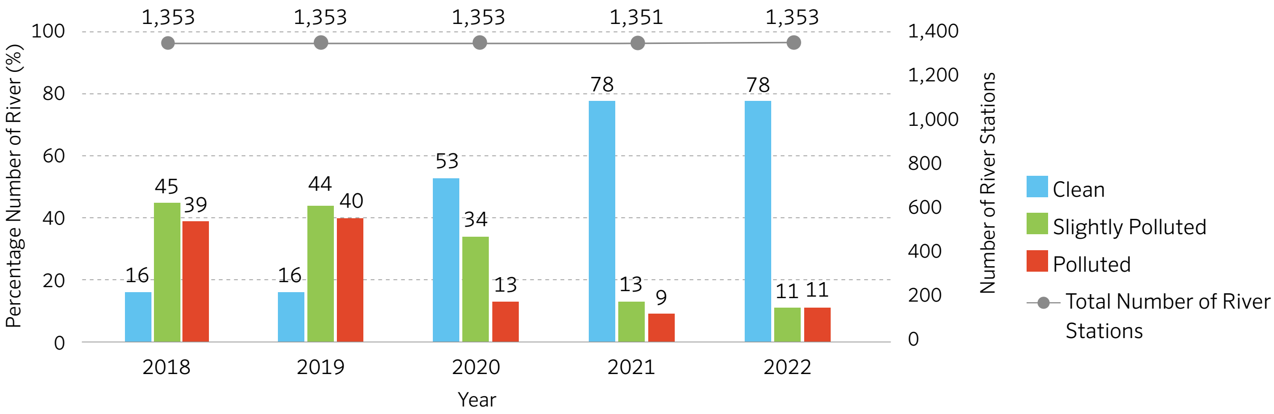


Figure 2.7.3 Trend in river water quality in Malaysia based on BOD sub-index (2018-2022) (Source: DOE 2022)

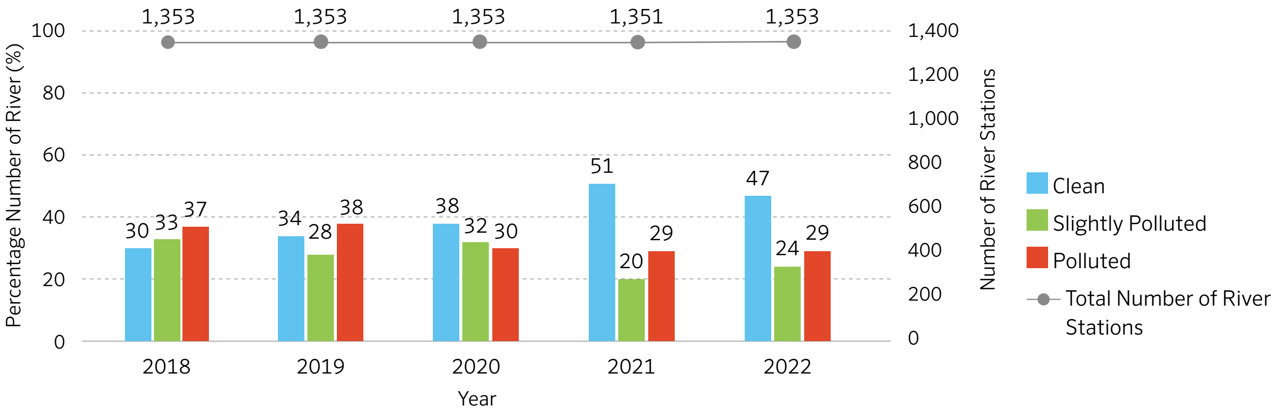


Figure 2.7.4 Trend in river water quality in Malaysia based on NH_3-N sub-index (2018-2022) (Source: DOE 2022)

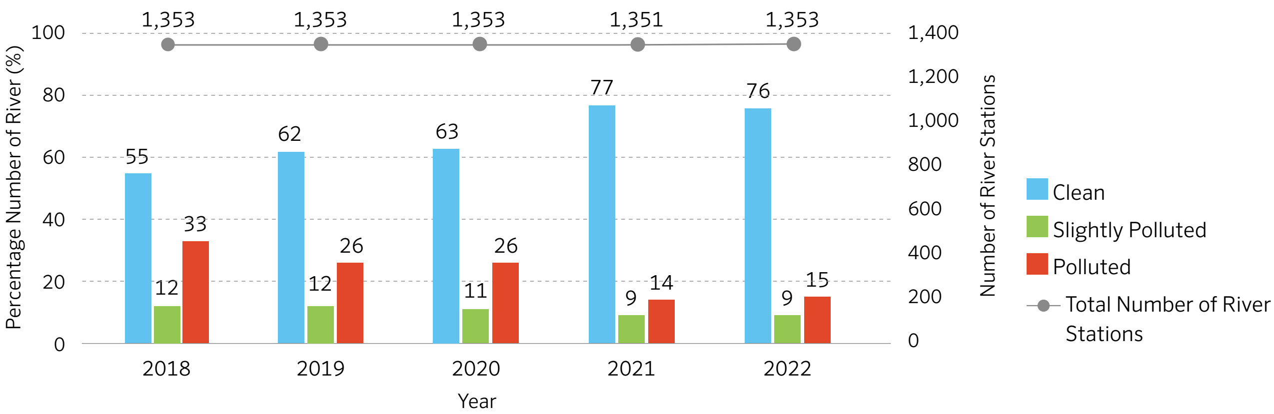


Figure 2.7.5 Trend in river water quality in Malaysia based on suspended solids (2018-2022) (Source: DOE 2022)

(2) Lakes and reservoirs

Lakes and reservoirs are managed by different authorities and owners and operators, which has meant 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) Coastal water

In 2022, the DOE monitored 188 coastal stations, 85 estuary stations, and 95 island stations, each with a sampling frequency of six, producing 1,128 samples from coastal stations, 510 from estuary stations, and 570 from island stations. The samples were analyzed, and the results were summarized based on the MMWQI across the six samplings (DOE 2022).

Figure 2.7.6 illustrates the trend in marine water quality status of Malaysia's coastal areas based on the MMWQI and the number of monitoring stations. It shows that stations indicating Excellent water quality increased from 85 to 88 over 2021-2022. For Good water quality, however, the number of stations indicating it decreased from 40 to 39 over 2021-2022. Notably, no station indicated Poor in 2022 (DOE, 2022).

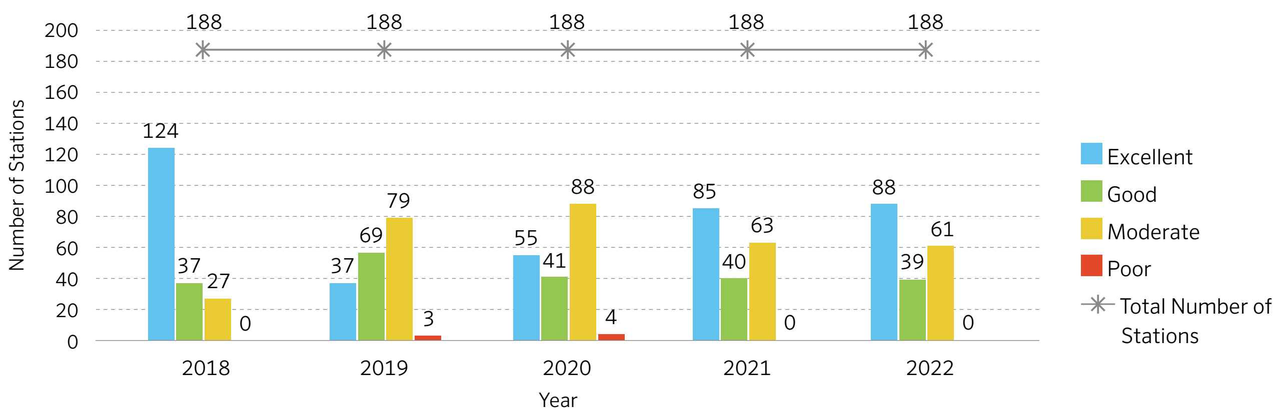


Figure 2.7.6 Trend in marine water status for coastal areas of Malaysia (2018-2022) (Source: DOE 2022)

(4) Groundwater

According to ASM (2014), the groundwater resource is currently still underused owing to relatively high exploration costs, and groundwater use mainly takes place in the State of Kelantan. In Sarawak, numerous villages, especially along the coast, obtain water from groundwater due to the low cost-efficacy of the pipework infrastructure installation necessary to connect 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.

Groundwater quality monitoring in Malaysia was established in 1997, with sites selected based on specific land use. In 2022, a total of 406 groundwater samples were analyzed for various parameters, including volatile organic compounds (VOCs), pesticides, heavy metals, anions, bacteria (coliform), phenolic compounds, total hardness, total dissolved solids (TDS), pH, temperature, conductivity, and dissolved oxygen. Out of 120 nationwide groundwater quality monitoring stations (wells), sampling took place at 109; no sampling took place at the remainder due to factors such as the lack of groundwater discharge from development activities and rock cracking at monitoring sites (DOE 2022).

4 | State of Wastewater Treatment

(1) Wastewater and major pollutants

Regarding the different key pollutants (BOD, SS and NH_3-N) of water bodies, the sources can generally be divided into five main categories, as reported by DOE (2022): manufacturing industries, agriculture-based industries, wet markets, sewage treatment systems and pig farming. In 2022, the daily pollutant discharge load on the environment included an estimated biochemical oxygen demand (BOD) pollution load of 667.35 tons per day, as detailed in Table 2.7.2. The largest contributor to BOD load was sewage treatment systems, accounting for 343.45 tons per day (51.47%). This was followed by pig farming activities at 228.53 tons per day (34.24%), manufacturing industries with 61.92 tons per day (9.28%), agriculture-based industries at 27.45 tons per day (4.11%), and wet markets at 6.00 tons per day (0.90%). The overall estimation for SS load was 915.17 tons/day. Total pollution load from pig farming activities showed the highest load at 474.64 tons/day (51.86%), followed by the sewage treatment systems at 326.89 tons/day (35.72%). Manufacturing industries contributed 55.82 tons/day (6.10%), followed by agriculture-based industries 50.08 tons/day (4.11%) and wet markets 7.75 tons/day (0.85%). In 2022, the NH_3-N load was estimated to be 274.61 tons/day in which sewage treatment systems remained the largest contributor, with a total load of 174.15 tons/day (70.33%), followed by pig farming activities at 28.13 tons/day (11.36%), agriculture-based industries at 25.50 tons/day (10.30%), manufacturing industries at 19.50 tons/day (7.88%) and wet markets at 0.33 tons/day.

Table 2.7.2 Summary of pollutant load estimation based on water pollution source in 2022

Water pollution source	BOD load (tons/day)	SS load (tons/day)	NH_3-N load (tons/day)
Manufacturing industries	61.92	55.82	19.50
Agriculture-based industries	27.45	50.08	25.50
Wet markets	6.00	7.75	0.33
Sewage treatment systems	343.45	326.89	174.15
Pig farming	228.53	474.54	28.13

(Source: DOE 2022)

(2) Facilities and status of wastewater treatment

Originally, sewage treatment and desludging works were assigned to Indah Water Konsortium (IWK), a wholly-owned company of the Ministry of Finance Incorporated (IWK 2022). To improve operation and maintenance, IWK gradually took over sewerage systems of various scales and types — over 8,800 from 1994 to 2008, while over 3,000 private systems remained under direct management of the owners. On average, IWK assumed control over 300 treatment facilities and 1,000 km of sewer network every year. However, in areas without large-scale sewerage systems, private developers continued to construct small-scale sewerage systems.

Although IWK was not the owner of the public facilities, it had the right to collect sewerage fees as the operator. However, the tariff it introduced for individuals and enterprises was not popular, which led to three fee reductions (JSC 2011). This put IWK into the red as it could not cover the business expenses and fee collection proved difficult. To avoid insolvency, which would have affected sewerage services, IWK was placed under governmental control in 2000 and has since been managed as a semi-private company under the Ministry of Finance, which controls capital expenditure. The role of implementing agency managing sewerage construction was then transferred to the Sewage Service Department (SSD), supplementing its 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 fees or to impose fines. However, as the new Act also integrated drinking water and sewerage services, it enabled overall management of water supply and the ability to cut supply to users defaulting on payments. 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 previously performed by IWK, SPAN thus handles monitoring and regulation of sewerage services. It also aims to improve the quality of new systems constructed by the private sector through providing conformity guidelines in order to ensure effluent quality requirements and standards are satisfied, as determined by the Department of Environment. Accordingly, developers are obliged to select only those systems approved by SPAN.

According to IWK, in 2022, the company's service area was 81,954 km^2, with a connected population equivalent (cPE) of 30.59 million. It operates and maintains 7,336 sewage treatment plants (STPs), 1,422 network pumping stations (NPS) and approximately 20,936 km of sewerage pipelines throughout Malaysia as of the end of December 2022. According to DOSM (2023) statistics provided by SPAN for 2022, there were 12,144 public and private sewage treatment plants, accounting for approximately 36 million cPE, as shown in Table 2.7.3. However, numbers of users of communal septic tanks, individual septic tanks and traditional systems increased from 2021 to 2022, and now stands at 13 million.

Table 2.7.3 Status of domestic wastewater treatment facilities (2019-2022)

Sewage Facilities	2019		2020		2021		2022	
	Quantity	Population Equivalent	Quantity	Population Equivalent	Quantity	Population Equivalent	Quantity	Population Equivalent
Public sewage treatment plant (a+b)	7,114	27,062,756	7,203	27,525,662	7,440	29,577,067	7,503	31,417,704
a. Multipoint Plant	7,012	18,045,882	7,101	18,321,827	7,336	19,881,838	7,395	20,186,013
b. Regional Plant	102	9,016,874	102	9,203,835	104	9,695,229	108	11,231,691
Private sewage treatment plant	4,119	4,302,350	4,215	4,512,796	4,464	4,882,300	4,641	4,957,337
communal septic tank	4,231	515,034	4,230	514,889	4,155	515,514	4,230	514,344
Individual septic tank	1,360,395	7,060,201	1,362,426	7,088,163	1,363,886	7,096,562	1,366,516	7,151,742
Traditional system	1,175,248	5,876,240	1,155,258	5,776,290	1,156,314	5,781,570	1,156,314	5,781,570
Network pumping station	1,272	n.a.	1,312	n.a.	1,375	n.a.	1,454	n.a.
Length of sewer network (km)	20,780	n.a.	21,216	n.a.	21,633	n.a.	21,964	n.a.

(Source: DOSM 2023)

5 | Frameworks for Water Environmental Management

(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 that "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 specify maximum permissible loads dischargeable by any source into inland waters, with reference either generally or specifically to the body of water concerned.

Several amendments or additions have since been made to this Act, and 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)
f. Regulations 2009
g. Environmental Quality (Industrial Effluent) Regulations 2009
h. Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015

Other laws and regulations are also shown in Fig. 2.7.7.

Other important policies related to water Environmental Management also exist. One is the National Water Resources Policy (NWRP), launched in March 2012 for the period 2010-2050, which is aimed at determining the future direction of the water resources sector based on a review of national water resources. The 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 Industry Act

6. Mining
Mining Enactment (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 Ordinance (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 on water quality management (Source: MOEJ 2009)

(2) Institutional arrangement

The Department of Environment (DOE) originally began as the Environment Division, established in 1975 under the Ministry of Local Government and Environment. It has since been reorganized several times due to realignments of government ministries and agencies and is now under the purview of the newly established Ministry of Natural Resources and Environmental Sustainability (NRES) as of December 2023. DOE is responsible for environmental protection, including water quality management. NRES's mission is to protect and manage the environment, drive climate action and promote green growth as well as preserve and conserve forests, biodiversity, geological heritage, and manage mineral resources in an optimum, sustainable and responsible way. As a result of a ministerial realignment in December 2023, the water sector is now under the responsibility of the newly established Ministry of Energy Transition and Water Transformation (PETRA). PETRA's mission is to ensure the sustainability and security of water through policy, strengthen governance and strategically manage and regulate the electricity supply industry by optimizing renewable energy and energy efficiency to guarantee reliable, affordable and sustainable services. 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, development and enforcement based on local authority bylaws.

(3) Ambient water quality standards

a. Water quality standards

Malaysia's National Water Quality Standards (NWQS), which apply to surface waters, set out standard values for 72 parameters in six water use classes (see 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 the water class one level higher.

Table 2.7.4 Water quality classes according to the national water quality standards

Grade	Description
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 2022)

For marine water quality, the Malaysian Marine Water Quality Standards (MQWS) and the Malaysian Marine Water Quality Index (MWQI) were established. MQWS consists of six classes, covering 22 parameters whereas the MWQI consists of six sub-indexes: DO, fecal coliform, NH_3, NO_3, PO_4, and TSS (DOE 2022).

While groundwater quality standards 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 act as the benchmark for evaluating groundwater quality monitoring results. Further, the Groundwater Quality Index (GWQI) is used as a benchmark to determine the groundwater quality status and category. Malaysia's GWQI was developed based on seven parameters with a quality scale ranging from 0 to 100, identifying the quality of the groundwater from the range of excellent to very poor (DOE 2022).

b. Water quality monitoring framework

The DOE's Environmental Quality Monitoring Programme (EQMP) monitors rivers, marine waters, and groundwater nationwide to assess environmental quality in the monitoring, prevention and control of pollution. EQMP serves as an early warning pollution detection system for cases such as oil spills, industrial disasters and illegal toxic waste dumping for mitigation and enforcement as well as to support planning and development efforts aimed at ensuring sustainable environmental management (DOE, 2019).

I. River water quality monitoring

River water quality monitoring in Malaysia comprises manual and continuous river water quality monitoring. The water quality index (WQI) is used to evaluate the status of river water quality and pollution levels, and thus the corresponding suitability in terms of water uses according to the national water quality standards for Malaysia (NWQS). The WQI for river water quality is calculated based on six parameters: DO, biochemical oxygen demand (BOD), chemical oxygen demand (COD), NH_3-N (Ammoniacal nitrogen), suspended solids (SS), and pH, and classified into three categories according to the index: clean, slightly polluted, and polluted (DOE 2022).

II. Coastal water quality monitoring

The DOE has been systematically monitoring marine water quality in Malaysia under the program since 1978 in Peninsular Malaysia, which was then later extended to Sabah and Sarawak in 1985. The program's primary goal is to evaluate the current condition of marine waters and identify pollution levels originating from both terrestrial and marine sources. This assessment is crucial as the detected pollution can significantly endanger the health and biodiversity of the marine ecosystem, threatening its sustainability. Monitoring stations established under the marine water quality monitoring program are classified into three categories: coastal stations, estuary stations and island stations (DOE 2022). Malaysia's marine water quality standards (MMWQS) and the Malaysian marine water quality index (MWQI) were also established. The MMWQI aggregates key marine water quality parameters to provide a comprehensive assessment of the marine water quality status of water bodies. The MMWQS consist of six classes covering 22 parameters, whereas the MMWQI consists of six parameters: DO, fecal coliform, NH_3, NO_3, PO_4, and TSS. The MMWQI aggregation is scaled from 0 to 100, with 0 indicating poor and 100 indicating excellent water quality (DOE 2022).

III. Groundwater monitoring

Monitoring of groundwater quality in Malaysia is carried out in accordance with the specific land use, categorized as one of agricultural area, used solid waste landfill, aquaculture, used gold mine, urban and suburban area, golf course, industrial site, water supply, rural area, resort and used animal burial site (DOE 2022). The Malaysia groundwater quality index (GWQI) serves as the benchmark to determine the status and category of groundwater quality, and was developed based on seven parameters: pH, Iron, total dissolved solids, nitrate, E. coli, phenol, and sulphate. The GWQI uses a scale from 0 to 100 to classify groundwater quality into categories of excellent, good, moderate, poor, and very poor (DOE 2022).

(4) Effluent standards

a. 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).

b. 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 hardcopy submission. Authorized DOE officials can carry out inspections of any 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, which 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 indicators. 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. Results show a compliance level of over 97% for public sewage treatment plants since 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. For years 2018-2022, the compliance level for sewage treatment plants refers to STPs operated by IWK only, with a value of 97.4% in 2022, whereas the compliance level of industrial effluents for non-prescribed premises was 99.0% in 2022.

Table 2.7.5 Summary of public sewage treatment plants and status of compliance with sewage effluent standards for 2010-2022

Year	Description
2022	97.4*
2021	97.7*
2019-2020	97.1*
2018	97.8*
2017	98.9
2016	98.5
2015	98.3
2014	97.6
2013	97.1
2012	97.3
2011	97.6
2010	97.9

*Sewage Treatment Plants (STPs) operated by IWK only

(Source: *IWK 2018-2022; SPAN 2017)

Table 2.7.6 Summary of industrial wastewater management and status of compliance for non-prescribed premises based on the Environmental Quality (Industrial Effluents) Regulations 2009

Year	No. of inspections		Compliance (%)	
2022	3,642		99.0	
2021	3,930		98.0	
2020	5,772		99.6	
2019	5,203		95.3	
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. of 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 2012-2022)

c. 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 2018b). Non-complying institutions or entities face penalties of up to 100,000 MYR or five-year jail terms.

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 (Industrial 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: Performance 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 and/or maximum 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 convicted, maximum penalty of RM 100,000 and/or maximum 5 years 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	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 convicted, maximum penalty of RM 100,000 and/or maximum 5 years jail and further fine of RM 1,000/day for continued offence

(5) Major policies on water environmental management

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

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

6 | Recent Developments in Water Environmental Management

The Twelfth Malaysia Plan, 2021–2025 (Twelfth Plan), a medium-term plan with the objective of 'A Prosperous, Inclusive, Sustainable Malaysia', marks the start of a new phase in Malaysia's development: the Shared Prosperity Vision 2030 (WKB 2030). Policies under this Plan are structured to achieve sustainable economic growth, with a focus on equitable wealth distribution, the wellbeing of the people and environmental sustainability. The Twelfth Plan introduces a new transformative approach based on 'three themes, four catalytic policy enablers and 14 game changers'. The national development priorities of the Twelfth Plan will continue to be aligned with the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development (2030 Agenda). The adoption of a nationwide approach is essential for SDGs implementation. Water environment management falls under Theme 3, Advancing Sustainability, which focuses on advancing green growth as well as enhancing energy sustainability and transforming the water sector. The Plan also augments green growth to achieve sustainability and resilience (Ministry of Economy 2021).

For water environment management, Malaysia will implement the Water Sector Transformation (WST) 2040 plan, which is aimed at achieving water security and sustainability as well as positioning water as an economic opportunity. The transformation will be carried out through four phases under Malaysia Plans (MP) with a specific focus in each phase, as stated below (EPU 2021):

i. Phase 1: 12 MP (2021–2025)—Accelerating adoption of Integrated Water Resource Management (IWRM)
ii. Phase 2: 13 MP (2026–2030)—Developing indigenous technology to be on par with international standards
iii. Phase 3: 14 MP (2031–2035)—Achieving economies of scale
iv. Phase 4: 15 MP (2036–2040)—Becoming the regional water industry hub

The first phase of WST 2040 falls under 12 MP (2021–2025), with the focus of accelerating the adoption of IWRM. Some related strategies under the 12 MP for water environment management are stated below (EPU 2021):

i. Empowering people through the establishment of public consultation platforms, implementation of awareness-raising, advocacy and capacity-building (AACB) programs as well as expansion of community-driven conservation activities with the aim of instilling a sense of ownership among the people in protecting and conserving water resources.
ii. Strengthening governance at all levels (federal, state and district level) to ensure better integrated and more effective water management by harmonizing the water-related legislation and enhancing water pollution mitigation measures to streamline with IWRM. Several laws will be revised to regulate emerging pollutants and increase penalties based on the polluter pays principle. 10 Total maximum daily load (TMDL) studies will be carried out to determine the loading capacity of river segments.
iii. Enhancing capability in data-driven decision-making by strengthening the water research institute as a one-stop center for water-related data and R&D&C&I, and raising the capacity of water industry players and the scientific community to support the development of indigenous water technology.
iv. Strengthening the financial sustainability of water service providers by implementing the tariff setting mechanism (TSM) for sewerage services to achieve operating costs recovery and improve the financial capabilities of service providers as well as to explore alternative non-tariff revenues, particularly from water recycling and wastewater treatment by-products.
v. Developing sustainable infrastructure with cost-effective technology by adopting alternative systems in rural areas and islands to achieve 98% of sanitation coverage, reduction in non-revenue water (NRW) level to 25% as well as emphasizing nature-based approaches in addressing water pollution issues, such as the application of constructed wetlands (CWs) in treating wastewater and improving effluent quality before release into the river system.

On April 2024, the Parliament (*Dewan Negara*) of Malaysia passed the Environmental Quality (Amendment) Bill 2023, which is comprised of a series of amendments to the Environmental Quality Act 1974 (Act 127). This Amendment is aimed at further strengthening enforcement, preventing environmental pollution and dealing with ongoing environment-related criminal activities by increasing penalty rates and fines, as well as enabling decisive action to be taken against environmental offenders. The bill involves amendments to 28 sections of Act 127, including the enhancement of penalties with a minimum fine range of not less than RM 5,000, a maximum fine not exceeding RM 10 million, and mandatory imprisonment not exceeding five years for offences involving water pollution, oil waste pollution, and waste disposal in Malaysian waters, as well as illegal disposal of scheduled waste (NST 2024; The Star 2024).

7 | Challenges and Future Plans

It could be said that the Earth was in a better state, environmentally, during the CORONOVIRUS pandemic. A biodiversity movement gathered momentum as a result of the cleaner air, rivers and lakes. However, as socio-economic activities returned to normal, pollution of the environment resumed and its effects on public health. In Malaysia, the existence of the Environmental Quality Act 1974 ensured that environment monitoring continued through the control of point-source and nonpoint-source pollution as well as assessments of the water environment. Many challenges still remain, however, as in other countries. A new direction for water environmental management has been incorporated in the Twelfth Malaysian Plan (12th MP) through to the Environmental Act. In order to improve the nation's future water environment, all state government and selected ministries will need to take the following actions:

i. Sharing knowledge of science, technologies, innovation and engineering (STIEs) via Malaysia's federal platform, the National Water Council, chaired by the Prime Minister of Malaysia
ii. Developing action plans for improving river water quality via Malaysia's federal platform: the Special Committee to Address the Deterioration of National River Water Quality, chaired by Deputy Prime Minister of Malaysia
iii. Enhancing grey water pollution control by state regulation such as for market discharges and discharges from laundries and other businesses
iv. Introducing an innovation-based approach of mixed-industrial sewerage treatment systems
v. Use of the communication, education and public awareness (CEPA) approach at the community level by leaders at the state government level, and federal agency initiatives such as Friends of Rivers (FoR)
vi. Applying the latest conceptual approaches, such as the Sustainable Development Goals (SDGs), environmental, social, and governance (ESG), internet of things (IoT), 4th Industrial Revolution (IR4.0) and artificial intelligence (AI).

Some of the additional challenges are as follows:

i. Lack of sewerage coverage (limited to urban areas)
ii. Lack of lake water quality management
iii. Illegal discharge of wastewater to rivers disrupting public water supply
iv. Lack of regulations or standards for grey water monitoring
v. Assessing river carrying capacities via Malaysia's 12th Plan for series research of total daily maximum loading (TDML) of selected rivers by Department of Environment, Malaysia (DOE) and Department of Irrigation and Drainage, Malaysia (DID)
vi. Natural Disaster of 'In' (Stagnant/Inundation flood or locally meaning Dreamy Flood) at township, 'Banjir Puing' (Debris Flood) due to uncertainty and intense rainfall of climate change impacts
vii. Heatwave episodes that affect water resources for agriculture
viii. Sedimentation transport that reduces water surface volume and water level

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

i. Amendment of Environmental Quality (Sewage) Regulations 2009 of Environmental Quality Act 1974, since October 2023
ii. Amendment of National Wetland Policies (*Dasar Tanah Lembap Negara*);
iii. Amendment of National Policy on the Environment (2002);
iv. Restructuring for environment empowerment by establishing Ministry of Natural Resources and Environment and Ministry of Energy Transition and Water Transformation (PETRA).