Aquatic Pollution in the Philippine Waters of South China Sea Large Marine Ecosystem (SCS-LME)

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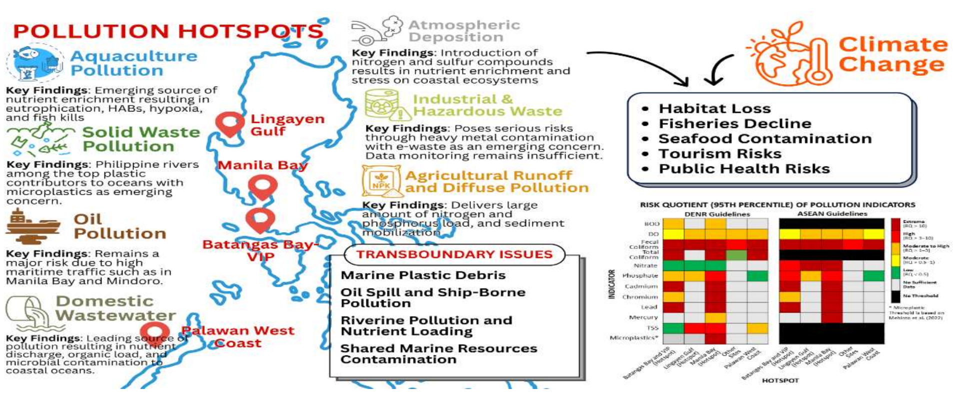
Abstract

Marine pollution poses one of the most persistent threats to the ecological and socio-economic sustainability of Philippine waters bordering the South China Sea Large Marine Ecosystem (SCS-LME). This chapter provides an updated assessment (2000–2024) of major pollution sources, pathways, and impacts. Domestic wastewater remains the dominant contributor, with less than 20% of the generated sewage being treated, and the majority being discharged untreated into estuaries and bays. Agricultural runoff and diffuse sediment pollution contribute significantly to nitrogen and phosphorus loads, intensifying eutrophication and harmful algal blooms in semi-enclosed systems, such as Manila Bay and Lingayen Gulf. Aquaculture and mariculture have further increased nutrient inputs, chemical residues, and antibiotic contamination, while industrial effluents remain a chronic source of heavy metals and hazardous chemicals. Solid waste and marine litter, particularly plastics, have rapidly emerged as critical national and transboundary concerns. The Philippines was identified as one of the world's leading sources of riverine plastic leakage to the ocean. Oil spills, ballast discharges, and atmospheric deposition compound risks, particularly in high-traffic and industrialized coastal areas. The analysis identifies Manila Bay, Lingayen Gulf, Batangas Bay, and Palawan's west coast as pollution hotspots, where ecological degradation intersects with fisheries decline, and tourism risks. Despite advances in environmental legislation and participation in regional initiatives, implementation gaps and limited infrastructure investment persist. Scientific data on persistent or emerging organic pollutants, pharmaceuticals, and microplastics in Philippine estuarine and coastal systems also remain scarce. Addressing these knowledge and management gaps is essential for evidence-based policymaking and for safeguarding the biodiversity and blue economy potential of the SCS-LME.

Keywords: Marine pollution, South China Sea, Philippines, plastic leakage, emerging contaminants

Graphical Abstract



3. Pollution

Philippine coastal waters which face the South China Sea Large Marine Ecosystem (SCS-LME) are under significant pollution pressure. As a middle-income country in the ASEAN region with 36,289 km of coastline and a population exceeding 110 million, the country's strategic position at the center of the Coral Triangle makes effective pollution management crucial. Since the 2000 Transboundary Diagnostic Analysis (Talaue-McManus,2000), the Philippines has strengthened its legal framework through the Clean Water Act and Ecological Solid Waste Management Act, developed integrated coastal management approaches, and increased participation in regional initiatives (Environmental Management Bureau [EMB], 2021a; EMB, 2022). However, rapid urbanization has outpaced infrastructure development, agricultural intensification continues to increase nutrient loads, and plastic pollution has emerged as a critical threat, further compounded by the effects of climate change.

3.1 Key Findings

- Domestic wastewater is the leading source of pollution, with less than 20% of the urban population connected to treatment systems, resulting in untreated discharges of nutrients, organics, and pathogens.
- Agricultural runoff delivers large nitrogen and phosphorus loads, fueling eutrophication and harmful algal blooms; upland erosion adds sediments that degrade reefs and seagrasses.
- Solid waste and plastics are highly visible and persistent, with Philippine rivers ranked among the top global contributors of plastic leakage to the ocean.
- Industrial effluents and hazardous wastes, including heavy metals, industrial by-products, and increasing e-waste, pose localized but serious risks; however, monitoring and data remain fragmented and incomplete.
- Oil pollution from vessel discharges and tanker accidents remains a major risk in high-traffic areas such as Manila Bay and Batangas Bay.
- Aquaculture and mariculture are emerging sources of nutrient enrichment and organic loading, contributing to localized hypoxia, fish kills, and harmful algal blooms (HAB) in semi-enclosed bays**.**
- Atmospheric deposition could introduce reactive nitrogen and sulfur compounds from power plants, vehicles, and biomass burning, creating an additional pathway for acidification, nutrient enrichment, and stress on coastal ecosystems.
- Hotspots including Manila Bay, Lingayen Gulf, and Batangas Bay-Verde Island Passage show consistently elevated microbial contaminants, nutrients, organic, and heavy-metal levels. The west coast of Palawan is an emerging hotspot.
- Emerging contaminants, notably persistent organic micropollutants, pharmaceuticals, and microplastics, are of growing concern, but scientific monitoring in Philippine coastal and estuarine waters remains scarce.
- Impacts include degraded habitats (corals, seagrass, mangroves), fishery decline, seafood contamination, tourism risks, and public health hazards.
- Climate change is expected to exacerbate pollution impacts through intensified rainfall, increased runoff, sea-level rise, and extreme events, which in turn increase contaminant mobilization.

3.2 Current Status by Indicator Group

3.2.1 Pollution Sources and Magnitude

Understanding the sources and magnitude of pollution is critical to assessing its ecological and socio-economic impacts on Philippine waters within the SCS-LME. This section examines the dominant land- and sea-based inputs, quantifying their contributions and highlighting persistent and emerging hotspots. See Annex 3.A for the definition of pollution indicators.

3.2.1.1 Domestic Wastewater

Domestic wastewater remains the largest contributor to marine pollution. Metro Manila generated over 800 Mm³/year wastewater in 2023, with only 16% treated (Figure 3.1). Wastewater treatment facilities increased from 56 in 2014 to 65 in 2020, while normalized treatment capacity by number of facilities grew steadily to nearly 2 Mm³/facility by 2023. This indicates improvements could come primarily from expanding existing plants rather than building new facilities (Figure 3.2). In 2015, less than 15% of the national population was connected to sewer systems (National Economic and Development Authority [NEDA], 2021). Metropolitan Waterworks and Sewerage System (MWSS) concessionaires in Metro Manila served approximately 2.20 million in septage and 2.40 million in sewerage services (Annex Figure 3.B.1), representing less than 3 percent of the national population. Limited coverage is thus expected to be more pronounced in rapidly expanding peri-urban areas along Manila Bay, Lingayen Gulf, and other population centers.

Domestic wastewater contributes about a third of total BOD nationwide (Annex Figure 3.B.2.) in terms of water pollution (EMB, 2020a). The limited infrastructure results in an estimated pollution load of 530,000 ± 30,000 tons/year BOD reaching coastal waters (SCS-LME) by 2025 (Annex Table 3.B.6), a 23% increase from 2000 reported by Talaue-McManus (2000). Nutrient loading contributes 93,000 ± 5,000 tons of nitrogen and 15,000 ± 700 tons of phosphorus annually (See Annex 3.B for complete calculation on pollution load estimates). Fecal coliform levels in major waterways exceed 10^5-10^6 MPN/100mL, well above the 200 MPN/100mL standard. Manila Bay Office of EMB reported from 2011-2015 (19 monitoring stations) that the average FC count ranges from 5.4×10^3 to 2.6×10^4 MPN, reflecting pervasive contamination at Manila Bay. According to EMB projections of pollution load (EMB, 2020a), Region 4A consistently contributes the highest pollutant loads among the regions affecting the Philippine Waters of SCS-LME, followed by the National Capital Region (NCR) and Region 3, particularly affecting Manila Bay (Annex Figure 3.B.4).

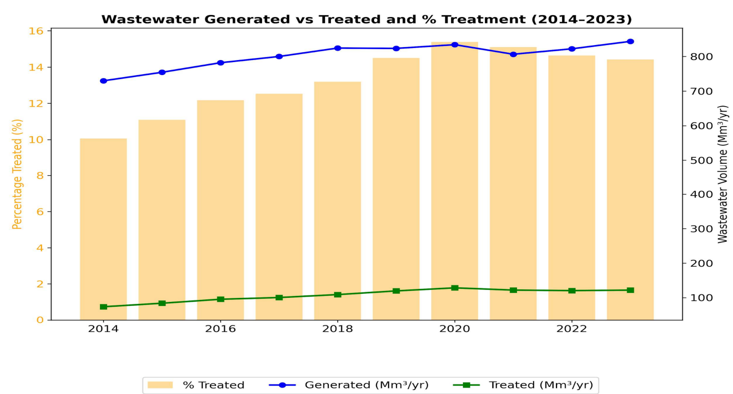


Figure 3.1. Wastewater generation and treatment trends in Metro Manila from 2014-2023. Data Source: PSA, 2024.

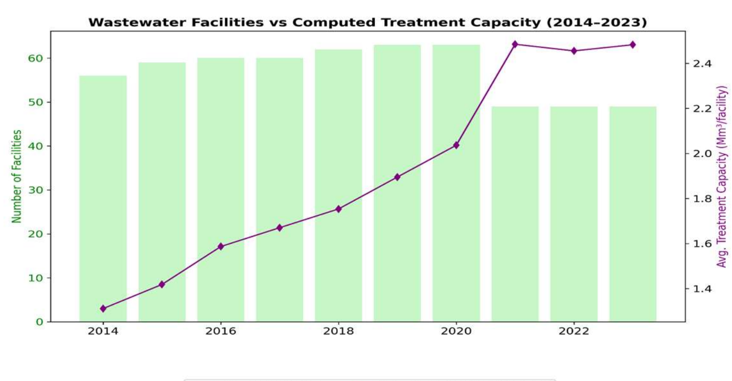


Figure 3.2. Trend of wastewater facilities and treatment capacity in Metro Manila from 2014-2023. Data source: PSA, 2024

Domestic wastewater contributes approximately 47,000 tons of nitrogen and 4,500 tons of phosphorus annually to Manila Bay, with the highest loads from densely populated Metro Manila (19,137 people/km²) and surrounding coastal provinces. This nutrient enrichment causes documented eutrophication and hypoxic conditions, with oxygen levels dropping to 2.1 mg/L during wet seasons. Nitrogen loads could increase by 27-469% by 2050, depending on population growth and sewage treatment improvements (Sotto et al., 2015).

Submarine groundwater discharge (SGD) represents another significant source of nutrient pollution in coastal waters, potentially transporting contaminated groundwater from terrestrial sources and coastal communities. In Bolinao, groundwater wells showed high ammonia concentrations (19-76 μM), indicating "areas of intense ammonification" from septic waste plumes (Senal et al., 2011). SGD also appears to be a significant source of inorganic nitrogen to Manila Bay, contributing fluxes equivalent to 42% from the Pampanga River and 96% of the Pasig River input (Taniguchi et al, 2008). These nutrient inputs stimulate dinoflagellate and cyanobacteria growth, triggering HABs formation and perpetuating the eutrophication-bloom-mortality cycle (Santos et al., 2021). The convergence of aquaculture-derived nutrients and SGD inputs could create multi-source pollution which amplifies the risk of ecological disruption in marine ecosystems.

Domestic wastewater is also a source of emerging contaminants such as PFAS (e.g., PFOS), pharmaceuticals, and endocrine disruptors, which can evade conventional treatment and pose a risk to human health and aquatic ecosystems (Guardian et al., 2020; Mariano et al., 2023). However, monitoring in Philippine coastal and estuarine waters remains scarce.

3.2.1.2 Industrial Effluents

Industrial activities generate significant pollution despite regulatory improvements. As of 2020, 820,253 industrial establishments operate nationwide, with 60% in the Manila Bay region (Tuddao, Jr., and Gonzales, 2020). Of these, 112,789 qualify as manufacturing plants, while the remainder include utilities, construction yards, repair shops, logistics depots, and other non-manufacturing facilities. Major sectors include food processing, textiles, electronics, and petroleum refining (Annex Table 3.B.9). Water Environment Partnership in Asia [WEPA] (2024) reports on the typical wastewater quality of these selected industries (Annex Table 3.B.10). Across the ten industries profiled, wastewater characteristics vary dramatically, reflecting the diversity of Philippine manufacturing processes. Industrial sources contribute 27-33% of the BOD load. Compliance rates remain low at 46% nationally and 35% in NCR (WEPA, 2021; Uyaco, 2022).

While industrial discharges contribute a smaller volume than agricultural and domestic sources (WEPA, 2024), their environmental impact is significantly greater due to their toxic composition. Industrial effluents often contain heavy metals, oils, and hazardous chemical wastes. For example, heavy metal contamination has reached severe levels in several rivers, such as the Marilao-Meycauayan-Obando River System (Pleto et al., 2020).

3.2.1.3 Agricultural Runoff and Diffuse Pollution

Agricultural intensification has led to a significant increase in fertilizer and pesticide use. Nitrogen application rose from 488,000 to 799,000 tons/year (2000-2022), while phosphorus and potassium showed over 200% increases (Annex Figure 3.C.1; see Annex 3.C for time-series graphs). Pesticide use increased from 50,000 to 85,000 tons/year (Annex Figure 3.C.2.). Rice cropping contributes approximately 23,706 tons of nitrogen to Manila Bay annually, representing a 51% loss of applied fertilizer (Magcale-Macandog et al., 2016). These inputs fuel eutrophication and harmful algal blooms in semi-enclosed bays.

Excessive fertilizer applications in Northern and Central Luzon exceed 100 kg N/ha in some provinces. Pampanga River monitoring showed phosphorus concentrations of 0.30-0.67 ppm (wet season) and 0.5-0.9 ppm (dry season) approaching Manila Bay, well above the 0.02 ppm threshold for algal growth (Magcale-Macandog et. al., 2016). A breakdown of nutrient loading into Manila Bay from the four major contributing sub-watersheds is shown in Figure 3.3. The Pasig River Basin would dominate nitrate (NO_3-N) loading, reflecting dense urban populations and untreated domestic wastewater inflows from Metro Manila. On the one hand, the Bataan Watershed would contribute the largest share of total phosphorus, likely driven by agricultural fertilizer runoff and soil erosion.

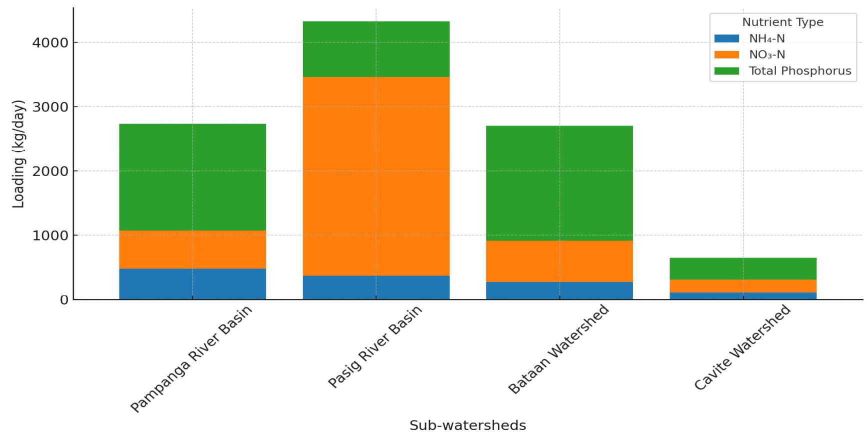


Figure 3.3. Stacked nutrient loading to Manila Bay by sub-watershed. Data source: Samar (2012) as cited in Magcale-Macandog et al. (2016)

Pesticide residues from agricultural runoff reach coastal waters, detected in rivers flowing into Lingayen Gulf and Manila Bay. While Pampanga River samples showed concentrations below the Limit of Quantitation (0.1 µL/L), paddy field drainage water contained higher residues (0.001-3.46 ppb) than inflow water (0.01-0.54 ppb). Isotopic mass balance analysis also revealed that 17-30% of the organic matter deposited in Manila Bay originates from agricultural activities (Bureau of Soils and Water Management (BSWM), 2013, as cited in Magcale-Macandog et al., 2016), providing direct evidence of agriculture's contribution to marine pollution in the Philippine Waters of the SCS-LME.

In addition to nutrient and pesticide inputs from runoff, diffuse sediment mobilization from upland erosion and land conversion has a significant impact on coastal waters. This sediment carries contaminants such as heavy metals, absorbed nutrients, and pesticides, creating multiple pollution pathways. Sediment loads from deforestation, mining activities, and poorly managed farms also increase turbidity which can smother sensitive habitats such as coral reefs and seagrass beds. Lingayen Gulf, for example, experiences heavy siltation from the Agno River system, degrading fisheries and benthic ecosystems (Deocadez et al., 2003).

3.2.1.4 Aquaculture and Mariculture Pollution

Aquaculture provides food security and economic opportunities in the Philippines, but has become a major source of nutrient enrichment and chemical pollution. In Manila Bay and Bolinao Bay, fishponds, pens, and mariculture systems discharge nitrogen, phosphorus, heavy metals, and antibiotic residues into surrounding ecosystems (Tahiluddin et al., 2025).

Between 2011 and 2018, fishponds around Manila Bay accounted for 41.19% of national aquaculture production (Baldoza et al., 2020). These produce effluents with ammonia-nitrogen (0.90-2.35 mg/L) and phosphate (1.02-2.42 mg/L) exceeding thresholds suitable for fish culture. The phosphate levels in Manila Bay also reach 0.03 mg/L, exceeding the marine water quality criterion of 0.015 mg/L (PEMSEA, 2004). Nutrient load estimations indicate that aquaculture around Manila Bay contributes approximately 12,697 metric tons of nitrogen and 2,363 metric tons of phosphorus annually, with fish pens/cages accounting for 88% of nitrogen and 86% of phosphorus loads (Montojo et al., 2020). In Bolinao Bay, nutrient discharges from milkfish pens cause localized acidification, deterioration of water quality, fish kills, and declining coral cover (San Diego-McGlone et al., 2008; Isah et al., 2022). Waste excrements and leftover fish feeds increase the amount of phosphorus, affecting the N/P ratio in Bolinao during the dry season. This phosphorus-rich environment becomes susceptible to algal blooms when nitrogen-containing freshwater arrives during the wet season (Ferrera et al., 2016).

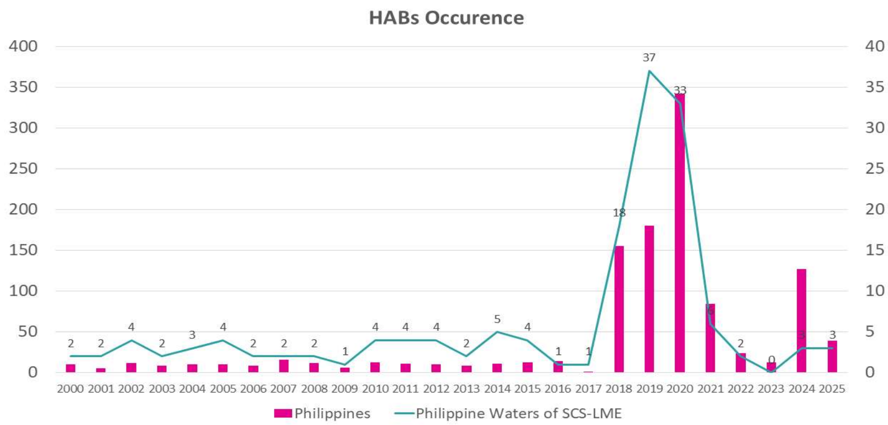


Figure 3.4. Occurrence of Harmful Algal Bloom in the Philippines and in the Philippine Waters of SCS-LME (2000-2025). Data source: Intergovernmental Oceanographic Commission, 2025.

Nutrient enrichment also drives harmful algal blooms (HABs), which threaten marine ecosystems and human health through the production of toxins. HAB events directly impact fisheries and aquaculture, including fish kills and shellfish toxicity. The Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) issues shellfish advisories indicating paralytic shellfish toxin (PST) contamination (See Annex 3.D). From the national data, there is an increase in HABs occurrences in the late 2010s to 2020s, peaking at 342 recorded occurrences in 2020 (Figure 3.4). Fish kill events persist, particularly in Bolino-Anda, Pangasinan, where intensive aquaculture operations create hypoxic conditions for mass mortality (Annex Table 3.D.1). The 2002 Bolinao fish kill coincided with a *Prorocentrum cordatum* bloom, demonstrating the linkage between eutrophication, HABs, and fish mortality (San Diego-McGlone et al., 2024).

Beyond nutrient pollution, aquaculture is also a growing source of chemical contaminants. Heavy metals, including cadmium, lead, chromium, and mercury, accumulate in sediments and fish, threatening food safety (Tahiluddin, et al., 2025). Antibiotic use, particularly oxytetracycline, promotes the development of antibiotic-resistant bacteria, with the Philippines identified as a potential hotspot for antimicrobial resistance (AMR) in aquaculture.

3.2.1.5 Solid Waste and Marine Litter

The Philippines faces a rapidly growing solid waste challenge, driven by economic and population pressures. Municipal solid waste (MSW) reached more than 40,000 tons/day in 2016 (Talavera et al., 2024) from 37,400 tons/day in 2012, and is projected to exceed 60,000 tons/day by 2023. Regional hotspots include Metro Manila, CALABARZON, and Central Luzon, with NCR alone surpassing 9,000 tons/day (Figure 3.5). Recent data from EMB confirm 61,000 tons/day in 2024, equivalent to 22–23 million tons annually, with plastics comprising 24% of the mix. These values closely align with government projections, underscoring a persistent upward trend.

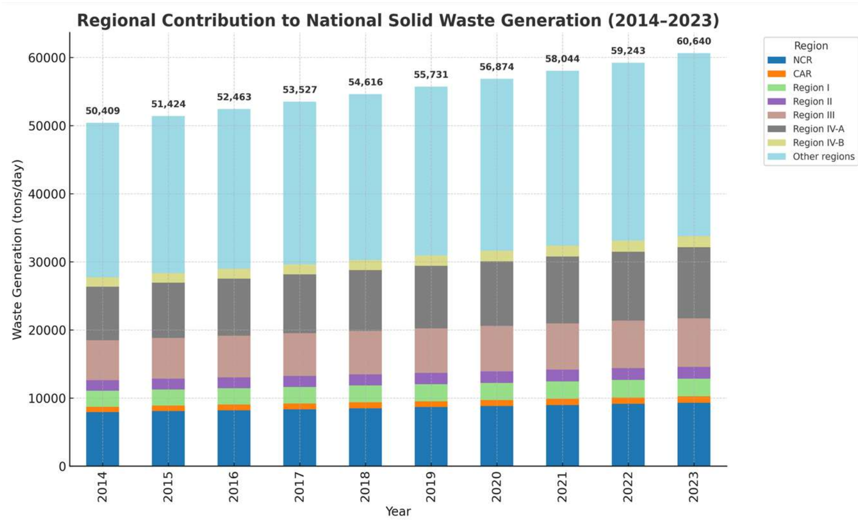


Figure 3.5. Projected Annual Solid Waste Generation and Regional Contribution from 2014-2023 (PSA, 2024)

Infrastructure, however, lags behind the demand. By 2023, the country had 11,823 material recovery facilities and 299 sanitary landfills, which fell short of the required number (Figure 3.6). Commission on Audit (COA) reports highlight chronic under-resourcing, with many barangays lacking proper facilities and resorting to open dumping or burning (Baclig, 2024). The waste composition is dominated by biodegradable material (52.31%), followed by recyclables such as paper, metals, glass, and plastics (EMB, 2020b). Plastic waste accounts for 10–11% of MSW by weight, but is disproportionately visible in waterways and seas.

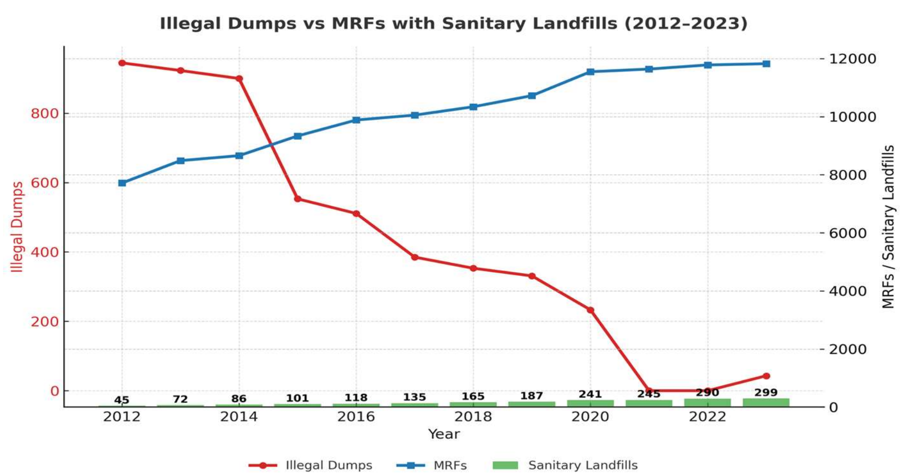


Figure 3.6. Trend on the Number of Disposal Facilities in the Philippines (2012-2023) Data source: PSA, 2024

The Philippines is thus identified as a leading contributor of marine litter from plastic waste leakage, with 0.75 million tons entering the ocean annually (World Bank Group, 2021). Modeled studies (Meijer et al., 2021) estimate over 150,000 tons/year flow through rivers, nine of which drain into the South China Sea LME, as shown in Figure 3.7 (see Annex 3.E for the complete list of rivers in the Philippines). Surveys in Manila Bay reveal more than 90% of beach debris is plastic, while mangrove habitats are increasingly clogged, impairing ecosystem services (Chaigne, 2021). Despite recent cleanup campaigns (GMA Integrated News, 2025), systemic solutions remain urgent.

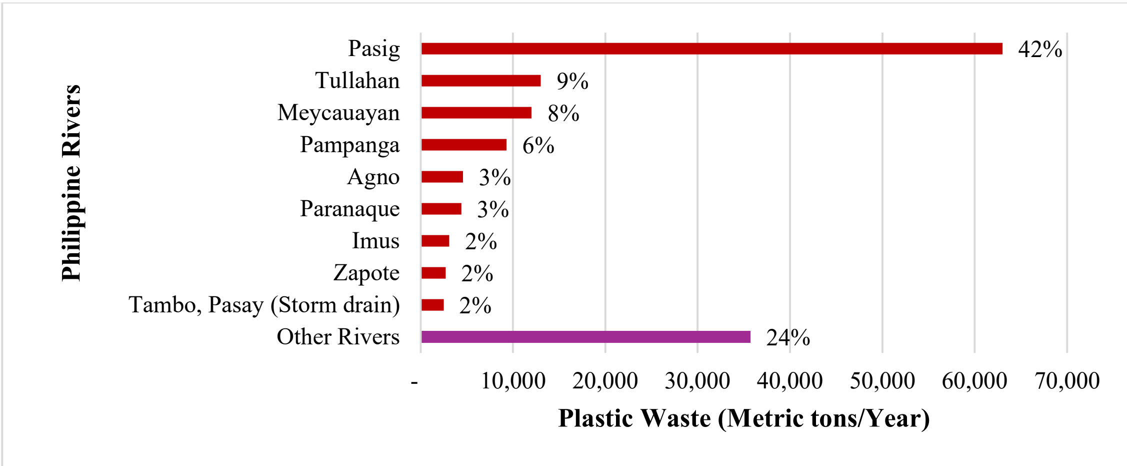


Figure 3.7. Top Plastic Emitting Rivers in the Philippines Draining to the Philippine waters of SCS-LME from the modeling study of Meijer et al. (2021). Percentages shown indicate the proportion of each river's contribution to the national total.

3.2.1.6 Hazardous Waste

Hazardous waste comprises substances with no safe commercial use that are generated from industrial, chemical, or related activities, that are toxic, corrosive, flammable, reactive, infectious, or otherwise harmful. Proper handling, treatment, and disposal are critical to prevent risk to human health and environmental contamination. From 2012 to 2023, oil waste (9 million tons), inorganic chemicals (4.9 million tons), and cyanide waste (4.3 million tons) dominated hazardous waste generation (Figure 3.8). Region 4A, Region 3, and the National Capital Region (NCR) consistently account for more than 80% of national output from 2020-2023 (Figure 3.9). Reported treatment rates improved to 92% by 2019, with TSD facilities increasing from 127 to 175 by 2023 (Figure 3.10). These registered treatment, storage, and disposal (TSD) facilities are designated locations where industrial and hazardous wastes are transported, stored, treated, recycled, or disposed of. The operationalization of the online Hazardous Waste Management System in 2020 has facilitated a more reliable platform for tracking hazardous waste volumes and movements. See Annex 3.F for the complete data on hazardous waste in the Philippines.

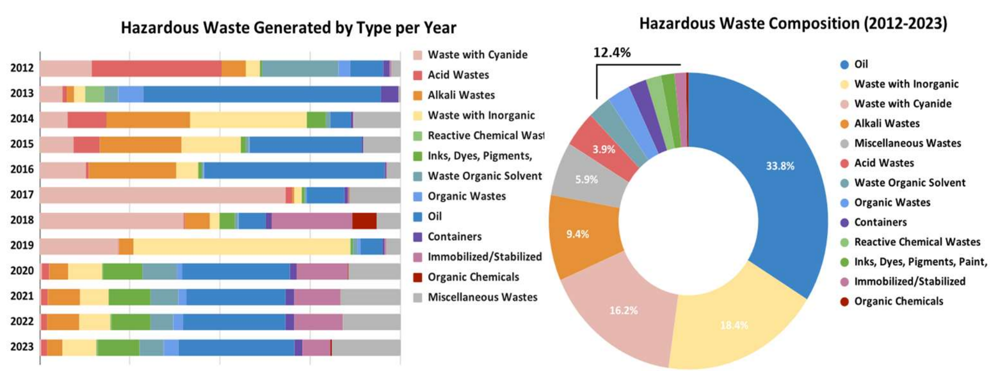


Figure 3.8. Composition of Hazardous Waste from 2012-2023. Data source: PSA, 2024

E-waste, formally categorized as "miscellaneous waste" under the Revised Procedures and Standards for the Management of Hazardous Waste (DAO, 2013-22), has rapidly grown in volume and significance in the Philippines. With rising consumer demand for electronics and short product lifecycles, e-waste generation is reported to be 4.7 kg per capita in 2022, making it one of the top generators in Southeast Asia (Baldé et al., 2025). With limited infrastructure for safe collection and treatment, informal recycling and disposal practices expose communities to hazardous substances, including lead, mercury, and brominated flame retardants.

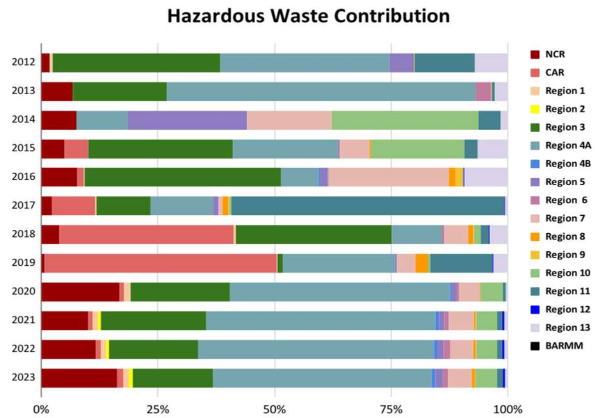


Figure 3.9. Contribution of Generated Hazardous Waste by Region from 2012-2023. Data source: PSA, 2024

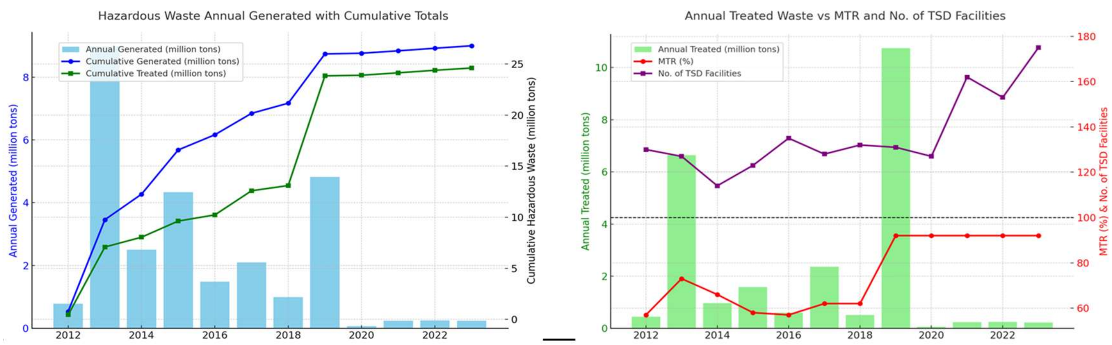


Figure 3.10. Hazardous waste generation and treatment trends in the Philippines, 2012–2023. Left panel: annual generated waste (bars) overlaid with cumulative generated and cumulative treated waste (lines). Right panel: annual treated waste (bars) overlaid with the multi-year treatment rate (MTR, %) and the number of treatments, storage, and disposal (TSD) facilities (lines) (PSA, 2024).

In addition to e-waste, other emerging hazardous waste streams should be examined as pointed out during the validation workshop (Annex 3.J). Their increasing volume in the coming decade underscores the need for early policy development, lifecycle management frameworks, and circular economy approaches for safe recovery and recycling. For example, end-of-life photovoltaic (PV) modules, batteries, and waste generated from renewable energy (RE) systems should also be examined, as these contain heavy metals, halogenated compounds, and complex composite materials that require specialized treatment and disposal pathways.

3.2.1.7 Oil Spills and Ship-Borne Pollution

The Philippines' strategic location along major shipping routes makes it highly vulnerable to oil and sea-borne pollution. Between 2000 and 2021, 467 oil spills occurred: 14 major (>10,000 liters), 62 medium, 306 minor. NCR recorded the highest frequency (87 spills), followed by Region IV-A (64) (Alea et al, 2022). The highest volume of oil spilled was recorded in 2006 (2,118,500 liters), attributed mainly to the Guimaras oil spill incident (Figure 3.11).

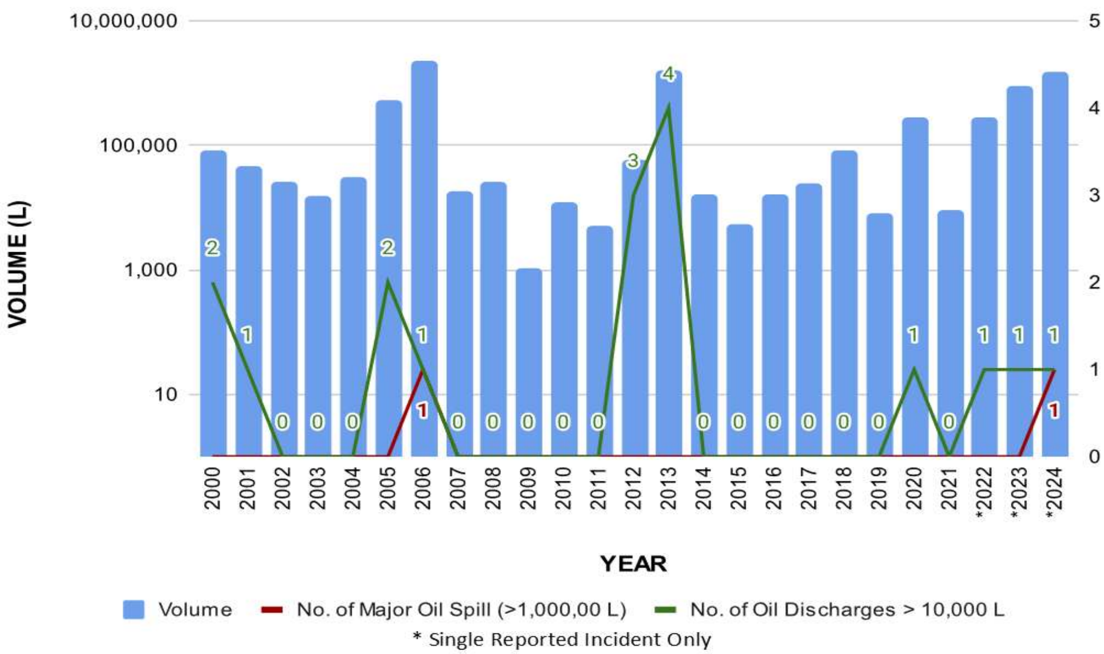


Figure 3.11. Total Volume of Recorded Oil Spill in the Philippines from 2000-2024. (Agaton et al., 2023; Alea et al., 2022; NDRRMC, 2024; Yuching, 2024)

Major incidents relevant to the SCS-LME (see Annex 3.G) include the 2000 Lingayen Gulf spill (57,000 liters), the 2013 Manila Bay pipeline leak (500,000 liters), and recent disasters: MT Princess Empress (800,000-900,000 liters, 2023) affecting Oriental Mindoro and Palawan's Verde Island (Agaton et al., 2023; Yuching, 2024), and MT Terra Nova (1,400,000-1,500,000 liters, 2024) capsizing in Manila Bay during Typhoon Gaemi, affecting Bataan, Bulacan, and Cavite fishing communities (NDRRMC, 2024). These disasters demonstrate the acute ecological and socio-economic impacts of oil pollution in bays and gulfs that drain into the South China Sea LME.

Ballast water discharge also poses another risk. Untreated ballast water introduces invasive species, microbes, and invertebrates across ecosystems (IMO, 2019). A notable case is the introduction of *Mytella strigata*, a mussel species native to South America, which was detected in Manila Bay between 2012 and 2014. The species has since spread to Lingayen Gulf, Aparri (Cagayan), and Batangas Port, disrupting local aquaculture (Vallejo, 2022).

3.2.1.8 Atmospheric Pollution and Deposition

Atmospheric pollution represents a significant yet often overlooked pathway of marine pollution, as airborne contaminants eventually settle into rivers, coasts, and the open ocean. Pollutants could be carried in the atmosphere, crossing watershed boundaries more easily than land-based discharges, making this pathway critical for transboundary ecosystems such as the South China Sea LME.

Point sources include coal-fired power plants and thousands of oil and gas generators, which release sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter. Mobile sources, such as cars, trucks, and buses dominate urban emissions, accounting for approximately 60% of NO_x and 28% of SO_2. According to the 2021 National Emission Inventory, 56% of emissions originate from mobile sources, 35% from stationary sources, and 9% from diffuse "area sources" including construction, agricultural burning, and open solid waste burning (EMB, 2021b).

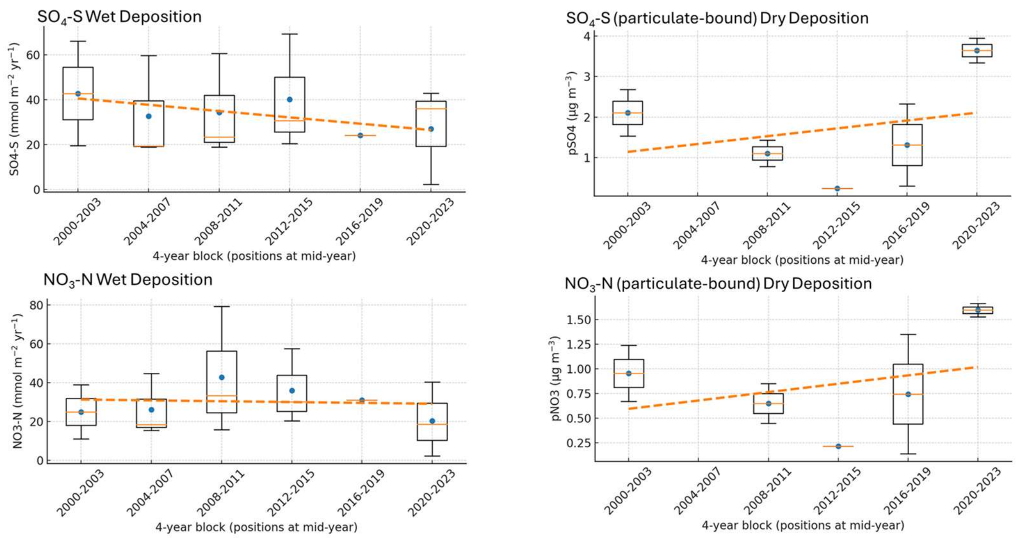


Figure 3.12. Trend analysis of wet deposition of SO_4 and NO_3 (left) and dry deposition of particulate-bound forms of SO_4 and NO_3 (right) (Network Center for EANET, 2025)

The Philippines is also part of the Acid Deposition Monitoring Network in East Asia, which provides long-term data on atmospheric deposition (Network Center for EANET, 2025). Figure 3.12 summarizes wet and dry deposition trends between 2000 and 2023, presented in four-year blocks. Wet deposition data show that sulfate-sulfur concentrations have declined slightly, reflecting the country's gradual transition to cleaner fuels and stricter sulfur limits, especially in Metro Manila and CALABARZON. In contrast, nitrate-nitrogen levels fluctuate, with lowland sites such as Manila and Los Baños reporting increases during certain periods, likely linked to vehicle emissions, agricultural ammonia, and rainfall variability. See Annex 3.H for the reported data on wet and dry deposition, and their descriptive statistics.

Dry deposition results highlight particle-bound SO_2 and NO_x compounds as persistent stressors, with generally increasing trends. These pollutants either fall directly onto ocean surfaces or accumulate on land and are then washed into coastal waters during rainfall. Their combined effects include acidification, nutrient enrichment, and hypoxia. Although nitrogen deposition can initially stimulate productivity, it may also elevate CO_2, reduce pH, and lower oxygen levels. These conditions stress coral reefs, mangroves, and fisheries across the South China Sea-Large Marine Ecosystem (LME).

3.2.2 Pollution Hotspots and Sensitive Areas

Several pollution hotspots along the Philippine coast of the South China Sea overlap with ecologically sensitive areas. Manila Bay is the most critical, with dense urbanization and industry producing high loads of coliform bacteria, nutrients, and solid waste. Its semi-enclosed character and limited tidal flushing trap pollutants, threatening fish nurseries and mangrove wetlands such as the Las Piñas–Parañaque Wetland Park. Health risks, fishery losses, and ecological degradation underscore the need for urgent remediation.

Lingayen Gulf is another hotspot where rivers such as the Agno and Dagupan carry sediments, nutrients, and contaminants (Deocadez et al., 2003). Sewage inputs from coastal towns, combined with upstream mining and logging, lead to increased turbidity and trace levels of mercury, cadmium, and lead. The gulf supports milkfish aquaculture, wild fisheries, and tourism (e.g., Hundred Islands National Park), making it highly vulnerable. Sewage and feed waste have triggered fish kills in aquaculture pens, while heavy metals in sediments pose a risk of bioaccumulation in seafood.

Batangas Bay and the Verde Island Passage (VIP) form a hotspot near refineries and power plants. Eastern Batangas Bay shows higher oil residues and heavy metal concentrations, whereas portions of the VIP, renowned as the “Amazon of the Oceans” for its biodiversity, are experiencing a decline in quality and trace metal pollution that could impair coral reefs and fisheries (Wagas & Andres, 2022) Likewise, even Palawan’s west coast, while less polluted, shows rising coliform counts. Recent environmental data provided by EMB regional offices were used to validate these initial findings (see Annex 3.J).

Collated data, though sparse and limited between 2000 and 2024, reinforces these hotspot patterns (Figure 3.13). Manila Bay shows elevated nutrients, coliform, and heavy metals (e.g., mercury, lead) with low DO levels, reflecting intense urban and industrial inputs (WEPA, 2025). Microplastics are also detected at elevated levels in the riverine discharge that drains to Manila Bay (Figure 3.13j). There is a growing threat of microplastic pollution at the Philippine waters of SCS-LME (Onda et al., 2024). In addition, persistent organic pollutants (POPS) such as polychlorinated biphenyls (PCBs) have been detected in plastic resin pellets (International Pellet Watch, 2025) found at Cavite City beaches and Manila Bay. These resins are industrial raw materials used to produce plastics that were unintentionally released to the environment.

On Palawan’s west coast, pressures are emerging near population and tourism centers. In Bacuit Bay (El Nido) and Coron Bay, fecal coliform levels frequently exceed standards due to inadequate sewage systems (Palawan Council for Sustainable Development [PCSD], 2023; Vicente, 2024). Nutrient enrichment poses a threat to adjacent reefs and seagrass beds. Moreover, the 200,000-ha Malampaya Sound Protected Area also receives marine litter inputs and could face risks from shipping and offshore gas operations (Coram et al., 2021; Haworth et al., 2024).

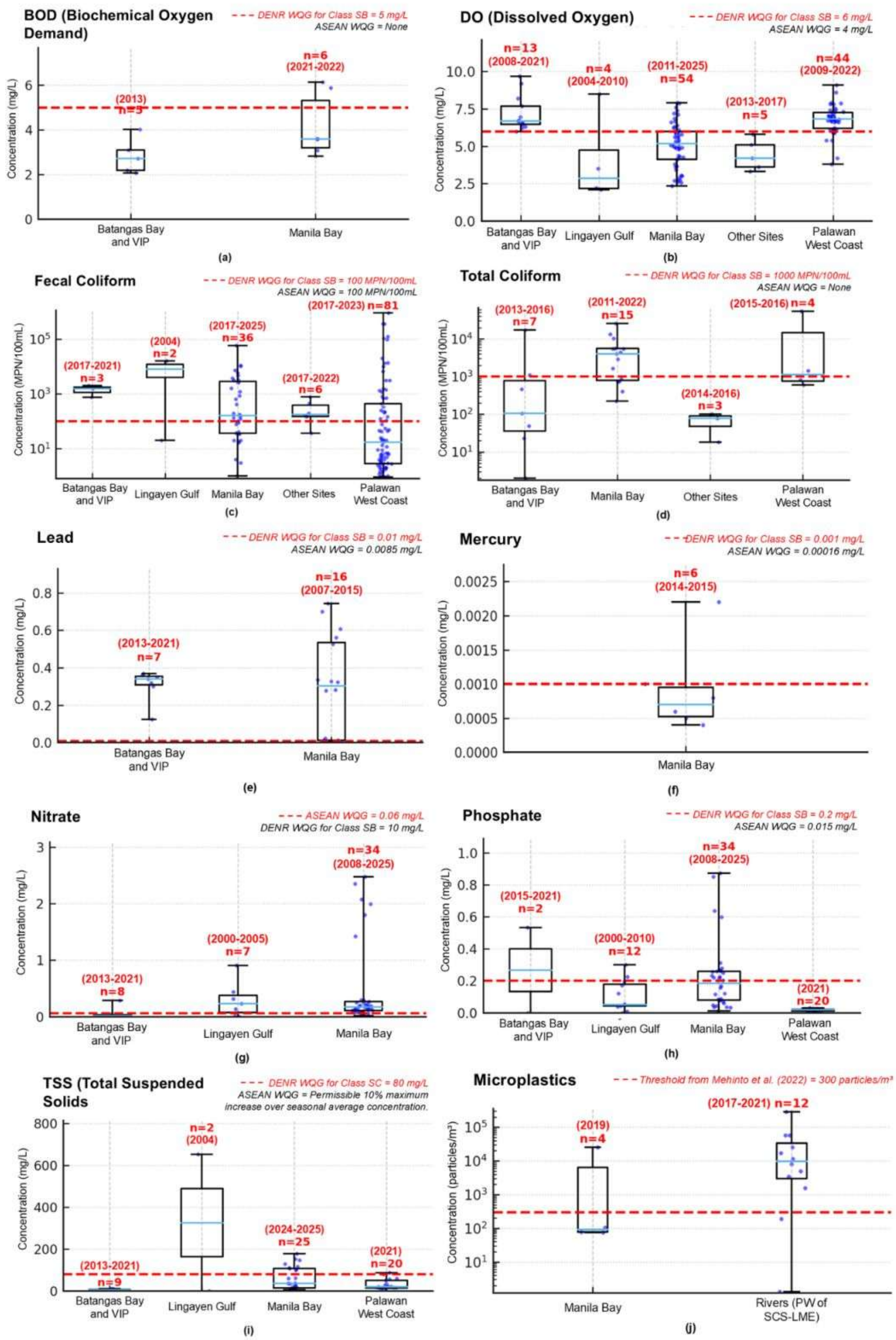


Figure 3.13. Box plot of measured concentrations of selected pollution indicators for coastal and estuarine water quality based on the compiled data (Annex 3.A) prior to the validation workshop. The box plot includes the number of datapoints (n) and temporal coverage, as well as the threshold for each water quality indicator.

3.3 Discussion and Conclusions

3.3.1 Priority Transboundary Pollution Issues

The South China Sea's interconnected oceanography creates transboundary pollution requiring multi-country collaboration:

- **Marine Plastic Debris**: Plastics drift across boundaries on ocean currents. Microplastics from the Mekong River reach the Philippines, which receives half of the Mekong-sourced particles stranded regionally (Nguyen et al., 2023). Philippine rivers contribute debris to Vietnam, Malaysia, and beyond, undermining marine life and tourism.
- **Oil Spills and Ship-Borne Pollution**: Heavy shipping traffic means spills spread across borders. Oil slicks drift to Vietnam, China, or Malaysia, depending on currents. Routine ship pollutants (bilge dumping, garbage, ballast water) have cumulative regional impacts. Joint preparedness under the ASEAN Oil Regional Spill Contingency Plan and the IMO conventions is vital.
- **Riverine Pollution and Nutrient Loading**: Rivers carry nutrients, sediment, and contaminants into shared waters. Philippine rivers (e.g., Pampanga, Agno) contribute to regional loadings. Nutrient plumes cause transboundary harmful algal blooms affecting multiple countries' fisheries. Mining siltation can smother distant coral reefs through sediment transport.
- **Shared Marine Resources Contamination**: Migratory species accumulate pollutants across regions. Microplastics, heavy metals, organometallic compounds, or persistent organic pollutants in Philippine waters could bioaccumulate in fish caught in the South China Sea LME. Conversely, pollutants released elsewhere contaminate Philippine seafood. Mercury, microplastics, POPs, and other emerging contaminants require monitoring, harmonized standards, and information exchange among regional partners.

Marine debris, oil pollution, nutrient enrichment, and toxic contaminants exemplify issues no country can address alone. These transboundary problems rank as priorities for regional cooperation and the Transboundary Diagnostic Analysis (TDA) of the South China Sea LME.

3.3.2 Impacts on Environment and Society

Pollution of coastal waters has wide-ranging environmental and societal impacts in the Philippines and across the South China Sea region. Degraded water quality undermines critical habitats. Coral reefs exposed to coastal acidification and eutrophication exhibit reduced coral cover and frequent algal overgrowth, as observed in the Lingayen Gulf (Isah et al., 2022). Seagrass beds and mangroves, vital fish nurseries, are smothered by silt and litter. In Manila Bay, remaining mangrove stands are choked with plastic waste, impairing ecological function. Biodiversity loss is evident, with declines in corals, while nutrient-driven red tides trigger mass mortality. Organic pollution load from sewage in semi-enclosed waters leads to hypoxia and periodic fish kills; Manila Bay has recorded such events alongside declining fisheries productivity. Chronic pollution also weakens ecosystem resilience to climate change, while extreme rainfall amplifies runoff of sediments and nutrients, fueling algal blooms and turbidity that further stress coral and seagrass ecosystems.

Societal impacts are equally severe. Public health is threatened as sewage contamination exposes beachgoers and coastal residents to pathogens, with extremely high coliform counts in Manila Bay and El Nido linked to gastroenteritis and other waterborne diseases. Seafood safety is at risk, as shellfish and fish accumulate bacteria and heavy metals, causing food poisoning or long-term health issues. Fisheries and aquaculture are compromised. In Dagupan (Lingayen Gulf), milkfish (bangus) ponds are affected by upstream waste discharges, which reduce the quality and prices of the fish (Stimson, 2023). Declining fish stocks and habitat degradation erode livelihoods, while smaller catches and fewer high-value species undermine incomes.

Tourism is also affected. Algal blooms, foul water, and trash-strewn beaches threaten destinations such as El Nido, where contamination has led to swimming bans. Pollution disproportionately affects poor coastal communities that rely heavily on natural resources. Informal settlers along estuaries and bays are highly vulnerable to pollution (health hazards) and its knock-on effects, such as the loss of fisheries and flooding from clogged waterways. Overall, degraded coastal waters erode ecosystem services, i.e., food, storm protection, and income, undermining the Philippines' $17 billion blue economy potential (ADB, 2025).

3.3.3 Risk Assessment

Pollution risks in Philippine coastal and marine habitats have intensified since the early 2000s, despite growing awareness and efforts to mitigate them. Rapid urbanization, industrialization, and tourism have driven pollutant loads beyond the capacity of existing infrastructure. In Metro Manila, population growth exacerbated the contamination of Manila Bay, with fecal coliform and nutrient levels remaining very poor throughout the 2000s. By 2018, parts of the bay were virtually unfit for recreation. Lingayen Gulf also faced siltation and heavy-metal contamination from mining and deforestation. Some improvements are evident. Fecal coliform levels in Manila Bay decreased from 126,000 MPN/100mL in 2019 to 51,300 in 2022 following rehabilitation efforts (Bautista, 2023). Batangas Bay's integrated coastal management (ICM) under PEMSEA likewise contributes to improving conditions. Yet these gains remain fragile, as fish kills, HABs, and coral die-offs have become more frequent, amplified by climate stressors.

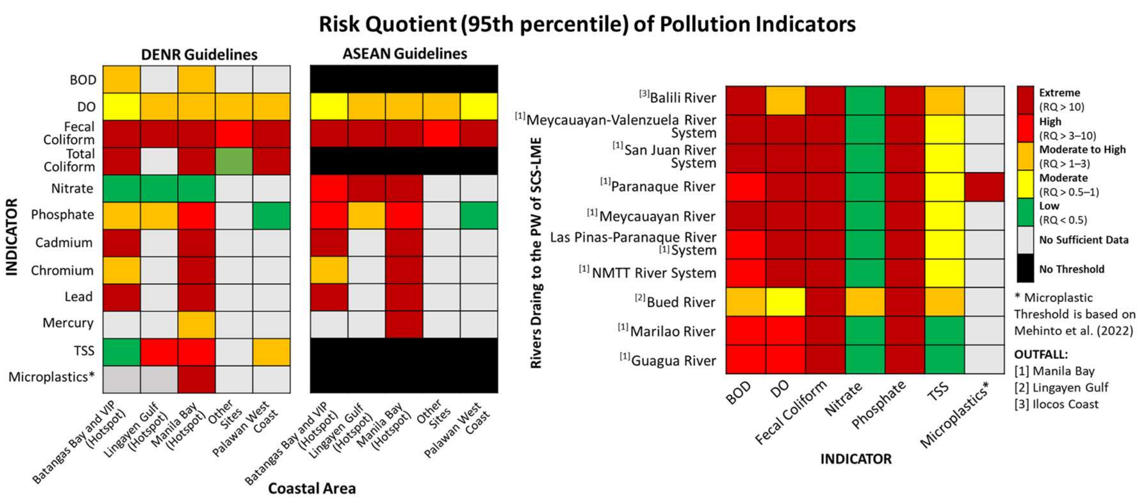


Figure 3.14. Left Panel: Heat Map for Coastal Hotspots in the Philippine Waters of SCS-LME (2000-2025). Right Panel: Heat Map for Rivers Draining to the Philippine Waters of SCS-LME (2000-2023). The DENR and ASEAN do not have established thresholds for microplastics; therefore, the threshold value was adopted from Mehinto et al. (2022). RQ was computed from the collated data of MEC prior to the validation workshop.

Figure 3.14 summarizes the risk quotient (RQ) analysis for a reasonable worst-case scenario using the DENR and ASEAN guidelines. Results show Manila Bay as the most critical hotspot, with phosphate, heavy metals, TSS, and coliforms exceeding thresholds, some in the Very High to Extreme risk bands (RQ >10 to >1000). Batangas Bay and Lingayen Gulf follow as secondary hotspots, while Palawan generally registers lower risks but still has localized exceedances. The ASEAN guidelines establish more conservative threshold values, resulting in most indicators across all sites being classified as high to extreme risk. See Annex 3.I for calculations and dataset on risk quotient analysis.

Rivers that are part of the watershed or river basin drainage to SCS-LME pose significant risks. Nitrate and TSS predominantly exhibit low to moderate risk levels. Dissolved oxygen (DO) levels indicate a moderate to high risk, with rivers in Metro Manila exhibiting extremely low DO concentrations. BOD risk levels vary considerably across different locations. In contrast, phosphate, microplastics, and particularly fecal coliform contamination register alarmingly high to extreme risk levels. These findings highlight the impact of riverine pollution and the significant role of these rivers as a major conduit for land-based pollution into coastal waters.

Figure 3.15 presents the risk matrix for priority pollution scenarios. Five priority concerns emerged.

- Nutrient-driven eutrophication, HAB, and hypoxia (critical risk quadrant): already frequent, causing fish kills and ecosystem collapse in bays.
- Marine plastics crisis (critical risk quadrant): chronic, high-likelihood, transboundary threat undermining fisheries and tourism.
- Major oil spill (high risk quadrant): low-moderate frequency but catastrophic severity, given dense South China Sea shipping.
- Sewage-driven HAB and public health outbreaks (high risk quadrant): moderate-high frequency, high human and economic impact.
- Bioaccumulation of toxic contaminants (moderate-to-high risk quadrant): moderate severity and likelihood through bioaccumulation of heavy metals, POPs, and microplastics in the food chain, presenting long-term health and trade implications.

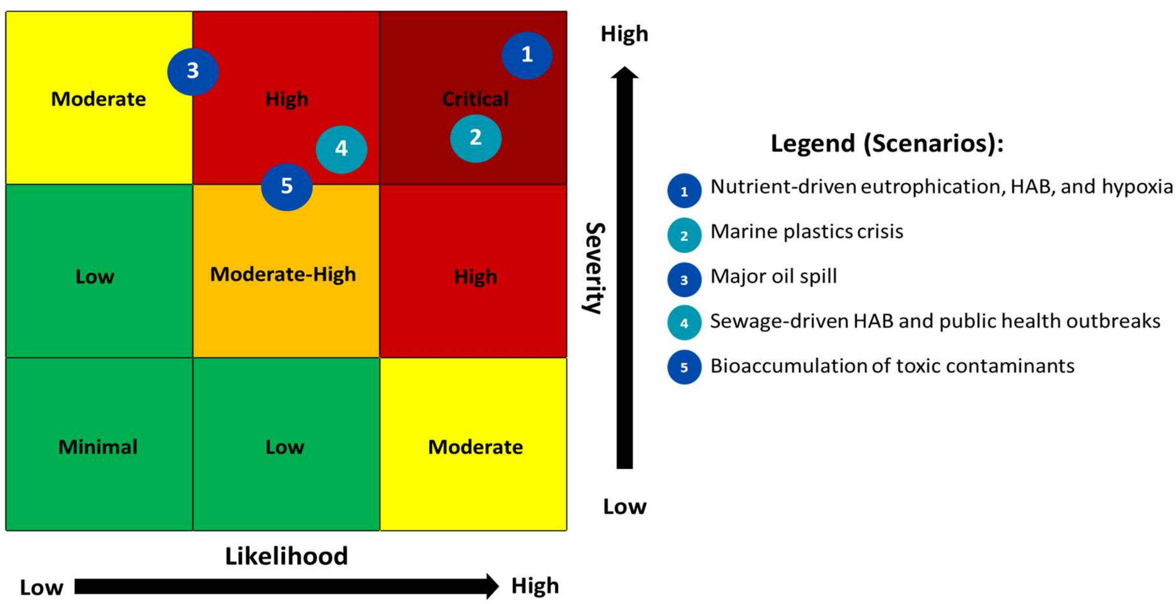


Figure 3.15. Risk Scenario Matrix

Without significant investment in wastewater and sanitation, as well as in nutrient and plastic management, high environmental and socio-economic risks are likely. Under such a "business-as-usual" scenario, persistent hypoxic zones in Manila Bay, as well as coastal habitats like coral reefs, would be under high threat from watershed-based pollution (Figure 3.16), resulting in biodiversity loss, and local fisheries decline. Climate change further compounds risks via heavier rainfall and flooding that flush pollutants into the sea.

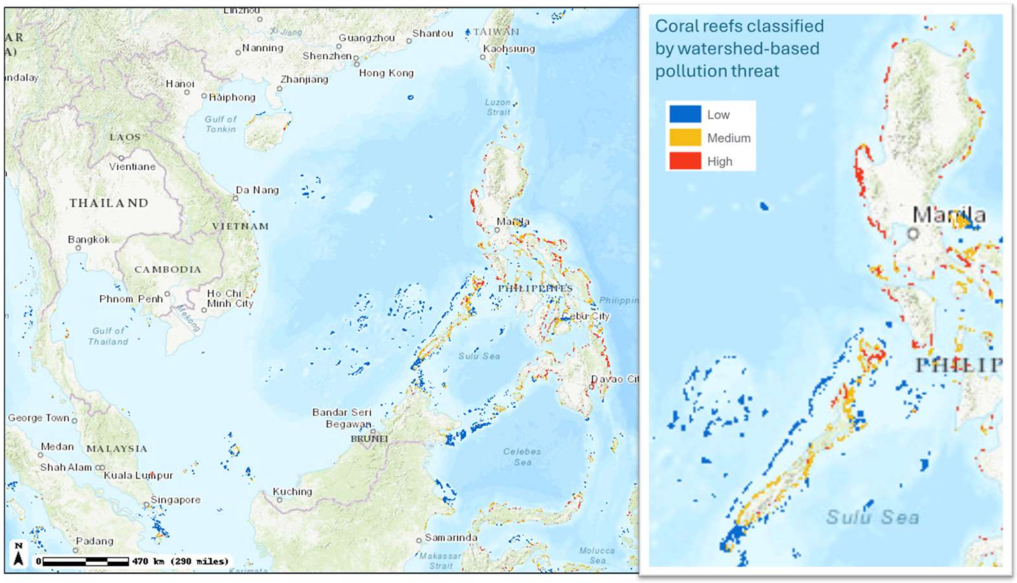


Figure 3.16. Coral reefs in the Philippine waters of the SCS-LME classified by watershed-based pollution threat (Burke, et al, 2011)

3.3.4 Current Management and Institutions

Marine pollution management in the Philippines involves multiple institutions across local, national, and regional levels. Key national frameworks include the Clean Water Act of 2004 and the Ecological Solid Waste Management Act of 2000, which are primarily implemented by the DENR-EMB, setting standards and monitoring protocols. While EMB guides the designation of Water Quality Management Areas, enforcement and infrastructure often lag. LGUs are frontline actors but face resource and capacity constraints, as seen in Manila and Dagupan, where sewage treatment remains limited. In Manila Bay, a Supreme Court Mandamus required 13 agencies to rehabilitate the bay and improve coordination, but also exposed overlapping mandates (Senate Economic Planning Office [SEPO], 2024). The Extended Producer Responsibility (EPR) Act of 2022 further strengthens plastic waste reduction by assigning producers responsibility for recovery and diversion, through compliance monitoring and integration with LGU systems remain evolving challenges.

High-profile cases highlight institutional gaps and responses driven by the institution. In Boracay (2018) and El Nido (2018–2023), closures and rehabilitation orders led to stricter enforcement of regulations on wastewater, establishment of treatment facilities, and monitoring of businesses, though low connection rates limit effectiveness (Fabro, 2018; PCSD, 2023). Civil society and universities also influence policy, e.g., studies on heavy metals in Batangas Bay prompted stricter oversight (Wagas & Andres, 2022). The Philippine Coast Guard has expanded its role in oil spill response and marine litter cleanup.

Regionally, the Philippines participates in PEMSEA's SDS-SEA (Sustainable Development Strategy for Seas of East Asia), with Batangas Bay as a pilot for integrated coastal management, resulting in unified management plans and oil spill contingency measures (PEMSEA, 2006). The country also participates in ASEAN's Regional Action Plan on Marine Debris (ASEAN, 2021), COBSEA's nutrient management framework (COBSEA, 2024), and bilateral cooperation such as JOMSRE-SCS with Vietnam and the Sulu-Sulawesi Marine Ecoregion program (Supreme Court of the Philippines, 2002; Dang, 2021).

Overall, while a strong framework exists, efforts remain fragmented. Strengthening integration across levels and sectors, as well as enhancing regional collaboration, are essential for effective marine pollution governance.

3.3.5 Gaps and Priority Challenges

Despite ongoing efforts, significant gaps thus remain in addressing pollution in the Philippine coastal and marine waters. These represent priority challenges to overcome:

- **Infrastructure Gap:** Only a small percentage of coastal cities have sewage treatment facilities; proper MRFs and landfills are also lacking.
- **Enforcement and Capacity Building Gaps:** Weak monitoring, corruption, and insufficient technical capacity at the LGU level for pollution control and management.
- **Fragmented Effort of Institutions:** Weak and uncoordinated implementation of the inter-agencies' and LGUs' mandate.
- **Financial Constraints:** Limited sustained funding for infrastructure and monitoring.
- **Weak Transboundary Coordination and Cooperation:** There is no joint pollution contingency plan among SCS nations.
- **Limited Public Awareness:** Poor understanding of cumulative impacts and behavior change challenges.
- **Scientific and Data Gaps:** Incomplete data on emerging contaminants and insufficient long-term datasets. Inaccessibility of data to assess pollution sources from the industrial sector. Weak data governance on environmental data.

3.3.6 Recommended Priority Actions

A set of priority actions is recommended to tackle pollution crises in the Philippine waters (SCS-LME). The following actions should be pursued through coordinated national efforts and reinforced by regional cooperation:

- **Invest in Wastewater and Waste Management Infrastructure:** Accelerate construction of resource recovery facilities and treatment plants in major coastal cities, targeting 50% coverage by 2025, 100% by 2030. Implement sustainable financing schemes, public-private partnerships, circular resource-oriented sanitation (Promentilla et al., 2022), and nature-based solutions.
- **Strengthen Enforcement:** Expand real-time monitoring in hotspots, enforce heavier penalties, train enforcement units, and harmonize ASEAN standards.
- **Expand ICM and Watershed Management:** Replicate successful models across all hotspots, integrate upstream-downstream management (e.g., ridge-to-reef framework), and align sustainable agricultural and aquaculture practices.
- **Strengthen Regional Contingency Plan:** Develop protocols for mutual spill response, early warning systems, and operationalize ASEAN disaster response for marine pollution.
- **Strengthen Marine Litter Reduction Program:** Implement a ban on single-use plastics, improve collection rates, support recycling markets and circular economy innovations, and organize ASEAN Coastal Cleanup Day.
- **Enhance Protection of Sensitive Ecosystems for Climate Resilience:** Designate marine protected areas with high water quality, launch habitat restoration projects, and collaborate through regional initiatives.
- **Enhance National and Regional Coordination:** Establish and enact the appropriate national oceans policy, increase capacity-building funding, and promote joint research programs. Establish the South China Sea Watershed Partnership.
- **Strengthen Community, Capacity Building, Education, Participation, and Awareness (CEPA) programs:** Develop education campaigns, sustain positive behavioral changes from social and behavioral change communication (SBCC), community-based waste-to-resource recovery programs, involve fisherfolk in monitoring, and establish a civil society platform.

- **Advance Science, Data Governance, and Innovation:** Strengthen long-term monitoring of emerging contaminants, expand research on pollution impacts, promote open data governance, and invest in circular economy and pollution-control technologies. A need for the whole-of-society approach to harmonize standards and SOPs, interoperable data systems, consistent monitoring, and clearer cross-sectoral accountability.

3.4 Methodology and Analysis

This analysis adopted the TDA guidance document on pollution indicators, utilizing collated data from the 2000s to the 2020s (Annex 3.A). Sources included government agencies (DENR-EMB, PSA), regional bodies (World Bank, UNEP, PEMSEA), and peer-reviewed literature. Critical hotspots were identified based on the DENR EMB National Implementation Report on Land-based Pollution (2021). Analysis faced limitations from sparse spatial-temporal data coverage, methodological inconsistencies between monitoring programs, and attribution challenges in multi-stressor ecosystems. Results from data analysis should be interpreted with caution. Small sample sizes ($n < 5$), as seen in several sites (e.g., DO in Lingayen Gulf, mercury samples in Manila Bay), limit statistical reliability. High variability (e.g., BOD and fecal coliform in Manila Bay) reflects the influence of multiple pollution sources and variable sampling conditions. Median values alone may not fully capture the dynamics of pollution. Risk quotient analysis thus used reasonable worst-case scenarios (see Annex 3.I.) to evaluate pollution risks across sites and indicators. Where quantitative data were lacking, qualitative assessment and triangulation were employed. The methodology was also further strengthened through a multi-stakeholder validation workshop, which provided a review of datasets, clarified institutional mandates, identified emerging pollution issues, and helped verify hotspot selection and data limitations across source categories (see Annex 3.J).

Glossary

- **Acidification (Coastal/Marine) -** Decrease in pH of seawater due to CO2 absorption and acidic inputs**.**
- **Agricultural Runoff / Diffuse Pollution -** Non-point source pollution from farmlands carrying nutrients, sediments, and pesticides.
- **Ammonia (NH_3-N) -** Un-ionized/ionized ammonia in water; toxic at elevated levels.
- **Antimicrobial Resistance (AMR) –** occurs when microorganisms has evolved to resist the effects of antimicrobial agents (e.g. drugs)
- **Aquaculture / Mariculture -** Cultivation of aquatic organisms in inland/coastal waters or marine environments.
- **ASEAN Regional Action Plan on Marine Debris -** ASEAN framework to reduce marine plastic pollution.
- **Atmospheric Deposition -** Transfer of pollutants from air to surface via wet or dry processes.
- **Ballast Water Discharge -** Release of water used to balance ships that may contain invasive species and pathogens.
- **Bioaccumulation -** Uptake and retention of substances in organisms over time.
- **Blue Economy -** Sustainable use of ocean resources for economic growth, livelihoods, and ecosystem health**.**
- **BOD (Biochemical Oxygen Demand) -** Amount of dissolved oxygen needed by microorganisms to break down organic matter in water over a specific period (commonly 5 days).
- **Box Plot -** Statistical chart showing distribution (median, quartiles, outliers).
- **Bureau of Fisheries and Aquatic Resources (BFAR) -** Fisheries policy and management bureau under the Department of Agriculture (DA)**.**

- **Bureau of Soils and Water Management (BSWM) -** DA-attached agency on soil and water research and management.
- **Circular Economy -** Economic model prioritizing resource efficiency, reuse, and closed loops.
- **Clean Water Act (RA 9275)** - Philippine law providing water quality management framework.
- **Coastal Zone / Estuary -** Interface where rivers meet the sea with strong gradients and high productivity.
- **COBSEA (Coordinating Body on the Seas of East Asia) -** UNEP regional body coordinating marine environmental protection in E/SE Asia.
- **COD (Chemical Oxygen Demand) -** Amount of oxygen required to chemically oxidize organic and inorganic matter in water.
- **Coliform –** rod-shaped, gram-negative bacteria that are indicators of fecal and/or pathogenic contamination
- **Commission on Audit (COA) -** Independent constitutional body auditing government use of funds.
- **Contaminants –** physical, chemical, biological, or radiological substances found in the environment in higher concentrations than what is natural that eventually cause harm.
- **Corrosive –** materials that causes damage to other materials that comes into contact with it through chemical reaction.
- **Coral Reef -** Marine ecosystem built by calcifying corals; biodiversity hotspot sensitive to pollution.
- **Department of Environment and Natural Resources (DENR) -** Philippine agency for environment and natural resource governance.
- **Diffuse sediments** – sediments carried into a waterbody with no single identifiable source.
- **DO (Dissolved Oxygen) -** Concentration of oxygen dissolved in water available for aquatic life.
- **Domestic Wastewater / Sewage -** Household wastewater containing organics, nutrients, and pathogens.
- **Dry Deposition -** Direct settling/adsorption of particles and gases onto surfaces without precipitation.
- **EANET -** Regional network for acid deposition monitoring in East Asia.
- **Ecological Solid Waste Management Act (RA 9003) -** Philippine law mandating segregation, recycling, and proper waste facilities.
- **Emerging Contaminants -** Chemicals newly recognized as potential risks (e.g., PPCPs, PFAS) lacking comprehensive regulation.
- **Endocrine Disrupting Chemicals (EDCs) / Endocrine disruptors -** Substances that interfere with hormonal systems in organisms.
- **Environmental Governance -** Structures and processes for decision-making on environmental issues.
- **Environmental Management Bureau (EMB) -** DENR bureau responsible for pollution management and monitoring.
- **Eutrophication -** Nutrient enrichment of water bodies leading to excessive plant/algal growth and oxygen depletion.
- **E-waste (Electronic Waste) -** Discarded electrical/electronic devices and components.
- **Fecal Coliform (FC) -** Indicator bacteria originating from human/animal feces used to assess sanitary quality of water.
- **Fish Pens / Cages / Fishponds -** Aquaculture structures confining fish/shellfish for grow-out.
- **Harmful Algal Bloom (HAB) -** Algal proliferation that can produce toxins or cause ecological/human health impacts.

- **Hazardous Waste / Toxic Waste -** Wastes exhibiting hazardous characteristics (toxic, corrosive, ignitable, reactive).
- **Heat Map -** Visual display using color gradients to depict intensity/values across locations.
- **Heavy Metals -** Metals and metalloids toxic at low concentrations (e.g., Cd, Pb, Hg, Cr).
- **Hotspot (Pollution Hotspot) -** Location with elevated pollutant levels or acute impacts requiring priority action.
- **Hypoxia -** Condition of low dissolved oxygen that stresses or kills aquatic organisms.
- **Indicator / Pollution Indicator -** Measured variable representing a pollution pressure, state, or impact.
- **Industrial Effluent -** Wastewater discharged from industrial facilities.
- **Integrated Coastal Management (ICM) -** Process for coordinated management of coastal zones integrating sectors and stakeholders.
- **Invasive Species -** Non-native species whose introduction causes harm to environment, economy, or health.
- **Land-based Pollution -** Pollution originating from land activities transported to marine/coastal waters via rivers, runoff, or air.
- **Local Government Unit (LGU) -** Municipal, city, or provincial government unit with local environmental mandates.
- **Mangroves -** Intertidal forests providing nursery habitat and coastal protection.
- **Marine Litter / Marine Debris -** Solid material discarded or abandoned in the marine environment.
- **Marine protected area –** designated marine area by law and is governed by specific guidelines to manage activities, protect, and conserve the marine ecosystem in the area.
- **Material Recovery Facility (MRF) -** Facility for segregation, recycling, and processing of solid waste.
- **Metropolitan Waterworks and Sewerage System (MWSS) -** Regulator for water supply and wastewater services in Metro Manila.
- **Microplastics -** Plastic particles <5 mm from fragmentation or microbeads.
- **Mobile source –** moving vehicles, engines, and equipment that generates air pollution through combustion of fuels
- **Modeling Study / Modeled Data -** Results derived from computational models rather than direct measurements.
- **Nanoplastics -** Plastic particles <1 µm potentially more bioavailable and reactive.
- **Nature-Based Solutions (NbS) -** Actions inspired by ecosystems to address societal challenges and provide co-benefits.
- **Nitrate (NO_3-N) -** Oxidized form of nitrogen in water; key nutrient contributing to eutrophication.
- **Nitrogen Oxides (NOx) -** Gases (NO, NO_2) from combustion contributing to ozone and nitrate formation.
- **Nonpoint source –** when an origin of pollutants is too broad or not identifiable.
- **Nutrient Load / Nutrient Flux -** Quantity of nutrients transported to a water body over time.
- **Oil Spill / Ship-borne Pollution -** Release of petroleum into the marine environment from accidents or operations.
- **Palawan Council for Sustainable Development (PCSD) -** Provincial body overseeing sustainable development and environment in Palawan.

- **Paralytic Shellfish Toxin (PST) –** neurotoxins released by microscopic algae that contaminates commercial shellfish.
- **Particulate Matter (PM) -** Airborne solid/liquid particles (e.g., PM10, PM2.5) affecting health and deposition.
- **Particulate Matter 2.5 (PM2.5) –** particles suspended in the air with diameters of 10 micrometers or smaller
- **Particulate Matter 10 (PM10) -** particles suspended in the air with diameters of 2.5 micrometers or smaller
- **Pathogens -** Disease-causing microorganisms (bacteria, viruses, protozoa) present in contaminated waters.
- **PEMSEA -** Partnerships in Environmental Management for the Seas of East Asia.
- **Persistent Organic Micropollutants -** Trace-level POP-like compounds persistent and bioactive at low concentrations.
- **Persistent Organic Pollutants (POPs) -** Toxic, bioaccumulative, and persistent chemicals subject to the Stockholm Convention.
- **PFAS (Per- and Polyfluoroalkyl Substances) -** Synthetic fluorinated chemicals resistant to degradation; linked to health risks.
- **Philippine Coast Guard (PCG)** - Maritime law enforcement and marine environmental protection agency.
- **Philippine Waters of the SCS-LME -** The portion of the SCS-LME within Philippine jurisdiction along the western seaboard.
- **Phosphate (PO_4-P) -** Orthophosphate concentration; a limiting nutrient that can drive algal blooms.
- **Plastic Leakage / Plastic Emission -** Escape of plastic waste from collection systems into the environment.
- **Pollution Load -** Mass of contaminants entering a water body per unit time.
- **Point source –** single, identifiable origin of pollution.
- **Public–Private Partnership (PPP) -** Cooperative arrangement between government and private sector for infrastructure/services.
- **Qualitative Assessment -** Non-numeric evaluation using expert judgment and triangulation.
- **Quantitative Assessment -** Numerical evaluation using measured or modeled data.
- **Reactive –** unstable materials that reacts violently with air or water, causing explosions.
- **Reasonable Worst-Case Scenario -** A conservative scenario using upper-bound concentrations to assess risk.
- **Regional Contingency Plan -** Cooperative protocol among states for emergency pollution response.
- **Resource-Oriented Sanitation -** Sanitation systems designed to recover water, nutrients, and energy.
- **Ridge-to-Reef Framework -** Integrated management approach linking uplands, rivers, and coasts.
- **Risk Band / Risk Matrix -** Categorization of risk by likelihood and consequence.
- **Risk Quotient (RQ) -** Ratio of measured concentration to guideline/threshold value to assess risk level.
- **Sanitary Landfill / Open Dumping -** Engineered facility for waste disposal vs. prohibited uncontrolled dumping.
- **Scenario Analysis -** Exploration of outcomes under different assumptions and interventions.
- **Seagrass -** Flowering marine plants forming coastal meadows essential for fisheries and carbon**.**
- **Sediment Load / Siltation -** Amount of eroded soil and particulate matter transported by water into aquatic systems.
- **Semi-enclosed Bay / Gulf -** Coastal water body with restricted exchange amplifying pollution impacts.

- **Sensitive Area / Critical Habitat -** Ecosystems highly vulnerable to pollution (e.g., reefs, seagrass, mangroves).
- **Solid Waste / Municipal Solid Waste (MSW) -** Garbage from households, commerce, institutions, and similar sources.
- **South China Sea Large Marine Ecosystem (SCS-LME) -** A high-biodiversity, semi-enclosed sea system shared by multiple countries, managed via LME approach.
- **Spatial–Temporal Coverage -** Extent of data across space and time used in analysis.
- **Stationary source –** nonmoving source of air pollution such as factories and power plants.
- **Strategic Action Programme (SAP) -** Agreed, policy-based regional program of actions addressing TDA-prioritized issues.
- **Submarine Groundwater Discharge (SGD) -** Flow of groundwater into the sea that can carry dissolved nutrients/contaminants.
- **Sulfur Dioxide (SO_2) -** Combustion-derived gas contributing to acid deposition.
- **Supreme Court Mandamus (Manila Bay Case) -** 2008 order directing 13 agencies to rehabilitate Manila Bay.
- **Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) -** Regional strategy for sustainable coastal and ocean governance.
- **Threshold Value / Guideline Value -** Benchmark concentration used to evaluate water quality and ecological risk.
- **Transboundary Diagnostic Analysis (TDA) -** Analytical process identifying priority transboundary problems, their causes, and impacts.
- **Transboundary Pollution -** Pollution that crosses national or jurisdictional boundaries via air or water.
- **Treatment, Storage, and Disposal (TSD) Facility -** Authorized facility to manage hazardous wastes before final disposition.
- **Trend Analysis -** Statistical examination of changes in indicators over time.
- **Triangulation -** Cross-validation using multiple data sources/methods to increase confidence.
- **TSS (Total Suspended Solids) -** Particles suspended in water that can be trapped by a filter.
- **Turbidity -** Cloudiness or haziness of water caused by suspended particles.
- **Waste-to-Resource / Waste Valorization -** Conversion of wastes into valuable products or energy.
- **Water Quality Management Area (WQMA) -** Designated area for focused water quality management under RA 9275.
- **Watershed / River Basin -** Land area draining to a common outlet (river, bay, or gulf).
- **Wet Deposition -** Removal of pollutants via precipitation (rain, fog).

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1. **Michael Angelo B. Promentilla -** Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing, Supervision, Validation.
2. **Nicole Alexandra C. Aguila –** Data curation, Formal Analysis, Visualization, Writing – original draft, Writing – review & editing.

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Chapter 3 Annexes

Annex 3.A. Definition of Pollution Indicators

This annex provides the pollution category and its indicators used in this report. The table below summarizes the categories, parameters, and indicators included in the database that was used for data analysis.

Table 3.A.1. Key Pollution Indicators

Pollution Category	Parameter	Indicator
Marine and coastal water quality	Nutrient Pollution Organic Pollution Coliform Heavy Metals Water Quality Contaminants of Emerging Concerns (CEC)	Nitrate, Phosphate, Ammonia BOD, DO Fecal, Total Coliform Cadmium, Chromium, Lead, Mercury TSS Microplastics
Aquaculture / mariculture pollution	Fish Kill Events Shellfish Advisories	Harmful Algal Blooms (HABs)
Wastewater and industrial	Wastewater Treatment Facility Pollution Load	Generated, Collected and Treated Nitrate, Phosphate, BOD, COD, TSS, Fecal Coliform
Agricultural runoff	Fertilizer Use Pesticide Use Nutrient Load	N, P, K Fertilizer Nitrate, Phosphorus
Solid waste	Projected Generation Disposal Facilities Top Plastic-Emitting Rivers in the Philippines	Illegal Dumps, Sanitary Landfill, MRFs
Hazardous waste	Hazardous Waste Types of Hazardous Waste Treatment Facility	Generated, Collected and Treated Waste with Cyanide, Acid Wastes, Alkali Wastes, Waste with Inorganic Chemicals, Reactive Chemical Wastes, Inks/Dyes/Pigments/ Paint/Latex/Adhesives/ Organic Sludge, Waste Organic Solvent, Organic Wastes, Oil, Containers, Immobilized/Stabilized Wastes, Organic Chemicals, Miscellaneous Wastes
Oil pollution	Oil Spill	Major Incidents, Volume
Atmospheric pollution	Wet Deposition Dry Deposition	Sulfate, Nitrate Sulfate (Particulate-bound), Nitrate (Particulate-bound)

The database in MS Excel contains several additional column parameters aside from the aforementioned ones. Key parameters include spatial characteristics (spatial resolution, region, spatial coverage, and specific site), temporal coverage (expressed in years), analytical values with corresponding units of measurement, and data sources. Additional attributes include limit of detection (LOD) values, environmental media classifications, waterbody class categories, relevance to Philippine Waters within the South China Sea Large Marine Ecosystem (SCS-LME), Predicted No Effect Concentration (PNEC) values and Risk Quotient calculations (based on DENR and ASEAN standards, see Annex 3.I.), and supplementary information. While these additional attributes are not required for all analyses, they may be essential for specific categories of pollution.

Coastal and Riverine Water Quality Indicators

This section presents statistical tables and box plot figures of water quality indicator concentration obtained from various data sources at identified pollution hotspots and rivers draining into the Philippine Waters of the SCS-LME. These statistical summaries provide insights into the concentration ranges, variability, and temporal coverage of key pollutants across sites. For detailed information on water quality thresholds, please check Annex 3.I.

Table 3.A.2. Summary Table for Number of Available Data on Water Quality by Pollution Hotspot.

Coastal Pollution Hotspots	BOD	DO	Fecal Coliform	Total Coliform	Cadmium	Chromium	Lead	Mercury	Nitrate	Phosphate	TSS	Micro-plastics
Batangas Bay and VIP (Hotspots)	5	13	3	7	1	1	7	0	8	2	9	0
Lingayen Gulf (Hotspot)	0	4	2	0	0	0	0	0	7	12	2	0
Manila Bay (Hotspot)	6	54	36	15	16	10	16	6	34	34	25	4
Other Sites	0	5	6	3	0	0	0	0	0	0	0	0
Palawan West Coast	0	44	81	4	0	0	0	0	0	20	20	0
Rivers (PW)	470	519	99	0	0	0	0	0	95	100	93	12

Table 3.A.3. Summary Table for Number of Available Data on Water Quality by Selected Rivers in the Philippines.

Rivers	BOD	DO	Fecal Coliform	Nitrate	Phosphate	TSS	Micro-plastics	Drains to Philippine Waters of SCS-LME?
Abra River	3	8	2	3	3	3	0	Yes
Agno River	13	19	3	2	3	3	0	Yes
Amburayan River	15	20	3	3	3	3	0	Yes
Angat River	11	14	3	3	3	3	0	Yes
Asin Gallano River	17	20	3	3	3	3	0	Yes
Atlag River	5	2	2	2	2	2	0	Yes
Balili River	15	20	3	2	3	3	0	No
Bocaue River	21	23	3	2	3	3	0	Yes
Bued River	18	23	2	1	2	3	0	Yes
Cagayan River	15	21	3	3	3	3	0	Yes
Calao-Delinquente River System	2	0	0	0	0	0	0	Yes
Calapan River	17	19	3	2	3	3	0	Yes
Calumpang River	6	3	3	3	3	3	0	Yes
Canas River	11	12	3	3	3	3	3	Yes
Dagupan River	7	10	0	0	0	0	0	Yes
Diadi River System	2	0	0	0	0	0	0	No
Guagua River	10	11	3	3	3	3	0	No
Hagonoy River	5	3	3	3	3	3	0	Yes
Imus River	17	17	3	3	3	3	0	Yes
Labangan River	6	3	3	3	3	3	0	Yes
Las Pinas-Paranaque River System	3	3	3	3	3	1	0	Yes
Madlum River	3	1	1	1	1	1	0	Yes
Marikina River	13	8	0	0	0	0	0	Yes
Marilao River	21	22	3	3	3	3	0	Yes
Meycauayan River	21	22	3	3	3	3	2	Yes
Meycauayan-Valenzuela River System	10	12	3	2	2	1	0	Yes
Naguilian River System	4	1	1	1	1	1	0	Yes
NMTT River System	6	20	3	3	3	1	0	Yes
Obando River	13	14	3	3	3	3	0	Yes
Pampanga River	17	21	3	3	3	3	0	Yes
Pansipit River	13	13	3	3	3	3	0	Yes
Paranaque River	20	23	2	2	2	1	2	Yes

Pasig River	11	14	0	0	0	0	3	Yes
Pinacanauan de Tuguigarao	5	8	1	1	1	1	0	Yes
Pinamalayan River	5	2	2	2	2	2	0	Yes
Pugo River	5	0	2	2	2	2	0	Yes
Rio Grande River	10	11	3	3	3	3	0	Yes
San Juan River System	13	18	3	3	3	1	0	No
San Miguel River	3	1	1	1	1	1	0	No
Sinocalan River	1	1	0	0	0	0	0	Yes
Sinuculan-Dagupan River	7	8	1	1	1	1	0	Yes
Sta Maria River	17	19	3	3	3	3	0	Yes
Talisay River	13	13	2	3	3	3	0	Yes
Tullahan River	0	0	0	0	0	0	2	No
Upper Chico River	3	0	2	2	2	2	0	No
Ylang-Ylang River	17	16	3	3	3	3	0	Yes
Rivers (ALL)	**470**	**519**	**99**	**95**	**100**	**93**	**12**	

Table 3.A.4. Descriptive Statistics for Water Quality on Pollution Hotspots.

Coastal Pollution Hotspots	Indicator	unit	count	mean	std	median	p25	p75	p5	p95	min	max
Batangas Bay and VIP (Hotspots)	BOD	mg/L	5	2.8	0.79	2.7	2.2	3.1	2.1	3.8	2.1	4
Batangas Bay and VIP (Hotspots)	DO	mg/L	13	7.2	1.2	6.7	6.5	7.7	6.1	9.4	6	9.7
Batangas Bay and VIP (Hotspots)	Fecal Coliform	MPN/100mL	3	1400	640	1500	1100	1800	830	2000	750	2000
Batangas Bay and VIP (Hotspots)	Total Coliform	MPN/100mL	7	2700	6400	110	36	780	8.3	12000	2	17000
Batangas Bay and VIP (Hotspots)	Cadmium	mg/L	1	0.12		0.12	0.12	0.12	0.12	0.12	0.12	0.12
Batangas Bay and VIP (Hotspots)	Chromium	mg/L	1	0.065		0.065	0.065	0.065	0.065	0.065	0.065	0.065
Batangas Bay and VIP (Hotspots)	Lead	mg/L	7	0.31	0.085	0.34	0.31	0.36	0.18	0.37	0.13	0.37
Batangas Bay and VIP (Hotspots)	Nitrate	mg/L	8	0.049	0.098	0.015	0	0.033	0	0.2	0	0.29
Batangas Bay and VIP (Hotspots)	Phosphate	mg/L	2	0.27	0.38	0.27	0.13	0.4	0.027	0.51	0	0.53
Batangas Bay and VIP (Hotspots)	TSS	mg/L	9	6.4	3.4	7	5	7.8	1.6	11	1	11
Lingayen Gulf (Hotspot)	DO	mg/L	4	4.1	3	2.9	2.2	4.8	2.1	7.8	2.1	8.5

Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100mL	2	8000	11000	8000	4000	12000	820	15000	20	16000
Lingayen Gulf (Hotspot)	Nitrate	mg/L	7	0.29	0.31	0.23	0.074	0.38	0.0041	0.77	0	0.91
Lingayen Gulf (Hotspot)	Phosphate	mg/L	12	0.1	0.097	0.051	0.042	0.18	0.0052	0.26	0	0.3
Lingayen Gulf (Hotspot)	TSS	mg/L	2	330	460	330	160	490	33	620	0.5	650
Manila Bay (Hotspot)	BOD	mg/L	6	4.2	1.5	3.6	3.2	5.3	2.9	6.1	2.8	6.2
Manila Bay (Hotspot)	DO	mg/L	54	5.1	1.5	5.2	4.1	6	2.7	7.5	2.4	7.9
Manila Bay (Hotspot)	Fecal Coliform	MPN/100mL	36	3400	10000	160	36	2800	3.8	11000	1	60000
Manila Bay (Hotspot)	Total Coliform	MPN/100mL	15	5400	6700	4000	800	5500	350	17000	220	26000
Manila Bay (Hotspot)	Cadmium	mg/L	16	15	21	2.1	0.00078	39	0.00028	50	0.0002	57
Manila Bay (Hotspot)	Chromium	mg/L	10	0.26	0.26	0.28	0.032	0.32	0.01	0.66	0.01	0.89
Manila Bay (Hotspot)	Lead	mg/L	16	0.3	0.27	0.3	0.014	0.54	0.0083	0.71	0.0078	0.74
Manila Bay (Hotspot)	Mercury	mg/L	6	0.00092	0.00066	0.0007	0.00053	0.00095	0.00043	0.0019	0.0004	0.0022
Manila Bay (Hotspot)	Nitrate	mg/L	34	0.48	0.74	0.17	0.11	0.27	0.061	2.2	0.016	2.5
Manila Bay (Hotspot)	Phosphate	mg/L	34	0.22	0.22	0.18	0.079	0.26	0.035	0.71	0.011	0.87
Manila Bay (Hotspot)	TSS	mg/L	25	62	55	37	15	110	6.9	150	6	180
Manila Bay (Hotspot)	microplastics	pc/m3	4	6300	12000	91	77	6300	75	21000	75	25000
Other Sites	DO	mg/L	5	4.4	1	4.2	3.6	5.1	3.4	5.7	3.3	5.8
Other Sites	Fecal Coliform	MPN/100mL	6	300	270	180	150	390	64	700	36	780
Other Sites	Total Coliform	MPN/100mL	3	66	43	77	48	89	24	99	18	100
Palawan West Coast	DO	mg/L	44	6.8	0.97	6.8	6.2	7.3	5.4	7.9	3.8	9.1
Palawan West Coast	Fecal Coliform	MPN/100mL	81	26000	120000	17	2.9	440	0.9	110000	0.9	920000
Palawan West Coast	Total Coliform	MPN/100mL	4	14000	26000	1100	750	15000	630	46000	590	54000
Palawan West Coast	Phosphate	mg/L	20	0.017	0.0059	0.019	0.01	0.02	0.01	0.026	0.01	0.03

Palawan West Coast	TSS	mg/L	20	34	26	21	16	52	13	84	13	89

Notes: std = Standard Deviation
p25 = 25th percentile of concentrations
p75 = 75th percentile of concentrations
p5 = 5th percentile of concentrations
p95 = 95th percentile of concentrations
MPN = Most Probable Number

Table 3.A.5. Descriptive Statistics for Water Quality on Selected Rivers in the Philippines.

Rivers	Indicator	unit	count	mean	std	median	p25	p75	p5	p95	min	max
Abra River	BOD	mg/L	3	1.2	0.19	1.2	1.1	1.3	1	1.3	0.98	1.4
Abra River	DO	mg/L	8	9	1.8	8.8	7.6	9.5	7.4	12	7.4	13
Abra River	Nitrate	mg/L	3	25	30	17	8.4	37	1.7	54	0.04	58
Abra River	Phosphate	mg/L	3	0.047	0.015	0.05	0.04	0.055	0.032	0.059	0.03	0.06
Abra River	TSS	mg/L	3	68	71	55	30	100	9.6	140	4.5	140
Abra River	Fecal Coliform	MPN/100mL	2	18000	19000	18000	11000	25000	5400	30000	4100	31000
Agno River	BOD	mg/L	13	2.6	2.1	1.3	1.2	2.3	1.1	6.7	1	6.9
Agno River	DO	mg/L	19	9.7	2.4	9.2	7.8	11	6.7	13	5.7	14
Agno River	Nitrate	mg/L	2	12	17	12	6.1	18	1.4	22	0.22	24
Agno River	Phosphate	mg/L	3	0.067	0.025	0.07	0.055	0.08	0.043	0.088	0.04	0.09
Agno River	TSS	mg/L	3	45	45	39	22	66	7.7	88	4.3	93
Agno River	Fecal Coliform	MPN/100mL	3	10000	9100	12000	6100	15000	1700	18000	540	18000
Amburayan River	BOD	mg/L	15	1.6	1.1	1.1	1	1.2	0.91	3.9	0.7	4.2
Amburayan River	DO	mg/L	20	9.4	1.7	9.2	8.3	10	7.4	12	7.1	14
Amburayan River	Nitrate	mg/L	3	6.5	7.2	4.1	2.5	9.3	1.1	14	0.8	15
Amburayan River	Phosphate	mg/L	3	0.04	0.01	0.04	0.035	0.045	0.031	0.049	0.03	0.05
Amburayan River	TSS	mg/L	3	14	4	13	12	16	11	18	11	19
Amburayan River	Fecal Coliform	MPN/100mL	3	77000	58000	99000	55000	110000	21000	120000	12000	120000
Angat River	BOD	mg/L	11	7.4	3.8	8.8	4.3	9.4	3.3	13	2.6	15
Angat River	DO	mg/L	14	4.9	0.98	4.8	4.1	5.6	3.8	6.3	3.6	7.1
Angat River	Nitrate	mg/L	3	0.66	0.39	0.69	0.48	0.87	0.3	1	0.26	1
Angat River	Phosphate	mg/L	3	0.17	0.046	0.16	0.15	0.19	0.13	0.21	0.13	0.22
Angat River	TSS	mg/L	3	23	12	16	16	26	15	35	15	37
Angat River	Fecal Coliform	MPN/100mL	3	22000	20000	29000	15000	34000	3100	37000	200	38000
Asin Gallano River	BOD	mg/L	17	1.4	0.69	1.1	1	1.1	0.98	2.5	0.9	3.4
Asin Gallano River	DO	mg/L	20	9.6	2.9	9.1	8.1	10	6.9	14	6.6	20
Asin Gallano River	Nitrate	mg/L	3	6.2	5.6	7.3	3.7	9.2	0.82	11	0.1	11
Asin Gallano River	Phosphate	mg/L	3	0.11	0.04	0.12	0.095	0.14	0.075	0.15	0.07	0.15
Asin Gallano River	TSS	mg/L	3	36	33	23	18	48	14	69	13	74
Asin Gallano River	Fecal Coliform	MPN/100mL	3	39000	26000	46000	28000	53000	14000	59000	9900	60000
Atlag River	BOD	mg/L	5	21	3.5	22	21	22	17	25	16	26
Atlag River	DO	mg/L	2	2.1	0.33	2.1	2	2.2	1.9	2.3	1.9	2.3
Atlag River	Nitrate	mg/L	2	0.24	0.028	0.24	0.23	0.25	0.22	0.26	0.22	0.26
Atlag River	Phosphate	mg/L	2	0.61	0.22	0.61	0.53	0.68	0.47	0.74	0.45	0.76
Atlag River	TSS	mg/L	2	32	14	32	27	37	23	41	22	42

Atlag River	Fecal Coliform	MPN/100mL	2	380000	110000	380000	340000	420000	310000	450000	300000	460000
Balili River	BOD	mg/L	15	39	18	37	29	47	12	66	7	72
Balili River	DO	mg/L	20	5.7	1.5	5.6	4.9	6.3	4.4	8.3	3.2	9.9
Balili River	Nitrate	mg/L	2	0.68	0	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Balili River	Phosphate	mg/L	3	1.2	0.52	1.2	0.95	1.5	0.73	1.7	0.68	1.7
Balili River	TSS	mg/L	3	38	34	19	19	48	18	71	18	77
Balili River	Fecal Coliform	MPN/100mL	3	1.5E+12	2E+12	4.2E+11	3.1E+11	2.1E+12	2.2E+11	3.5E+12	2E+11	3.8E+12
Bocaue River	BOD	mg/L	21	18	12	12	8.8	32	6.3	37	2.5	39
Bocaue River	DO	mg/L	23	3.5	2	2.6	2	5.4	1.5	6.7	1.1	7.9
Bocaue River	Nitrate	mg/L	2	0.82	0.15	0.82	0.76	0.87	0.72	0.91	0.71	0.92
Bocaue River	Phosphate	mg/L	3	2.4	0.99	2.8	2	2.9	1.4	3	1.2	3.1
Bocaue River	TSS	mg/L	3	34	8.5	38	31	39	25	39	24	40
Bocaue River	Fecal Coliform	MPN/100mL	3	520000	300000	650000	410000	690000	230000	730000	180000	740000
Bued River	BOD	mg/L	18	4.8	4.8	2.2	1.3	8.8	0.85	13	0	16
Bued River	DO	mg/L	23	8.1	2.1	8.5	7.7	9.3	6.4	10	0.05	11
Bued River	Nitrate	mg/L	1	7.9		7.9	7.9	7.9	7.9	7.9	7.9	7.9
Bued River	Phosphate	mg/L	2	0.53	0.15	0.53	0.47	0.58	0.43	0.62	0.42	0.63
Bued River	TSS	mg/L	3	130	10	130	120	130	120	140	120	140
Bued River	Fecal Coliform	MPN/100mL	2	1300000	17000	1300000	1300000	1300000	1300000	1300000	1300000	1300000
Cagayan River	BOD	mg/L	15	2.3	1.6	2	1.8	2.5	1	4.2	1	7.7
Cagayan River	DO	mg/L	21	7.4	0.78	7.2	6.9	7.9	6.4	8.2	6	9.4
Cagayan River	Nitrate	mg/L	3	0.18	0.081	0.23	0.16	0.23	0.1	0.23	0.09	0.23
Cagayan River	Phosphate	mg/L	3	0.083	0.0058	0.08	0.08	0.085	0.08	0.089	0.08	0.09
Cagayan River	TSS	mg/L	3	69	19	69	59	79	51	86	49	88
Cagayan River	Fecal Coliform	MPN/100mL	3	3700	1400	3700	3000	4400	2400	5000	2200	5100
Calao-Delinquente River System	BOD	mg/L	2	2.7	0.021	2.7	2.6	2.7	2.6	2.7	2.6	2.7
Calapan River	BOD	mg/L	17	9.1	4.1	9.3	5.6	11	4	16	3.8	17
Calapan River	DO	mg/L	19	2.4	0.89	2.6	1.8	3.1	1.2	3.4	0.9	4.3
Calapan River	Nitrate	mg/L	2	1.1	0.93	1.1	0.78	1.4	0.52	1.7	0.45	1.8
Calapan River	Phosphate	mg/L	3	0.4	0.13	0.45	0.35	0.47	0.27	0.49	0.25	0.49
Calapan River	TSS	mg/L	3	16	0.93	16	15	16	15	16	14	16
Calapan River	Fecal Coliform	MPN/100mL	3	78000	32000	89000	65000	96000	47000	100000	42000	100000
Calumpang River	BOD	mg/L	6	20	19	14	9.8	21	5.5	47	4.3	56
Calumpang River	DO	mg/L	3	4.2	1.7	5.1	3.6	5.2	2.5	5.2	2.2	5.2
Calumpang River	Nitrate	mg/L	3	1.2	0.67	0.98	0.86	1.5	0.76	1.9	0.73	2
Calumpang River	Phosphate	mg/L	3	1.6	0.77	1.5	1.2	2	1	2.4	0.95	2.5
Calumpang River	TSS	mg/L	3	30	6.7	34	28	34	24	34	22	34
Calumpang River	Fecal Coliform	MPN/100mL	3	20000	13000	15000	13000	25000	10000	33000	9900	35000
Canas River	BOD	mg/L	11	4.9	1.6	4.6	3.8	5.7	3	7.4	2.9	7.7
Canas River	DO	mg/L	12	6	0.53	6	5.5	6.4	5.4	6.8	5.3	7
Canas River	Nitrate	mg/L	3	1.5	0.51	1.2	1.2	1.6	1.1	2	1.1	2
Canas River	Phosphate	mg/L	3	1	0.28	1.1	0.9	1.2	0.75	1.2	0.71	1.3
Canas River	TSS	mg/L	3	66	14	65	59	73	54	79	53	81
Canas River	microplastics	pc/m3	3	99000	160000	7900	4700	150000	2200	260000	1600	290000

Canas River	Fecal Coliform	MPN/100mL	3	180000	33000	180000	160000	190000	140000	200000	140000	200000
Dagupan River	BOD	mg/L	7	6.1	1.9	6	5	7.7	3.8	8.2	3.3	8.4
Dagupan River	DO	mg/L	10	4.3	0.55	4.3	3.7	4.8	3.6	4.9	3.6	4.9
Diadi River System	BOD	mg/L	2	2.1	0.83	2.1	1.8	2.4	1.5	2.6	1.5	2.7
Guagua River	BOD	mg/L	10	24	14	24	16	30	5	43	1.6	51
Guagua River	DO	mg/L	11	3.1	1.3	3.1	2.4	3.7	1.4	5.2	1	5.7
Guagua River	Nitrate	mg/L	3	0.25	0.12	0.2	0.19	0.3	0.17	0.37	0.17	0.39
Guagua River	Phosphate	mg/L	3	1.3	0.23	1.2	1.2	1.4	1.2	1.6	1.2	1.6
Guagua River	TSS	mg/L	3	33	7.2	37	31	37	26	38	25	38
Guagua River	Fecal Coliform	MPN/100mL	3	750000	400000	950000	620000	980000	360000	1000000	290000	1000000
Hagonoy River	BOD	mg/L	5	15	8.1	13	9.6	19	8.3	26	8	28
Hagonoy River	DO	mg/L	3	3.2	0.89	3.4	2.8	3.7	2.3	3.9	2.2	3.9
Hagonoy River	Nitrate	mg/L	3	0.45	0.081	0.44	0.41	0.49	0.39	0.53	0.38	0.54
Hagonoy River	Phosphate	mg/L	3	0.28	0.044	0.3	0.27	0.31	0.24	0.31	0.23	0.31
Hagonoy River	TSS	mg/L	3	45	4.2	43	42	46	42	49	42	49
Hagonoy River	Fecal Coliform	MPN/100mL	3	120000	60000	110000	92000	150000	79000	180000	75000	190000
Imus River	BOD	mg/L	17	11	3.2	10	9.5	12	7.1	16	5.7	19
Imus River	DO	mg/L	17	5.5	2.2	5.2	4.7	5.7	3.9	7.5	3	14
Imus River	Nitrate	mg/L	3	1.4	0.34	1.2	1.2	1.5	1.2	1.7	1.2	1.8
Imus River	Phosphate	mg/L	3	1.5	0.065	1.5	1.5	1.6	1.5	1.6	1.5	1.6
Imus River	TSS	mg/L	3	76	47	54	49	92	45	120	44	130
Imus River	Fecal Coliform	MPN/100mL	3	480000	310000	470000	320000	630000	210000	760000	180000	800000
Labangan River	BOD	mg/L	6	12	4.1	12	8.8	14	7.5	17	7.3	18
Labangan River	DO	mg/L	3	3.4	0.81	3.3	3	3.8	2.7	4.2	2.7	4.3
Labangan River	Nitrate	mg/L	3	0.38	0.08	0.38	0.34	0.42	0.31	0.45	0.3	0.46
Labangan River	Phosphate	mg/L	3	0.28	0.11	0.22	0.22	0.31	0.21	0.38	0.21	0.4
Labangan River	TSS	mg/L	3	36	16	31	27	42	24	51	24	54
Labangan River	Fecal Coliform	MPN/100mL	3	56000	31000	66000	44000	74000	26000	80000	22000	82000
Las Pinas-Paranaque River System	BOD	mg/L	3	49	10	43	42	52	42	59	42	61
Las Pinas-Paranaque River System	DO	mg/L	3	0.29	0.33	0.13	0.11	0.4	0.085	0.62	0.08	0.67
Las Pinas-Paranaque River System	Nitrate	mg/L	3	0.3	0.12	0.29	0.24	0.36	0.2	0.41	0.19	0.42
Las Pinas-Paranaque River System	Phosphate	mg/L	3	2.1	0.28	2.3	2	2.3	1.8	2.3	1.8	2.3
Las Pinas-Paranaque River System	TSS	mg/L	1	55		55	55	55	55	55	55	55
Las Pinas-Paranaque River System	Fecal Coliform	MPN/100mL	3	39000000	15000000	43000000	32000000	47000000	24000000	50000000	21000000	51000000
Madlum River	BOD	mg/L	3	3.6	0.8	3.2	3.2	3.9	3.1	4.4	3.1	4.6
Madlum River	DO	mg/L	1	7.1		7.1	7.1	7.1	7.1	7.1	7.1	7.1
Madlum River	Nitrate	mg/L	1	0.24		0.24	0.24	0.24	0.24	0.24	0.24	0.24
Madlum River	Phosphate	mg/L	1	0.07		0.07	0.07	0.07	0.07	0.07	0.07	0.07
Madlum River	TSS	mg/L	1	18		18	18	18	18	18	18	18
Madlum River	Fecal Coliform	MPN/100mL	1	11000		11000	11000	11000	11000	11000	11000	11000
Marikina River	BOD	mg/L	13	25	8.1	25	18	29	14	36	12	42
Marikina River	DO	mg/L	8	3.4	0.96	3.5	2.9	3.8	2.2	4.7	2.2	5
Marilao River	BOD	mg/L	21	30	11	29	23	39	11	45	8.2	52
Marilao River	DO	mg/L	22	2.3	1.2	2.1	1.6	2.5	0.97	4.9	0.8	5.4

Marilao River	Nitrate	mg/L	3	0.44	0.11	0.47	0.39	0.5	0.33	0.52	0.31	0.53
Marilao River	Phosphate	mg/L	3	1.7	0.38	1.8	1.5	1.9	1.3	1.9	1.2	1.9
Marilao River	TSS	mg/L	3	32	8.7	33	28	37	24	40	23	41
Marilao River	Fecal Coliform	MPN/100mL	3	2000000	400000	1900000	1800000	2200000	1700000	2400000	1700000	2500000
Meycauayan River	BOD	mg/L	21	67	27	59	49	85	38	120	36	140
Meycauayan River	DO	mg/L	22	1.7	1.7	1.2	0.8	2.2	0.45	5	0.05	6.9
Meycauayan River	Nitrate	mg/L	3	0.27	0.13	0.23	0.2	0.33	0.18	0.4	0.17	0.42
Meycauayan River	Phosphate	mg/L	3	1.8	0.21	1.8	1.7	1.9	1.6	1.9	1.5	1.9
Meycauayan River	TSS	mg/L	3	30	2.1	31	30	32	28	32	28	32
Meycauayan River	microplastics	pc/m3	2	29000	41000	29000	15000	43000	3100	55000	190	58000
Meycauayan River	Fecal Coliform	MPN/100mL	3	29000000	40000000	5900000	5900000	40000000	5900000	68000000	5900000	74000000
Meycauayan-Valenzuela River System	BOD	mg/L	10	64	14	67	59	76	42	77	40	78
Meycauayan-Valenzuela River System	DO	mg/L	12	1.2	1.2	0.85	0.43	1.5	0.078	3.3	0.05	3.8
Meycauayan-Valenzuela River System	Nitrate	mg/L	2	0.23	0.22	0.23	0.15	0.3	0.086	0.36	0.07	0.38
Meycauayan-Valenzuela River System	Phosphate	mg/L	2	1.9	0.74	1.9	1.6	2.2	1.4	2.4	1.4	2.4
Meycauayan-Valenzuela River System	TSS	mg/L	1	47		47	47	47	47	47	47	47
Meycauayan-Valenzuela River System	Fecal Coliform	MPN/100mL	3	89000000	100000000	35000000	29000000	120000000	24000000	190000000	22000000	210000000
Naguilian River System	BOD	mg/L	4	2.6	0.92	2.2	2.1	2.7	2	3.7	2	4
Naguilian River System	DO	mg/L	1	9.3		9.3	9.3	9.3	9.3	9.3	9.3	9.3
Naguilian River System	Nitrate	mg/L	1	0.43		0.43	0.43	0.43	0.43	0.43	0.43	0.43
Naguilian River System	Phosphate	mg/L	1	0.09		0.09	0.09	0.09	0.09	0.09	0.09	0.09
Naguilian River System	TSS	mg/L	1	16		16	16	16	16	16	16	16
Naguilian River System	Fecal Coliform	MPN/100mL	1	3200		3200	3200	3200	3200	3200	3200	3200
NMTT River System	BOD	mg/L	6	42	5.9	42	38	46	35	49	34	49
NMTT River System	DO	mg/L	20	1.6	1.2	1.8	0.4	2.4	0.05	3.4	0.05	3.6
NMTT River System	Nitrate	mg/L	3	0.56	0.4	0.44	0.34	0.72	0.25	0.94	0.23	1
NMTT River System	Phosphate	mg/L	3	1.5	0.24	1.4	1.4	1.6	1.4	1.8	1.4	1.8
NMTT River System	TSS	mg/L	1	51		51	51	51	51	51	51	51
NMTT River System	Fecal Coliform	MPN/100mL	3	31000000	18000000	34000000	22000000	41000000	13000000	46000000	11000000	47000000
Obando River	BOD	mg/L	13	36	37	31	16	36	11	85	9.8	150
Obando River	DO	mg/L	14	3	1.1	2.9	2.5	3.7	1.4	4.7	1.3	5.2
Obando River	Nitrate	mg/L	3	0.28	0.13	0.29	0.22	0.35	0.16	0.39	0.15	0.4
Obando River	Phosphate	mg/L	3	2	2.1	0.73	0.73	2.6	0.73	4.1	0.73	4.5
Obando River	TSS	mg/L	3	27	2.8	28	26	29	25	30	24	30
Obando River	Fecal Coliform	MPN/100mL	3	220000	180000	140000	120000	290000	110000	400000	100000	430000
Pampanga River	BOD	mg/L	17	11	12	9.4	4	13	2	30	1.8	52
Pampanga River	DO	mg/L	21	5.1	1.2	5.4	4.3	5.9	3.4	7	3	7.2
Pampanga River	Nitrate	mg/L	3	0.72	0.37	0.66	0.53	0.89	0.42	1.1	0.39	1.1
Pampanga River	Phosphate	mg/L	3	0.23	0.04	0.25	0.22	0.25	0.19	0.25	0.18	0.25
Pampanga River	TSS	mg/L	3	53	14	53	46	60	40	65	39	67
Pampanga River	Fecal Coliform	MPN/100mL	3	24000	3800	22000	21000	25000	21000	27000	20000	28000
Pansipit River	BOD	mg/L	13	2.9	1.5	2.3	1.7	4	1.2	5.1	1.2	5.7
Pansipit River	DO	mg/L	13	6.5	1.3	6.7	6.2	7.4	4.5	7.9	4.1	8.5
Pansipit River	Nitrate	mg/L	3	0.43	0.075	0.43	0.39	0.47	0.36	0.49	0.35	0.5

Pansipit River	Phosphate	mg/L	3	0.72	0.075	0.72	0.69	0.76	0.66	0.79	0.65	0.8
Pansipit River	TSS	mg/L	3	21	6.8	22	18	24	14	26	13	27
Pansipit River	Fecal Coliform	MPN/100mL	3	2000	1900	1400	980	2800	640	3800	550	4100
Paranaque River	BOD	mg/L	20	46	9.5	43	39	55	29	59	29	61
Paranaque River	DO	mg/L	23	1.1	1	0.9	0.1	1.7	0.05	3	0.05	3.3
Paranaque River	Nitrate	mg/L	2	0.54	0.16	0.54	0.48	0.59	0.43	0.64	0.42	0.65
Paranaque River	Phosphate	mg/L	2	1.6	1.6	1.6	0.99	2.1	0.53	2.6	0.42	2.7
Paranaque River	TSS	mg/L	1	47		47	47	47	47	47	47	47
Paranaque River	microplastics	pc/m3	2	15000	14000	15000	10000	20000	6000	24000	5000	25000
Paranaque River	Fecal Coliform	MPN/100mL	2	61000000	16000000	61000000	55000000	66000000	51000000	71000000	49000000	72000000
Pasig River	BOD	mg/L	11	32	19	24	16	54	12	56	11	57
Pasig River	DO	mg/L	14	3.1	0.89	3	2.3	3.4	2.2	4.8	2.1	4.9
Pasig River	microplastics	pc/m3	3	6800	9000	3400	1700	10000	340	16000	1.3	17000
Pinacanauan de Tuguigarao	BOD	mg/L	5	1.2	0.18	1.1	1.1	1.2	1.1	1.4	1.1	1.5
Pinacanauan de Tuguigarao	DO	mg/L	8	8.9	2.8	8.1	7.5	9.7	6.1	13	5.6	15
Pinacanauan de Tuguigarao	Nitrate	mg/L	1	0.12		0.12	0.12	0.12	0.12	0.12	0.12	0.12
Pinacanauan de Tuguigarao	Phosphate	mg/L	1	0.04		0.04	0.04	0.04	0.04	0.04	0.04	0.04
Pinacanauan de Tuguigarao	TSS	mg/L	1	8.1		8.1	8.1	8.1	8.1	8.1	8.1	8.1
Pinacanauan de Tuguigarao	Fecal Coliform	MPN/100mL	1	200		200	200	200	200	200	200	200
Pinamalayan River	BOD	mg/L	5	7.1	3.9	4.9	4.4	9.5	3.9	12	3.8	13
Pinamalayan River	DO	mg/L	2	4.4	0.88	4.4	4.1	4.7	3.8	4.9	3.8	5
Pinamalayan River	Nitrate	mg/L	2	0.51	0.24	0.51	0.43	0.6	0.36	0.66	0.34	0.68
Pinamalayan River	Phosphate	mg/L	2	0.13	0.014	0.13	0.13	0.14	0.12	0.14	0.12	0.14
Pinamalayan River	TSS	mg/L	2	16	0.31	16	16	17	16	17	16	17
Pinamalayan River	Fecal Coliform	MPN/100mL	2	14000	16000	14000	8800	20000	4300	25000	3100	26000
Pugo River	BOD	mg/L	5	0.95	0.04	0.95	0.93	0.98	0.91	1	0.9	1
Pugo River	Nitrate	mg/L	2	4.8	4.7	4.8	3.1	6.4	1.8	7.8	1.5	8.1
Pugo River	Phosphate	mg/L	2	0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pugo River	TSS	mg/L	2	7	4.2	7	5.5	8.5	4.3	9.7	4	10
Pugo River	Fecal Coliform	MPN/100mL	2	13000	15000	13000	8000	19000	3600	23000	2500	24000
Rio Grande River	BOD	mg/L	10	6	1.8	5.9	4.8	7	3.7	8.7	3.7	9.6
Rio Grande River	DO	mg/L	11	5.9	0.66	6.1	5.6	6.5	4.9	6.6	4.5	6.6
Rio Grande River	Nitrate	mg/L	3	2.3	0.84	2.2	1.8	2.7	1.6	3.1	1.5	3.2
Rio Grande River	Phosphate	mg/L	3	0.99	0.16	1	0.93	1.1	0.84	1.1	0.82	1.1
Rio Grande River	TSS	mg/L	3	51	14	55	45	59	37	62	35	63
Rio Grande River	Fecal Coliform	MPN/100mL	3	150000	53000	130000	120000	170000	110000	200000	100000	210000
San Juan River System	BOD	mg/L	13	54	14	55	44	67	33	71	33	74
San Juan River System	DO	mg/L	18	1.4	1.1	1.4	0.2	2.4	0.05	3	0.05	3.1
San Juan River System	Nitrate	mg/L	3	0.2	0.11	0.18	0.15	0.25	0.12	0.31	0.11	0.32
San Juan River System	Phosphate	mg/L	3	2.3	0.11	2.3	2.3	2.4	2.2	2.4	2.2	2.4
San Juan River System	TSS	mg/L	1	45		45	45	45	45	45	45	45
San Juan River System	Fecal Coliform	MPN/100mL	3	76000000	50000000	71000000	50000000	100000000	33000000	120000000	29000000	130000000
San Miguel River	BOD	mg/L	3	6.7	3.2	6.4	5	8.2	3.9	9.6	3.7	10
San Miguel River	DO	mg/L	1	5.8		5.8	5.8	5.8	5.8	5.8	5.8	5.8

San Miguel River	Nitrate	mg/L	1	0.45		0.45	0.45	0.45	0.45	0.45	0.45	0.45
San Miguel River	Phosphate	mg/L	1	0.17		0.17	0.17	0.17	0.17	0.17	0.17	0.17
San Miguel River	TSS	mg/L	1	62		62	62	62	62	62	62	62
San Miguel River	Fecal Coliform	MPN/100mL	1	110000		110000	110000	110000	110000	110000	110000	110000
Sinocalan River	BOD	mg/L	1	2.2		2.2	2.2	2.2	2.2	2.2	2.2	2.2
Sinocalan River	DO	mg/L	1	5.8		5.8	5.8	5.8	5.8	5.8	5.8	5.8
Sinuculan-Dagupan River	BOD	mg/L	7	6.1	3.2	4.3	4.2	7	3.8	11	3.8	12
Sinuculan-Dagupan River	DO	mg/L	8	5.8	0.57	5.7	5.3	6.1	5.2	6.7	5.2	6.8
Sinuculan-Dagupan River	Nitrate	mg/L	1	0.46		0.46	0.46	0.46	0.46	0.46	0.46	0.46
Sinuculan-Dagupan River	Phosphate	mg/L	1	0.41		0.41	0.41	0.41	0.41	0.41	0.41	0.41
Sinuculan-Dagupan River	TSS	mg/L	1	18		18	18	18	18	18	18	18
Sinuculan-Dagupan River	Fecal Coliform	MPN/100mL	1	8700		8700	8700	8700	8700	8700	8700	8700
Sta Maria River	BOD	mg/L	17	20	11	15	12	26	7.7	37	7.4	47
Sta Maria River	DO	mg/L	19	3.3	1.4	2.9	2.5	4.1	1.8	5.2	1.3	6.7
Sta Maria River	Nitrate	mg/L	3	0.76	0.38	0.79	0.58	0.96	0.41	1.1	0.37	1.1
Sta Maria River	Phosphate	mg/L	3	2.5	1.6	2	1.6	3.2	1.3	4.1	1.2	4.4
Sta Maria River	TSS	mg/L	3	26	3.5	26	24	28	23	29	22	29
Sta Maria River	Fecal Coliform	MPN/100mL	3	440000	460000	240000	180000	600000	130000	890000	120000	960000
Talisay River	BOD	mg/L	13	5.9	3	5.7	4	6.6	2.1	11	2	12
Talisay River	DO	mg/L	13	5.2	1.2	5.3	4.2	6.3	3.6	6.7	3.4	6.7
Talisay River	Nitrate	mg/L	3	0.37	0.096	0.35	0.32	0.41	0.29	0.46	0.28	0.47
Talisay River	Phosphate	mg/L	3	0.12	0.0058	0.12	0.12	0.12	0.11	0.12	0.11	0.12
Talisay River	TSS	mg/L	3	25	6.4	22	22	27	21	32	21	33
Talisay River	Fecal Coliform	MPN/100mL	2	93000	18000	93000	86000	99000	81000	100000	80000	110000
Tullahan River	microplastics	pc/m3	2	34000	32000	34000	23000	46000	14000	55000	11000	57000
Upper Chico River	BOD	mg/L	3	1.2	0.25	1.1	1.1	1.3	1	1.5	1	1.5
Upper Chico River	Nitrate	mg/L	2	17	24	17	8.4	25	1.7	32	0.04	33
Upper Chico River	Phosphate	mg/L	2	0.05	0.014	0.05	0.045	0.055	0.041	0.059	0.04	0.06
Upper Chico River	TSS	mg/L	2	21	10	21	18	25	15	28	14	28
Upper Chico River	Fecal Coliform	MPN/100mL	2	15000	8100	15000	12000	18000	9600	20000	9000	20000
Ylang-Ylang River	BOD	mg/L	17	40	44	23	8.3	64	5.2	120	4.9	130
Ylang-Ylang River	DO	mg/L	16	5	0.66	4.9	4.6	5.4	4.1	6.1	4	6.2
Ylang-Ylang River	Nitrate	mg/L	3	1.8	0.43	1.6	1.5	1.9	1.5	2.2	1.5	2.3
Ylang-Ylang River	Phosphate	mg/L	3	1.3	0.44	1	1	1.4	0.99	1.7	0.98	1.8
Ylang-Ylang River	TSS	mg/L	3	99	85	50	50	120	50	180	50	200
Ylang-Ylang River	Fecal Coliform	MPN/100mL	3	210000	55000	180000	180000	230000	180000	270000	180000	280000

Notes: std = Standard Deviation
p25 = 25th percentile of concentrations
p75 = 75th percentile of concentrations
p5 = 5th percentile of concentrations
p95 = 95th percentile of concentrations
MPN = Most Probable Number

Organic Pollution

BOD and DO serve as key indicators of organic pollution. BOD levels above 5 mg/L indicate elevated organic matter loadings, often from sewage or agricultural runoff. Conversely, DO levels below 6 mg/L may reflect oxygen depletion and stress on aquatic life. In this dataset, Manila Bay and Lingayen Gulf exhibit signs of organic enrichment and occasional hypoxia. The variability underscores the influence of temporal factors such as seasonality and hydrodynamic mixing.

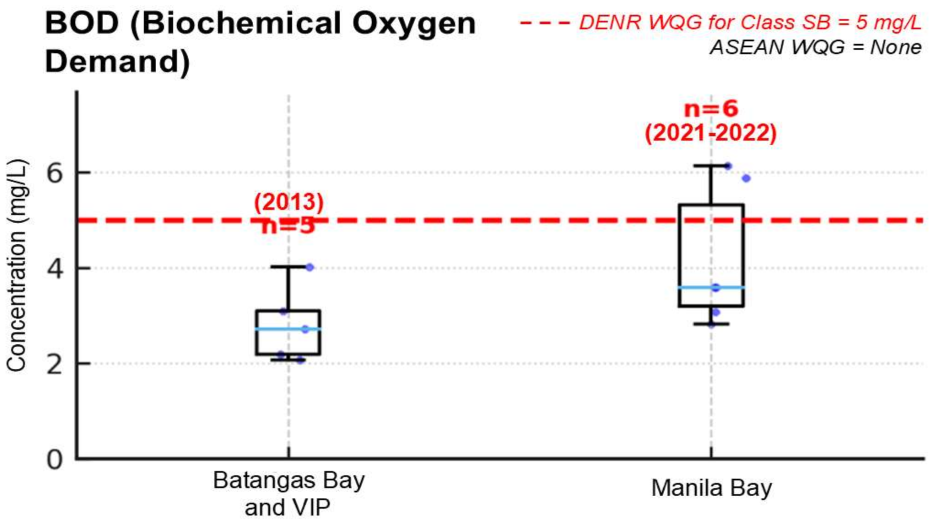

Figure 3.A.1. Box Plot for Biochemical Oxygen Demand in Coastal Pollution Hotspots

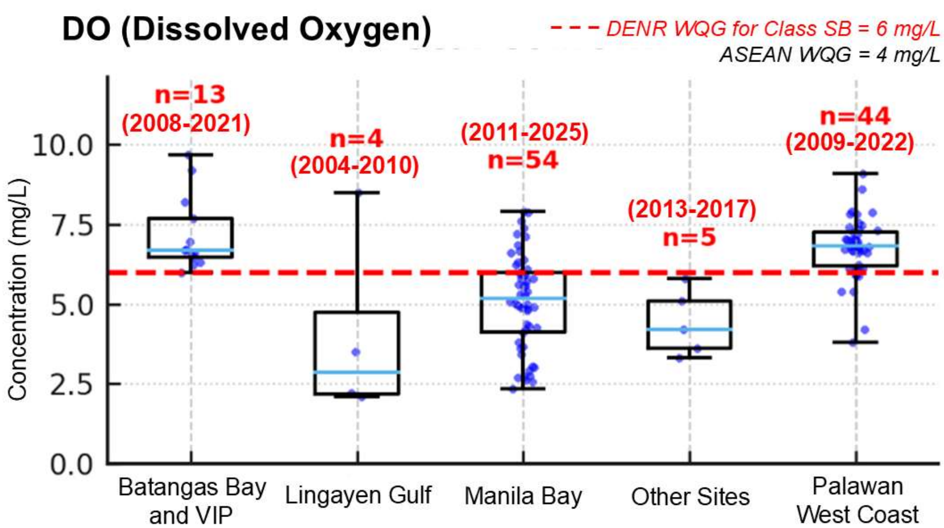

Figure 3.A.2. Box Plot for Dissolved Oxygen in Coastal Pollution Hotspots

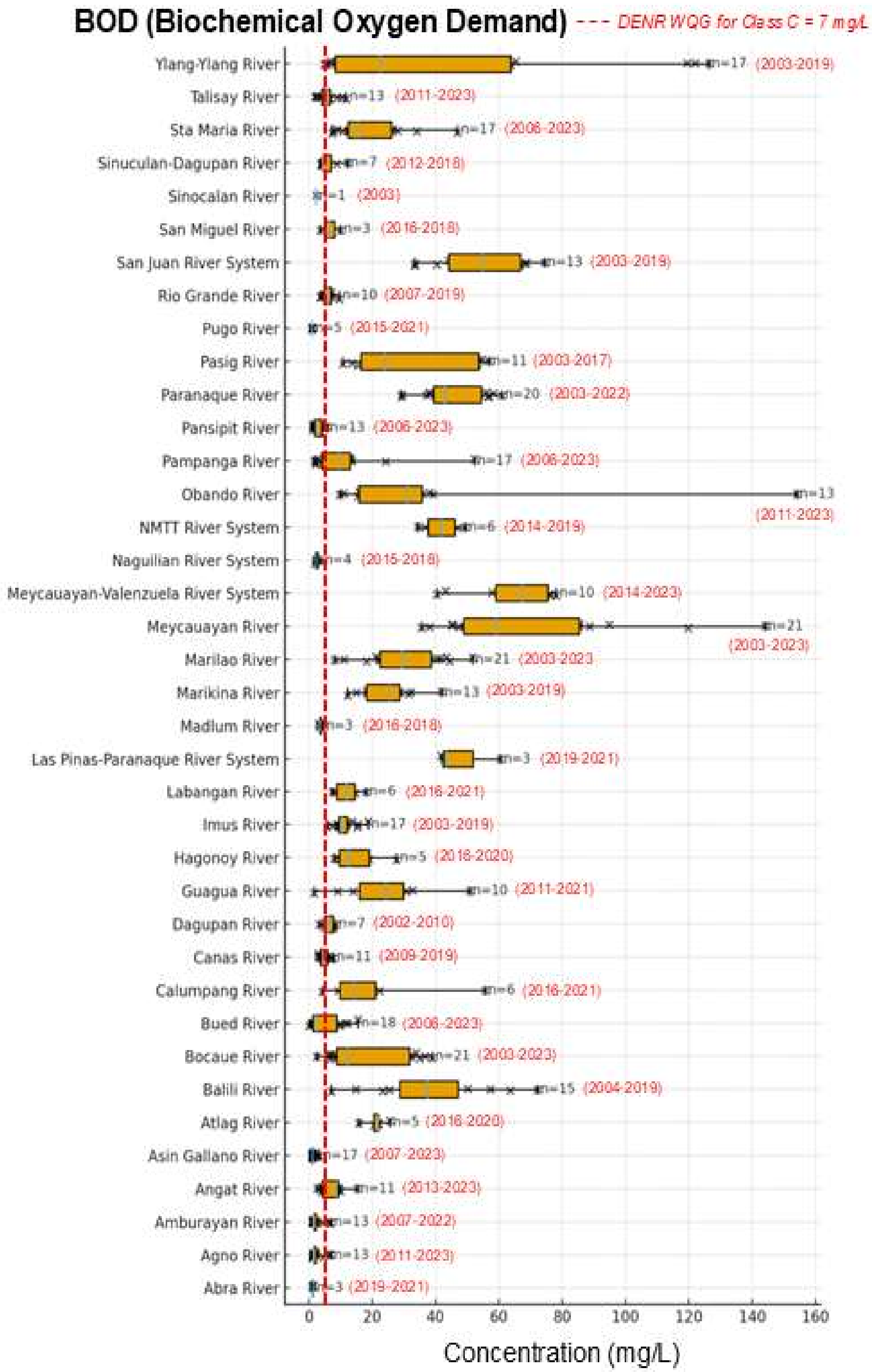

Figure 3.A.3. Box Plot for Biochemical Oxygen Demand in Rivers Draining to Philippine Waters of SCS-LME

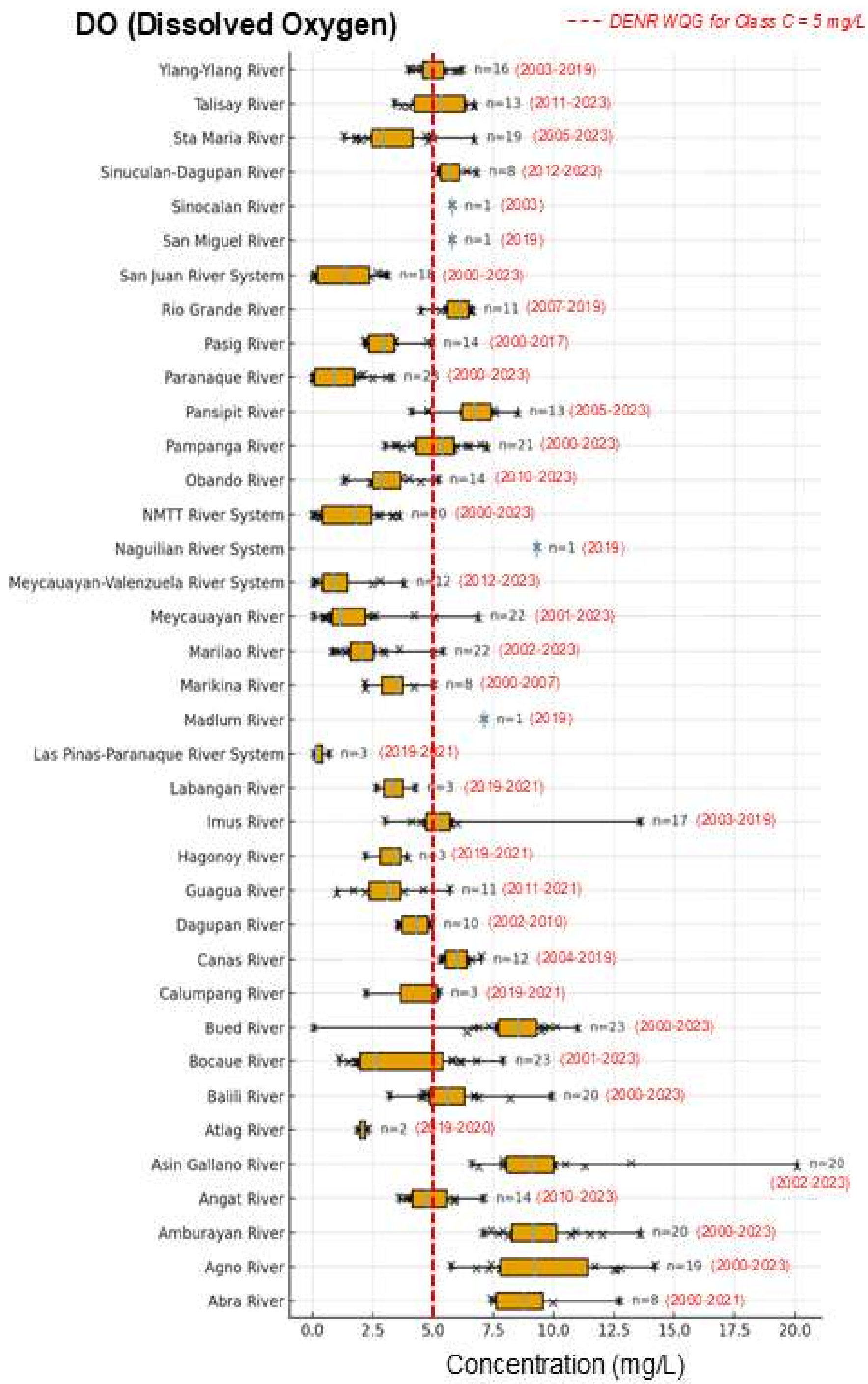

Figure 3.A.4. Box Plot for Dissolved Oxygen in Rivers Draining to Philippine Waters of SCS-LME

Microbial Contaminants

Total and fecal coliform levels provide important indications of microbial contamination linked to untreated domestic wastewater and poor sanitation infrastructure. Exceedances above the thresholds of 1,000 MPN/100 mL (Total Coliform) and 100 MPN/100 mL (Fecal Coliform) suggest elevated public health risks. Sites such as Manila

Bay consistently show high microbial counts. However, caution is advised when interpreting sites with limited samples (small n), as a few extreme values may disproportionately influence medians.

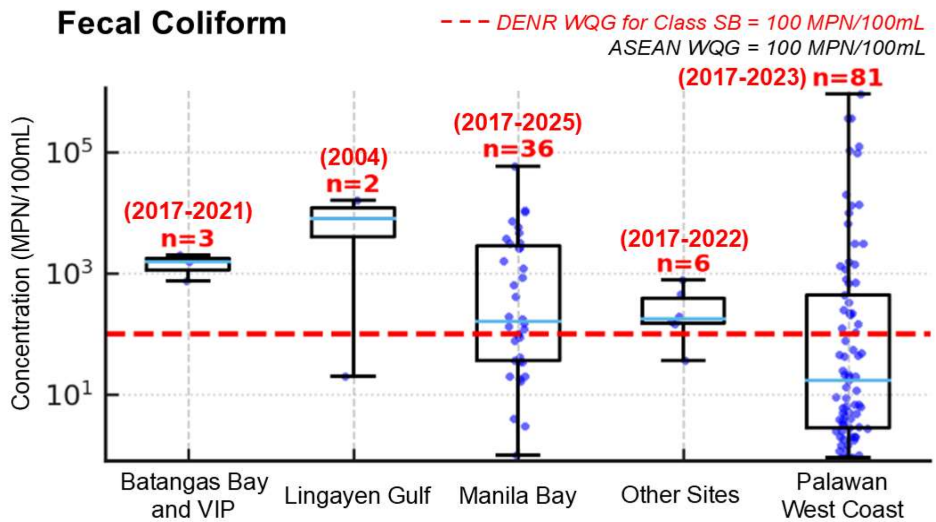

Figure 3.A.5. Box Plot for Fecal Coliform in Coastal Pollution Hotspots

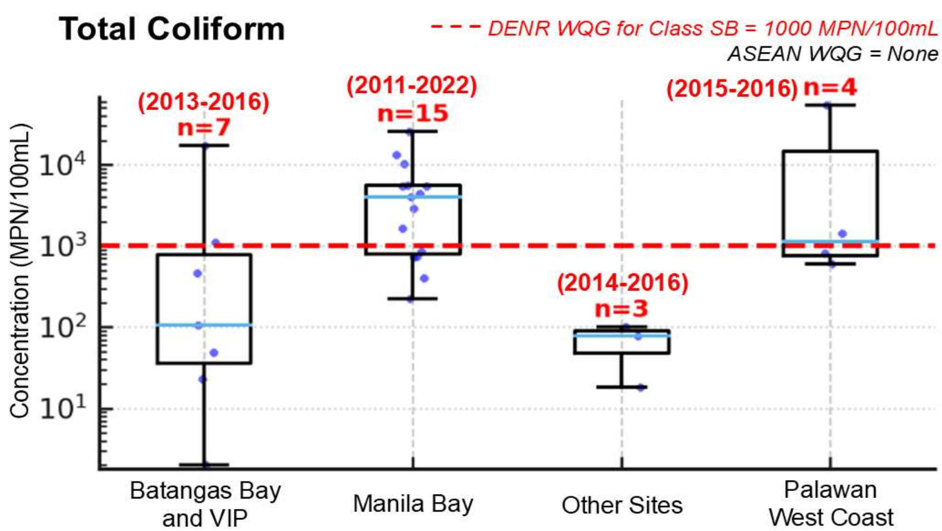

Figure 3.A.6. Box Plot for Total Coliform in Coastal Pollution Hotspots

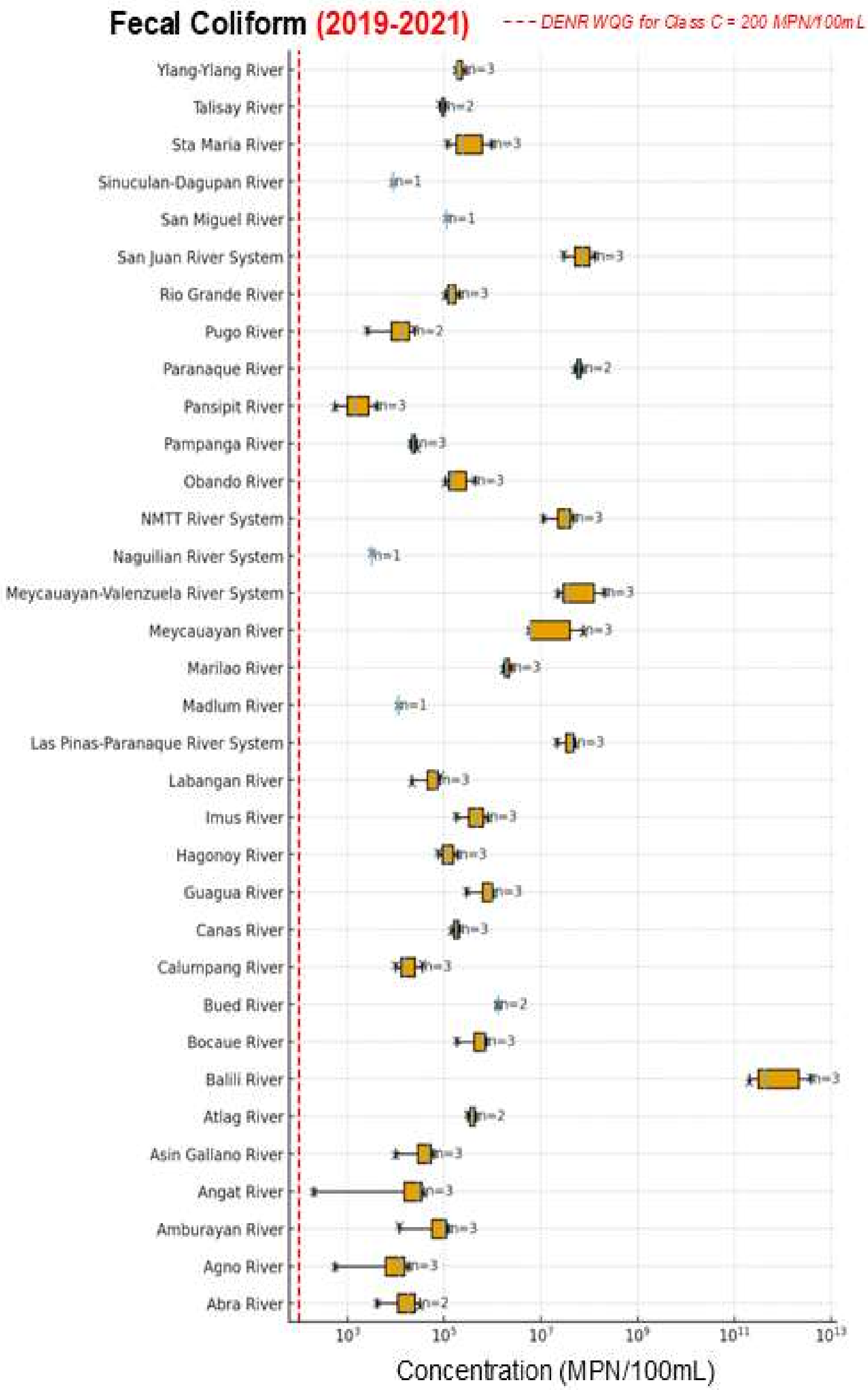

Figure 3.A.7. Box Plot for Fecal Coliform in Rivers Draining to Philippine Waters of SCS-LME

Heavy Metals

Lead and mercury represent toxic trace contaminants with serious ecological and human health implications. Lead values near or above the 0.01 mg/L threshold and mercury near or above 0.001 mg/L highlight risks of industrial and mining discharges, particularly in Manila Bay. While data for mercury are sparse, observed values warrant continued monitoring and stricter pollution control measures.

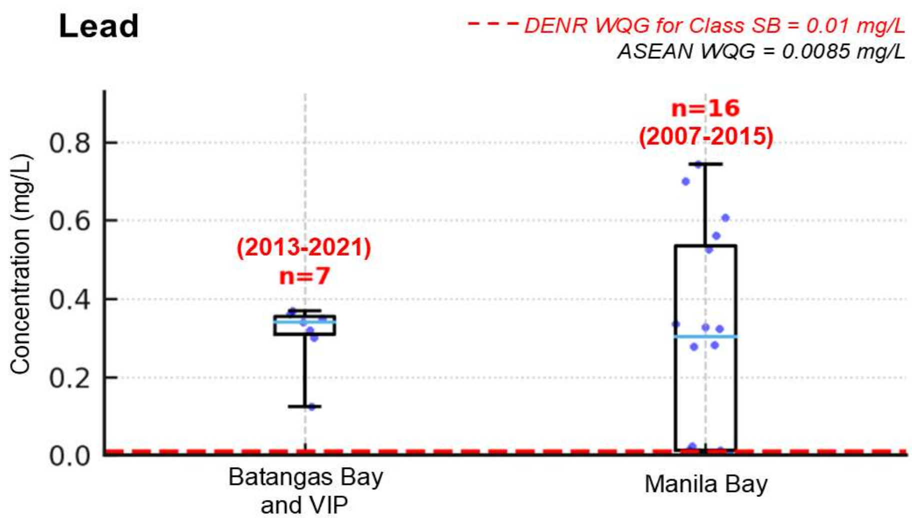

Figure 3.A.8. Box Plot for Lead in Coastal Pollution Hotspots

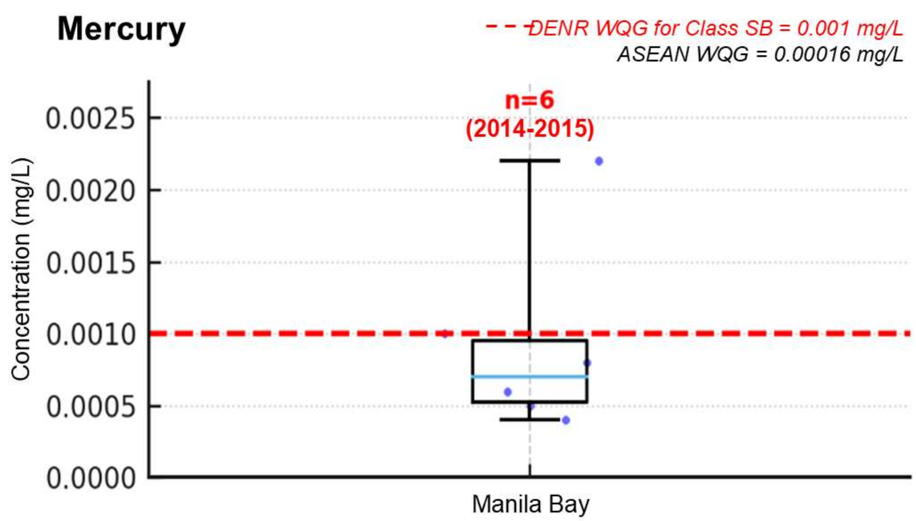

Figure 3.A.9. Box Plot for Mercury in Coastal Pollution Hotspots

<u>**Nutrients**</u>

Phosphates and nitrates are critical drivers of eutrophication. Concentrations above 0.2 mg/L (phosphates) and 0.06 mg/L (nitrates) suggest risks of algal blooms and water quality degradation. Elevated values are evident in Manila Bay and Palawan West Coast, consistent with inputs from domestic wastewater and agriculture. Care must be taken in interpreting sites with limited data, as nutrient fluxes are highly dynamic and sensitive to rainfall and seasonal agricultural cycles.

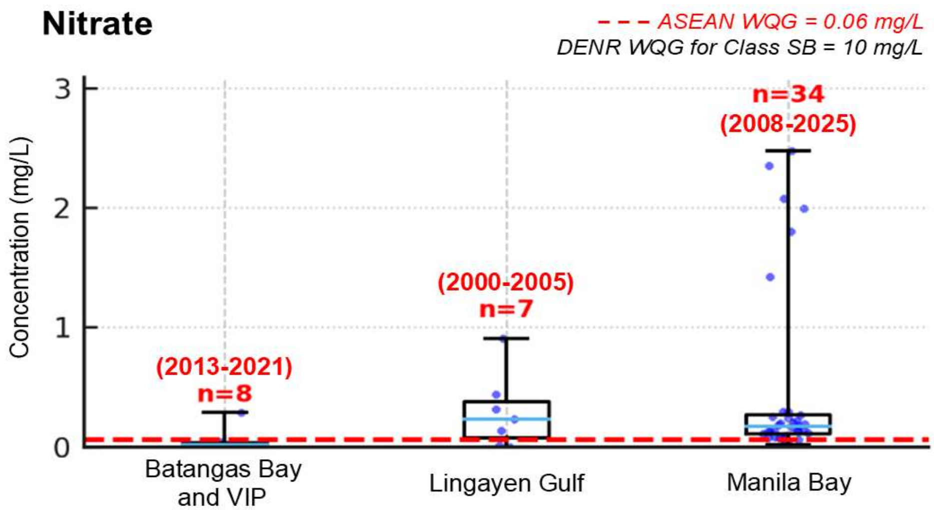

Figure 3.A.10. Box Plot for Nitrate in Coastal Pollution Hotspots

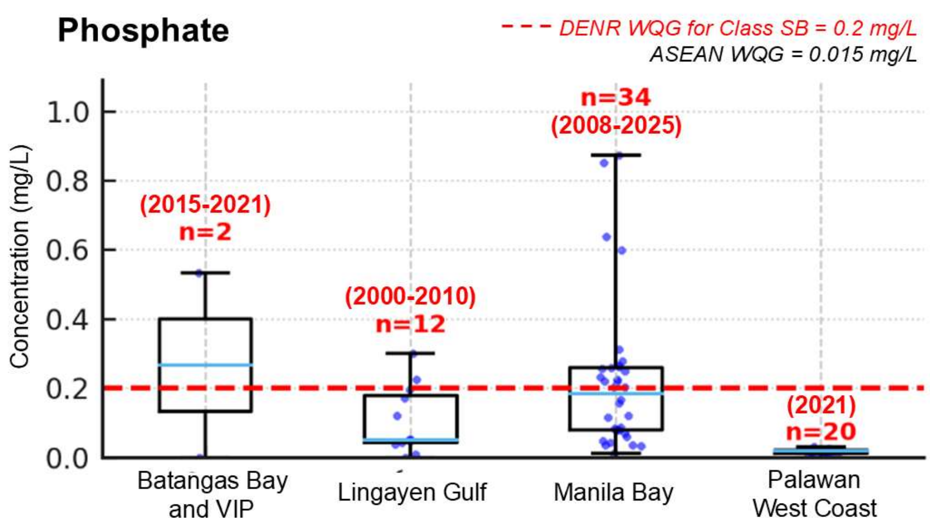

Figure 3.A.11. Box Plot for Phosphate in Coastal Pollution Hotspots

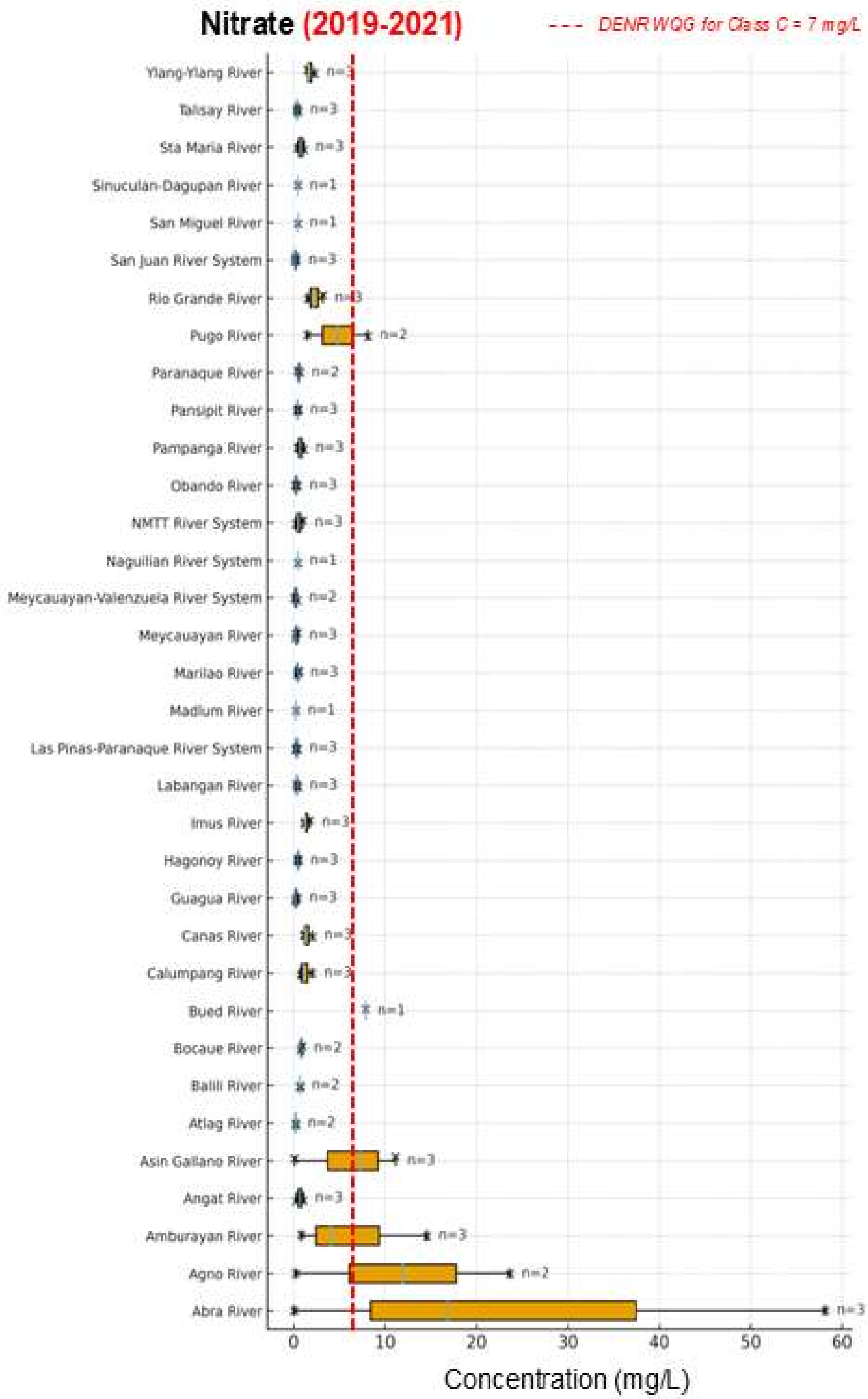

Figure 3.A.12. Box Plot for Nitrate in Rivers Draining to Philippine Waters of SCS-LME

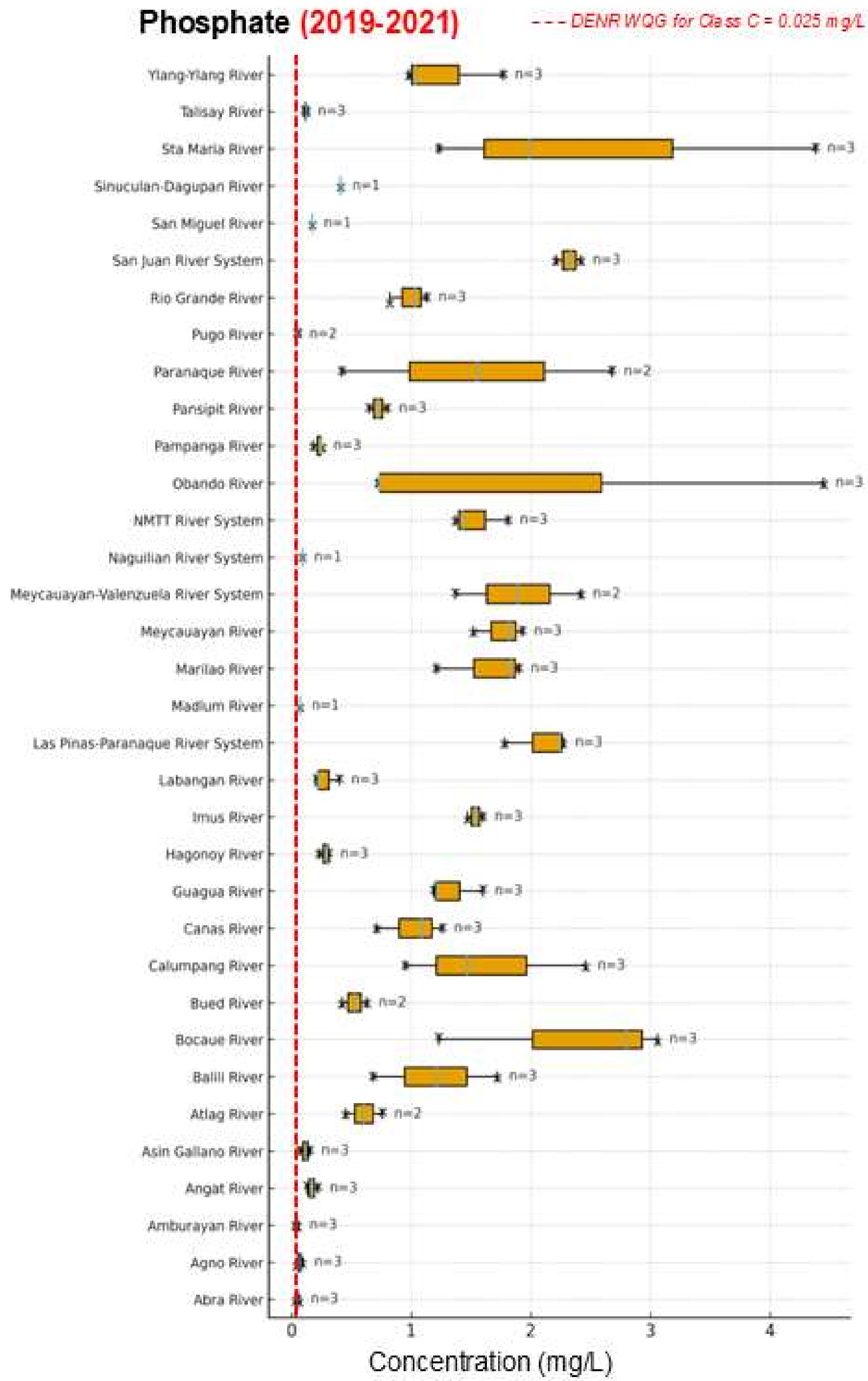

Figure 3.A.13. Box Plot for Phosphate in Rivers Draining to Philippine Waters of SCS-LME

Particles

TSS and microplastics capture different dimensions of particulate pollution. TSS above 80 mg/L indicates high sediment and particulate loads, often driven by erosion, runoff, or reclamation activities. Microplastics are an emerging contaminant of concern, with a provisional threshold of 300 particles/m³ applied here. Sites exceeding this level highlight risks to aquatic organisms via ingestion and bioaccumulation. The field remains data-limited, and more systematic monitoring is needed.

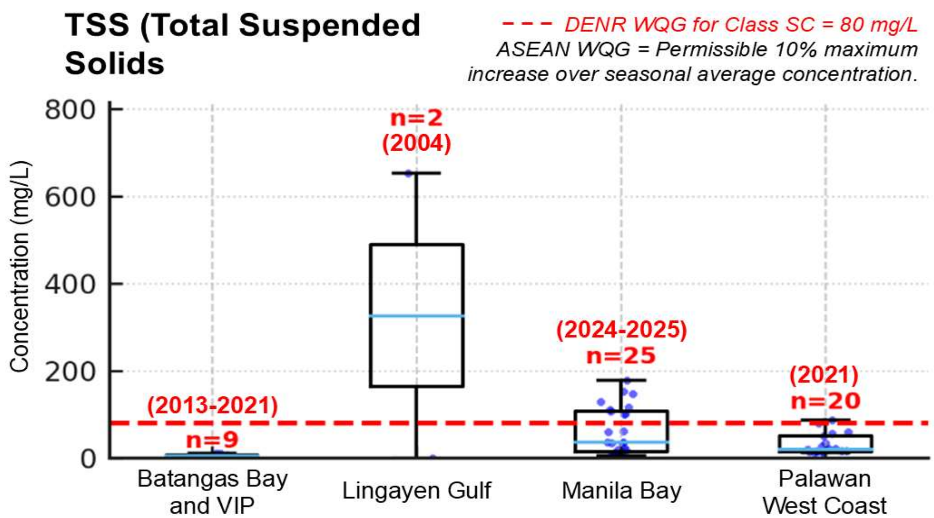

Figure 3.A.14. Box Plot for Total Suspended Solids in Coastal Pollution Hotspots

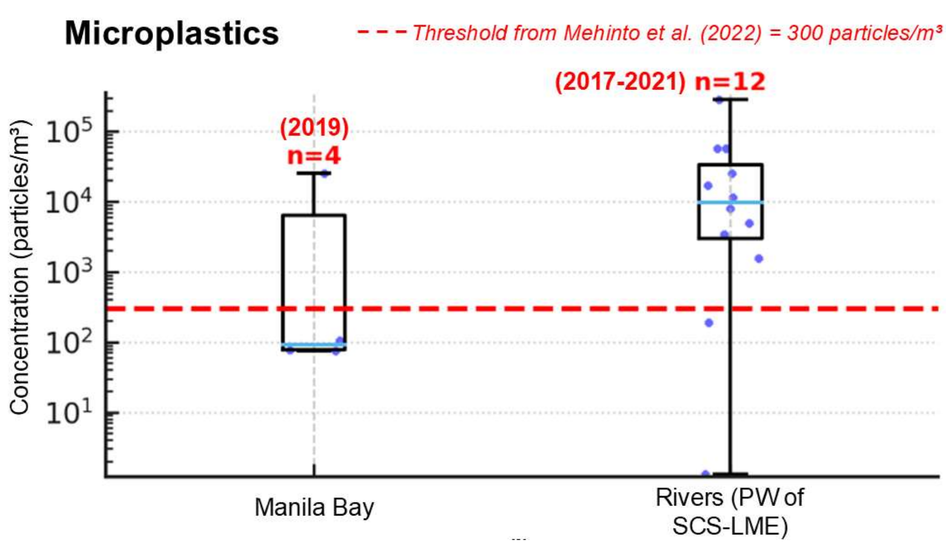

Figure 3.A.15. Box Plot for Microplastics in Coastal Pollution Hotspots

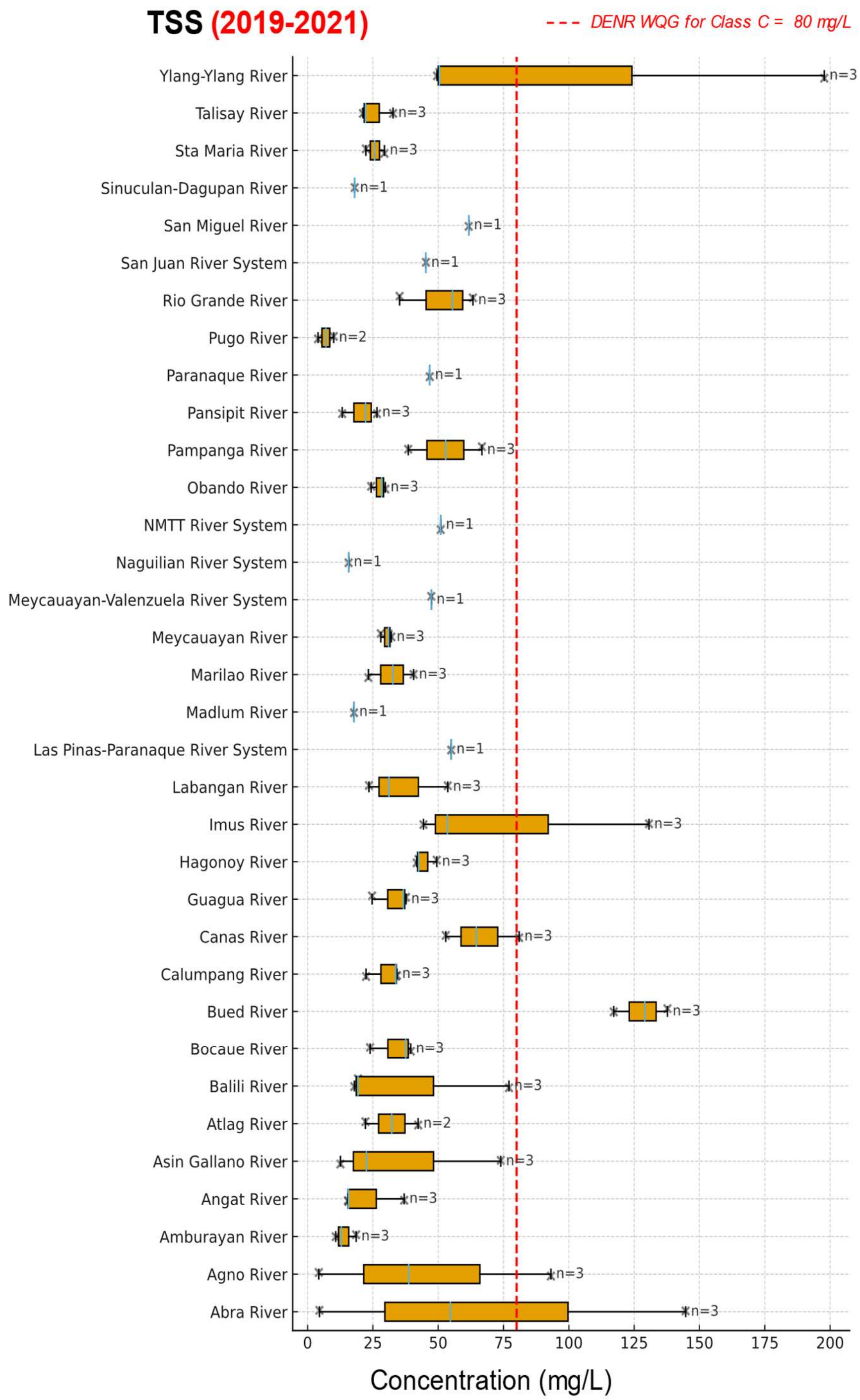

Figure 3.A.16. Box Plot for Total Suspended Solids in Rivers Draining to Philippine Waters of SCS-LME

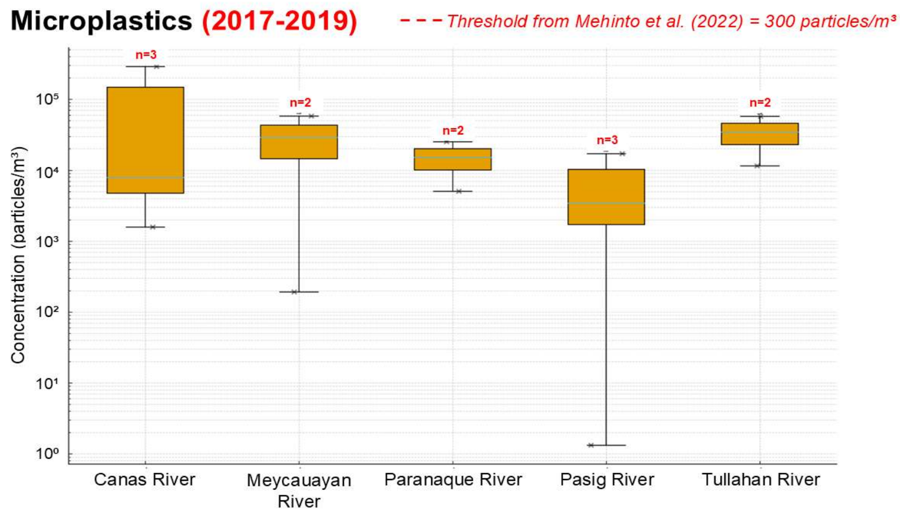

Figure 3.A.17. Box Plot for Microplastic Concentration in Rivers Draining to Philippine Waters of SCS-LME

TARGET SITES

The Philippines has designated the following target sites for implementation of the current Strategic Action Programme for the South China Sea and Gulf of Thailand (SCS SAP): Malampaya Sound Protected Landscape and Seascape (MSPLS) under the municipalities of Taytay and San Vicente in Palawan; Coron and Busuanga in Palawan; and Mabini and Tingloy in Batangas. This section examines the state of these sites in terms of the pollution indicators as well as current interventions done in the municipalities.

Wastewater

Taytay, Palawan (MSPLS)

According to the Palawan Council for Sustainable Development or PCSD (2020), there is no organized sewage disposal in the municipality. Domestic wastewater is discharged to septic tanks and open pits, with some discharged to earth canals that drain to creeks or rivers or simply allowed to seep naturally into the ground.

San Vicente, Palawan (MSPLS)

There is no centralized sewerage system established nor wastewater treatment plant installed in the municipality. However, under the Comprehensive Development Plan for San Vicente, the LGU aims to improve sewerage system in households and public market. Establishment of wastewater treatment facility in Poblacion Public Market and Barangay Port Barton were also included. The LGU also plan to have a strict implementation on discharge permit requirements and conduct information education campaign with the community on the importance oof wastewater management (Municipal Planning and Development Office, 2022).

Coron, Palawan

Similarly, there is no sewerage system in Coron (Abrenica et al., 2020). But plans on building a new septage treatment are in talks (Adonis, 2023) and a resolution was released to award the construction of a sewage treatment facility in Coron recently (TIEZA, 2025) all to manage the wastewater issues in the municipality.

Mabini and Tingloy, Batangas

The following issue to be discussed pertains to the entire province of Batangas. In terms of wastewater management, there is limited access to sewage and septage treatment. There is a lack of centralized wastewater connection system and inadequate sanitation and sewerage management. Point sources of untreated wastewater entering the waterways are largely from agricultural (45%) followed by domestic (31%) and industrial (24%). In 2016, around 12.68% of households have no sanitary toilet and resort to open defacation. The province of Batangas, as part of their action program, aims to establish an individual and centralized wastewater treatment facility/sewage treatment plant as per their Strategic Environmental Management Plan (Awitan, 2023).

Solid Waste

Taytay, Palawan (MSPLS)

Overall, poor solid waste management is an issue in the municipality of Taytay. Disposing of garbage through burning were done by 39% of the households in Taytay, 29% through dumping in open pits, 25% by burying, while only 8% are collected by garbage truck and 7% are disposed through garbage pit or composting. Only one garbage truck is in operation which collects waste daily and disposed in an open pit dumpsite in Barangay Poblacion. There is no Material Recovery Facility (MRF) or Sanitary Landfill in the municipality. The increasing solid and liquid waste together with poor waste management leads to environmental and marine pollution in the MSLPS.

Local initiatives include identifying suitable landfill sites and conducting information, education, and communication (IEC) campaigns in schools on proper waste disposal practices. A resolution prohibiting plastic and styrofoam use is currently under consideration, and regular coastal cleanup activities are being implemented. In 2018, the Palawan Council for Sustainable Development (PCSD) approved Taytay's Ten-Year Solid Waste Management Plan (2017-2027) (PCSD, 2020; *MSPLS Protected Area Management Plan 2025-2035*, 2024).

San Vicente, Palawan (MSPLS)

Majority of the waste generated comes from the residential sector at 90.35% based on the Waste Analysis and Characterization Study (WACS) done in 2018 (Table 3.E.4). In terms of waste composition (Table 3.E.5), biodegradable materials constitute the largest proportion at 43.31%, followed by recyclables at 23.86%. The high biodegradable percentage most likely indicates organic waste from food and vegetation. From the conducted WACS, a daily per capita rate of 0.448 kg was computed.

Table 3.A.6. Waste Disposed by Sector in San Vicente, Palawan (2018) (Municipal Planning and Development Office, 2025)

Sector	Kg/day	Kg/yr	Tons/yr	Percentage (%)
Residential	12,715.39	4,641,117.75	4,641.12	90.35
Commercial	1,036.76	378,418.10	378.42	7.37
Institution	296.38	108,177.20	108.18	2.11
Industry	25.57	9,334.27	9.33	0.18
Total	**14,074.10**	**5,127,713.06**	**5,127.71**	**100**

Table 3.A.7. Waste Disposed by Composition in San Vicente, Palawan (2018) (MPDO, 2025)

Sector	Kg/day	Kg/yr	Tons/yr	Percentage (%)
Biodegradables	6,095.72	2,224,938.37	2,224.94	43.31
Recyclables	3,357.57	1,225,511.66	1,225.51	23.86
Residuals (with potential for diversion)	1,886.47	688,559.83	688.56	13.40
Residuals	2,219.94	810,277.08	810.28	15.77
Special Wastes	514.41	187,760.38	187.76	3.66
Total	**14,074.10**	**5,137,047.32**	**5,137.05**	**100**

In 2022, waste management practices varied considerably: 62.66% of households segregated waste, 31.55% utilized garbage truck collection services, and 23.97% engaged in composting. However, a large number of households (56.46%) still burned their waste. By 2024, waste infrastructure had improved, with 8 out of 10 barangays having an established MRFs and the LGU is actively pursuing the development of a sanitary landfill. The Solid Waste Management Code of the Municipality of San Vicente, Palawan (Ordinance No. 2006-04-108) is also in place (Municipal Planning and Development Office, 2022; 2025).

Busuanga, Palawan

As of 2020, there is no Sanitary Landfill in the municipality. Most of the garbage waste are disposed by burning or dumping in open pits (Bautista et al. 2020).

Coron, Palawan

In terms of solid waste management in Coron, most of the domestic waste are disposed through open pit in their backyards to naturally decompose, while others throw their wastes unattended in public spaces and coastal area. Only selected barangays are served by dump trucks where a municipal open dump site becomes the final disposal site. There is no established MRF in the municipality.

To mitigate the issue on solid waste, the LGU performs IEC programs on waste management, coastal cleanup activities, and regular garbage collection. A proposal on the establishment of Sanitary Landfill is also underway (Abrenica et al., 2020).

Mabini and Tingloy, Batangas

Waste generation is among the pressing issues in Batangas wherein 874,810 kg/day was generated for 2014-2015. The computed per capita generation is 0.33 kg/day. Biodegradable waste has the highest composition at 47.62%, followed by recyclables (27.37%), residuals (12.15%) while 11.09% of generated waste has potential for diversion. In 2015, the computed per capita generation for Mabini is 0.1149 kg/day while 0.1422 kg/day for the municipality of Tingloy.

The Provincial Government Environment and Natural Resources Office (PGENRO) of Batangas aims for a more effective implementation of RA 9003 (Ecological Solid Waste Management Act) by approved Solid Waste Management Plan (SWMP) for all LGUs with annual reports on the status and implementation. As of 2023, The Ten-Year SWMP of Mabini was approved in 2018 while the Ten-Year SWMP of Tingloy is subject for evaluation. Mabini also has a designated MRF and Sanitary Landfill for waste disposal. The (PGENRO action program also prioritizes eliminating uncontrolled dumping and open burning while expanding sanitary landfill capacity. The program also encourages community participation through public awareness campaigns on waste management, capacity-building seminars, and training initiatives to enhance knowledge and practices for sustainable agricultural waste management. Small and medium enterprises (SME) are also encouraged to establish recycling facilities and organic farming.

Hazardous Waste

San Vicente, Palawan (MSPLS)

In handling hazardous waste management, the LGU of San Vicente plans to construct a concrete vault as a storage for hazardous waste, provide plastic drums to store collected used oil, and establish storage area for batteries and electronic devices. Operational improvements involve coordinating with Treatment, Storage, and Disposal (TSD) companies and incorporating hazardous waste management provisions into business permit application requirements (Municipal Planning and Development Office, 2022).

Oil Pollution

Malampaya Sound

Given that MSPLS habitat consists primarily of shallow reef flats and steep drop-offs, oil spill incidents could result in severe ecological damage. Oil spills in the area may result from vessel groundings, leakages, collisions, and allisions. Response strategies should prioritize environmentally safe dispersants, solidifiers, and treatment agents while considering potential secondary impacts.

To mitigate the possible threat caused by oil spill, strict compliance to maritime regulations and continuous updated training for personnel are being implemented. Regular monitoring of weather conditions are also done to prevent maritime accidents (Response Plan of MSPLS, Taytay, Palawan 2023-2028, 2025).

Atmospheric Deposition

San Vicente, Palawan (MSPLS)

Air quality management initiatives encompass both monitoring and mitigation strategies. These include the installation of monitoring stations and establishment of airsheds to assess atmospheric conditions, alongside greenhouse gas (GHG) reduction programs such as the Zero Carbon Resort Initiative. Policy frameworks incorporate the Climate Change Program, Clean Development Mechanism, and other carbon crediting initiatives, complemented by enforcement measures such as anti-smoke belching campaigns to reduce vehicular emissions (Municipal Planning and Development Office, 2022).

Annex 3.B. Wastewater Pollution Indicators and Modeled Pollution Load

The dataset was extracted from various government reports by the PSA, NEDA, EMB, and EMB-MBO. This Annex provides the data used for the analysis and visualization, and the formulas to compute the pollution load estimates and removal in wastewater prior to discharge.

Table 3.B.1. Data on wastewater generation and treatment in Metro Manila (2014-2023) (PSA, 2024)

Year	Total wastewater generated (Mm^3/yr)	Total wastewater treated (Mm^3/yr)	Total number of facilities	Percentage treated	Average treatment capacity (Mm^3/facility)
2014	729.69	73.42	56	10%	1.3
2015	754.3	83.67	59	11%	1.4
2016	781.97	95.2	60	12%	1.6
2017	800.04	100.22	60	13%	1.7
2018	824.35	108.72	62	13%	1.8
2019	823.42	119.41	63	15%	1.9
2020	834.21	128.3	63	15%	2.0
2021	806.52	121.76	49	15%	2.5
2022	822.21	120.32	49	15%	2.5
2023	843.75	121.66	49	14%	2.5

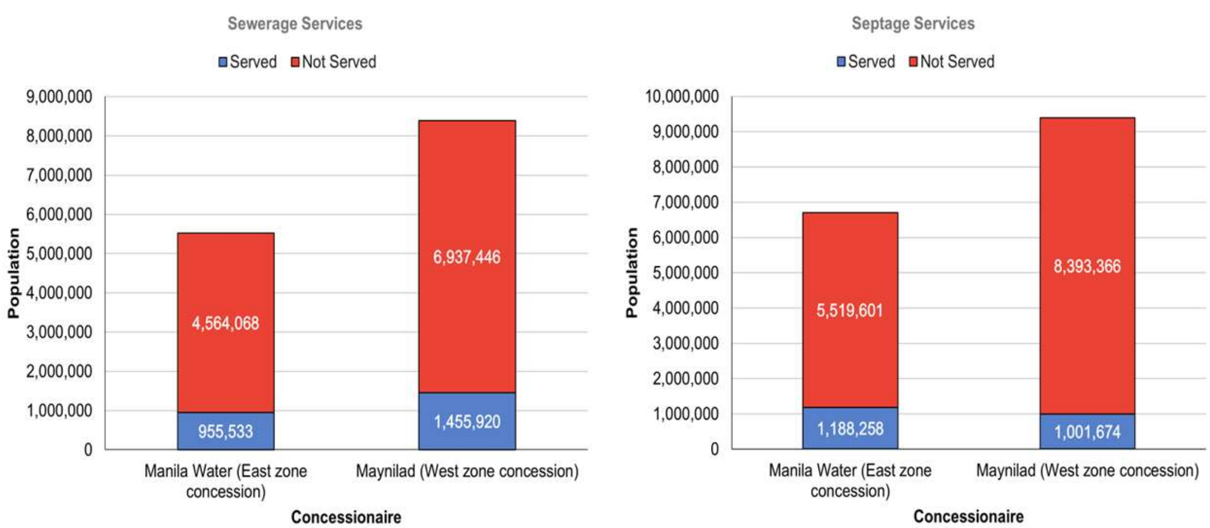

Figure 3.B.1 Sewerage and Septage Services in Metro Manila as of 2017. Stacked-bar chart showing the population in the East and West Zone of Metro Manila with and without sewerage services (left panel) and septage services (right panel) (NEDA, 2021).

Table 3.B.2. Septage and Sewerage Coverage of MWSS Concessionaires in Metro Manila, 2017, Data source: NEDA, 2021

Concessionaire	Total Population	Septage Population Served	Population Not Served with Septage	Septage Coverage (%)	Not Served (%)	Sewerage Population Served	Population Not Served with Sewerage	Sewerage Coverage (%)	Not Served (%)

Manila Water (East zone concession)	6,707,859	1,188,258	5,519,601	17.7	82.29	955,533	4,564,068	14.2	68.04
Maynilad (West zone concession)	9,395,040	1,001,674	8,393,366	10.7	89.34	1,455,920	6,937,446	15.5	73.84
Total	16,102,899	2,189,932	13,912,967	13.6	86.40	2,411,453	11,501,514	15	71.43

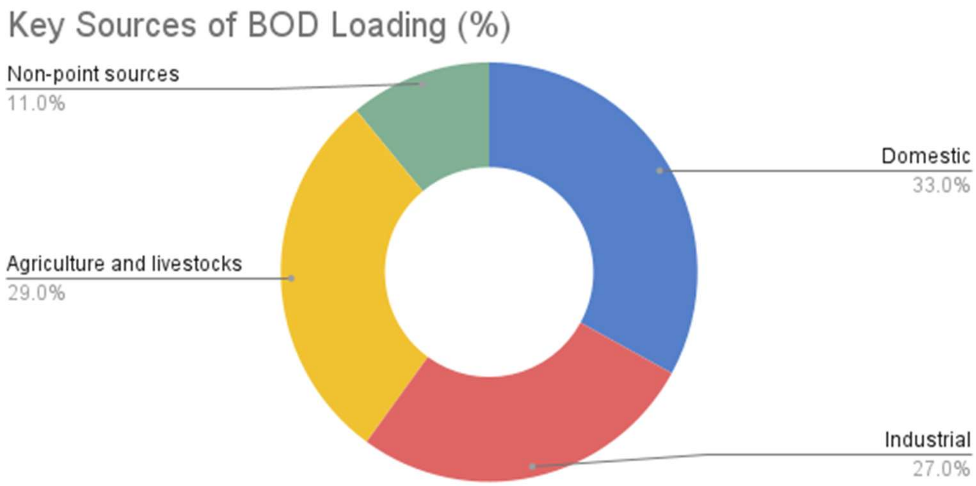

Figure 3.B.2. Four Key Sources of BOD Loading for Water Pollution. Data source: EMB DENR (2020b).

Pollution Load Estimates from Domestic Wastewater

Nomenclature

HDWL – Household Waste Load, (kg/day, for Fecal Coliform – MPN/day)
SF – Sewage Flow (use 50 gal/cap/day based in PD 856)
PUL – Pollution Unit Load assumption
HDPL – Household Pollution Load (kg/day, for Fecal Coliform – MPN/day)
TE – Treatment Efficiency
PLR – Pollution Load Removed

To estimate the domestic pollution load, the EMB Memorandum Circular 2020-25 (EMB, 2020a) was used as a reference. The calculation applied the Philippine Statistics Authority's 2025 projected mid-year population, aggregating the populations of provinces expected to contribute wastewater from the watershed or river basins into the Philippine waters of the SCS-LME. Provinces included specifically are NCR, Benguet, Abra, Ilocos Norte, Ilocos Sur, La Union, Pangasinan, Batanes, Zambales, Nueva Ecija, Tarlac, Bataan, Pampanga, Bulacan, Cavite, Batangas, Laguna, Rizal, Occidental Mindoro, Palawan, and some municipalities/cities in Mountain Province, Nueva Vizcaya, Aurora, Quezon, and Oriental Mindoro. The following formula was used to calculate the domestic waste generated:

HDWL = Population x SF x PUL

Table 3.B.3. Household Domestic Pollution Unit Load (PUL) Assumption (Tchobanoglus et al., 2003)

Parameter/Pollutant	Pollution Unit Load or Concentration	Unit
Biochemical Oxygen Demand (BOD5)	200	mg/L
Chemical Oxygen Demand (COD)	508	mg/L
Nitrate as NO3-N	35	mg/L
Phosphate as Phosphorus	5.6	mg/L
Total Suspended Solids	195	mg/L
Fecal Coliform	10,000 – 1,000,000	MPN/100mL

Table 3.B.4. Projected 2025 Mid-Year Population in Selected Provinces (PSA, 2025)

Region	Province	Population	Year
NCR	NCR	14,521,657	2025
CAR	Mountain Province (2 municipalities)	25,306	2025
CAR	Benguet	892,600	2025
CAR	Abra	252,070	2025
Region 1	Ilocos Norte	628,200	2025
Region 1	Ilocos Sur	735,053	2025
Region 1	La Union	859,561	2025
Region 1	Pangasinan	3,235,249	2025
Region 2	Batanes	18,571	2025
Region 2	Nueva Vizcaya (5 municipalities)	115,108	2025
Region 3	Aurora (3 municipalities)	105,318	2025
Region 3	Zambales	949,718	2025
Region 3	Nueva Ecija	2,582,695	2025
Region 3	Tarlac	1,533,124	2025
Region 3	Bataan	896,684	2025
Region 3	Pampanga	3,115,786	2025
Region 3	Bulacan	3,923,826	2025
Region 4A	Cavite	4,639,491	2025
Region 4A	Batangas	3,423,043	2025
Region 4A	Laguna	3,583,594	2025
Region 4A	Quezon (2 municipalities)	75,777	2025
Region 4A	Rizal	3,464,226	2025
Region 4B	Occidental Mindoro	536,768	2025
Region 4B	Oriental Mindoro (4 municipalities/cities)	257,737	2025
Region 4B	Palawan	1,303,583	2025
TOTAL		51,674,745	

To estimate the pollution load removed through onsite sanitation systems, it was assumed that approximately 90% of households have access to sanitation facilities, based on the 2024 CPES report from the PSA. In 2021, the proportion of households with improved sanitation facilities in regions bordering the SCS-LME ranged from 91.9% to 99.3%; thus, a conservative estimate of 90% was applied. In this scenario, this 90% is assumed to be connected to septic tanks; thus, a 25% treatment efficiency was applied. Additionally, it was assumed that 5% of the population is connected to Wastewater Treatment Facilities (WWTFs) (Tuddao, 2019), while the remaining 5% discharge directly into waterways. All computations are subject to a 5% margin of error. The pollution load removed was then computed using the following formula:

$$\mathbf{HDPL = [HDWL \times 90\% \times (1\text{-}TE\_septic)] \times [HDWL \times 5\% (1\text{-}TE\_WWTF)] + [HDWL \times 5\% \times (1\text{-}TE\_direct)]}$$

$$\mathbf{PLR = HDWL - HDPL}$$

Table 3.B.5. Treatment Efficiency (TE) Assumption (EMB, 2020a)

Treatment	Efficiency
WWTF	60% or (1-0.60)
Septic Tank	25% or (1-0.25)
Direct Discharge or raw/untreated	0%

Table 3.B.6. Estimated Pollution Load on Selected Provinces based on PSA's Projected Population for 2025

Indicator	HDWL	HDPL	PLR
BOD	710,000±36,000	530,000±27,000	180,000±9,100
COD	1,800,000±91,000	1,400,000±68,000	460,000±23,000
Nitrate as NO3-N	120,000±6,200	93,000±4,700	32,000±1,600
Phosphate as Phosphorus	20,000±1,000	15,000±740	5,100±250
TSS	700,000±35,000	520,000±26,000	180,000±8,900

Table 3.B.7. Fecal Coliform statistics in Manila Bay (19 Monitoring Stations**)** (EMB-MBO, 2016)

Year	Geometric Mean (MPN/100mL)	Min Count (MPN/100mL)	Max Count (MPN/100mL)	% Exceed 200 MPN
2011	5,429	1,150.00	33,000.00	100.0%
2012	10,149	85.08	160,000.00	85.7%
2013	13,389	393.28	540,000.00	100.0%
2014	5,396	266.00	200,000.00	100.0%
2015	25,517	183.33	5,580,000.00	94.1%

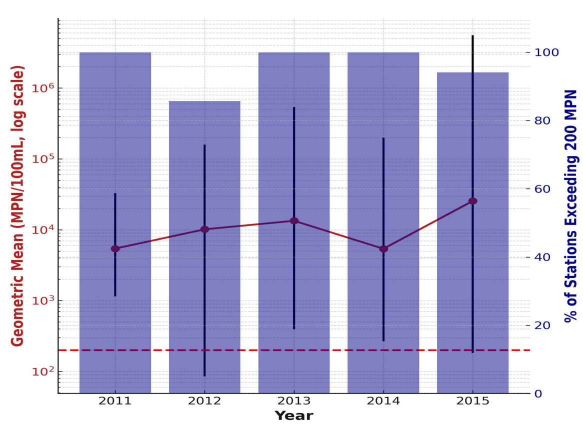

Figure 3.B.3. Fecal Coliform Levels in Manila Bay in 19 Monitoring Stations (2011-2015) (EMB-MBO, 2016).

Table 3.B.8. Pollution Load Data on Wastewater from Selected Regions in the Philippines (2019) (EMB, 2020b).

Region	BOD (tons)	COD (tons)	Nitrate (tons)	Phosphate (tons)	TSS (tons)	Fecal Coliform (MPN/100mL)
NCR	143,231.88	363,808.98	25,065.58	4,010.49	139,651.09	1.99E+14
CAR	20,954.34	53,224.02	3,667.01	586.72	20,430.48	2.91E+13
Region I	57,842.79	146,920.68	10,122.49	1 ,619.60	56,396.72	8.03E+13
Region II	41,040.63	104,243.19	7,182.11	1,149.14	40,014.61	5.70E+13
Region III	132,959.72	337,717.70	23,267.95	3,722.87	129,635.73	1.85E+14
Region IV-A	171,082.65	434,549.93	29,939.46	4,790.31	166,805.58	2.38E+14
MIMAROPA	36,192.56	91,929.10	6,333.70	1,013.39	35,287.75	5.03E+13

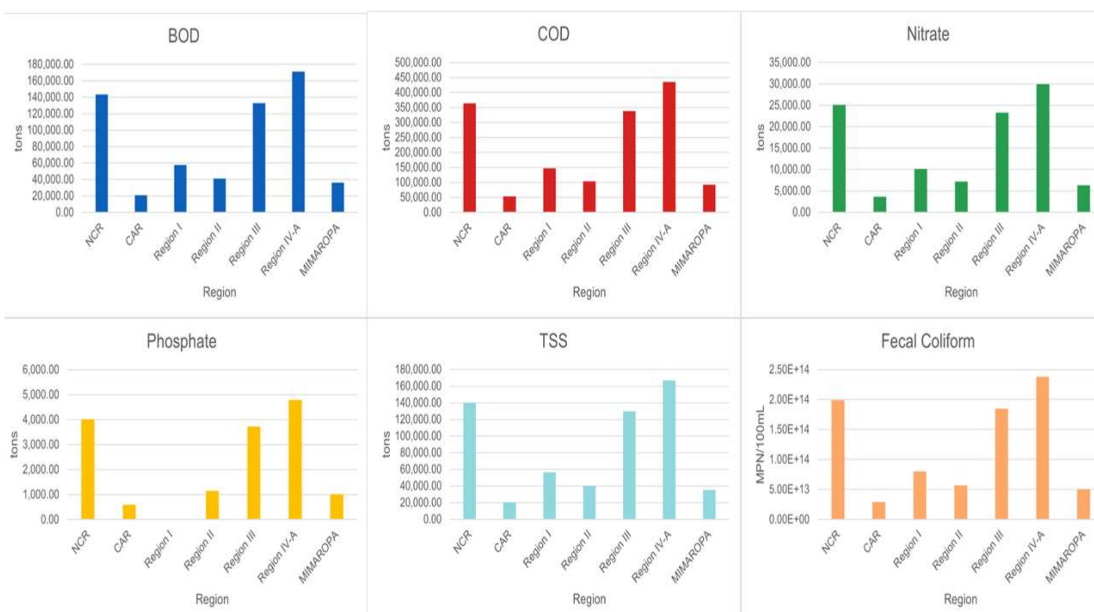

Figure 3.B.4. Projected Pollution Load on Wastewater from Selected Regions in Philippines for 2019 (EMB, 2020b).

Table 3.B.9. Sectoral profile of manufacturing plants

Sector	Typical product streams	Environmental signature/key pollutant
Pulp & paper	Kraft paper, newsprint, packaging board	High-BOD & color in wastewater; fibre sludge
Sugar mills & alcohol distilleries	Raw & refined sugar, bioethanol, rum	Molasses-rich, high-BOD effluent; bagasse waste
Food processing	Canned fruit, meat, beverages	Organic-rich effluent; oil & grease

Plastic & consumer goods	Flexible packaging, toys, housewares	Solvent VOCs; pellet micro-plastics
Base-material plants	Copper smelter, glass and steel works, cement kilns	Metal particulates; SO_2/NO_x; slag
Electronics assembly & aerospace	Semiconductors, PCB, aircraft parts	Acid/alkali rinse water; PFAS; heavy metals
Textiles	Garments, yarn, and fabric dyeing	Dyestuff-laden wastewater; high TDS
Petroleum refining & shipbuilding	Fuels, lubricants, and ocean-going vessels	Hydrocarbon effluent, bilge & sludge oils

Table 3.B.10. Wastewater qualities of selected industry types in the Philippines (WEPA, 2024)

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
Manufacture of ethanol	60,000	110,000	6,000	48–50	4–4.5
Canning of fish products	30,000	45,000	10,700	25	6.5–7.5
Manufacture of beverages	900	1,500	250	25	11–12
Meat processing	1,000–1,500	2,000	250	–	7
Copper cathode	–	–	43	30.4	8.15
Swine farm	2,000–4,200	4,000–5,429	1,600–5,380	–	–
Bottling services	400	1,647.05	90	32.2	8.35
Manufacturing of desiccated coconut	6,000–10,000	17,000–20,000	2,000–4,000	–	5.0–6.3
Pineapple processing plant	10,200	20,000	585	40–50	4.5–6.5

Annex 3.C. Agricultural Runoff and Diffuse Pollution Indicators

The dataset on pesticide and fertilizer use in the Philippines was extracted from the Food and Agriculture Organization's (2025) database to create time-series graphs illustrating trends in agricultural inputs over time. Data on nutrient loads in selected watersheds and river basins were sourced from Magcale-Macandog et al. (2016). A summary table of all data and figures is provided in the annex.

Table 3.C.1. Fertilizer Use per Area from 2000-2022 (FAO, 2025a; FAO, 2025b)

Spatial Coverage	Year	Unit	N Fertilizer	P Fertilizer	K Fertilizer	Pesticide
Philippines	2000	kg/ha	50.2	12.8	12.6	1.8
Philippines	2001	kg/ha	52.4	15.4	13	1.8
Philippines	2002	kg/ha	46.2	13.4	11.7	1.9
Philippines	2003	kg/ha	58.8	13.3	13.1	1.9
Philippines	2004	kg/ha	63.2	13	12.1	1.8
Philippines	2005	kg/ha	55.2	13.9	10.4	1.9
Philippines	2006	kg/ha	47.1	14.8	11.6	1.9
Philippines	2007	kg/ha	50.5	19.9	11.4	1.9
Philippines	2008	kg/ha	38.2	7.5	8.7	1.9
Philippines	2009	kg/ha	40.4	6.2	16.5	1.9
Philippines	2010	kg/ha	56	8.7	11	2
Philippines	2011	kg/ha	48.2	14	11.2	2
Philippines	2012	kg/ha	43	7.4	10.1	2
Philippines	2013	kg/ha	48.1	18.4	13	2
Philippines	2014	kg/ha	54.2	12.4	13.5	2
Philippines	2015	kg/ha	47.8	11.9	11	2.1
Philippines	2016	kg/ha	56.8	14.3	14.7	2
Philippines	2017	kg/ha	68.7	18.8	19.7	1.9
Philippines	2018	kg/ha	58.5	12	14.6	1.9
Philippines	2019	kg/ha	63.7	15.9	18.6	2.2
Philippines	2020	kg/ha	67.3	18.5	19.1	3.1
Philippines	2021	kg/ha	64	23.1	28.9	3.4
Philippines	2022	kg/ha	71.5	35.9	35.3	3.4

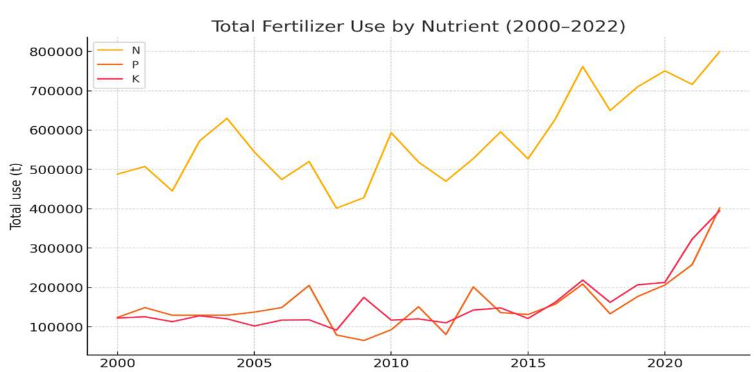

Figure 3.C.1. Trend of Annual Total Fertilizer Use (2000-2022)

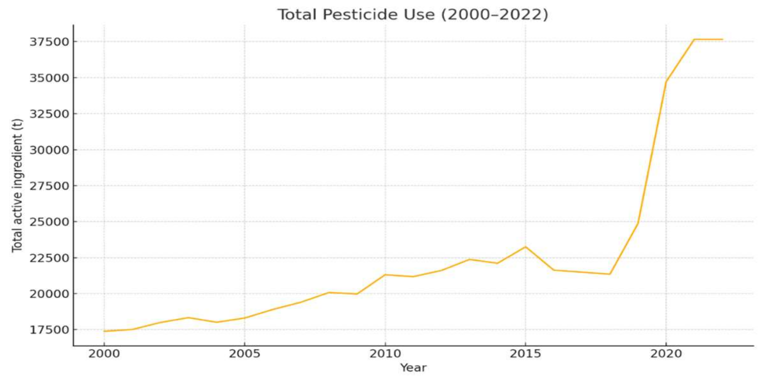

Figure 3.C.2. Trend of Annual Total Pesticide Use (2000-2022)

Table 3.C.2. Fertilizer Use by Mass Input per Year from 2000-2022 (FAO, 2025a; FAO, 2025b)

Spatial Coverage	Year	Unit	N Fertilizer	P Fertilizer	K Fertlizer	Pesticide
Philippines	2000	tons/yr	488,177	124,113	122,260	17382.7
Philippines	2001	tons/yr	507,348	148,655	125,412	17509.8
Philippines	2002	tons/yr	445,244	129,401	113,000	17995.3
Philippines	2003	tons/yr	572,571	129,401	128,000	18330.6
Philippines	2004	tons/yr	629,808	129,401	120,200	18010.9
Philippines	2005	tons/yr	544,134	137,311	102,000	18304
Philippines	2006	tons/yr	474,332	148,819	117,000	18899
Philippines	2007	tons/yr	519,960	205,168	117,612	19403.5
Philippines	2008	tons/yr	401,297	79,239	91,567	20075.7
Philippines	2009	tons/yr	428,140	65,149	174,660	19975.8
Philippines	2010	tons/yr	593,226	92,446	116,936	21311.1
Philippines	2011	tons/yr	518,448	150,962	120,084	21179.5
Philippines	2012	tons/yr	470,000	80,400	110,000	21608
Philippines	2013	tons/yr	527,459	201,419	142,463	22374.1
Philippines	2014	tons/yr	595,539	136,122	147,889	22111.6
Philippines	2015	tons/yr	526,906	131,228	121,243	23250.7
Philippines	2016	tons/yr	628,136	157,588	162,480	21632.1
Philippines	2017	tons/yr	761,288	208,515	218,624	21491.3
Philippines	2018	tons/yr	649,676	132,990	162,050	21350.5
Philippines	2019	tons/yr	709,569	176,654	206,534	24879
Philippines	2020	tons/yr	750,453	206,193	212,602	34715.3
Philippines	2021	tons/yr	715,904	258,040	323,078	37660.4
Philippines	2022	tons/yr	799,021	401,638	394,868	37660.4

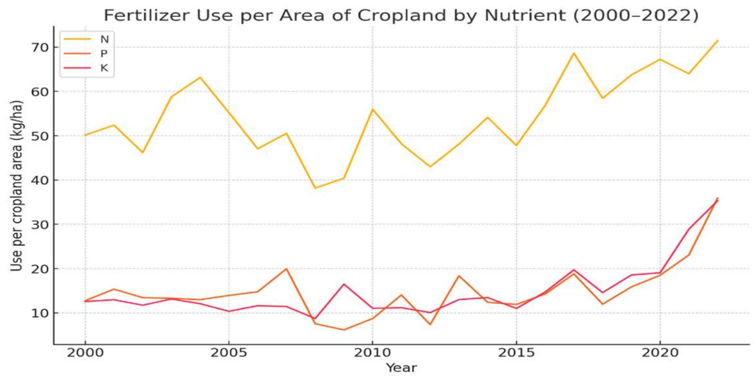

Figure 3.C.3. Trend of Annual Fertilizer Use per Area of Cropland (2000–2022)

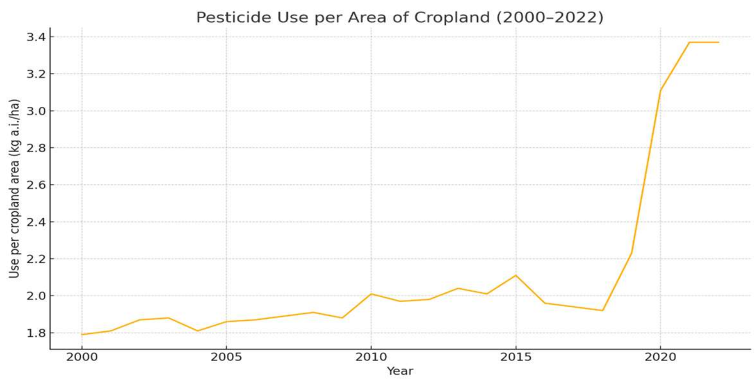

Figure 3.C.4. Trend of Pesticide Use per Area of Cropland (2000–2022)

Table 3.C.3 Nutrient Load in Selected Watersheds and River Basins, kg/day (2016) (Magcale-Macandog et al., 2016).

Watershed	Ammonium	Nitrate	Phosphorus
Pampanga River Basin	482.89	590.2	1,663.29
Pasig River Basin	372.82	3,089.74	861.24
Bataan Watershed	274.58	646.09	1,788.88
Cavite Watershed	114.95	199.97	336.1

Annex 3.D. Aquaculture Pollution Indicators

The Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) is responsible for the development, improvement, law enforcement, management, and conservation of the Philippines ' fisheries and aquatic resources. BFAR plays a crucial role in the management of aquaculture in the country. Since HAB events directly impact fisheries and aquaculture, including fish kills and shellfish toxicity, BFAR monitors these events and shares this information to the Intergovernmental Oceanographic Commission. The dataset for the frequency of shellfish advisories to visualize harmful algal bloom occurrences in the Philippines was extracted from the Intergovernmental Oceanographic Commission (2025). Data on fish kills were obtained from academic journals.

Table 3.D.1. Occurrence of Harmful Algal Bloom in the Philippines (2000-2025) (Intergovernmental Oceanographic Commission, 2025)

Year	Philippines	Philippine Waters of SCS-LME	% of Occurrence in SCS-LME to National
2000	10	2	20.0%
2001	5	2	40.0%
2002	12	4	33.3%
2003	9	2	22.2%
2004	10	3	30.0%
2005	10	4	40.0%
2006	9	2	22.2%
2007	16	2	12.5%
2008	12	2	16.7%
2009	6	1	16.7%
2010	13	4	30.8%
2011	11	4	36.4%
2012	10	4	40.0%
2013	9	2	22.2%
2014	11	5	45.5%
2015	13	4	30.8%
2016	14	1	7.1%
2017	1	1	100.0%
2018	155	18	11.6%
2019	180	37	20.6%
2020	342	33	9.6%
2021	84	6	7.1%
2022	24	2	8.3%
2023	13	0	0.0%
2024	127	3	2.4%
2025	39	3	7.7%

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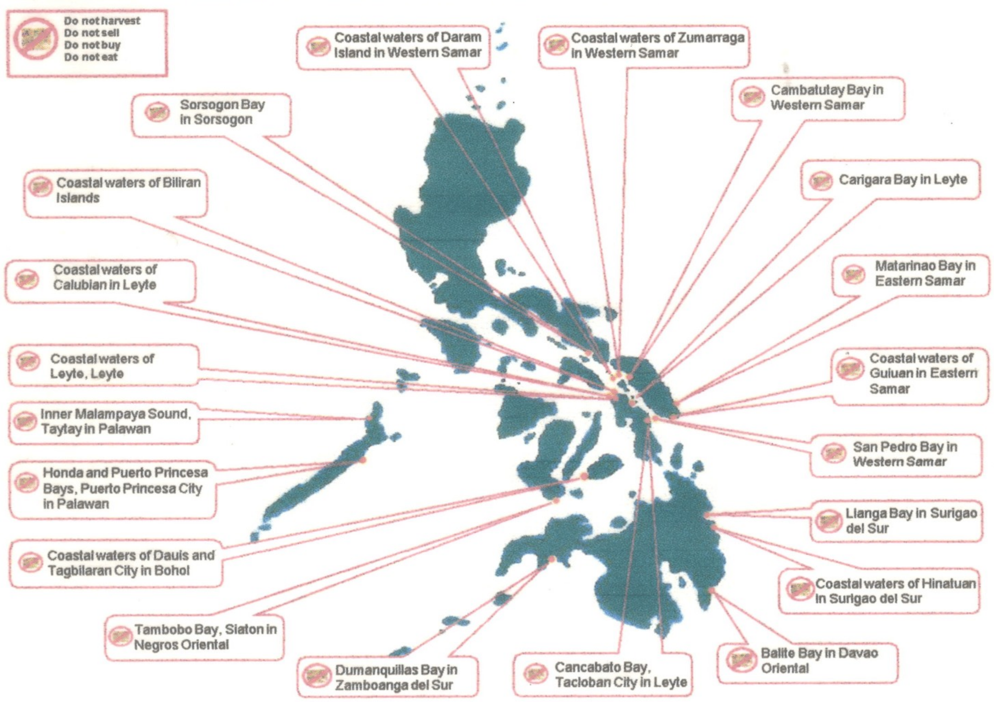
Shellfish Bulletin No. 02
Series of 2021
28 January 2021

Based on the latest laboratory results of the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Units (LGUs), shellfishes collected at **Honda and Puerto Princesa Bays in Puerto Princesa City, and Coastal waters of Inner Malampaya Sound, Taytay in Palawan; Sorsogon Bay in Sorsogon; Coastal waters of Dauis and Tagbilaran City in Bohol; Tambobo Bay, Siaton in Negros Oriental; Coastal waters of Daram Island, Zumarraga, and Cambatutay Bay in Western Samar; Coastal waters of Calubian, Leyte, Carigara Bay, and Cancabato Bay, Tacloban City in Leyte; Coastal waters of Biliran Islands; Coastal waters of Guiuan and Matarinao Bay in Eastern Samar; Balite Bay, Mati City in Davao Oriental; Lianga Bay and Coastal waters of Hinatuan in Surigao del Sur; and Dumanquillas Bay in Zamboanga del Sur** are still **positive** for paralytic shellfish poison that is beyond the regulatory limit. **Moreover, San Pedro Bay in Western Samar is now positive for red tide toxin.**



All types of shellfish and *Acetes sp.* or alamang gathered from the areas shown above are NOT SAFE for human consumption. Fish, squids, shrimps and crabs are safe for human consumption provided that they are fresh and washed thoroughly, and internal organs such as gills and intestines are removed before cooking.

The following areas continue to be **FREE from toxic red tides**: coastal waters of Cavite, Las Piñas, Parañaque, Navotas, Bulacan and Bataan (Mariveles, Limay, Orion, Pilar, Balanga, Hermosa, Orani, Abucay and Samal) in Manila Bay; coastal waters of Bolinao, Anda, Alaminos, Sual and Wawa, Bani in Pangasinan; coastal waters of Pampanga; Masinloc Bay in Zambales; coastal waters of Mandaon in Masbate; Juag Lagoon, Matnog in Sorsogon; coastal waters of Gigantes Islands, Carles in Iloilo; coastal waters of Pilar, Panay, President Roxas and Roxas City in Capiz; Sapian Bay (Ivisan and Sapian in Capiz; Mambuquiao and Camanci, Batan in Aklan); Altavas, Batan and New Washington in Batan Bay, Aklan; coastal waters of E.B. Magalona, Talisay City, Silay City, Bacolod City, Hinigaran and Victorias City in Negros Occidental; Siit Bay, Siaton and Bais Bay, Bais City in Negros Oriental; Irong-irong, Maqueda and Villareal Bays in Western Samar; Ormoc Bay, Ormoc City in Leyte; Panguil Bay, Tangub City in Misamis Occidental; Murcielagos Bay in Zamboanga del Norte and Misamis Occidental; Taguines Lagoon, Benoni, Mahinog in Camiguin Island; Coastal waters of Nasipit in Agusan del Norte; Bislig Bay and Coastal waters of Cortez in Surigao del Sur; and Litalit Bay in Surigao del Norte. **Moreover, Coastal waters of Milagros in Masbate is now free of the toxic red tides.**

EDUARDO B. GONGONA
BFAR National Director

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Figure 3.D.1. Shellfish Bulletin no. 2 Issued by BFAR in 2021 including Malampaya Sound in Taytay, Palawan.

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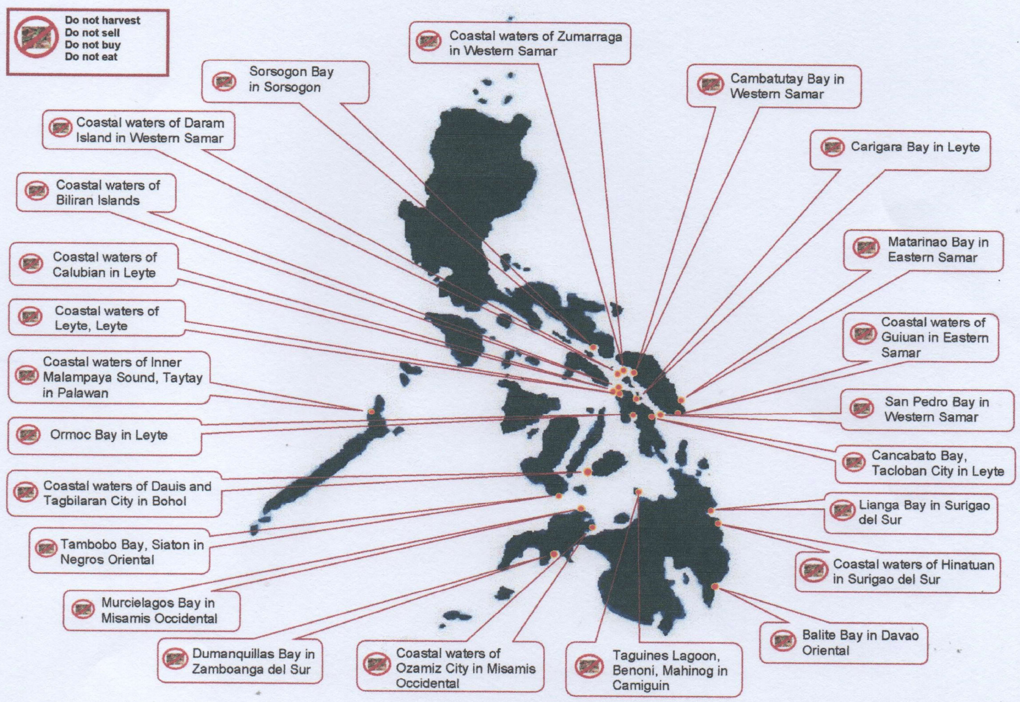
Shellfish Bulletin No. 05
Series of 2021
26 February 2021

Based on the latest laboratory results of the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Units (LGUs), shellfishes collected at **Coastal waters of Inner Malampaya Sound, Taytay in Palawan; Sorsogon Bay in Sorsogon; Coastal waters of Dauis and Tagbilaran City in Bohol; Tambobo Bay, Siaton in Negros Oriental; Coastal waters of Daram Island, Zumarraga, San Pedro and Cambatutay Bays in Western Samar; Coastal waters of Calubian, Leyte, Carigara Bay, Ormoc Bay and Cancabato Bay, Tacloban City in Leyte; Coastal waters of Biliran Islands; Coastal waters of Guiuan and Matarinao Bay in Eastern Samar; Dumanquillas Bay in Zamboanga del Sur; Balite Bay, Mati City in Davao Oriental; and Lianga Bay and Coastal waters of Hinatuan in Surigao del Sur** are still **positive** for paralytic shellfish poison that is beyond the regulatory limit. **Moreover, Murcielagos Bay (Sapang Dalaga and Baliangao) and Coastal waters of Ozamiz City in Misamis Occidental; and Taguines Lagoon, Benoni, Mahinog in Camiguin are now positive for red tide toxin.**



All types of shellfish and *Acetes sp.* or alamang gathered from the areas shown above are NOT SAFE for human consumption. Fish, squids, shrimps and crabs are safe for human consumption provided that they are fresh and washed thoroughly, and internal organs such as gills and intestines are removed before cooking.

The following areas continue to be **FREE from toxic red tides**: coastal waters of Cavite, Las Piñas, Parañaque, Navotas, Bulacan and Bataan (Mariveles, Limay, Orion, Pilar, Balanga, Hermosa, Orani, Abucay and Samal) in Manila Bay; coastal waters of Bolinao, Anda, Alaminos, Sual and Wawa, Bani in Pangasinan; coastal waters of Pampanga; Masinloc Bay in Zambales; Honda and Puerto Princesa Bays, Puerto Princesa City in Palawan; coastal waters of Milagros and Mandaon in Masbate; Juag Lagoon, Matnog in Sorsogon; coastal waters of Gigantes Islands, Carles in Iloilo; coastal waters of Pilar, Panay, President Roxas and Roxas City in Capiz; Sapian Bay (Ivisan and Sapian in Capiz; Mambuquiao and Camanci, Batan in Aklan); Altavas, Batan and New Washington in Batan Bay, Aklan; coastal waters of E.B. Magalona, Talisay City, Silay City, Bacolod City, Hinigaran and Victorias City in Negros Occidental; Siit Bay, Siaton and Bais Bay, Bais City in Negros Oriental; Irong-irong, Maqueda and Villareal Bays in Western Samar; Panguil Bay, Tangub City in Misamis Occidental; Murcielagos Bay in Zamboanga del Norte; Coastal waters of Nasipit in Agusan del Norte; Bislig Bay and Coastal waters of Cortez in Surigao del Sur; and Litalit Bay in Surigao del Norte.

Commodore EDUARDO B. GONGONA, PCG (Ret.)
BFAR National Director

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Figure 3.D.2. Shellfish Bulletin no. 5 Issued by BFAR in 2021 including Malampaya Sound in Taytay, Palawan.

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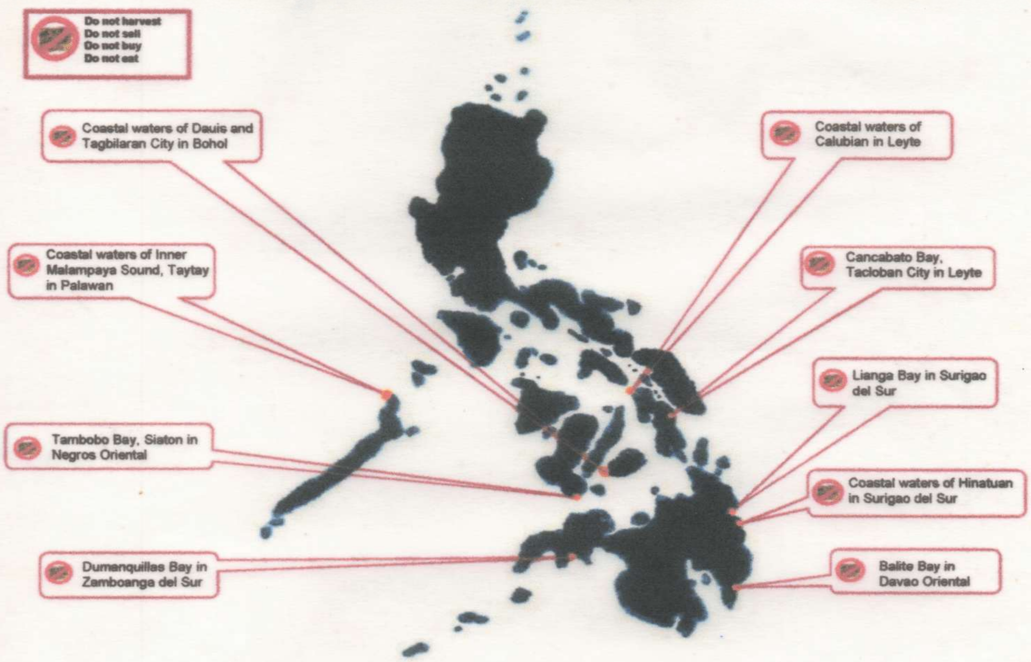
8

Shellfish Bulletin No. 08
Series of 2021
29 March 2021

Based on the latest laboratory results of the Bureau of Fisheries and Aquatic Resources (BFAR) and Local Government Units (LGUs), shellfishes collected at **coastal waters of Inner Malampaya Sound, Taytay in Palawan; coastal waters of Dauis and Tagbilaran City in Bohol; Tambobo Bay, Siaton in Negros Oriental; coastal waters of Calubian, and Cancabato Bay, Tacloban City in Leyte; Dumanquillas Bay in Zamboanga del Sur; Balite Bay, Mati City in Davao Oriental; and Lianga Bay and coastal waters of Hinatuan in Surigao del Sur** are still **positive** for paralytic shellfish poison that is beyond the regulatory limit.



All types of shellfish and *Acetes sp.* or alamang gathered from the areas shown above are NOT SAFE for human consumption. Fish, squids, shrimps and crabs are safe for human consumption provided that they are fresh and washed thoroughly, and internal organs such as gills and intestines are removed before cooking.

The following areas continue to be **FREE from toxic red tides**: coastal waters of Cavite, Las Piñas, Parañaque, Navotas, Bulacan and Bataan (Mariveles, Limay, Orion, Pilar, Balanga, Hermosa, Orani, Abucay and Samal) in Manila Bay; coastal waters of Bolinao, Anda, Alaminos, Sual and Wawa, Bani in Pangasinan; coastal waters of Pampanga; Masinloc Bay in Zambales; Honda and Puerto Princesa Bays, Puerto Princesa City in Palawan; coastal waters of Milagros and Mandaon in Masbate; Sorsogon Bay and Juag Lagoon, Matnog in Sorsogon; coastal waters of Gigantes Islands, Carles in Iloilo; coastal waters of Pilar, Panay, President Roxas and Roxas City in Capiz; Sapian Bay (Ivisan and Sapian in Capiz; Mambuquiao and Camanci, Batan in Aklan); Altavas, Batan and New Washington in Batan Bay, Aklan; coastal waters of E.B. Magalona, Talisay City, Silay City, Bacolod City, Hinigaran and Victorias City in Negros Occidental; Siit Bay, Siaton, and Bais Bay, Bais City in Negros Oriental; coastal waters of Daram Island, and Zumarraga, San Pedro, Cambatutay, Irong-irong, Maqueda and Villareal Bays in Western Samar; coastal waters of Leyte, Carigara and Ormoc Bays in Leyte; coastal waters of Biliran Islands; coastal waters of Guiuan and Matarinao Bay in Eastern Samar; Panguil Bay, Tangub City in Misamis Occidental; Murcielagos Bay in Zamboanga del Norte; coastal waters of Nasipit in Agusan del Norte; Bislig Bay and coastal waters of Cortez in Surigao del Sur; and Litalit Bay in Surigao del Norte. **Moreover, Murcielagos Bay (Sapang Dalaga and Baliangao) and coastal waters of Ozamiz City in Misamis Occidental; and Taguines Lagoon, Benoni, Mahinog in Camiguin are now free of the toxic red tides.**

Commodore EDUARDO B. GONGONA, PCG (Ret.)
BFAR National Director

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Figure 3.D.3. Shellfish Bulletin no. 8 Issued by BFAR in 2021 including Malampaya Sound in Taytay, Palawan.

Table 3.D.2. Fish Kill Events in the Philippine Waters of SCS-LME (Yniguez et al., 2021); San Diego-McGlone et al., 2024).

Year	Site	Number of Events
2002	Bolinao-Anda, Pangasinan	2
	Balayan Bay, Batangas	1
	Eastern side of Luzon	1
	San Antonio, Zambales	1
2003	Bolinao-Anda, Pangasinan	1
	Dagupan City, Pangasinan	1
	Vigan City, Ilocos Sur	2
	Sto. Tomas, La Union	1
2004	Bolinao-Anda, Pangasinan	1
	Sto. Tomas, La Union	1
2005	West coast of Palawan	1
	Dagupan City, Pangasinan	2
	Binmaley, Pangasinan	1
	Bolinao-Anda, Pangasinan	1
	Bani, Pangasinan	1
2007	Bolinao-Anda, Pangasinan	1
2010	Bolinao-Anda, Pangasinan	1
2011	Bolinao-Anda, Pangasinan	1
2013	Anda, Pangasinan	1
2015	Bani, Pangasinan	1
	Bolinao-Anda, Pangasinan	1
	Subic, Zambales	1
2016	Bolinao-Anda, Pangasinan	1
	Orion, Bataan	1
2017	Sual, Pangasinan	1
	Vigan City, Ilocos Sur	1
	Obando, Bulacan	1
	Bulacan	1
2018	Anda, Pangasinan	1
	Bolinao, Pangasinan	1
	Bani, Pangasinan	1
	San Vicente, Ilocos Sur	1
	Bulacan, Manila Bay	1
2019	Sual, Pangasinan	1
	Las Piñas-Parañaque	1
2020	Dagupan City, Pangasinan	1
	San Fernando City, La Union	1
	Nasugbu, Batangas	1
2021	San Fabian, Pangasinan	1
	San Vicente, Ilocos Sur	1
	Sta. Catalina, Ilocos Sur	1
	Dagupan City, Pangasinan	1
2022	San Vicente, Ilocos Sur	1
	Obando, Bulacan	1
2023	Sto. Tomas, La Union	2
	Cañacao Bay, Cavite City	1
2024	Bolinao-Anda, Pangasinan	1
	Nasugbu, Batangas	1
	Magsaysay, Occidental Mindoro	1
2025	San Juan, La Union	1
	Obando, Bulacan	1

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I										
	1	2003	Pangasinan	Dagupan City	Pugaro & Salapingao	Dissolved Oxygen depletion	Milkfish	Not reported	Not reported	Conduct regular monitoring and technical advice/assistance on Good Aquaculture Practices to affected fishfarmers.
	2	5/29/2003	Ilocos Sur	Vigan City	Pantay River, Brgy. Mindoro	-Water is murky and color reddish brown - DO is 1.5 mg/L	Milkfish	Not reported	Not reported	Recommended the transfer of tilapia to safer fishponds to prevent further mortality and the immediate opening of the estuary to flush out polluted water to the sea to prevent further fishkill in the area
	3	6/2/2003	Ilocos Sur	Vigan City	Pantay Daya	- Water has rotten odor, color turned blackish - DO is 0.01mg/L	Tilapia	Not reported	Not reported	Recommended the transfer of tilapia to safer fishponds to prevent further mortality and the immediate opening of the estuary to prevent further fishkill
	4	11/21/2003	La Union	Sto. Tomas	Cabaroan	Presence of parasites (kuto) which was sticking to the flesh and gills of the fish	Grouper, Siganid, Prawn	Not reported	Not reported	Ocular investigation was conducted by Fish Health Officer. Obtained fish, water and soil samples for laboratory analyses. Technical advice on affected fishfarmers.
	5	02/04-09/2004	La Union	Sto Tomas	Casantaan (Mariculture Zone Project)	-Presence of white color at back of the fish -Fin rot, skin abrasion -Cork screw swimming pattern	Milkfish	Not reported	Not reported	Fish and water samples were collected for further analysis
	6	5/24/2005	Pangasinan	Dagupan and Binmaley		-Dissolved Oxygen depletion and overstocking	Milkfish, eels, tilapia, shrimp, sapsap, crabs, spade fish	Not reported	Not reported	BFAR RFO I staff with OPAG personnel conducted water quality monitoring. Water/plankton samples were collected for further analysis at BFAR CO.
	7	10/25/2005	Pangasinan	Dagupan City	Calmay Ilocano	- Unregulated water flow/circulation	Milkfish	5,000 fingerlings	Not reported	Ocular investigation was conducted by Fish Health Officer. Obtained fish, and water samples for laboratory analyses. Technical advice on affected fishfarmer.
	8	5/30/2006	Pangasinan	Bani	Masidem	-low dissolved oxygen -dominated with 100% of Plankton composition by Scrippsiella trochoida	Kabasi Anodontostoma chacunda	Not reported	Not reported	Submitted samples to the Marine Biotoxin Unit, BFAR Central Office
	9	04/02-05/2013 (Monitoring)	Pangasinan	Dagupan City	Tococ	-White coloration	Mikfish	Not reported	Not reported	Forced harvest of affected fishpond and fishpen
	10	5/24/2013	Pangasinan	Anda	Siapar	-Over stocking -Natural upwelling -Excessive plankton growth -Decaying organic matter	Milkfish	Not reported	Not reported	
	11	4/20/2015	Pangasinan	Bani	Banog Norte	- low dissolved oxygen (0.04-1.19 mg/l)	Assorted fish (shrimp, goby, etc.)	270kgs	Not reported	collected from Bani River, no specific farm affected
	12	04/26-30/2015	Pangasinan	Bolinao		- low dissolved oxygen (0.02mg/l)	Assorted fish (shrimp, goby, etc.)	2,300MT	P218.50M	
	13	5/21/2016	Pangasinan	Anda	Siapar	- low dissolved oxygen (1.71mg/l) - over stocking	milkfish	affected size: post fingerlings, 250g/piece		
	14	10/1-2/2017	Pangasinan	Sual		- low dissolved oxygen (0.55mg/l) - over stocking	Milkfish	- 2 fishcages operator with a total of 43 fish cages (18x18Norwegian cage) was greatly affected - affected size: fingerlings, 350-550g	30.7Million	

Figure 3.D.4a. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I										
	15	05/25-26/2017	Ilocos Sur	Vigan City	San Pedro	- over stocking - low water level - restricted water movement -	Milkfish and tilapia	4MT (tilapia) 2MT (milkfish) Size of cage: 100 sq. m. 35 fish cage operators affected	Not reported	
	16	2/27/2018	Ilocos Sur	San Vicente		- overstocking		Not reported	Not reported	Update and amend certain prohibitions of the Municipal Fishery Ordinance, to include: allocations of proper distances between cages, setting of stocking densities (maximum of 40pcs/m3) per cage operator, feeding management (5-10% ABW/day), use of floater feeds only, cage size regulation, Enforcement of permitting system (allowable number of cages/operator); and Conduct of Orientation and Training on Good Aquaculture Practices to fish cage/pen operators.
	17	5/7/2018	Pangasinan	Bani		- low water level - low dissolved oxygen		Not reported	Not reported	LGU seriously consider clearing the river of structures obstructing water flow, and desiltation. Likewise, fishpond operators must observe good aquaculture practices (proper waste disposal), and a monitoring body be established to regularly monitor water quality condition.
	18	05/29-31/2018	Pangasinan	Anda		- Waters along Catubig turned rusty in color combined with foul odor - Fishy/foul odor - various species of crab begun to move out of the water towards the ground - "tribunada" struck some parts of Anda particularly along Catubig area - low dissolved oxygen - Temperature is high while Salinity, pH and nitrite are within the desirable level for fish culture.	Milkfish	55,000pcs, 100% mortality	Not reported	Recommended one month Moratorium on stocking and/or issuance by DENR of Cease-and-Desist Order, Imposition of ECC as a requirement for Mariculture, Permitting by LGU and unconditional enforcement of "NO FISHPEN" Policy
	19	05/29-31/2018	Pangasinan	Bolinao		- "Gataw" occurs along areas where the passing of "milky-white" colored water - low dissolved oxygen - Ammonia levels are in sub-lethal condition. - Temperature is high while Salinity, pH and nitrite are within the desirable level for fish culture.		1,030,000 Fingerlings (pcs) 965.09MT	Not reported	Recommended one month Moratorium on stocking and/or issuance by DENR of Cease-and-Desist Order, Imposition of ECC as a requirement for Mariculture, Permitting by LGU and unconditional enforcement of "NO FISHPEN" Policy
	20	9/25/2019	Pangasinan	Sual		- low level of dissolved oxygen at 10m depth - ammonia levels are in sub-lethal condition - plankton identification and count showed presence of Amnesic Shellfish Poisoning (ASP)	Milkfish	Not reported	Not reported	Operators to ensure regular collection of dead fishes by their cage workers, LGU to ensure and monitor proper disposal of dead fishes and wastes in the designated disposal facility, stocking density and proper feeding management be strictly followed, LGU to strictly enforce ordinance and development plan relative to the capacity and distancing of structures.

Figure 3.D.4b. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I										
	21	04/25-29/2020	Pangasinan	Dagupan City		- high temperature - low dissolved oxygen - lethal level of ammonia	Milkfish, siganids and groupers	Not reported	Not reported	Recommended; A. For Farm Operators – operators to be on guard 24/7 to monitor of their cultured stocks, strictly follow the recommended stocking density and report immediately to LGU any abnormal situation during farm operation and equip farms with basic water quality monitoring equipment. B. For LGU – strictly implement "NO FISHPEN POLICY", advice operators to adhere to Good Aquaculture Practices and require all aquaculture farms to register with BFAR. C. BFAR 1 action on the repeated fish kill – conduct fish kill investigations (preliminary and final), submitted report o the DA, OCD, BFAR I for damage report and prepared and submitted rehab plan.
	22	11/5-6/2020	La Union	San Fernando City		- simultaneous overflowing of water from the polluted creeks		Not reported	Not reported	Recommended that to re-direct or re-channel the flow of water in the canal not directly to the sea, to conduct regular water quality monitoring, to advice the residents not to consume dead fishes and request DENR to check compliances of the establishment in the area re: discharges.
	23	1/28/2021	Pangasinan	San Fabian		- low level of dissolved oxygen - lethal level of ammonia - overcrowding of stocks in one unit	Milkfish	Cultured Milkfish (100,000 pcs)	Not reported	Strict implementation of Municipal Fishery Ordinance for the establishment of fishery structures and good aquaculture practices, capacitate operators with water quality monitoring instruments/ equipment/kits to regularly monitor water quality, report immediately any unusual mortalities/events involving cultured stocks and observe proper disposal of dead milkfish.
	24	5/31/2021	Ilocos Sur	San Vicente		- critical level of dissolved oxygen - high temperature - lethal level of ammonia	Milkfish, Siganid and Tilapia		Tilapia – 9.27 million Milkfish – 747 thousand Siganid – 3.4 million	Enactment/updating of Municipal Fishery Ordinance to include permitting system, aquaculture activities, zonation, size regulation, stocking density, feeding, among others; conduct of regular water quality monitoring considering the intensive aquaculture activities in the area; observance and training of operators/caretakers of Good Aquaculture Practices; procurement of water quality equipment.
	25	5/31/2021	Ilocos Sur	Sta. Catalina		- critical level of dissolved oxygen - high temperature - lethal level of ammonia	Tilapia and Milkfish		Tilapia – 2.1 million Milkfish – 264 thousand	Enactment/updating of Municipal Fishery Ordinance to include permitting system, aquaculture activities, zonation, size regulation, stocking density, feeding, among others; conduct of regular water quality monitoring considering the intensive aquaculture activities in the area; observance and training of operators/caretakers of Good Aquaculture Practices; procurement of water quality equipment.
	26	5/20/2021	Pangasinan	Dagupan City		- high temperature - low water level		665,685 pcs (fry/fingerlings, juvenile, marketable)	Total Loss (19 million)	Recommended that need re-validation to determine actual damage losses in the area.

Figure 3.D.4c. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION I										
	27	1/24/2022	Ilocos Sur	San Vicente		- critical level of dissolved oxygen - lethal level of ammonia - 40% of the total river area was occupied for cage culture with no proper cage spacing	Milkfish and Tilapia	Not reported	Not reported	Enactment/updating of Municipal Fishery Ordinance to include permitting system, aquaculture activities, zonation, size regulation, stocking density, feeding, among others; conduct of regular water quality monitoring considering the intensive aquaculture activities in the area; observance and training of operators/caretakers of Good Aquaculture Practices; procurement of water quality equipment.
	28	2/20/2023	La Union	Sto. Tomas		- smell, and species affected from the wild, it is possible that the water during the incident is contaminated with pesticides	Shrimp, eel, serew, talakitok, goby, oysters	Not reported	Not reported	The technician of the pond be equipped with technical knowhow regarding pond preparation and management to improve aquaculture practices; PFO personnel to be aware of the protocol during fishkill investigation; and an IEC be conducted to all aquaculture operators to equip them with the appropriate knowledge.
	29	3/10/2023	La Union	Sto. Tomas		- salinity is higher (31-25 ppt) - no assistance yet or projects received from the government			Not reported	LGU must declare the proposed site for the MSN project; provide marker buoys for the demarcation of the proposed site; and orientation for beneficiaries prior to turn-over of the project.
	30	4/19/2024	Pangasinan	Natividad		- no pond preparation and fertilization was conducted since the start of operation - overstocking - no water quality monitoring - fishes were not fed on the onset of mortality	Tilapia	Not reported	Not reported	Practice pond preparation, install nets in the pond gates to prevent entry/transfer of predators, trim the grasses in the dike and surroundings of the pond and for the operator participate trainings on fish culture.
	31	4/26/2023	Ilocos Sur	San Ildefonso		- to critical levels of water quality parameters associated with turbid, oily, and stinky water - low dissolved oxygen - absence of water movement and the presence of macro aquatic plants in the production area		4.75MT	Not reported	The LGU should procure water quality equipment for monitoring purposes and conduct of regular monitoring of the aquaculture area; operators must observe Good Aquaculture and to be vigilant and observant on the status of cultured stocks; unwanted aquatic plants adjacent to the fish cages should be removed throughout the culture period; collect all dead fish and buried, and lift the cages with no stocks to restore the quality of the water and conduct emergency harvest if needed.
	32	6/5/2024	Pangasinan	Anda and Bolinao		- turbidity - low of quality water monitoring - low of dissolved oxygen - high ammonia levels	Milkfish	Not reported	Not reported	There is no FISH KILL incident, the incident is identified as isolated fish mortalities since only 14% of the total fish cage units in the area are affected and LGU Anda, despite undermanned, continuously monitors its fish landing port
	33	2/18/2025	La Union	San Juan		- slow movement of water - low dissolved of oxygen - above desirable of monia-nitrogen	Milkfish	3000 pcs or 75 pcs/m2	Not reported	All operators, feeders, and caretakers of fishponds, fishpen, and fishcages must undergo orientation on the Good Aquaculture Practices (GAqP) . LGU is advise to regularly conduct water quality monitoring and declare feasible area as an aquaculture zone.

Figure 3.D.4d. Region I, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	number/volume of Affected	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION II										
	1	5/8/2017	Isabela	Mallig	San Jose	High level of ammonia	Tilapia	200 pcs.	Not Reported	Water Quality Analysis/Parasitological Analysis
	2	6/3/2017	Batanes	Itbayat	Kavaywan Lake	Dissolved Oxygen Depletion/ Open Stocking	Tilapia	90%	Not Reported	Water Quality Analysis/Parasitological Analysis/ Aflatoxin Test
	3	6/19/2017	Quirino	Aglipay	Pinalipad	overstocking	Tilapia	40%	Not Reported	Water Quality Analysis/Parasitological Analysis
	4	7/4/2017	Cagayan	Peñablanca	Cabasan	Very High Stocking density	Tilapia	20%	Not Reported	Water Quality Analysis/Parasitological Analysis/
	5	7/5/2017	Cagayan	Sta.Ana	Rapuli	high level of ammonia/high level of salinity	Tilapia	10%	Not Reported	Water Quality Analysis/Parasitological Analysis/ Mocrobial Analysis/ Fish Necropsy
	6	7/5/2017	Cagayan	Sta.Ana		high level of ammonia/high level of salinity/ high level of Carbon dioxide	Tilapia	10%	Not Reported	Water Quality Analysis/Parasitological Analysis/ Mocrobial Analysis/ Fish Necropsy
	7	8/18/2017	Isabela	Cauayan	Nungnungan	high level of ammonia, low level of DO, Overstocking	Tilapia	200 pcs.	Not Reported	Water Quality Analysis/Parasitological Analysis
	8	8/18/2017	Isabela	Cauayan City	Nungnungan	high level of ammonia, low level of DO, Overstocking	Tilapia	200 pcs.	Not Reported	Water Quality Analysis/Parasitological Analysis
	9	10/9/2017	Cagayan	Sta. Teresita		Formation of Molds in Organic Feeds fed with crabs	Poly culture of Bangus and Crabs	100%	Not Reported	Water Quality Analysis
	10	11/10/2017	Cagayan	Aparri	Aparri Farm Station	high level of ammonia/ Abrupt change in water	Tilapia	55%	Not Reported	Water quality analysis/Microbial Analysis/Fish Examination
	11	11/14/2017	Nueva Vizcaya	Solano	Galima	low DO level/ over stocking	Tilapia	600%	Not Reported	Water quality analysis
	12	11/28/2017	Cagayan	Allacapan		high level of ammonia/ Abrupt change in water/ Open Stocking	Tilapia	30%	Not Reported	Water quality analysis
	13	6/6/2018	Isabela	Mallig	Victoria	Overstocking, Thermal destratification/overturn, Low DO, high level Ammonia Nitrogen	Tilapia	50%	Not Reported	Onsite water quality analysis, Flushing of pond is recommended
	14	6/12/2018	Isabela	San Mariano	Sta. Filomena	Oxygen depletion, Overstocking	Tilapia	70%	Not Reported	Onsite water quality analysis, transfering of remaining stocks is recommended
	15	1/21/2020	Isabela	Sta. Maria	Buena Vista	Presence of Fish Louse	Koi Carp	30%	Not Reported	Short Salt Bath and Lond Salt bath
	16	3/25/2020	Isabela	Sta. Maria	Sitio Bayabo	High Stocking Density	Tilapia	5%	Not Reported	Water Quality Analysis, Fish Examination
	17	8/24/2021	Isabela	Sta. Maria	Buena Vista	High Stocking Density	Tilapia	50%	Not Reported	Onsite water quality analysis, transfering of remaining stocks is recommended
	18	2/22/2022	Isabela	Delfin Albano		High Stocking Density, Overturn Caused by heavy rain	Tilapia	2.76%	Not Reported	Onsite water quality analysis, transfering of remaining stocks is recommended
	19	3/14/2022	Isabela	Delfin Albano	Villa Pereda	High Stocking Density, Overturn Caused by heavy rain, Pesticide Toxicity (suspected)	Tilapia	100.00%	Not Reported	Onsite water quality analysis, transfering of remaining stocks is recommended
	20	4/26/2023	Isabela	Sta. Maria	Buenavista	Low concentration of Dissolved Oxygen	Tilapia	1,140 pieces	Not Reported	Conducted water quality analysis. Recommenadtions of installing a drainage outlet for each pond, removal of orgagnic matter, and attending training on Fish Health Managment and Tilapia Pond Management was given.
	21	5/25/2023	Isabela	Cabagan		Low concentration of Dissolved Oxygen, High concentration of Ammonia Nitrogen and Carbon Dioxide, Acidic (low pH) condition.	Catfish	2,000 kg in harvestable size	Not Reported	Water quality analysis was conducted. Recommendations such as installation and securing safe source of water, reconstruction of pond layout, and controlling growth of aquatic vegetation were given.
	22	6/19/2023	Isabela	Quirino	Luna	High levels of Ammonia Nitrogen and low Dissolved Oxygen	Tilapia	600 pieces of larger fish	Not Reported	Conducted water quality analysis , recommended to follow stocking density of 5pcs per square meter, replenish pond water, proper feeding to avoid build-up of toxic ammonia, and cleaning of ponds regularly and removal of dead fish.
	23	6/26/2023	Cagayan	Solana	Sampaguita	Critical level of Dissolved Oxygen, toxic concentration of Ammonia-Nitrogen, and Nitrite-Nitrogen.	Tilapia	> 200 kg	Not Reported	Conduced on-site water qualit analysis. Recommendation of immediate harvesting of remaining stocks, improve water system, and consultation to the bureau for asssitance in proper pond construction were given.
	24	7/24/2023	Cagayan	Tuao East	Naruangan	Low Dissolved Oxygen, High Ammonia-Nitrogen, Alkalinity, and Carbon Dioxide levels.	Catfish	18 pieces	Not Reported	On-site Water Quality Analysis was conducted. Recommendations such as strict monitoring of pond, maintining good water quality, proper stocking density of 8-10 pcs of catfish per m2, removal of unwanted plants, and pratice of proper fish pond prep weregiven.

Figure 3.D.5a. Region II, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Date Reported [mm/dd/yyyy]	Location			Cause/s of Fish Kill	Affected Species	number/volume of Affected	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION II										
	25	7/31/2023	Cagayan	Tuao	Mambacag	Abnormal levels of Ammonia-Nitrogen	Tilapia	825 pieces	Not Reported	Conducted On-site water quality analysis and parasitlogical examination. Recommendation of disposition and proper collection of dead fish from ponds, keeping animals in separate area, and conducting water exchange in the ponds were given.
	26	8/1/2023	Cagayan	Lasam	Finugo	High levels of Ammonia Nitrogen and low Dissolved Oxygen	Tilapia	30 kg	Not Reported	Conducted on-site water quality analysis and parasitlogical examination. Recommendations such as conducting water exchange in the ponds, reducing feeding frequency during rainy days, removal of natural debris in the pond, and proper collection and disposal of dead fish were given.
	27	8/24/2023	Cagayan	Iguig	Garab	Low Dissolved Oxygen	Tilapia	10	Not Reported	
	28	2/15/2024	Cagayan	Solana	Sampaguita	High stocking density	Tilapia	98	Not Reported	on site water quality analysis, occular inspection and parasitological analysis were conducted
	29	4/30/2024	Cagayan	Solana	Nangalisan	No adequate suplly od water thus water level is only one meter, Low concentration of dissolved oxygen high concentration of Ammonia Nitrogen and Nitrite nitrogen level	Tilapia		Not Reported	ocular inspection, water quality analysis and recommended to follow stocking density of 5pcs per square meter
	30	5/20/2024	Cagayan	Alcala	Pussian	High concentration of Ammonia Nitrogen	Tilapia		Not Reported	on site water quality analysis, occular inspection
	31	5/21/2024	Cagayan	Alcala	Carallangan	High concentration of Ammonia Nitrogen	Tilapia	100	Not Reported	on site water quality analysis, occular inspection
	32	6/17/2024	Isabela	Ramon	Aguinaldo	Low water levels due to insufficient supply from the irrigation, critically low dissolved oxygen levels, heavy rainfall	Tilapia	2,700	Not Reported	occular inspection, on-site water quality analysis, and necropsy was conducted
	33	6/18/2024	Isabela	Quezon	Isabela		Ulang		Not Reported	
	34	7/4/2024	Cagayan	Peñablanca	San Roque	Water level is low, pond water exhibited a brown-green color and was noticeably muddy,	Tilapia		Not Reported	On-site water quality analysis, ocular inspection and water microbial analysis
	35	7/12/2024	Isabela	Quezon	Estrada	Rainfall occurence caused thermal de-stratification resulting in low oxygen levels	Tilapia	300	Not Reported	On-site water quality analysis, ocular inspection
	36	7/12/2024	Isabela	Quezon	Barucboc	Rainfall occurence caused thermal de-stratification resulting in low oxygen levels	Tilapia	500	Not Reported	On-site water quality analysis, ocular inspection
	37	7/12/2024	Isabela	Quezon	Barucboc	Rainfall occurence caused thermal de-stratification resulting in low oxygen levels	Tilapia	500	Not Reported	On-site water quality analysis, ocular inspection
	38	7/15/2024	Cagayan	Piat		Water color is noticeably muddy, depth is less than one meter, low dissolved oxygen levels	Tilapia	120	Not Reported	On-site water quality analysis, ocular inspection
	39	2/7/2025	Cagayan	Solana		ammonia and carbon dioxide is above the normal	tilapia	100%	Not Reported	conduct water quality analysis
	40	3/14/2025	Isabela	Marranao SWIP, San Mariano	Marranao SWIP	ammonia is too high	tilapia	9%	Not Reported	occular inspection, water quality analysis, collected tilapia samples for TiLV analysis and parasitological analysis
	41	3/27/2025	Cagayan	Amulung	Dadda	carbon dioxide too high	catfish	80%	Not Reported	occular inspection, water quality analysis, recommended water exchangfe and increase level of water in the tank, collection and diposal of dead fingerlings
	42	4/30/2025	Isabela	Cordon	Taliktik	overstocking, low DO due to thermal destratification, high ammonia level	tilapia	70-80%	Not Reported	occular inspection, water quality analysis, recommended not to cover stock and follow the stocking density
	43	5/22/2025	Isabela	Quezon	Barucboc	above normal levels of alkalinity, CO2, and hardness. below normal level of DO	tilapia	8%	Not Reported	occular inspection, water quality analysis, gross morphology
	44	5/30/2025	Cagayan	Ballesteros	Nararagan	overstocking, low DO due to thermal destratification	tilapia	80%	Not Reported	on-site water quality analysis, gross morphological analysis, occular inspection, microbiological analysis
	45	7/7/2025	Cagayan	Rizal	Duyun	fish gasping on the surface	tilapia	8%	Not Reported	on site water quality analysis, occular inspection
	46	7/10/2025	Cagayan	Amulung	Nagsabaran	low dissolved oxygen	tilapia	80%	Not Reported	on site water quality analysis, occular inspection

Figure 3.D.5b. Region II, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported (mm/dd/yyy	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION III										
	1	9/23/2014	Bulacan	Balagtas	Panginay	• Extremely Low Dissolved Oxygen • Extremely High Unionized Ammonia • Floods brought by Typhoon Mario	-	-	Not Reported	-
	2	11/3/2014	Bataan (San Juan River)	Samal	Daan Bago	Extremely Low Dissolved Oxygen	Tilapiang Gloria	-	Not Reported	-
	3	1/23/2015	Zambales	Subic	Nagyantok	Extremely high levels of Total Unionized Ammonia		-	Not Reported	Alleged Fishkill No mortalities found upon investigation
	4	7/22/2015	Pampanga River	Candaba/Macabebe/Masantol		Extremely low dissolved oxygen. Possible overturn brought about by sudden heavy rains	Freshwater fishes	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	5	8/28/2015	Bulacan	Balagtas	Panginay	Flood due to Heavy Rains	Tilapia	-	Not Reported	Reported late Mortalities were disposed upon investigation
	6	8/1/2016	Bataan	Orion	Capunitan	Possible overturn brought about by sudden heavy rains in the late afternoon	Marine Fishes, shrimps, crabs	-	Not Reported	Reported late, no mortalities found upon investigation. Conducted on-site fish kill investigation and water quality monitoring.
	7	1/2/2017	Bulacan	Obando		Extremely Low Dissolved Oxygen	Milkfish	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	8	7/14/2017	Pampanga	Lubao		Extremely low dissolved oxygen	Tilapia	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	9	7/14/2017	Bulacan (Calumpit River)			Possible overturn brought about by sudden heavy rains in the late afternoon	Freshwater fishes	-	Not Reported	Reported late, no mortalities found upon investigation. Conducted on-site fish kill investigation and water quality monitoring.
	10	7/15/2017	Pampanga	Guagua		Extremely low dissolved oxygen	Tilapia	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	11	7/18/2017	Pampanga	Minalin		Extremely low dissolved oxygen	Tilapia	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	12	9/21/2017	Pampanga (Delta) River	Masantol/Apalit/Macabebe		Extremely Low Dissolved Oxygen	Freshwater fishes Kanduli, common carps, big head carps, ulang,tilapia, ayungin	-	Not Reported	Conducted on-site fish kill investigation and water quality monitoring.
	13	5/16/2022	Bulacan	Obando	Tawiran	Oxygen depletion due to the eutrophication and intense heat then followed by days of heavy rains which lead to a sudden drop of temperature		-	Not Reported	• on-site assessment and investigation • water sample tested for physico-chemical parameters • interview with the locals to gather information on what actually happened on that day and the days prior to the incident
	14	8/31/2023	Tarlac	Concepcion	Dungan	Poor water quality aggravated by the sudden change of temperature brought by the changing weather patterns	Tilapia	atleast 5 metric tons	Not Reported	• onsite water quality assessment • water sample tested for physico-chemical parameters • fish sample tested for TiLV (found NEGATIVE)
	15	4/21/2025	Bulacan	Obando		Oxygen depletion due to the eutrophication and intense by fluctuating temperature brought about the light rain showers before the alleged fishkill incidence. Lowtide also aggravated the stratification by stirring up the sediments which further depletes the oxygen.		-	Not Reported	• on-site assessment and investigation • water sample tested for physico-chemical parameters • interview with the locals to gather information on what actually happened on that day and the days prior to the incident

Figure 3.D.6. Region III, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/yy	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION IV-A										
	1	2/13/2020	Batangas	Mataas na kahoy	Barangay Lumanglipa	Oxygen depletion as water level decreased in the area after Taal volcano eruption.	Sardinella tawilis	0.22 MT	No estimated value of loss (Php) declared by the LGU	BIFTOS • Conducted on-site fish kill investigation and water quality monitoring in the affected areas on February 13, 2020 and provided advisories afterwards. • 2. Advised the residents and fisher folks not to eat and market those dead tawilis fishes seen from their area but instead, collect and bury them properly.
	2	06/20/20	Laguna	San Pablo	Sampaloc Lake	Phosphate levels in the samples exceeded the acceptable limits. The presence of external parasites such as Trichodina spp. and Gyrodactylus spp. indicated parasite infestation. Growth on blood agar exhibited characteristics consistent with Streptococcus spp.	Tilapia	16.5 MT	Php 1,500,000.00	"RFL • Interview of some cage operators about common husbandry practices of rearing caged tilapia in Sampaloc Lake. • Conducted on-site physical and chemical water quality testing. • Collected water samples for microbiological analysis. • Collected moribund tilapia samples for disease diagnosis.
	3	6/22/2020	Batangas	Agoncillo	Barangay Bilibinwang and Bañaga	Oxygen depletion due to heavy rain, sudden change of weather and temperature.	Tilapia	2 MT	*No estimated value of loss (Php) declared by the LGU.	BIFTOS • Conducted on-site fish kill investigation and water quality monitoring in the affected areas on June 23, 2020 and provided advisories afterwards. • Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest. • Advised fish cage operators and caretakers to bury their stocks in the designated mortality pits and don't just throw outside the fish cages and lake water.
	4	7/15/2020	Batangas	Agoncillo	Barangay Bilibinwang and Bañaga	Oxygen depletion due to sudden change in weather (intense heat followed by heavy rains brought about by strong hanging-habagat).	Tilapia	40 MT	*No estimated value of loss (Php) declared by the LGU.	BIFTOS • Conducted on-site fish kill investigation and water quality monitoring in the affected areas on July 16, 2020 and provided advisories afterwards. • Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest and refrain temporarily from feeding their stocks.
	5	7/29/2020	Batangas	Nasugbu	Palico River	high ammonia and phosphate levels may cause algal blooms or heavy plant growth that can be detrimental to the fish and other aquatic life. Likewise, oxygen is consumed as ammonia is oxidized (nitrification), and low oxygen levels increase ammonia levels by inhibiting nitrification.	Igat, Dalag, Kitang, Sugpo, Hipon, Sapsap, Aligasin, Dangat, Buwan-buwan, Managat, Biya and Tilapia	500 kg	Affected 94 registered fisher folks who are all members of Bucana Fisherfolks Association	RFL • Conducted interview of some fisher folk and residents. • Conducted on-site physical and chemical water quality testing. • Collected water samples for microbiological analysis. • Collected moribund fish samples for disease diagnosis.

Figure 3.D.7a. Region IV-A, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/yy	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION IV-A										
	6	8/4/2020	Batangas	Laurel	Barangay Gulod, Balakilong and Leviste	Oxygen depletion due to sudden change in weather (calm, hot and dry weather followed by heavy rains brought about by strong hanging-habagat).	*Tilapia Bangus *	290 MT 5 MT	*Php 23,857,500.00 Php 600,000.00 *	BIFTOS • Conducted on-site fish kill investigation and water quality monitoring in the affected areas on August 3, 2020 and provided advisories afterwards. • Conducted post-fish kill water quality monitoring on August 4, 2020. • Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest. • Advised fish cage operators and caretakers to bury their stocks in the designated mortality pits and don't just throw outside the fish cages and lake water.
	7	9/28/2020	Rizal	Jalajala	Laguna Lake	There was an observed proliferation of water lilies and a significant increase in the green coloration of the water, indicating possible algal presence.	Bangus	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	*RFL • Conducted interview of some fisher folk and residents. • Identified 6 sampling sites and Conducted on-site physical and chemical water quality testing. • Collected water samples for microbiological analysis. • Collected moribund fish samples for disease diagnosis.
	8	9/30/2020	Batangas	Agoncillo	Barangay Balakilong, Laurel and Brgy. Bañaga, Brgy. Bilibinwang	Oxygen depletion due to sudden change in weather (calm, hot and dry weather followed by heavy rains.	Tilapia	20 MT	*No estimated value of loss (Php) declared by the LGU.	BIFTOS • Conducted on-site fish kill investigation and water quality monitoring in the affected areas on September 30, 2020 and provided advisories afterwards. • Conducted post-fish kill water quality monitoring on October 1-2, 2020. • Advised the operators and caretakers to provide aerators and oxygen tanks in their remaining stocks as DO levels were still critical. Also, to perform emergency harvest. • Advised fish cage operators and caretakers to bury their stocks in the designated mortality pits and don't just throw outside the fish cages and lake water.
	9	3/11/2022	Laguna	San Pablo City	Calibato Lake	Typhoon	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	RFL Conducted Laboratory Analysis, Advised Locals and LGU's, Created Fish Kill Incidence Report
	10	12/27/2022	Laguna	San Pablo City	Calibato Lake	Sulfur Upwelling	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	Conducted Laboratory Analysis, Advised Locals and LGU's, Created Fish Kill Incidence Report
	11	12/27/2022	Laguna	San Pablo City	Sampaloc Lake	Sulfur Upwelling	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	Conducted Laboratory Analysis, Advised Locals and LGU's, Created Fish Kill Incidence Report
	12	01/23/2023	Laguna	Los Baños	Brgy. Bambang	High Levels of Ammonia	Tilapia	*No estimated number declared by the fisherfolk	*No estimated number declared by the fisherfolk	Conducted Laboratory Analysis to determine the cause of fish kill and informed the Local Government Units.
	13	7/6/2023	Quezon	Lucena City	Iyam River	Low Dissolved Oxygen and High levels of Ammonia	Tilapia & Other unidentified species	200kg	No estimated number declared by the LGU	Conducted Laboratory Analysis and informed the Provincial Fisheries Office of Quezon about the result
	14	1/9/2023	Quezon	Dolores	Farmko Drawout Hatchery	High Levels of Ammonia	Pangasius	No estimated value provided by the farm owner	No estimated value provided by the farm owner	Informed the owners of the farm regarding the results and provided advice for maintaining the water quality
	15	4/15/2024	Batangas	Nasugbu	Sitio Hulo, Brgy. Calayo	Low Dissolved Oxygen and Harmful Algal Bloom	Eel, Puffer Fish & Other unidentified fish species			

Figure 3.D.7b. Region IV-A, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Region	No.	Reported [mm/dd/y	Location			Cause/s of Fish Kill	Affected Species	Estimated number/volume of Affected Species	Approximate damage (in PHP)	Actions taken
			Province	City/Municipality	Barangay Address					
REGION IV-B										
	1	4/2/2024	Occidental Mindoro	Magsaysay	Laste	Ice-ice, pitting, algae in seaweeds, and aquatic animal grazing on seaweeds	Seaweeds	1000 rumbay	Php 450,000	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collected seaweeds samples
	2	9/26/2024	Oriental Mindoro	Bansud	Salcedo	Dissolve oxygen depletion due to overstocking	Tilapia (juvenile)	1000 pcs tilapia	Php 3,750	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collected live fish samples (no clinical signs) 5. Conducted parasitology 6. Collected another set of fish samples for VNN, Iridovirus, and TiLV analyses 7. Submitted fish samples to BFAR CO NFLD- negative results
	3	10/23/2024	Oriental Mindoro	Bongabong	Labasan	Used of expired commercial feeds and fluctuations in water parameters due to continuous	Milkfish (juvenile)	509 pcs Milkfish	Php 2,240	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collected fish samples for VNN, and Iridovirus analyses
	4	3/28/2025	Oriental Mindoro	Naujan	Barcenaga	Parasitism (Trichodina spp.)	Tilapia (breeders)	6 pcs tilapia	Php 3,600	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collection of live samples (with clinical signs) 5. Conducted parasitology
	5	6/3/2025	Oriental Mindoro	San Teodoro	Calsapa	Suspected pesticide poisoning	Needlefish, Trevally, Barracuda, Goby, Shrimp, Grunter, Mullet, Glassy Perchlet, Northern Whiting	Estimated: More than 7kgs Submitted: 128 pcs fishes equivalent to 1.074 kgs	Php 1,400	1. Data gathering through interview 2. On-site inspection 3. Conduct of water quality analysis 4. Collection of samples (dead fishes) 5. Conducted fish necropsy 6. Adviced LGU to submit 2 sets of fish samples (pelagic and demersal), caught as live for pesticide analysis. However, no samples were submitted

Figure 3.D.8. Region IV-B, 2000-2025 Fish Mortality Incidence Report (BFAR, 2025)

Annex 3.E. Solid Waste Pollution Indicators

The solid waste dataset used in the narrative was obtained from the Compendium of Philippine Environment Statistics (CPES) published by the Philippine Statistics Authority (PSA), supplemented with data from an academic journal. The PSA projected annual waste generation was computed using the 2010 Philippine Population Census as the baseline. Meanwhile, the identification of the top plastic-emitting rivers was based on a modelled study conducted by Meijer et al. (2021). Given that this report focuses on regions and provinces contributing to the Philippine Waters of the SCS-LME, data from other regions were aggregated to be concise.

Table 3.E.1. Projected Amount of Solid Waste Generated in the Philippines per Day (2014-2023) (PSA, 2024).

Year	Unit	Philippines	NCR	CAR	Region I	Region II	Region III	Region IV-A	Region IV-B	Other Regions
2014	Mass (tons/day)	50,409	7,933	798	2,350	1,557	5,863	7,854	1,375	22,679
2015	Mass (tons/day)	51,424	8,073	812	2,379	1,579	5,990	8,105	1,401	23,085
2016	Mass (tons/day)	52,463	8,216	827	2,408	1,601	6,120	8,365	1,429	23,497
2017	Mass (tons/day)	53,527	8,363	842	2,438	1,624	6,252	8,634	1,457	23,917
2018	Mass (tons/day)	54,616	8,512	858	2,469	1,646	6,388	8,912	1,486	24,345
2019	Mass (tons/day)	55,731	8,665	873	2,499	1,669	6,526	9,200	1,515	24,784
2020	Mass (tons/day)	56,874	8,821	889	2,531	1,693	6,668	9,498	1,545	25,229
2021	Mass (tons/day)	58,044	8,981	906	2,562	1,716	6,813	9,806	1,576	25,684
2022	Mass (tons/day)	59,243	9,144	922	2,594	1,740	6,962	10,125	1,608	26,148
2023	Mass (tons/day)	60,640	9,290	962	2,584	1,762	7,095	10,455	1,614	26,878

Table 3.E.2. Number of Disposal Facilities in the Philippines from 2012-2023 (PSA, 2024).

Spatial Coverage	Year	Illegal Dump	MRFs	Sanitary Landfill
Philippines	2012	945	7,713	45
Philippines	2013	923	8,486	72
Philippines	2014	900	8,656	86
Philippines	2015	553	9,335	101
Philippines	2016	511	9,883	118
Philippines	2017	385	10,052	135
Philippines	2018	353	10,340	165
Philippines	2019	331	10,722	187
Philippines	2020	233	11,546	241
Philippines	2021	0	11,637	245
Philippines	2022	0	11,779	290
Philippines	2023	43	11,823	299

Table 3.E.3. Top Plastic Emitting Rivers in the Philippines based on the model study of Meijer et al. (2021).

Ranking (from Meijer et al. in 2021)	River	Best Calibrated Scenario (tons/yr)	Drains to the Philippine Waters of SCS-LME?
1	Pasig	63,000	Yes (drains through Manila Bay)
2	Tullahan	13,000	Yes (drains through Manila Bay)
5	Meycauayan	12,000	Yes (drains through Manila Bay)
6	Pampanga	9,300	Yes (drains through Manila Bay)
7	Libmanan	7,100	No
9	Rio Grande de Mindanao	5,300	No
10	Agno	4,600	Yes (drains through Lingayen Gulf)
11	Agusan	4,600	No
12	Paranaque	4,400	Yes (drains through Manila Bay)
13	Iloilo	4,200	No
24	Imus	3,100	Yes (drains through Manila Bay)
29	Zapote	2,700	Yes (drains through Manila Bay)
32	Cagayan de Oro	2,600	No
33	Davao RIver	2,600	No
38	Malaking Tubig	2,500	No
40	Tambo, Pasay (Storm drain)	2,500	Yes (drains through Manila Bay)
42	Jalaur River	2,300	No
46	Cagayan River	2,300	No
50	Hamulauon	2,200	No

Figure 3.E.1 Plastic Debris found in the coastal waters of Balayan Bay, Mabini, Batangas.

Annex 3.F. Hazardous Waste Pollution Indicators

The dataset for hazardous waste was extracted from the Compendium of Philippine Environment Statistics (CPES), released periodically by the Philippine Statistics Authority. Table 3.F.1 presents the hazardous waste generated, classified by type, while Table 3.F.2 presents the aggregated hazardous waste generated by region per year. Table 3.F.3 shows the amount generated and treated, as well as the cumulative generated and treated waste. The Multi-Year Treatment Rate (MTR) was obtained by getting the ratio of cumulative treatment to the cumulative generated per year. The last column contains the number of TSD Facilities in the Philippines.

Table 3.F.1. Hazardous Waste Generated by Type per Year in tons (2012-2023)

Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	Mean
Waste with Cyanide	112,620.48	565,841.03	190,714.45	401,467.43	191,367.41	1,428,453.17	395,537.25	1,047,561.50	465.6	899.98	977.58	781.46	4,336,687.34	361,390.61
Acid Wastes	281,166.97	100,891.15	271,959.28	317,403.61	10,096.50	39,024.07	2,759.65	15,314.82	1,282.65	4,481.85	3,952.36	4,220.61	1,052,553.52	87,712.79
Alkali Wastes	53,086.00	195,009.36	579,074.32	983,030.13	361,916.41	14,703.85	70,538.76	193,714.02	3,556.62	21,258.78	22,725.57	9,944.48	2,508,558.30	209,046.53
Waste with Inorganic Chemicals	29,081.96	269,815.90	806,358.72	710,107.45	88,511.56	43,219.74	24,349.58	2,896,162.86	6,309.88	18,781.08	21,555.88	22,443.65	4,936,698.26	411,391.52
Reactive Chemical Wastes	337.11	464,668.17	63.15	330.35	425.82	503.17	367.06	5,041.30	97	245.02	995.34	802.79	473,876.28	39489.69
Inks, Dyes, Pigments, Paint, Latex, Adhesives, Organic Sludge	5,475.11	10,418.35	134,881.37	67,807.14	14,604.04	16,595.62	41,948.78	36,191.36	7,381.62	27,381.62	27,685.19	27,953.24	418,323.44	34,860.29
Waste Organic Solvent	165,136.98	352,381.23	27,970.13	33,822.49	6,941.93	7,398.92	8,373.92	57,277.32	6,448.80	18,445.97	15,572.87	15,888.76	715,659.32	59,638.28
Organic Wastes	23,958.78	620,720.09	513.06	5,365.68	1,961.19	3,280.06	2,454.35	32,645.43	930.47	5,343.55	6,899.72	9,586.89	713,659.27	59,471.61
Oil	72,674.83	5,918,533.65	144,694.29	1,351,706.03	744,758.48	220,331.10	75,344.75	302,401.17	20,084.39	65,457.17	71,958.19	76,328.12	9,064,272.17	755,356.01
Containers	13,856.43	432,478.33	13,448.22	15,564.60	5,149.26	17,837.93	15,012.94	28,539.21	1,276.54	5,603.30	6,167.08	5,671.32	560,605.16	46,717.10
Immobilized/ Stabilized Wastes	3,401.79	1,486.10	4,846.70	2,377.17	2,797.70	6,164.20	222,024.56	18,843.93	9,609.25	30,645.36	33,720.60	18,430.64	354,348.00	29,529.00
Organic Chemicals	36.86	115.04	2,302.40	928.82	237.85	2,386.55	67,572.90	345.01	39.35	312.27	203.95	619.05	75,100.05	6258.3375
Miscellaneous Wastes	19,689.37	44,597.59	322,161.56	442,311.44	57,039.85	298,646.89	64,971.54	189,122.62	9,683.63	39,316.14	40,344.33	45,586.91	1,573,471.87	131,122.66

Table 3.F.2. Total Hazardous Waste Generated Per Region in tons (2012-2023)

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	% Ctrbn
NCR	14,710.66	606,417.84	187,607.56	218,753.01	114,969.90	47,575.91	38,899.32	33,754.75	11,252.21	23,877.16	29,709.49	38,679.98	1,366,207.79	5.10
CAR	0	0	0	217,809.10	21,304.08	194,739.83	369,559.49	2,403,828.32	672.22	2,437.74	2,641.66	3,264.74	3,216,257.18	12.01
Region 1	4,374.63	0	1,467.93	2,030.48	1,691.13	4,378.35	4,905.67	3,704.25	892.08	2,859.79	2,874.98	2,871.67	32,050.96	0.12
Region 2	279.2	73.82	51.61	0	10.25	109.97	156.3	944.61	58.78	1,265.86	1,670.46	1,819.46	6440.32	0.02
Region 3	279,848.18	1,809,183.89	0	1,344,076.60	626,366.99	246,407.70	331,613.98	49,065.38	14,288.58	54,032.95	48,166.12	40,994.90	4,844,045.27	18.09
Region 4A	282,846.18	5,943,932.49	273,669.50	976,186.65	118,569.78	278,059.85	106,116.86	1,171,473.12	31,709.44	117,083.09	127,486.15	111,612.97	9,538,746.08	35.61
Region 4B	0	0	65.17	0	3,211.57	712.65	342.52	480.87	255.5	1,724.59	2,374.41	2,108.76	11276.04	0.04
Region 5	41,127.70	0	639,622.88	8,637.65	26,656.01	23,197.66	498.43	10,565.65	613.95	2,921.80	2,816.47	3,605.26	760,263.46	2.84
Region 6	0	299,290.69	1,299.29	1,950.38	1,133.76	3,643.43	3,773.78	2,998.08	399.34	2,299.21	3,852.46	2,777.01	323417.43	1.21

Region 7	0	0	451,877.11	278,022.55	383,674.06	18,069.68	51,016.18	191,328.01	3,017.31	12,718.34	12,432.67	12,096.72	1414252.63	5.28
Region 8	0	0	508.64	10,674.41	20,777.07	24,044.80	10,892.73	129,992.52	42.88	938.15	1,087.50	1,448.91	200407.61	0.75
Region 9	978.56	8,073.58	688.46	527.33	23,217.20	3,384.50	2,069.54	1,391.26	26.57	242.38	540.07	402.27	41541.72	0.16
Region 10	0	1,983.11	786,482.29	871,931.94	0	9,603.50	14,309.28	18,989.13	3,227.68	10,764.48	11,147.49	11,014.22	1739453.12	6.49
Region 11	101,179.64	55,171.40	116,589.34	120,472.02	4,476.86	1,230,147.51	16,763.83	648,227.49	381.5	2,625.43	2,993.54	3,002.94	2,302,031.50	8.59
Region 12	0	0	280.88	0	406.71	1,417.46	1,689.30	2,077.42	84.94	878.77	1,093.09	1,132.38	9060.95	0.03
Region 13	55,177.92	252,829.17	38,777.00	281,150.20	139,342.63	13,052.48	38,648.86	154,339.68	242.82	1,872.33	1,872.11	1,425.73	978,730.93	3.65
BARMM	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Table 3.F.3. Hazardous Waste Generated, Treated, Cumulative, Multi-Year Treatment Rate, and TSD Facilities in the Philippines (2012-2023).

Spatial Coverage	Year	Generated (tons)	Treated (tons)	Cumulative Generated (tons)	Cumulative Treated (tons)	MTR (%)	TSD Facilities (n)
Philippines	2012	780,522.67	444,358.91	780,522.67	444,358.91	56.93	130
Philippines	2013	8,976,955.99	6,638,379.99	9,757,478.66	7,082,738.90	72.59	127
Philippines	2014	2,498,987.65	962,400.78	12,256,466.31	8,045,139.68	65.64	114
Philippines	2015	4,332,222.34	1,579,719.49	16,588,688.65	9,624,859.17	58.02	123
Philippines	2016	1,485,808.00	603,470.61	18,074,496.65	10,228,329.78	56.59	135
Philippines	2017	2,098,545.27	2,363,934.01	20,173,041.92	12,592,263.79	62.42	128
Philippines	2018	991,256.04	510,659.39	21,164,297.96	13,102,923.18	61.91	132
Philippines	2019	4,823,160.55	10,740,340.85	25,987,458.51	23,843,264.03	91.75	131
Philippines	2020	67,165.80	58,569.14	26,054,624.31	23,901,833.17	91.74	127
Philippines	2021	238,172.09	237,412.88	26,292,796.40	24,139,246.05	91.81	162
Philippines	2022	252,758.66	247,010.66	26,545,555.06	24,386,256.71	91.87	153
Philippines	2023	238,257.92	222,706.01	26,783,812.98	24,608,962.72	91.88	175

Annex 3.G. Oil Pollution Indicator

The dataset for oil pollution was compiled from multiple sources, including academic journals, news articles, and government reports. The volume from major oil spill events were aggregated per year from Table 3.G.2 to provide a comprehensive assessment of their contribution to the available total national data and their potential impact on marine ecosystems.

Table 3.G.1. Total Volume of Recorded Oil Spill in the Philippines from 2000-2021 (Agaton et al., 2023; Alea et al., 2022; NDRRMC, 2024; Yuching, 2024).

Spatial Coverage	Year	Volume	No. of Major Oil Spill (>1,000,00 L)	No. of Incidence with Oil Discharge > 10,000 L
Philippines	2000	76,660	0	2
Philippines	2001	45,014	0	1
Philippines	2002	24,800	0	0
Philippines	2003	14,990	0	0
Philippines	2004	28,750	0	0
Philippines	2005	516,500	0	2
Philippines	2006	2,118,500	1	1
Philippines	2007	17,750	0	0
Philippines	2008	24,100	0	0
Philippines	2009	1,000	0	0
Philippines	2010	11,400	0	0
Philippines	2011	4,710	0	0
Philippines	2012	56,595	0	3
Philippines	2013	1,496,600	0	4
Philippines	2014	15,600	0	0
Philippines	2015	5,000	0	0
Philippines	2016	15,600	0	0
Philippines	2017	22,736	0	0
Philippines	2018	78,615	0	0
Philippines	2019	7,676	0	0
Philippines	2020	269,904	0	1
Philippines	2021	8,787	0	0
Philippines	2022*	269,000	0	1
Philippines	2023*	850,000	0	1
Philippines	2024*	1,450,000	1	1

* Single Oil Spill Event Only as Reported

Table 3.G.2. Assessment of oil pollution contribution to the national data and their potential impact on marine ecosystems (Agaton et al., 2023; Alea et al., 2022; NDRRMC, 2024; Yuching, 2024).

Date	Locality	Region	Volume (liters)	Cause	Relevance to Philippine Waters of SCS-LME
Jan 27, 2000	Lingayen Gulf	I	57,000	The bulk carrier M/V Nol Scheddar ran aground.	Important: Located in Lingayen Gulf facing Philippine Waters of SCS-LME.
Jun 29, 2000	Ilana Bay	ARMM	18,000	A hose that pumps diesel from a tanker to a Caltex depot was sliced by an unidentified assailant.	Not directly relevant
Jul 17, 2001	Davao Gulf	XI	12,500	Singapore-owned container vessel Pacific Eagle collided with M/V Dingalan Bay causing it to sink.	Not directly relevant

Mar 06, 2005	Davao Gulf	XI	128,000	The oil tank of M/V Cala Piccola cracked.	Not directly relevant
Dec 18, 2005	Semirara Island	VI	364,000	NPC Power Barge 106 ran aground that ruptured its tanks.	Not directly relevant
Aug 11, 2006	Guimaras Strait	VI	2,100,000	Oil tanker M/T Solar 1 sank. This was considered the worst oil spill in Philippine history at that time.	Not directly relevant
Feb 21, 2012	La Union	I	10,000	Leaked in the pipeline while M/T Panglao Island was transferring diesel fuel to a Chevron Bulk Plant.	Important: Located in La Union facing Philippine Waters of SCS-LME
Apr 03, 2012	Polilo Island	IV-A	10,000	Leaked in the generator of the NPC's power source.	Not directly relevant
Feb 07, 2012	Mactan Channel	VII	10,000	M/V B & E Uno sank.	Not directly relevant
Feb 17, 2013	Bolinao	I	10,000	M/V Harita Bauxite encountered engine troubles causing it to sink.	Important: Located in Pangasinan facing Philippine Waters of SCS-LME
Aug 08, 2013	Manila Bay, Cavite	IV-A	500,000	Leaked in the submerged pipeline of Petron Corporation.	Important: Manila Bay connects to Philippine Waters of SCS-LME
Aug 16, 2013	Mactan Channel	VII	160,000	Domestic passenger ferry M/V St. Thomas Aquinas collided with M/V Sulpicio Express Siete causing it to sink.	Not directly relevant
Nov 09, 2013	Estancia, Iloilo	VI	800,000	NPC Power Barge 103 dislodged from its mount caused by Super Typhoon Haiyan.	Not directly relevant
Jul 03, 2020	Iloilo Strait	VI	268,949	AC Energy Power Barge 102 exploded.	Not directly relevant
Feb 28, 2023	Off Naujan, Oriental Mindoro	MIMAROPA	800,000-900,000	MT Princess Empress, en route from Bataan to Iloilo, sank after encountering rough seas. The oil spread to parts of Oriental Mindoro, Batangas, Palawan, and Antique.	Important: Affected parts of Palawan which faces Philippine Waters of SCS-LME
Jul 25, 2024	Limay, Bataan (Manila Bay)	III	1,400,000-1,500,000	MT Terra Nova capsized and sank due to rough seas during Typhoon Gaemi. Oil spill spread to multiple provinces along Manila Bay.	Important: Manila Bay connects to Philippine Waters of SCS-LME

Annex 3.H. Atmospheric Deposition Pollution Indicators

The dataset was extracted from the EANET database to compile the complete Philippine wet-deposition and dry concentration time-series (2000 – 2023) for sulfate-S and nitrate-N for all three EANET sites into a single tidy worksheet. Site code: PHA001 (Manila), PHA002 (Los Banos), and PHA003 (Mt. Sto Tomas)

This report summarizes 4-year block averages (2000–2003 … 2020–2023) of wet deposition (SO4-S, NO3-N) and dry concentrations (pSO4, pNO3) at PHA001–PHA003, with overlays of site series against the aggregate (mean across sites). Missing data may imply issues with monitoring equipment.

The Annex includes Tables of summarized data with descriptive statistics: number of valid years (n), completeness (n/4), mean, standard error (SE), standard deviation (SD), median, minimum, and maximum for each site × indicator × block.

Table 3.H.1. Raw Data for Wet Deposition (SO4-S, NO3-N, mmol/m²y) (Network Center for EANET, 2025).

Indicator	Year	Monitoring Stations		
		Manila Observatory	Los Banos	Mt. Sto Tomas
NO3-N	2000	49	14	
NO3-N	2001	42	25	
NO3-N	2002	52	14	
NO3-N	2003	29	8	
NO3-N	2004	33	11	
NO3-N	2005	51	16	
NO3-N	2006	33	18	1
NO3-N	2007	49	19	18
NO3-N	2008	50	15	20
NO3-N	2009	33	23	19
NO3-N	2010	135	65	15
NO3-N	2011	53	20	12
NO3-N	2012	81.37	25.01	35
NO3-N	2013	49	19	37
NO3-N	2014	42	17	18
NO3-N	2015	33	14	21
NO3-N	2016	91.8	67.7	25.5
NO3-N	2017			
NO3-N	2018			
NO3-N	2019	31		
NO3-N	2020	28		
NO3-N	2021	34		
NO3-N	2022	50	20	2
NO3-N	2023	49	17	
SO4-S	2000	94	28	
SO4-S	2001	86	28	
SO4-S	2002	78	27	
SO4-S	2003	38	11	
SO4-S	2004	44	15	

SO4-S	2005	57	16	
SO4-S	2006	47	24	1
SO4-S	2007	78	26	19
SO4-S	2008	59	34	18
SO4-S	2009	51	26	24
SO4-S	2010	54	15	18
SO4-S	2011	68	20	22
SO4-S	2012	107.6	26.53	42
SO4-S	2013	53	16	34
SO4-S	2014	47	19	17
SO4-S	2015	47	21	25
SO4-S	2016	54.7	27	24.4
SO4-S	2017			
SO4-S	2018			
SO4-S	2019	24		
SO4-S	2020	29		
SO4-S	2021	46		
SO4-S	2022	45	33	2
SO4-S	2023	51	39	

Table 3.H.2. Raw Data for Dry Deposition (pSO4, pNO3, mg/L) (Network Center for EANET, 2025).

Indicator	Year	Monitoring Stations		
		Manila Observatory	Los Banos	Mt. Sto Tomas
pNO3	2000	0.074406	0.031002	
pNO3	2001	0.117809	0.086807	
pNO3	2002	0.111609	0.049604	
pNO3	2003	0.080606	0.031002	
pNO3	2004	0.093007	0.037203	
pNO3	2005	0.136411	0.062005	
pNO3	2006	0.074406	0.049604	0.012401
pNO3	2007	0.086807	0.037203	0.031002
pNO3	2008	0.13021	0.049604	0.024802
pNO3	2009	0.055804	0.049604	0.024802
pNO3	2010	0.310025	0.192215	0.024802
pNO3	2011	0.086807	0.049604	0.018601
pNO3	2012	0.112849	0.074406	0.037203
pNO3	2013	0.086807	0.049604	0.049604
pNO3	2014	0.099208	0.049604	0.031002
pNO3	2015	0.080606	0.055804	0.018601
pNO3	2016	0.225698	0.238719	0.035963
pNO3	2017			
pNO3	2018			
pNO3	2019	0.080606		
pNO3	2020	0.068205		

pNO3	2021	0.080606		
pNO3	2022	0.111609	0.055804	0.024802
pNO3	2023	0.086807	0.049604	
pSO4	2000	0.220938	0.105666	
pSO4	2001	0.355422	0.153696	
pSO4	2002	0.249756	0.153696	
pSO4	2003	0.163302	0.067242	
pSO4	2004	0.19212	0.076848	
pSO4	2005	0.230544	0.09606	
pSO4	2006	0.172908	0.105666	0.009606
pSO4	2007	0.211332	0.076848	0.057636
pSO4	2008	0.24015	0.172908	0.028818
pSO4	2009	0.134484	0.086454	0.04803
pSO4	2010	0.19212	0.067242	0.04803
pSO4	2011	0.182514	0.086454	0.04803
pSO4	2012	0.231505	0.124878	0.067242
pSO4	2013	0.14409	0.067242	0.076848
pSO4	2014	0.172908	0.086454	0.04803
pSO4	2015	0.182514	0.124878	0.038424
pSO4	2016	0.20845	0.147932	0.052833
pSO4	2017			
pSO4	2018			
pSO4	2019	0.09606		
pSO4	2020	0.105666		
pSO4	2021	0.172908		
pSO4	2022	0.153696	0.14409	0.038424
pSO4	2023	0.134484	0.172908	

Table 3.H.3. Aggregated across sites — Wet deposition (SO4-S, NO3-N): stats per 4-yr block

Phase	Indicator	Block	n_sites	mean	se	std	median	min	max
wet	NO3-N	2000-2003	2	24.958	13.872	19.618	24.958	11.086	38.83
wet	NO3-N	2004-2007	3	26.165	9.284	16.08	18.467	15.381	44.647
wet	NO3-N	2008-2011	3	42.777	18.959	32.837	33.286	15.731	79.315
wet	NO3-N	2012-2015	3	35.972	11.124	19.268	30.207	20.244	57.464
wet	NO3-N	2016-2019	1	31.007			31.007	31.007	31.007
wet	NO3-N	2020-2023	3	20.392	11.035	19.114	18.492	2.3	40.385
wet	SO4-S	2000-2003	2	42.788	23.223	32.843	42.788	19.565	66.011
wet	SO4-S	2004-2007	3	32.699	13.516	23.411	19.403	18.963	59.73
wet	SO4-S	2008-2011	3	34.302	13.197	22.857	23.299	19.027	60.58
wet	SO4-S	2012-2015	3	40.163	14.878	25.77	30.76	20.415	69.314
wet	SO4-S	2016-2019	1	24.118			24.118	24.118	24.118
wet	SO4-S	2020-2023	3	27.079	12.515	21.676	36.003	2.365	42.868

Table 3.H.4. Aggregated across sites — Dry concentrations (pSO4, pNO3): stats per 4-yr block

Phase	Indicator	Block	n_sites	mean	se	std	median	min	max
dry	pNO3	2000-2003	2	0.955	0.285	0.403	0.955	0.67	1.24
dry	pNO3	2008-2011	2	0.65	0.2	0.283	0.65	0.45	0.85

dry	pNO3	2012-2015	1	0.215			0.215	0.215	0.215
dry	pNO3	2016-2019	2	0.745	0.605	0.856	0.745	0.14	1.35
dry	pNO3	2020-2023	2	1.596	0.069	0.097	1.596	1.527	1.665
dry	pSO4	2000-2003	2	2.105	0.575	0.813	2.105	1.53	2.68
dry	pSO4	2008-2011	2	1.105	0.325	0.46	1.105	0.78	1.43
dry	pSO4	2012-2015	1	0.242			0.242	0.242	0.242
dry	pSO4	2016-2019	2	1.315	1.015	1.435	1.315	0.3	2.33
dry	pSO4	2020-2023	2	3.642	0.307	0.435	3.642	3.335	3.95

Annex 3.I. Methodology for Computing Risk Quotients (RQs) for Pollution Indicators

1. Purpose and Scope

This document provides guidance for using the Risk Quotient (RQ) method to assess water quality. While environmental agencies primarily use standard water quality indices to assess parameters such as dissolved oxygen, nutrients, total suspended solids (TSS), and biochemical oxygen demand (BOD), the RQ method offers an approach for assessing ecological risks associated with specific pollutants. This document thus provides a step-by-step, ready-to-implement procedure to estimate the Risk Quotients (RQs) for the aquatic ecosystem associated with the pollution indicators identified as critical for the Philippines' waters in the South China Sea LME. The approach follows the standard environmental risk paradigm where RQ = (PEC or MEC) ÷ Threshold (PNEC or guideline). See Annex 3.A for raw data on concentrations used for computing the RQs.

2. Key Definitions

- PEC: Predicted Environmental Concentration at the site
- MEC: Measured Environmental Concentration at the site
- PNEC/Threshold: environmental concentration protective of aquatic life or a relevant guideline/criterion.
- RQ (Risk Quotient): (PEC or MEC) ÷ PNEC. RQ > 1 indicates potential risk that may require management decision to take action.
- Risk Band Thresholds: Typically, RQ ≤ 1 is acceptable (no risk indicated) and RQ > 1 is a potential risk (ECHA, 2008), for management prioritization in this project, the following risk bands are used:

Table 3.I.1. Risk Quotient

Risk Band	RQ Threshold	Interpretation
Green	≤ 0.5	Low concern
Yellow	> 0.5 – 1	Watch / near threshold
Orange	> 1 – 3	Moderate to high; investigate sources
Red	> 3 – 10	High to very high; action most likely
Dark Red	> 10	Very high; immediate action

3. Step-by-step Procedure

1. Select indicator(s) from the compiled pollution indicators database (e.g., nitrate, ammonia, phosphate, dissolved oxygen, total suspended solids, fecal coliform, and plastic pollution—see Annex 3.1).
2. Compile site measurements or reported data as MEC values. PEC values are estimated from the sample statistics. For a reasonable worst-case scenario, the 95th percentile of the computed risk quotients is used for the computation. Handle non-detects using half the detection limit unless the project policy specifies otherwise
3. Choose the most conservative threshold source for PNEC from the following sources: (a) Philippine marine WQG for the water class (DENR, 2016; updated items per DENR, 2021); (b) ASEAN AMWQC for aquatic-life protection (ASEAN Secretariat, 2008); (c) peer-reviewed PNEC from authoritative frameworks (ECHA, 2008; US EPA, 1985).
4. Ensure unit consistency (e.g., convert ASEAN nutrient criteria in µg/L to mg/L or vice versa).
5. Compute RQ = (PEC or MEC) ÷ Threshold for each record. Note that for Dissolved Oxygen as an indicator, the inverse is used to compute the RQ.
6. Assign management bands (see Table 3.I.1). ECHA (2008) considers RQ ≤ 1 acceptable; project bands further prioritize actions.
7. Aggregate and map results (e.g., by site category). Flag any indicators with RQ > 1 or repeated exceedances.

8. Estimate the 95th percentile RQ in each indicator for different sites as the reasonable worst-case (rwc) scenario.
9. Document assumptions, detection limits, and any conversions performed.

4. Worked example

Example: PEC for nitrate (as NO_3-N) = 0.80 mg/L at a Class SB site. Threshold choices:

- PH WQG (SB): 10 mg/L → RQ = 0.80 / 10 = 0.08 (Green). (DENR, 2016)
- ASEAN AMWQC: 60 µg/L = 0.060 mg/L → RQ = 0.80 / 0.060 ≈ 13.3 (Red). (ASEAN Secretariat, 2008)
- For a conservative risk estimate, such as for a reasonable worst-case scenario, use ASEAN AMWC. The national ambient WQG indicates compliance, but the ASEAN ecological criterion signals a sensitivity concern; both could be reported transparently depending on the management context.

5. Summary of Results

The risk quotient (RQ) analysis provides a quantitative basis for evaluating pollution risks across sites and indicators. Using site-specific measured concentrations, we derived central tendencies and extreme values, and then translated these into risk quotients relative to predicted no-effect concentrations (PNECs).

For most indicators, the reasonable worst-case (RWC) condition was represented by the 95th percentile RQ (RQ_p95). These statistics allow us to distinguish typical risk levels (median RQ) from worst-case scenarios.

The traffic-light classification highlights distinct spatial and indicator-specific patterns:

- Red and Dark Red bands dominate in Manila Bay and Lingayen Gulf, especially for fecal coliforms, nutrients (nitrate, phosphate), and TSS, indicating frequent exceedances of ecological thresholds.
- Batangas Bay and VIP show elevated risks for BOD, heavy metals (lead, cadmium), and oil-related parameters, reflecting industrial activity.
- Palawan West Coast generally falls in the Green–Yellow bands, except for localized hotspots (microbial contamination in Bacuit Bay).
- Rivers (PW) exhibit extreme values in microbial and nutrient indicators, with RQ_p95 exceeding Dark Red thresholds, signifying high pollution loading from upstream catchments.

Overall, the RQ analysis confirms that nutrient enrichment, organic pollution, and microbial contamination remain the highest risk concerns in Philippine coastal waters, with emerging risks from microplastics and metals. The traffic-light pivots offer a transparent, visual tool for prioritizing management interventions and aligning them with hotspot-specific conditions.

Table 3.I.2. PNEC Values based on DENR and ASEAN Water Quality Standard (DENR Administrative Order 2016-08, DENR Administrative Order 2021-19*, DENR Administrative Order No. 34 s. 1990**, ASEAN Marine Water Quality Management Guidelines and Monitoring).

PARAMETER	Unit	PNEC VALUES FOR WATER QUALITY									
		ASEAN Marine WQC	DENR (Marine Water)				DENR (Freshwater)				
			SA	SB	SC	SD	AA	A	B	C	D
Nitrate	mg/L	0.06	10	10	10	15	7	7	7	7	15
Nitrite	mg/L	0.055	-	-	-	-	-	-	-	-	-
Ammonia	mg/L	0.07	0.04*	0.06*	0.06*	0.3*	0.06*	0.06*	0.06*	0.06*	0.3*
Phosphate	mg/L	0.015/0.045 (coastal/estuarine)	0.1*	0.2*	0.2*	0.4*	0.025*	0.025*	0.025*	0.025*	0.05*
BOD	mg/L	-	3**	5**	7**	-	1	3	5	7	15
DO (minimum)	mg/L	4	6	6	5	2	5	5	5	5	2
Fecal Coliform	MPN/100mL	100	20*	100*	200*	400*	20*	50*	100*	200*	400*
Total Coliform**	MPN/100mL	-	70	1000	5000	-	50	1000	1000	5000	-
TSS	mg/L	Permissible 10% maximum increase over seasonal average concentration.	25	50	80	110	25	50	65	80	110
Oil and grease	mg/L	0.14	1	2	3	5	<1	1	1	2	5
Arsenic	mg/L		0.01	0.01	0.02	0.04	0.01	0.01	0.01	0.02	0.04
Cadmium	mg/L	0.01	0.003	0.003	0.005	0.01	0.003	0.003	0.003	0.005	0.01
Chromium (VI)	mg/L	0.05	0.05	0.05	0.05	0.1	0.01	0.01	0.01	0.01	0.02
Copper	mg/L	0.008	0.2*	0.2*	0.2*	0.4*	0.2*	0.2*	0.2*	0.2*	0.4*
Iron	mg/L		1.5	1.5	1.5	7.5	1	1	1	1.5	7.5
Lead	mg/L	0.0085	0.01	0.01	0.05	0.1	0.01	0.01	0.01	0.05	0.1
Zinc	mg/L		0.04	0.05	0.8	1.5	2	2	2	2	4
Mercury	mg/L	0.00016	0.001	0.001	0.002	0.004	0.001	0.001	0.001	0.002	0.004

Table 3.I.3. PNEC Values for General Effluent Standard on Fecal Coliform based on DENR Administrative Order 2021-19
NDA – No Discharge Allowed

Parameter	Unit	DENR (Marine Water)				DENR (Freshwater)				
		SA	SB	SC	SD	AA	A	B	C	D
Fecal Coliform	MPN/100mL	NDA	200	400	800	NDA	100	200	400	800

Table 3.I.4. PNEC Value for Microplastics in Waterbodies based from Mehinto et al. (2022)

Parameter	Unit	Threshold
Microplastics	particles/m^3	300

Summary Tables and Heat Map for Risk Quotients (RQ)

This section provides the summary table for computations of RQ as mentioned above, and obtaining the median, minimum, maximum, 95th percentile of the RQs. The 95th percentile is considered the reasonable worst-case scenario (rwc).

Table 3.I.5. Computed RQs based on DENR Water Quality Standards for Pollution Hotspots.

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP (Hotspots)	BOD	mg/L	5	0.9	0.69	1.3	1.3	1.3
Batangas Bay and VIP (Hotspots)	DO	mg/L	13	0.83	0.62	0.96	0.95	0.95
Batangas Bay and VIP (Hotspots)	Fecal Coliform	MPN/100mL	3	15	7.5	20	20	20
Batangas Bay and VIP (Hotspots)	Total Coliform	MPN/100mL	7	0.7	0.021	17	14	14
Batangas Bay and VIP (Hotspots)	Cadmium	mg/L	1	25	25	25	25	25
Batangas Bay and VIP (Hotspots)	Chromium	mg/L	1	1.3	1.3	1.3	1.3	1.3
Batangas Bay and VIP (Hotspots)	Lead	mg/L	7	32	2.5	37	37	37
Batangas Bay and VIP (Hotspots)	Nitrate	mg/L	8	0.0015	0	0.029	0.02	0.02
Batangas Bay and VIP (Hotspots)	Phosphate	mg/L	2	1.3	0	2.7	2.5	2.5
Batangas Bay and VIP (Hotspots)	TSS	mg/L	9	0.2	0.013	0.44	0.44	0.44
Lingayen Gulf (Hotspot)	DO	mg/L	4	1.8	0.59	2.4	2.4	2.4
Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100mL	2	40	0.1	80	76	76
Lingayen Gulf (Hotspot)	Nitrate	mg/L	7	0.023	0	0.091	0.077	0.077
Lingayen Gulf (Hotspot)	Phosphate	mg/L	12	0.25	0	1.5	1.3	1.3
Lingayen Gulf (Hotspot)	TSS	mg/L	2	4.1	0.0063	8.1	7.7	7.7
Manila Bay (Hotspot)	BOD	mg/L	6	0.72	0.56	1.2	1.2	1.2
Manila Bay (Hotspot)	DO	mg/L	54	1.2	0.76	2.6	2.3	2.3
Manila Bay (Hotspot)	Fecal Coliform	MPN/100mL	36	1.6	0.01	600	110	110
Manila Bay (Hotspot)	Total Coliform	MPN/100mL	15	4	0.22	26	17	17
Manila Bay (Hotspot)	Cadmium	mg/L	16	700	0.067	19000	17000	17000
Manila Bay (Hotspot)	Chromium	mg/L	10	5.6	0.2	18	13	13
Manila Bay (Hotspot)	Lead	mg/L	16	30	0.78	74	71	71
Manila Bay (Hotspot)	Mercury	mg/L	6	0.7	0.4	2.2	1.9	1.9
Manila Bay (Hotspot)	Nitrate	mg/L	34	0.017	0.0016	0.25	0.22	0.22
Manila Bay (Hotspot)	Phosphate	mg/L	34	0.92	0.054	4.4	3.6	3.6
Manila Bay (Hotspot)	TSS	mg/L	25	0.74	0.12	3.6	3	3
Manila Bay (Hotspot)	microplastics	pc/m3	4	0.3	0.25	84	71	71
Other Sites	DO	mg/L	5	1.4	1	1.8	1.8	1.8
Other Sites	Fecal Coliform	MPN/100mL	6	1.8	0.36	7.8	7	7
Other Sites	Total Coliform	MPN/100mL	3	0.077	0.018	0.1	0.099	0.099
Palawan West Coast	DO	mg/L	44	0.88	0.66	1.6	1.1	1.1
Palawan West Coast	Fecal Coliform	MPN/100mL	81	0.17	0.0045	4600	540	540
Palawan West Coast	Total Coliform	MPN/100mL	4	1.1	0.59	54	46	46
Palawan West Coast	Phosphate	mg/L	20	0.095	0.05	0.15	0.13	0.13
Palawan West Coast	TSS	mg/L	20	0.42	0.25	1.8	1.7	1.7

Note: RQ_median - median of RQ values
RQ_min – minimum from the RQ values
RQ_max – maximum from the RQ values
RQ_p95 – 95th percentile of the computed values
RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.I.6. Computed RQs based on ASEAN Water Quality Standards for Pollution Hotspots.

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP (Hotspots)	DO	mg/L	13	0.6	0.41	0.67	0.65	0.65
Batangas Bay and VIP (Hotspots)	Fecal Coliform	MPN/100mL	3	15	7.5	20	20	20
Batangas Bay and VIP (Hotspots)	Cadmium	mg/L	1	12	12	12	12	12
Batangas Bay and VIP (Hotspots)	Chromium	mg/L	1	1.3	1.3	1.3	1.3	1.3
Batangas Bay and VIP (Hotspots)	Lead	mg/L	7	40	15	44	43	43
Batangas Bay and VIP (Hotspots)	Nitrate	mg/L	8	0.25	0	4.8	3.4	3.4
Batangas Bay and VIP (Hotspots)	Phosphate	mg/L	2	1.8	0	3.6	3.4	3.4
Lingayen Gulf (Hotspot)	DO	mg/L	4	1.5	0.47	1.9	1.9	1.9
Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100mL	2	80	0.2	160	150	150
Lingayen Gulf (Hotspot)	Nitrate	mg/L	7	3.9	0	15	13	13
Lingayen Gulf (Hotspot)	Phosphate	mg/L	12	0.34	0	2	1.7	1.7
Manila Bay (Hotspot)	DO	mg/L	54	0.77	0.51	1.7	1.5	1.5
Manila Bay (Hotspot)	Fecal Coliform	MPN/100mL	36	1.6	0.01	600	110	110
Manila Bay (Hotspot)	Cadmium	mg/L	16	210	0.02	5700	5000	5000
Manila Bay (Hotspot)	Chromium	mg/L	10	5.6	0.2	18	13	13
Manila Bay (Hotspot)	Lead	mg/L	16	36	0.92	87	84	84
Manila Bay (Hotspot)	Mercury	mg/L	6	4.4	2.5	14	12	12
Manila Bay (Hotspot)	Nitrate	mg/L	34	2.8	0.27	41	36	36
Manila Bay (Hotspot)	Phosphate	mg/L	34	1.2	0.072	5.8	4.8	4.8
Manila Bay (Hotspot)	microplastics	pc/m3	4	0.3	0.25	84	71	71
Other Sites	DO	mg/L	5	0.95	0.69	1.2	1.2	1.2
Other Sites	Fecal Coliform	MPN/100mL	6	1.8	0.36	7.8	7	7
Palawan West Coast	DO	mg/L	44	0.59	0.44	1.1	0.74	0.74
Palawan West Coast	Fecal Coliform	MPN/100mL	81	0.07	0.009	31	14	14
Palawan West Coast	Phosphate	mg/L	20	0.13	0.067	0.2	0.18	0.18

Note: RQ_median - median of RQ values
RQ_min – minimum from the RQ values
RQ_max – maximum from the RQ values
RQ_p95 – 95th percentile of the computed values
RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.I.7. Computed RQs based on DENR Water Quality Standards for Selected Rivers in the Philippines

Site Category	Indicator	Unit	count	RQ_med.	RQ_min	RQ_max	RQ_p95	RQ_rwc	Drains to PH Waters of SCS-LME
Abra River	BOD	mg/L	3	0.25	0.2	0.27	0.27	0.27	Yes
Abra River	DO	mg/L	8	0.57	0.39	0.68	0.67	0.67	Yes
Abra River	Fecal Coliform	MPN/100mL	2	180	41	310	300	300	Yes
Abra River	Nitrate	mg/L	3	2.4	0.0057	8.3	7.7	7.7	Yes
Abra River	Phosphate	mg/L	3	2	1.2	2.4	2.4	2.4	Yes
Abra River	TSS	mg/L	3	0.84	0.07	2.2	2.1	2.1	Yes

Agno River	BOD	mg/L	13	0.26	0.2	1.4	1.3	1.3	Yes
Agno River	DO	mg/L	19	0.54	0.35	0.87	0.75	0.75	Yes
Agno River	Fecal Coliform	MPN/100mL	3	120	5.4	180	180	180	Yes
Agno River	Nitrate	mg/L	2	1.7	0.031	3.4	3.2	3.2	Yes
Agno River	Phosphate	mg/L	3	2.8	1.6	3.6	3.5	3.5	Yes
Agno River	TSS	mg/L	3	0.6	0.066	1.4	1.3	1.3	Yes
Amburayan River	BOD	mg/L	15	0.22	0.14	0.83	0.78	0.78	Yes
Amburayan River	DO	mg/L	20	0.55	0.37	0.7	0.68	0.68	Yes
Amburayan River	Fecal Coliform	MPN/100mL	3	990	120	1200	1200	1200	Yes
Amburayan River	Nitrate	mg/L	3	0.59	0.11	2.1	1.9	1.9	Yes
Amburayan River	Phosphate	mg/L	3	1.6	1.2	2	2	2	Yes
Amburayan River	TSS	mg/L	3	0.2	0.17	0.29	0.28	0.28	Yes
Angat River	BOD	mg/L	11	1.3	0.37	2.2	1.8	1.8	Yes
Angat River	DO	mg/L	14	1.1	0.7	1.4	1.3	1.3	Yes
Angat River	Fecal Coliform	MPN/100mL	3	150	1	190	190	190	Yes
Angat River	Nitrate	mg/L	3	0.099	0.037	0.15	0.14	0.14	Yes
Angat River	Phosphate	mg/L	3	6.4	5.2	8.8	8.6	8.6	Yes
Angat River	TSS	mg/L	3	0.2	0.19	0.46	0.44	0.44	Yes
Asin Gallano River	BOD	mg/L	17	0.22	0.18	0.69	0.5	0.5	Yes
Asin Gallano River	DO	mg/L	20	0.55	0.25	0.76	0.73	0.73	Yes
Asin Gallano River	Fecal Coliform	MPN/100mL	3	460	99	600	590	590	Yes
Asin Gallano River	Nitrate	mg/L	3	1	0.014	1.6	1.5	1.5	Yes
Asin Gallano River	Phosphate	mg/L	3	4.8	2.8	6	5.9	5.9	Yes
Asin Gallano River	TSS	mg/L	3	0.35	0.19	1.1	1.1	1.1	Yes
Atlag River	BOD	mg/L	5	3.1	2.3	3.7	3.5	3.5	Yes
Atlag River	DO	mg/L	2	2.4	2.2	2.7	2.7	2.7	Yes
Atlag River	Fecal Coliform	MPN/100mL	2	1900	1500	2300	2300	2300	Yes
Atlag River	Nitrate	mg/L	2	0.034	0.031	0.037	0.037	0.037	Yes
Atlag River	Phosphate	mg/L	2	24	18	30	30	30	Yes
Atlag River	TSS	mg/L	2	0.4	0.28	0.53	0.52	0.52	Yes
Balili River	BOD	mg/L	15	7.5	1.4	14	13	13	Yes
Balili River	DO	mg/L	20	0.9	0.51	1.6	1.1	1.1	Yes
Balili River	Fecal Coliform	MPN/100mL	3	4200000000	2000000000	38000000000	35000000000	35000000000	Yes
Balili River	Nitrate	mg/L	2	0.097	0.097	0.097	0.097	0.097	Yes
Balili River	Phosphate	mg/L	3	48	27	69	67	67	Yes
Balili River	TSS	mg/L	3	0.3	0.28	1.2	1.1	1.1	Yes
Bocaue River	BOD	mg/L	21	1.7	0.36	5.6	5.2	5.2	Yes
Bocaue River	DO	mg/L	23	1.9	0.63	4.5	3.3	3.3	Yes
Bocaue River	Fecal Coliform	MPN/100mL	3	3200	900	3700	3700	3700	Yes
Bocaue River	Nitrate	mg/L	2	0.12	0.1	0.13	0.13	0.13	Yes
Bocaue River	Phosphate	mg/L	3	110	49	120	120	120	Yes
Bocaue River	TSS	mg/L	3	0.47	0.3	0.49	0.49	0.49	Yes
Bued River	BOD	mg/L	18	0.44	0	3.1	2.6	2.6	Yes
Bued River	DO	mg/L	23	0.59	0.45	100	0.78	0.78	Yes

Bued River	Fecal Coliform	MPN/100mL	2	13000	13000	13000	13000	13000	Yes
Bued River	Nitrate	mg/L	1	1.1	1.1	1.1	1.1	1.1	Yes
Bued River	Phosphate	mg/L	2	21	17	25	25	25	Yes
Bued River	TSS	mg/L	3	2	1.8	2.1	2.1	2.1	Yes
Cagayan River	BOD	mg/L	15	0.29	0.14	1.1	0.6	0.6	No
Cagayan River	DO	mg/L	21	0.69	0.53	0.83	0.78	0.78	No
Cagayan River	Fecal Coliform	MPN/100mL	3	19	11	25	25	25	No
Cagayan River	Nitrate	mg/L	3	0.033	0.013	0.033	0.033	0.033	No
Cagayan River	Phosphate	mg/L	3	3.2	3.2	3.6	3.6	3.6	No
Cagayan River	TSS	mg/L	3	0.86	0.61	1.1	1.1	1.1	No
Calao-Delinquente River System	BOD	mg/L	2	0.38	0.38	0.38	0.38	0.38	No
Calapan River	BOD	mg/L	17	1.3	0.55	2.4	2.2	2.2	No
Calapan River	DO	mg/L	19	1.9	1.2	5.6	4.3	4.3	No
Calapan River	Fecal Coliform	MPN/100mL	3	440	210	520	510	510	No
Calapan River	Nitrate	mg/L	2	0.16	0.064	0.25	0.24	0.24	No
Calapan River	Phosphate	mg/L	3	18	10	20	19	19	No
Calapan River	TSS	mg/L	3	0.2	0.18	0.2	0.2	0.2	No
Calumpang River	BOD	mg/L	6	2	0.61	8	6.8	6.8	Yes
Calumpang River	DO	mg/L	3	0.98	0.95	2.3	2.1	2.1	Yes
Calumpang River	Fecal Coliform	MPN/100mL	3	76	49	180	170	170	Yes
Calumpang River	Nitrate	mg/L	3	0.14	0.1	0.29	0.27	0.27	Yes
Calumpang River	Phosphate	mg/L	3	59	38	98	94	94	Yes
Calumpang River	TSS	mg/L	3	0.42	0.28	0.43	0.43	0.43	Yes
Canas River	BOD	mg/L	11	0.66	0.42	1.1	1.1	1.1	Yes
Canas River	DO	mg/L	12	0.83	0.71	0.94	0.93	0.93	Yes
Canas River	Fecal Coliform	MPN/100mL	3	910	700	1000	1000	1000	Yes
Canas River	Nitrate	mg/L	3	0.17	0.16	0.29	0.28	0.28	Yes
Canas River	Phosphate	mg/L	3	44	28	50	50	50	Yes
Canas River	TSS	mg/L	3	0.81	0.66	1	0.99	0.99	Yes
Canas River	microplastics	pc/m3	3	26	5.3	960	870	870	Yes
Dagupan River	BOD	mg/L	7	0.86	0.47	1.2	1.2	1.2	Yes
Dagupan River	DO	mg/L	10	1.2	1	1.4	1.4	1.4	Yes
Diadi River System	BOD	mg/L	2	0.3	0.21	0.38	0.37	0.37	No
Guagua River	BOD	mg/L	10	3.5	0.23	7.3	6.1	6.1	Yes
Guagua River	DO	mg/L	11	1.6	0.88	5	4	4	Yes
Guagua River	Fecal Coliform	MPN/100mL	3	4800	1500	5100	5000	5000	Yes
Guagua River	Nitrate	mg/L	3	0.029	0.024	0.056	0.053	0.053	Yes
Guagua River	Phosphate	mg/L	3	48	48	64	62	62	Yes
Guagua River	TSS	mg/L	3	0.46	0.31	0.47	0.47	0.47	Yes
Hagonoy River	BOD	mg/L	5	1.8	1.1	4	3.7	3.7	Yes
Hagonoy River	DO	mg/L	3	1.5	1.3	2.3	2.2	2.2	Yes
Hagonoy River	Fecal Coliform	MPN/100mL	3	540	380	960	910	910	Yes
Hagonoy River	Nitrate	mg/L	3	0.063	0.054	0.077	0.076	0.076	Yes
Hagonoy River	Phosphate	mg/L	3	12	9.2	12	12	12	Yes

Hagonoy River	TSS	mg/L	3	0.53	0.52	0.62	0.61	0.61	Yes
Imus River	BOD	mg/L	17	1.5	0.81	2.7	2.3	2.3	Yes
Imus River	DO	mg/L	17	0.97	0.37	1.7	1.3	1.3	Yes
Imus River	Fecal Coliform	MPN/100mL	3	2300	890	4000	3800	3800	Yes
Imus River	Nitrate	mg/L	3	0.17	0.17	0.25	0.25	0.25	Yes
Imus River	Phosphate	mg/L	3	62	59	64	64	64	Yes
Imus River	TSS	mg/L	3	0.67	0.55	1.6	1.5	1.5	Yes
Labangan River	BOD	mg/L	6	1.7	1	2.6	2.5	2.5	Yes
Labangan River	DO	mg/L	3	1.5	1.2	1.9	1.9	1.9	Yes
Labangan River	Fecal Coliform	MPN/100mL	3	330	110	410	400	400	Yes
Labangan River	Nitrate	mg/L	3	0.054	0.043	0.066	0.065	0.065	Yes
Labangan River	Phosphate	mg/L	3	8.8	8.4	16	15	15	Yes
Labangan River	TSS	mg/L	3	0.39	0.29	0.67	0.64	0.64	Yes
Las Pinas-Paranaque River System	BOD	mg/L	3	6.2	6	8.6	8.4	8.4	Yes
Las Pinas-Paranaque River System	DO	mg/L	3	38	7.5	63	60	60	Yes
Las Pinas-Paranaque River System	Fecal Coliform	MPN/100mL	3	220000	110000	250000	250000	250000	Yes
Las Pinas-Paranaque River System	Nitrate	mg/L	3	0.041	0.027	0.06	0.058	0.058	Yes
Las Pinas-Paranaque River System	Phosphate	mg/L	3	90	71	91	91	91	Yes
Las Pinas-Paranaque River System	TSS	mg/L	1	0.69	0.69	0.69	0.69	0.69	Yes
Madlum River	BOD	mg/L	3	0.46	0.45	0.65	0.63	0.63	Yes
Madlum River	DO	mg/L	1	0.7	0.7	0.7	0.7	0.7	Yes
Madlum River	Fecal Coliform	MPN/100mL	1	56	56	56	56	56	Yes
Madlum River	Nitrate	mg/L	1	0.034	0.034	0.034	0.034	0.034	Yes
Madlum River	Phosphate	mg/L	1	2.8	2.8	2.8	2.8	2.8	Yes
Madlum River	TSS	mg/L	1	0.22	0.22	0.22	0.22	0.22	Yes
Marikina River	BOD	mg/L	13	3.6	1.7	6	5.2	5.2	Yes
Marikina River	DO	mg/L	8	1.4	0.99	2.3	2.3	2.3	Yes
Marilao River	BOD	mg/L	21	4.2	1.2	7.4	6.4	6.4	Yes
Marilao River	DO	mg/L	22	2.4	0.93	6.3	5.2	5.2	Yes
Marilao River	Fecal Coliform	MPN/100mL	3	9300	8500	12000	12000	12000	Yes
Marilao River	Nitrate	mg/L	3	0.067	0.044	0.076	0.075	0.075	Yes
Marilao River	Phosphate	mg/L	3	74	48	76	76	76	Yes
Marilao River	TSS	mg/L	3	0.41	0.29	0.51	0.5	0.5	Yes
Meycauayan River	BOD	mg/L	21	8.4	5.1	21	17	17	Yes
Meycauayan River	DO	mg/L	22	4.4	0.73	100	11	11	Yes
Meycauayan River	Fecal Coliform	MPN/100mL	3	30000	29000	370000	340000	340000	Yes
Meycauayan River	Nitrate	mg/L	3	0.033	0.024	0.06	0.057	0.057	Yes
Meycauayan River	Phosphate	mg/L	3	73	61	77	77	77	Yes
Meycauayan River	TSS	mg/L	3	0.39	0.35	0.4	0.4	0.4	Yes
Meycauayan River	microplastics	pc/m3	2	96	0.64	190	180	180	Yes
Meycauayan-Valenzuela River System	BOD	mg/L	10	9.6	5.8	11	11	11	Yes
Meycauayan-Valenzuela River System	DO	mg/L	12	6.1	1.3	100	73	73	Yes

Meycauayan-Valenzuela River System	Fecal Coliform	MPN/100mL	3	180000	110000	1000000	960000	960000	Yes
Meycauayan-Valenzuela River System	Nitrate	mg/L	2	0.032	0.01	0.054	0.052	0.052	Yes
Meycauayan-Valenzuela River System	Phosphate	mg/L	2	76	55	97	95	95	Yes
Meycauayan-Valenzuela River System	TSS	mg/L	1	0.59	0.59	0.59	0.59	0.59	Yes
Naguilian River System	BOD	mg/L	4	0.32	0.28	0.56	0.53	0.53	Yes
Naguilian River System	DO	mg/L	1	0.54	0.54	0.54	0.54	0.54	Yes
Naguilian River System	Fecal Coliform	MPN/100mL	1	16	16	16	16	16	Yes
Naguilian River System	Nitrate	mg/L	1	0.061	0.061	0.061	0.061	0.061	Yes
Naguilian River System	Phosphate	mg/L	1	3.6	3.6	3.6	3.6	3.6	Yes
Naguilian River System	TSS	mg/L	1	0.2	0.2	0.2	0.2	0.2	Yes
NMTT River System	BOD	mg/L	6	6	4.9	7.1	7	7	Yes
NMTT River System	DO	mg/L	20	2.8	1.4	100	100	100	Yes
NMTT River System	Fecal Coliform	MPN/100mL	3	170000	55000	240000	230000	230000	Yes
NMTT River System	Nitrate	mg/L	3	0.063	0.033	0.14	0.13	0.13	Yes
NMTT River System	Phosphate	mg/L	3	57	55	72	71	71	Yes
NMTT River System	TSS	mg/L	1	0.64	0.64	0.64	0.64	0.64	Yes
Obando River	BOD	mg/L	13	4.4	1.4	22	12	12	Yes
Obando River	DO	mg/L	14	1.8	0.96	3.8	3.7	3.7	Yes
Obando River	Fecal Coliform	MPN/100mL	3	710	510	2100	2000	2000	Yes
Obando River	Nitrate	mg/L	3	0.041	0.021	0.057	0.056	0.056	Yes
Obando River	Phosphate	mg/L	3	29	29	180	160	160	Yes
Obando River	TSS	mg/L	3	0.35	0.3	0.37	0.37	0.37	Yes
Pampanga River	BOD	mg/L	17	1.3	0.25	7.5	4.3	4.3	Yes
Pampanga River	DO	mg/L	21	0.93	0.69	1.7	1.5	1.5	Yes
Pampanga River	Fecal Coliform	MPN/100mL	3	110	100	140	140	140	Yes
Pampanga River	Nitrate	mg/L	3	0.094	0.056	0.16	0.15	0.15	Yes
Pampanga River	Phosphate	mg/L	3	10	7.2	10	10	10	Yes
Pampanga River	TSS	mg/L	3	0.66	0.48	0.83	0.82	0.82	Yes
Pansipit River	BOD	mg/L	13	0.33	0.17	0.81	0.73	0.73	Yes
Pansipit River	DO	mg/L	13	0.75	0.59	1.2	1.1	1.1	Yes
Pansipit River	Fecal Coliform	MPN/100mL	3	7	2.8	21	19	19	Yes
Pansipit River	Nitrate	mg/L	3	0.061	0.05	0.071	0.07	0.07	Yes
Pansipit River	Phosphate	mg/L	3	29	26	32	32	32	Yes
Pansipit River	TSS	mg/L	3	0.28	0.17	0.33	0.33	0.33	Yes
Paranaque River	BOD	mg/L	20	6.1	4.2	8.7	8.4	8.4	Yes
Paranaque River	DO	mg/L	23	5.6	1.5	100	100	100	Yes
Paranaque River	Fecal Coliform	MPN/100mL	2	300000	250000	360000	350000	350000	Yes
Paranaque River	Nitrate	mg/L	2	0.076	0.06	0.093	0.091	0.091	Yes
Paranaque River	Phosphate	mg/L	2	62	17	110	100	100	Yes
Paranaque River	TSS	mg/L	1	0.58	0.58	0.58	0.58	0.58	Yes
Paranaque River	microplastics	pc/m3	2	50	17	84	80	80	Yes
Pasig River	BOD	mg/L	11	3.5	1.5	8.1	8	8	Yes
Pasig River	DO	mg/L	14	1.7	1	2.3	2.3	2.3	Yes

Pasig River	microplastics	pc/m3	3	11	0.0044	57	52	52	Yes
Pinacanauan de Tuguigarao	BOD	mg/L	5	0.16	0.15	0.21	0.21	0.21	No
Pinacanauan de Tuguigarao	DO	mg/L	8	0.62	0.34	0.89	0.83	0.83	No
Pinacanauan de Tuguigarao	Fecal Coliform	MPN/100mL	1	0.5	0.5	0.5	0.5	0.5	No
Pinacanauan de Tuguigarao	Nitrate	mg/L	1	0.017	0.017	0.017	0.017	0.017	No
Pinacanauan de Tuguigarao	Phosphate	mg/L	1	1.6	1.6	1.6	1.6	1.6	No
Pinacanauan de Tuguigarao	TSS	mg/L	1	0.074	0.074	0.074	0.074	0.074	No
Pinamalayan River	BOD	mg/L	5	0.7	0.54	1.8	1.7	1.7	No
Pinamalayan River	DO	mg/L	2	1.2	1	1.3	1.3	1.3	No
Pinamalayan River	Fecal Coliform	MPN/100mL	2	72	16	130	120	120	No
Pinamalayan River	Nitrate	mg/L	2	0.073	0.049	0.097	0.095	0.095	No
Pinamalayan River	Phosphate	mg/L	2	5.2	4.8	5.6	5.6	5.6	No
Pinamalayan River	TSS	mg/L	2	0.2	0.2	0.21	0.21	0.21	No
Pugo River	BOD	mg/L	5	0.19	0.18	0.2	0.2	0.2	Yes
Pugo River	Fecal Coliform	MPN/100mL	2	130	25	240	230	230	Yes
Pugo River	Nitrate	mg/L	2	0.68	0.21	1.2	1.1	1.1	Yes
Pugo River	Phosphate	mg/L	2	2	2	2	2	2	Yes
Pugo River	TSS	mg/L	2	0.11	0.062	0.15	0.15	0.15	Yes
Rio Grande River	BOD	mg/L	10	0.84	0.52	1.4	1.2	1.2	Yes
Rio Grande River	DO	mg/L	11	0.82	0.76	1.1	1	1	Yes
Rio Grande River	Fecal Coliform	MPN/100mL	3	670	520	1000	1000	1000	Yes
Rio Grande River	Nitrate	mg/L	3	0.31	0.22	0.45	0.44	0.44	Yes
Rio Grande River	Phosphate	mg/L	3	41	33	45	45	45	Yes
Rio Grande River	TSS	mg/L	3	0.69	0.44	0.79	0.78	0.78	Yes
San Juan River System	BOD	mg/L	13	7.8	4.8	11	10	10	Yes
San Juan River System	DO	mg/L	18	3.7	1.6	100	100	100	Yes
San Juan River System	Fecal Coliform	MPN/100mL	3	350000	150000	650000	620000	620000	Yes
San Juan River System	Nitrate	mg/L	3	0.026	0.016	0.046	0.044	0.044	Yes
San Juan River System	Phosphate	mg/L	3	93	88	97	96	96	Yes
San Juan River System	TSS	mg/L	1	0.57	0.57	0.57	0.57	0.57	Yes
San Miguel River	BOD	mg/L	3	0.92	0.52	1.4	1.4	1.4	Yes
San Miguel River	DO	mg/L	1	0.86	0.86	0.86	0.86	0.86	Yes
San Miguel River	Fecal Coliform	MPN/100mL	1	560	560	560	560	560	Yes
San Miguel River	Nitrate	mg/L	1	0.064	0.064	0.064	0.064	0.064	Yes
San Miguel River	Phosphate	mg/L	1	6.8	6.8	6.8	6.8	6.8	Yes
San Miguel River	TSS	mg/L	1	0.77	0.77	0.77	0.77	0.77	Yes
Sinocalan River	BOD	mg/L	1	0.73	0.73	0.73	0.73	0.73	Yes
Sinocalan River	DO	mg/L	1	0.86	0.86	0.86	0.86	0.86	Yes
Sinuculan-Dagupan River	BOD	mg/L	7	0.61	0.54	1.7	1.6	1.6	Yes
Sinuculan-Dagupan River	DO	mg/L	8	0.89	0.74	0.96	0.96	0.96	Yes
Sinuculan-Dagupan River	Fecal Coliform	MPN/100mL	1	44	44	44	44	44	Yes
Sinuculan-Dagupan River	Nitrate	mg/L	1	0.066	0.066	0.066	0.066	0.066	Yes
Sinuculan-Dagupan River	Phosphate	mg/L	1	16	16	16	16	16	Yes

Sinuculan-Dagupan River	TSS	mg/L	1	0.23	0.23	0.23	0.23	0.23	Yes
Sta Maria River	BOD	mg/L	17	2.2	1.1	6.7	5.2	5.2	Yes
Sta Maria River	DO	mg/L	19	1.7	0.75	3.8	2.9	2.9	Yes
Sta Maria River	Fecal Coliform	MPN/100mL	3	1200	580	4800	4400	4400	Yes
Sta Maria River	Nitrate	mg/L	3	0.11	0.053	0.16	0.16	0.16	Yes
Sta Maria River	Phosphate	mg/L	3	80	49	180	170	170	Yes
Sta Maria River	TSS	mg/L	3	0.32	0.28	0.37	0.36	0.36	Yes
Talisay River	BOD	mg/L	13	0.81	0.29	1.7	1.6	1.6	Yes
Talisay River	DO	mg/L	13	0.94	0.75	1.5	1.4	1.4	Yes
Talisay River	Fecal Coliform	MPN/100mL	2	460	400	530	520	520	Yes
Talisay River	Nitrate	mg/L	3	0.05	0.04	0.067	0.065	0.065	Yes
Talisay River	Phosphate	mg/L	3	4.8	4.4	4.8	4.8	4.8	Yes
Talisay River	TSS	mg/L	3	0.28	0.26	0.41	0.4	0.4	Yes
Tullahan River	microplastics	pc/m3	2	110	38	190	180	180	Yes
Upper Chico River	BOD	mg/L	3	0.22	0.21	0.3	0.29	0.29	No
Upper Chico River	Fecal Coliform	MPN/100mL	2	150	90	200	200	200	No
Upper Chico River	Nitrate	mg/L	2	2.4	0.0057	4.8	4.5	4.5	No
Upper Chico River	Phosphate	mg/L	2	2	1.6	2.4	2.4	2.4	No
Upper Chico River	TSS	mg/L	2	0.33	0.21	0.44	0.43	0.43	No
Ylang-Ylang River	BOD	mg/L	17	3.2	0.7	18	18	18	Yes
Ylang-Ylang River	DO	mg/L	16	1	0.81	1.3	1.2	1.2	Yes
Ylang-Ylang River	Fecal Coliform	MPN/100mL	3	920	910	1400	1300	1300	Yes
Ylang-Ylang River	Nitrate	mg/L	3	0.22	0.22	0.33	0.32	0.32	Yes
Ylang-Ylang River	Phosphate	mg/L	3	41	39	71	68	68	Yes
Ylang-Ylang River	TSS	mg/L	3	0.63	0.62	2.5	2.3	2.3	Yes

Note: RQ_median – median of RQ values

RQ_min – minimum from the RQ values

RQ_max – maximum from the RQ values

RQ_p95 – 95th percentile of the computed values

RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

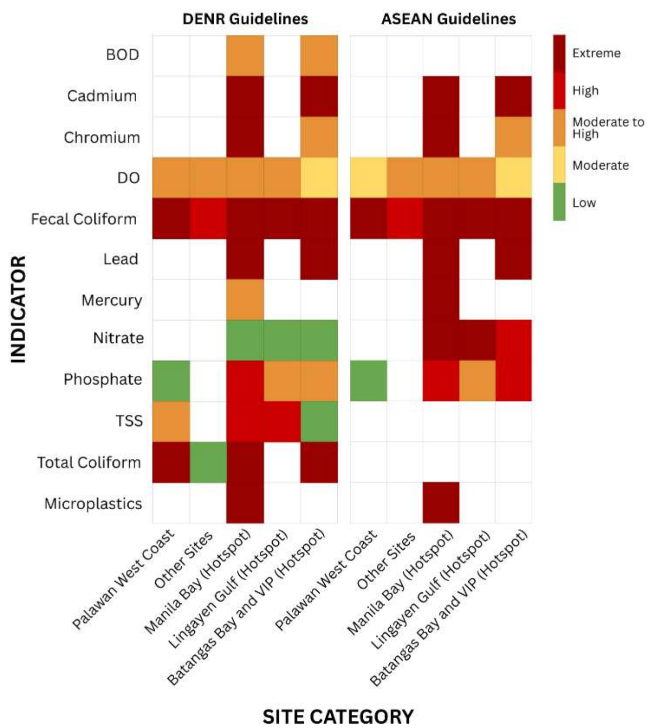

Figure 3.I.1. Heat Map for Pollution Hotspots using the 95th Ppercentile Risk Quotient

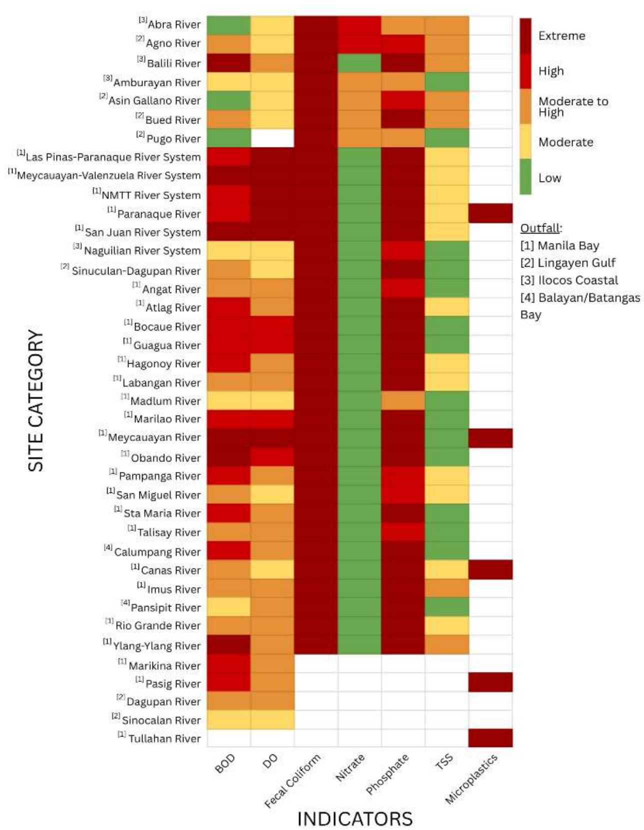

Figure 3.I.2. Heat Map for Rivers Draining to the Philippine Waters of SCS-LME using the 95th Percentile Risk Quotient.

Annex 3.J. Output from the Multi-stakeholder Validation Workshop

The validation workshop for the Pollution Component of the Philippine Transboundary Diagnostic Analysis (TDA) was convened to validate results from the collated data, refine analytical findings, and identify remaining gaps in assessing pollution pressures on the South China Sea Large Marine Ecosystem (SCS-LME). The session brought together representatives from the Environmental Management Bureau (EMB), Philippine Coast Guard (PCG), Biodiversity Management Bureau (BMB), Laguna Lake Development Authority (LLDA), Manila Bay Coordinating Office (MBCO), and civil society organizations, among others. The discussion emphasized the need to strengthen the evidence-informed governance and to harmonize institutional roles in monitoring, reporting, and regulating multiple pollution sources.

Stakeholders confirmed that domestic wastewater remains the dominant contributor to national pollution loads, reflecting low sewerage coverage and persistent untreated discharges into rivers and coastal waters. EMB and LLDA emphasized that the domestic sector continues to exceed other source categories in nutrient, organic, and pathogen loading. Nonpoint sources, particularly agricultural runoff, sedimentation from upland erosion and other land-based activities, and diffuse nutrient discharges, were also identified as significant sources but poorly quantified, with limited available datasets on nitrogen, phosphorus, and sediment load calculations. EMB noted ongoing work to develop sediment quality guidelines.

The workshop also validated the contribution of aquaculture and mariculture operations as emerging sources of pollution, especially in semi-enclosed bays. However, participants underscored weak coordination between DA BFAR and DENR EMB in monitoring aquaculture effluents, resulting in fragmented datasets and limited reporting of environmental quality attributed to aquaculture/mariculture activities. For industrial effluent and hazardous wastes, EMB highlighted ongoing efforts to improve data systems, including the development of industry-specific pollution load databases and disaggregated hazardous waste inventories from different sources. During the validation workshop, it was noted that confidence in reported hazardous waste data has been improved since 2020 with the operationalization of the online Hazardous Waste Management System (https://hwms.emb.gov.ph). Key features include online registration for these different entities, an interface to enter regulatory compliance data, and reports to track hazardous waste volumes and movements.

The Philippine Coast Guard identified incomplete oil spill datasets, particularly for minor spill events after 2022. A formal request from PCG was recommended to access the full oil spill inventory for the most recent years if needed. Though the Philippine Archipelagic Sea Lanes Act (RA 12065) has recently been enacted and stipulated the prohibition of marine pollution that includes oil discharges and ballast water, the absence of Implementing Rules and Regulations (IRR) also emerged as a critical gap, with implications for both chemical and biological pollution, including invasive alien species from ballast water from ships.

Participants validated four major pollution hotspots: Manila Bay, Lingayen Gulf, Batangas Bay–Verde Island Passage (VIP), and the west coast of Palawan. These areas exhibit exceedances in microbial contaminants, nutrients, and industrial pollutants, and are considered priority locations for management intervention, given the reasonable worse-case scenario. DENR Manila Bay Coordinating Office and DENR EMB Regional Offices (e.g., Region 4A and 4B) are willing to provide recent data to supplement the analysis in Batangas Bay and the west coast of Palawan. It was also mentioned during the workshop that several letters of request had already been sent to pertinent government agencies during the study's conduct for such data.

Batangas Bay and VIP

Nitrate concentrations have exceeded ASEAN Water Quality Guidelines (WQG) thresholds post-validation but remain compliant within the DENR WQG standards. Pre-validation data has indicated potential phosphate concerns in Batangas Bay and VIP hotspot; however, these assessments were based on only two data points. Subsequent validation revealed that phosphate levels have actually complied with DENR WQG standards in recent years (2024-2025). Wagas and Andres (2022) reported an increasing trend in heavy metal concentrations exceeding thresholds in Batangas Bay The recent monitoring data (2024-2025) indicates that chromium concentrations have complied with DENR WQG standards. However, caution must be exercised when interpreting these data, as the parameters can be subjected to factors such as seasonal variability.

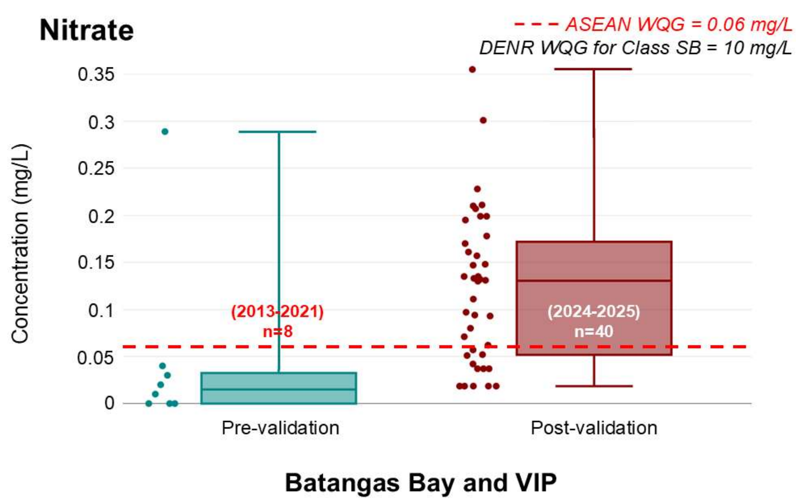

Figure 3.J.1. Box Plot for Nitrate Concentration in Batangas Bay (Pre- and Post-Validation)

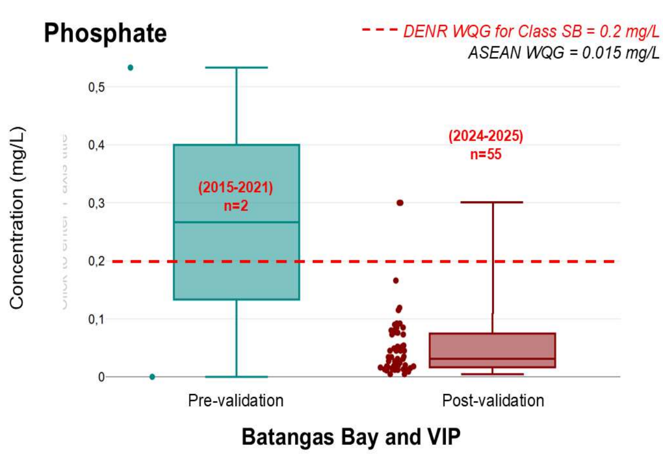

Figure 3.J.2. Box Plot for Phosphate Concentration in Batangas Bay (Pre- and Post-Validation)

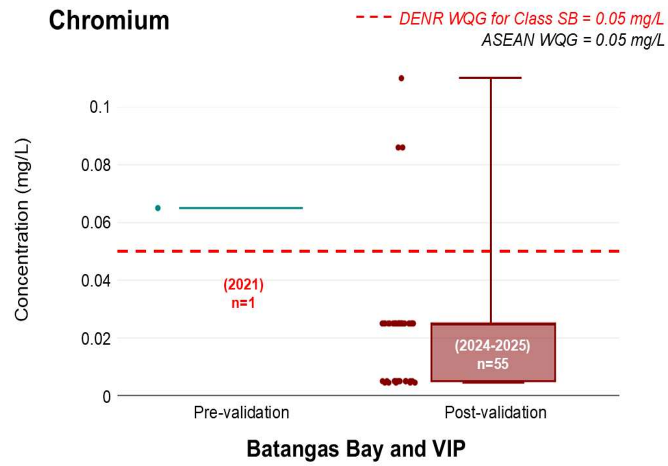

Figure 3.J.3. Box Plot for Chromium Concentration in Batangas Bay (Pre- and Post-Validation)

West Coast of Palawan

Generally, TSS levels in the west coast of Palawan falls in compliance to the DENR WQG for Class SB. Although there is a notable change in the trend for TSS concentration in Palawan (post-validation) where a significant number exceeds the DENR WQG, some in extreme exceedances. Siltation from rivers and anthropogenic activities such as quarrying may have caused the increased TSS levels. Enhanced monitoring as well as appropriate intervention is recommended, as TSS affects light penetration which in turn affects productivity in marine ecosystems. Similarly, caution must be exercised in interpreting due to the aggregation of data, as the parameter can be subjected to factors such as seasonal variability.

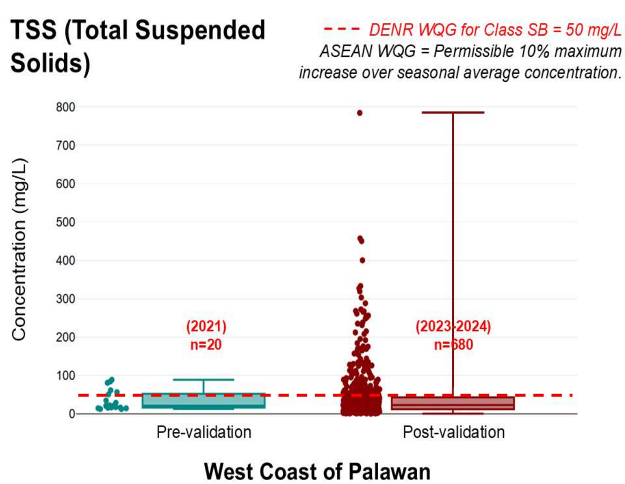

Figure 3.J.4. Box Plot for Total Suspended Solids Concentration in the west coast of Palawan (Pre- and Post-Validation)

Lingayen Gulf

Acquiring data for water quality in Lingayen Gulf remains a challenge due to limited accessibility. Following validation, the EMB Region 1 provided fecal coliform concentration data, significantly enhancing the reliability of data assessment. These post-validation data, which address previous data scarcity, reveal findings that contrast with earlier assessments. Fecal coliform levels in Lingayen Gulf generally comply with DENR Water Quality Guidelines for Class SB waters (100 MPN/100 mL), though notable exceedances occurred between 2014-2025. While results are encouraging, they underscore the need for stricter regulation and continuous monitoring to maintain compliance.

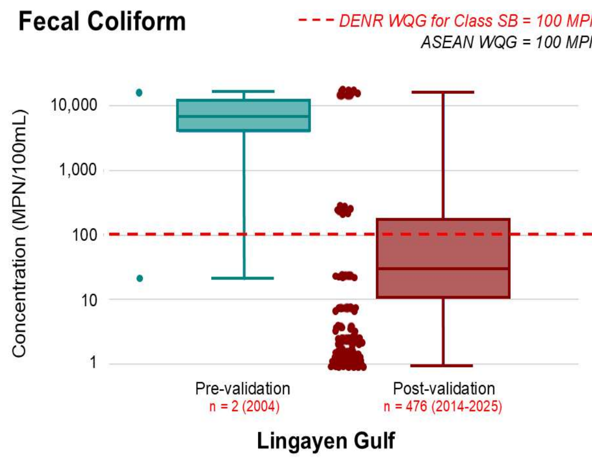

Figure 3.J.5. Box Plot for Fecal Coliform Concentration in Lingayen Gulf (Pre- and Post-Validation)

<u>Risk Assessment</u>

A similar risk assessment was done using the dataset provided by the concerned agencies (Figure 3.J.6). Nitrate levels for the hotspots remain a low to moderate concern, but increase in monitoring should be prioritized in the rivers draining to Manila Bay. Phosphate, BOD, DO, and TSS levels in Manila Bay (coastal and from riverine inputs) remain high to extreme risk, solidifying its position as the most critical hotspot. Despite ongoing Manila Bay rehabilitation efforts mandated by the Supreme Court, it continues to face significant environmental challenges. Enhanced water quality monitoring, stricter enforcement of environmental regulations, and increased stakeholder engagement remain essential for meaningful progress. The risk for phosphate and chromium in Batangas Bay is lowered to moderate using the dataset provided by the EMB region 4A, compared to the moderate to high risk from the previous heat map (due to limited data). However, the risk for TSS levels has increased from low to moderate, which could be attributed to the industrial activities surrounding the area. Coliform levels remain problematic for all hotspots, which could be due to the limited connections of households to sewage and septage systems in the national level. If this continues, the elevated levels of coliform would become a threat not only to the marine ecosystems but also pose risk to public health. Following the ASEAN guidelines reflect moderate to extreme risks for most indicators due to a more conservative threshold as it was developed in consideration to aquatic life protection, compared to the DENR guidelines which was developed for a waterbody’s intended use aside from ecosystem health. The additional data points have significantly increased the accuracy of the risk assessment for Batangas Bay and VIP area, Lingayen Gulf, Manila Bay, and the west coast of Palawan, with significant addition of the coasts of Ilocos.

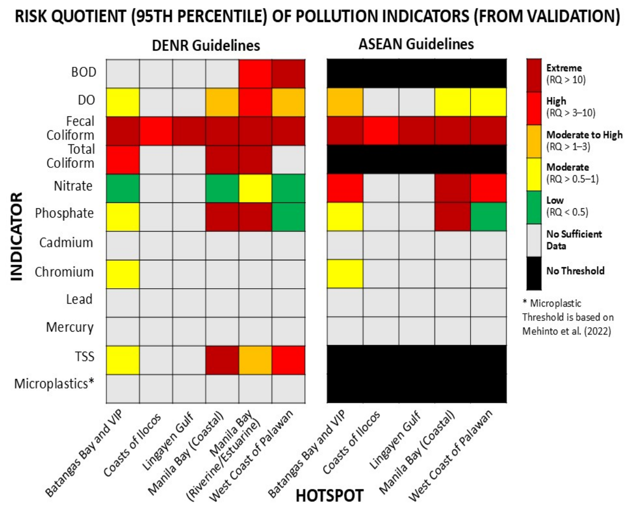

Figure 3.J.6. Heat Map for Pollution Hotspots (Post-validation) in the Philippine Waters of SCS-LME (2011-2025)

Water Quality Index (WQI) of Manila Bay

To date, the DENR EMB has no existing guidelines on measuring marine or coastal water quality index. Water quality indices provide a simplified, standardized metric for assessing complex datasets through qualitative categories such as "poor," "moderate," and "good." To evaluate coastal water quality in Manila Bay, the Canadian Council of Ministers of the Environment (CCME) Water Quality Index was applied. The CCME WQI was selected for its simplicity and flexibility in handling missing data and parameters, treating all variables with equal weight. However, this approach is susceptible to bias, particularly with incomplete parameter and temporal datasets as in the case of this assessment for Manila Bay. Despite the limitation, this assessment is necessary for communicating the water quality status of Manila Bay effectively.

Table 3.J.1. CCME WQI Category

Rating	Value	Definition
Excellent	95-100	water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.
Good	80-94	water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
Fair	65-79	water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
Marginal	45-64	water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
Poor	0-44	water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

As provided by the Manila Bay Coordinating Office, a total of 5,386 datapoints and six parameters (DO, fecal coliform, total coliform, nitrate, phosphate, and TSS) were considered in computing for the CCME WQI. Figure 3.J.7 presents the time-series of water quality in Manila Bay assessed using the CCME WQI. A gradual upward trend is observed, potentially attributed to the rehabilitation efforts mandated by the Supreme Court mandamus. However, annual WQI values consistently fall within the "poor" category (Table 3.J.2), indicating that most parameters fail to meet DENR Water Quality Guidelines (see Table 3.J.7 for detailed calculations). The highest WQI value occurs in

2025 at 27, followed by 2017 at 24; notably, the 2025 value are subject to change as monitoring continues through year-end.

Consistent with the TDA report findings, these results reflect Manila Bay's location within the nation's most densely populated region. Given that domestic wastewater and solid waste are among the primary sources of pollution, wherein both are directly affected by population, the persistently poor water quality highlights the immediate need for more effective rehabilitation strategies to protect the marine ecosystems and sustain the livelihoods of communities dependent on Manila Bay's natural resources.

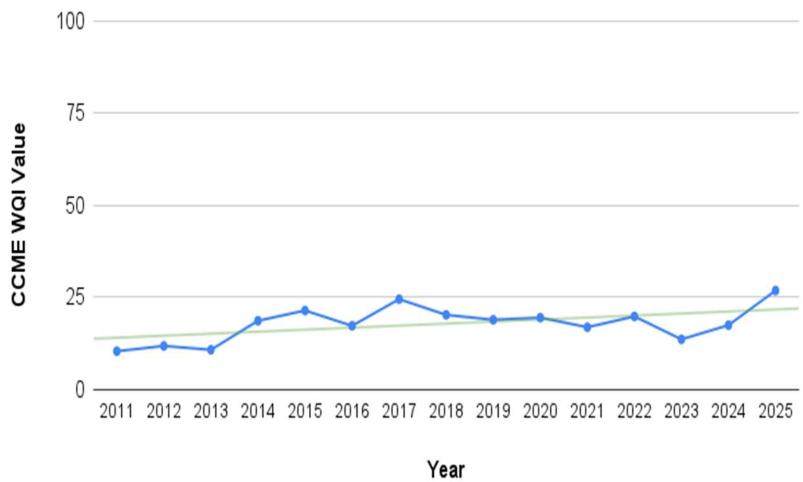

Figure 3.J.7. Time Series of CCME WQI Values in Manila Bay (2011-2025)

Table 3.J.2. CCME WQI Rating in Manila Bay from 2011-2025

Spatial Coverage	Year	CCME WQI Value	Rating
Manila Bay (Coastal)	2011	10	Poor
Manila Bay (Coastal)	2012	12	Poor
Manila Bay (Coastal)	2013	11	Poor
Manila Bay (Coastal)	2014	19	Poor
Manila Bay (Coastal)	2015	21	Poor
Manila Bay (Coastal)	2016	17	Poor
Manila Bay (Coastal)	2017	24	Poor
Manila Bay (Coastal)	2018	20	Poor
Manila Bay (Coastal)	2019	19	Poor
Manila Bay (Coastal)	2020	19	Poor
Manila Bay (Coastal)	2021	17	Poor
Manila Bay (Coastal)	2022	20	Poor
Manila Bay (Coastal)	2023	14	Poor
Manila Bay (Coastal)	2024	17	Poor
Manila Bay (Coastal)	2025	27	Poor

Several emerging pollution issues were also validated and identified, including those related to antimicrobial resistance (AMR), e-waste and other emerging hazardous waste streams, noise pollution from maritime activities, and the transport of other pollutants attached to microplastics. EMB also highlighted ongoing national initiatives to enhance marine litter monitoring, including the development of a marine debris profiling database and the implementation of the Marine Litter Management Project in Manila Bay.

To complement the national consultation workshops, a structured validation survey was conducted to systematically capture stakeholder perspectives on (a) priority causes of land-based pollution, (b) major pollution sources and pathways, and (c) perceived transboundary pollution concerns affecting the Philippine waters of the South China Sea Large Marine Ecosystem (SCS-LME) (d) gaps and challenges in pollution control and management, and (e) recommended priority actions. There is a total of twenty-five (25) respondents from multiple stakeholders, in which majority are from the government (19 respondents), followed by respondents from NGO and civil society (6), two respondents are from the community group/fisherfolk organization and one respondent from the academic/research institution.

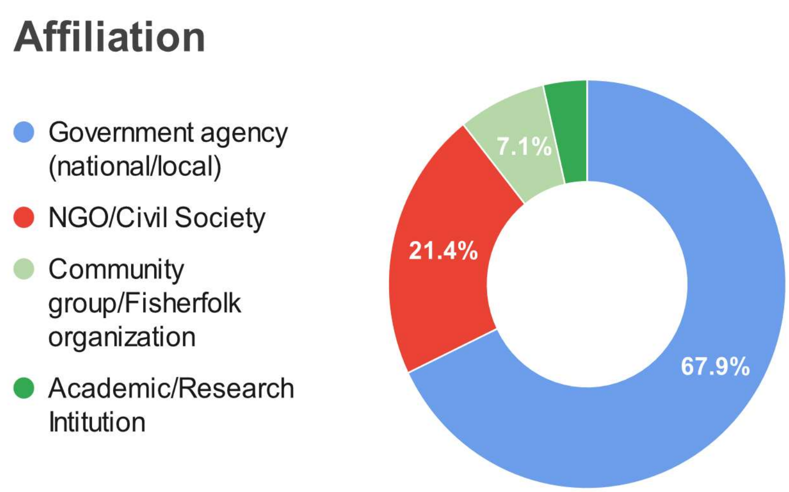

Figure 3.J.8. Composition of Stakeholders' Affiliation

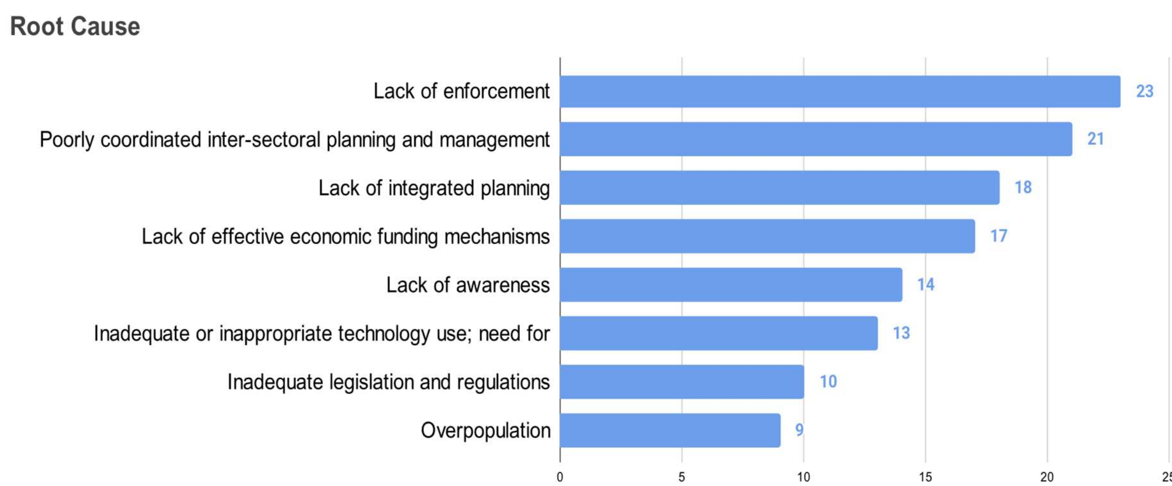

Figure 3.J.9. Ranking of Root Causes of Pollution

Twenty-three respondents have chosen lack of enforcement among their top five root cause, followed by poorly coordinated inter-sectoral planning and management (21 respondents), lack of integrated planning (18), lack of effective funding mechanisms (17), and lack of awareness (14). The five primary root causes of land-based pollution reflect systemic governance challenges. Respondents indicated that existing environmental laws is adequate; however, enforcement and implementation remain lacking. There is gap in environmental awareness existing within communities, with some LGU officials unfamiliar with environmental laws. To address these challenges, some respondents recommended implementing incentives to promote behavioral change, alongside strengthening environmental programs and activities. This suggests that effective pollution control requires not only regulatory frameworks but also comprehensive awareness campaigns, institutional and intentional capacity building, and positive reinforcement strategies to encourage compliance and sustainable practices.

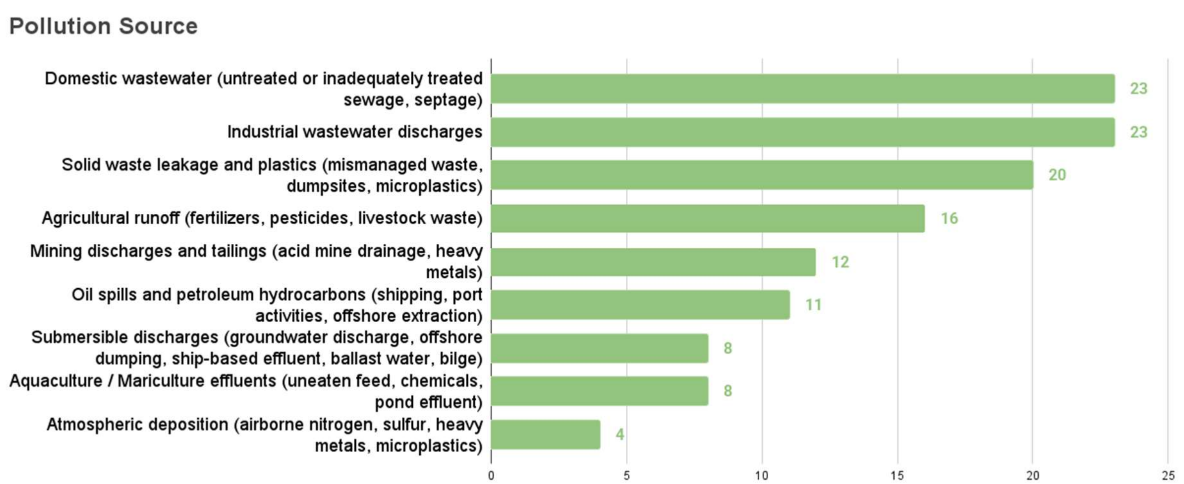

Figure 3.J.10. Ranking of Pollution Sources

Wastewater discharge (domestic and industrial) remains the top contributor of pollution especially to marine waters (23 respondents each), followed by solid waste and plastic leakage (20 respondents), and agricultural source (16 respondents). This validation survey has further strengthened and supported the findings of the TDA report. Mining discharges and tailings (12 respondents) was also considered as a major contributor to pollution. However, data is limited to accurately assess the impact of mining activities and remains a significant knowledge gap.

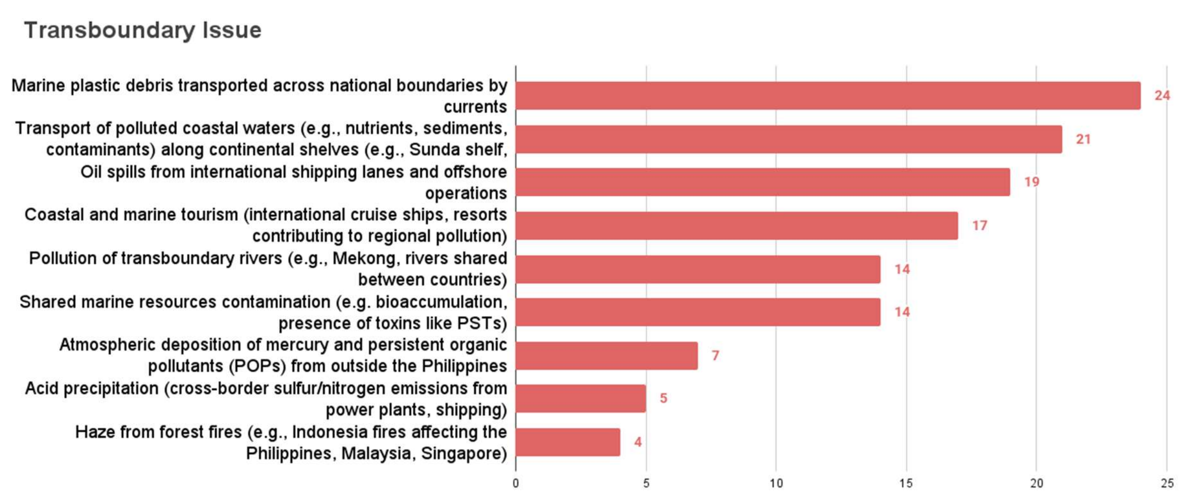

Figure 3.J.11. Primary Transboundary Issues for Pollution

The results of the validation survey support the transboundary issues presented in the TDA report. With marine plastic debris transport as the top transboundary issue (22 respondents). However, the respondents (17) also identified the increasing coastal and marine tourism-related activities as among the top five transboundary issue. This warrants consideration to develop appropriate regulations and management strategies concerning the developing coastal tourism sector among countries.

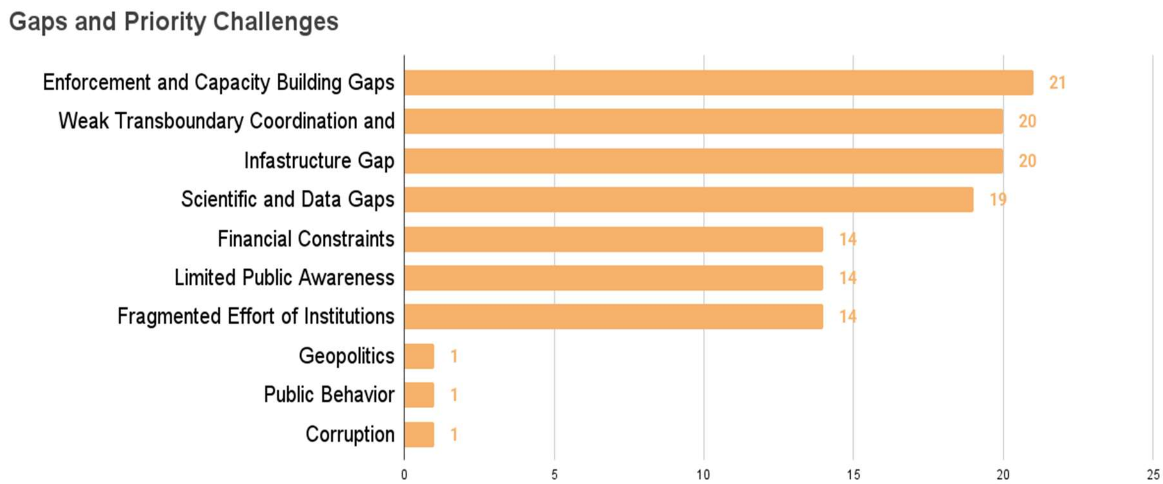

Figure 3.J.12. Gaps and Priority Challenges in Pollution Mitigation

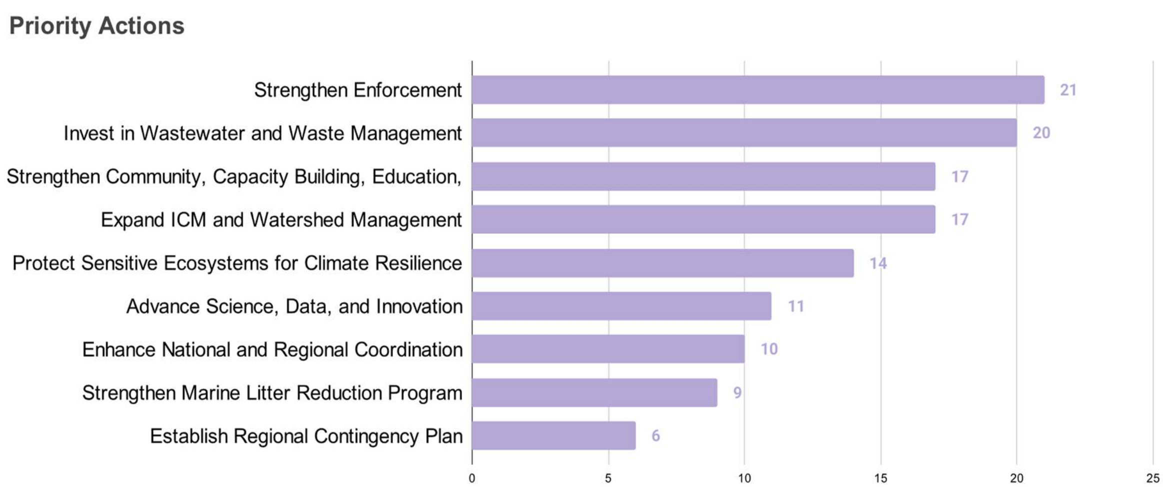

Figure 3.J.13. Priority Actions in Pollution Mitigation

Enforcement and capacity building gap is considered as the top priority challenge by 21 respondents. This is followed by weak transboundary cooperation and infrastructure gaps (20 respondents each). Scientific and data gaps (19), financial constraints (14), limited public awareness (14), and fragmented effort of institutions (14) are also considered. As mentioned, existing environmental laws are adequate and comprehensive, the apparent problem lies to enforcement and implementation. Infrastructure gaps can be connected to financial constraints. Scientific and data gaps are also highlighted that could result to the lack of public awareness. To answer these challenges, the respondents also identified the top priority actions. Strengthening enforcement (21 respondents) emerges as the top priority to address pollution. Investing to wastewater treatment infrastructure follows (20), reflecting the significance of domestic wastewater as the top contributor to land-based pollution. Strengthening CEPA activities (17 respondents) addresses the gap in public awareness. It is followed by the expansion of ICM and watershed management (17) and protection of sensitive ecosystems for climate resilience (14) which not only addresses pollution but also contributes to the ecosystem services in which the population within the SCS-LME can benefit from.

Overall, the workshop affirmed the robustness of the initial update to TDA, while emphasizing the need for strengthened interagency coordination, improved data accessibility, and updated datasets to address information gaps. The consolidated feedback will guide the refinement of the TDA and the integration of validated evidence and recommendations into the final TDA.

Table 3.J.3. Summary Table for Number of Available Data on Water Quality by Pollution Hotspot (Post-Validation)

Coastal Pollution Hotspots	BOD	DO	Fecal Coliform	Total Coliform	Cadmium	Chromium	Lead	Mercury	Nitrate	Phosphate	TSS	Micro-plastics
Batangas Bay and VIP	0	0	55	35	40	0	0	40	55	30	40	0
Coasts of Ilocos	0	0	0	0	321	0	0	0	0	0	0	0
Lingayen Gulf (Hotspot)	0	0	0	0	476	0	0	0	0	0	0	0
Manila Bay (Coastal)	0	0	0	310	438	0	0	219	225	269	154	0
Manila Bay (Riverine/Estuarine)	402	0	0	701	714	0	0	675	721	708	287	0
West Coast of Palawan	0	44	81	4	0	0	0	0	0	20	20	0

Table 3.J.4 Descriptive Statistics for Water Quality on Pollution Hotspots (Post-Validation)

Coastal Pollution Hotspots	Indicator	unit	count	mean	std	median	q25	q75	p5	p95	min	max
Batangas Bay and VIP	Nitrate	mg/L	40	0.12	0.081	0.13	0.052	0.17	0.019	0.23	0.019	0.36
Batangas Bay and VIP	Phosphate	mg/L	55	0.052	0.059	0.031	0.017	0.075	0.01	0.13	0.0045	0.3
Batangas Bay and VIP	DO	mg/L	35	6.6	0.74	6.6	6.5	6.8	5.5	7.6	4	8
Batangas Bay and VIP	TSS	mg/L	30	26	12	24	17	32	12	41	10	68
Batangas Bay and VIP	Total Coliform	MPN/100 mL	40	9400	27000	1000	350	4000	32	36000	6.1	160000
Batangas Bay and VIP	Fecal Coliform	MPN/100 mL	40	1000	2700	210	39	720	8.8	3600	0.9	16000
Batangas Bay and VIP	Chromium	mg/L	55	0.022	0.02	0.025	0.005	0.025	0.0045	0.043	0.0045	0.11
Coasts of Ilocos	Fecal Coliform	MPN/100 mL	321	240	1500	23	7	76	0.9	540	0.9	24000
Lingayen Gulf (Hotspot)	Fecal Coliform	MPN/100 mL	476	560	2100	45	11	170	0.9	1700	0.9	16000
West Coast of Palawan	Nitrate	mg/L	616	0.2	0.08	0.25	0.15	0.25	0.029	0.25	0.005	0.71
West Coast of Palawan	Phosphate	mg/L	679	0.018	0.035	0.01	0.01	0.01	0.01	0.054	0	0.53
West Coast of Palawan	DO	mg/L	787	6.2	1.5	6.4	5.6	7	3.3	8.5	0.51	11
West Coast of Palawan	TSS	mg/L	680	42	64	23	12	43	4	160	0.5	780
West Coast of Palawan	Fecal Coliform	MPN/100 mL	857	240000	5500000	79	9	700	0.9	37000	0.9	1.6E+08
West Coast of Palawan	BOD	mg/L	22	33	33	29	12	39	7.1	77	4.5	160
Manila Bay (Coastal)	Nitrate	mg/L	219	190	1600	0.2	0.14	0.3	0.077	1.7	0.027	15000
Manila Bay (Coastal)	Phosphate	mg/L	225	290	2500	0.14	0.085	0.27	0.054	4.1	0.03	22000
Manila Bay (Coastal)	DO	mg/L	310	92	890	5.8	4.2	6.5	2.5	8.7	0.9	10000
Manila Bay (Coastal)	TSS	mg/L	269	2700	13000	74	44	120	13	13000	5	140000
Manila Bay (Coastal)	Total Coliform	MPN/100 mL	154	7300000	42000000	5700	800	27000	22	480000	1.4	3.3E+08

Manila Bay (Coastal)	Fecal Coliform	MPN/100mL	438	3.6E+10	7.6E+11	9000	1900	88000	91	22000000	1.7	1.6E+13
Manila Bay (Riverine/Estuarine)	Nitrate	mg/L	675	2	11	0.35	0.2	0.83	0.11	6.1	0.031	250
Manila Bay (Riverine/Estuarine)	Phosphate	mg/L	721	3.9	22	0.83	0.23	1.5	0.11	14	0.031	430
Manila Bay (Riverine/Estuarine)	DO	mg/L	701	110000	1700000	3.9	2.8	5.2	1.7	7	0.42	27000000
Manila Bay (Riverine/Estuarine)	TSS	mg/L	708	46	76	36	25	52	13	100	1.3	1700
Manila Bay (Riverine/Estuarine)	Total Coliform	MPN/100mL	287	1.6E+09	1.5E+10	350000	51000	1500000	8.1	36000000	3	2E+11
Manila Bay (Riverine/Estuarine)	Fecal Coliform	MPN/100mL	714	1.3E+09	1.2E+10	93000	2200	1100000	34	4.1E+08	0.49	1.8E+11
Manila Bay (Riverine/Estuarine)	BOD	mg/L	402	2200	38000	25	11	46	3.1	78	1.9	760000

Notes: std = Standard Deviation

p25 = 25th percentile of concentrations

p75 = 75th percentile of concentrations

p5 = 5th percentile of concentrations

p95 = 95th percentile of concentrations

MPN = Most Probable Number

Table 3.J.5. Computed RQs based on DENR Water Quality Standards for Pollution Hotspots (Post-Validation).

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP	Nitrate	mg/L	40	0.013	0.0019	0.036	0.023	0.023
Batangas Bay and VIP	Phosphate	mg/L	55	0.16	0.023	1.5	0.67	0.67
Batangas Bay and VIP	DO	mg/L	35	0.76	0.63	1.3	0.9	0.9
Batangas Bay and VIP	TSS	mg/L	30	0.29	0.13	0.85	0.51	0.51
Batangas Bay and VIP	Total Coliform	MPN/100mL	40	0.2	0.0012	32	7.2	7.2
Batangas Bay and VIP	Fecal Coliform	MPN/100mL	40	1	0.0045	80	18	18
Batangas Bay and VIP	Chromium	mg/L	55	0.5	0.09	2.2	0.87	0.87
Coasts of Ilocos	Fecal Coliform	MPN/100mL	321	0.23	0.009	240	5.4	5.4
Lingayen Gulf	Fecal Coliform	MPN/100mL	476	0.45	0.009	160	17	17
West Coast of Palawan	Nitrate	mg/L	616	0.025	0.0005	0.071	0.025	0.025
West Coast of Palawan	Phosphate	mg/L	679	0.05	0	2.7	0.27	0.27
West Coast of Palawan	DO	mg/L	787	0.94	0.52	12	1.7	1.7
West Coast of Palawan	TSS	mg/L	680	0.46	0.01	16	3.2	3.2
West Coast of Palawan	Fecal Coliform	MPN/100mL	857	0.79	0.009	800000	250	250
West Coast of Palawan	BOD	mg/L	22	4.1	0.64	23	11	11
Manila Bay (Coastal)	Nitrate	mg/L	219	0.02	0.0027	1500	0.17	0.17
Manila Bay (Coastal)	Phosphate	mg/L	225	0.71	0.15	110000	20	20
Manila Bay (Coastal)	DO	mg/L	310	1	0.00059	6.7	2.4	2.4
Manila Bay (Coastal)	TSS	mg/L	269	1.5	0.1	2900	250	250
Manila Bay (Coastal)	Total Coliform	MPN/100mL	154	5.7	0.0014	330000	480	480
Manila Bay (Coastal)	Fecal Coliform	MPN/100mL	438	90	0.017	1.6E+11	220000	220000
Manila Bay (Riverine/Estuarine)	Nitrate	mg/L	675	0.05	0.0022	36	0.75	0.75
Manila Bay (Riverine/Estuarine)	Phosphate	mg/L	721	14	0.035	17000	160	160
Manila Bay (Riverine/Estuarine)	DO	mg/L	701	1.3	0.00000019	12	3	3
Manila Bay (Riverine/Estuarine)	TSS	mg/L	708	0.44	0.016	22	1.2	1.2
Manila Bay (Riverine/Estuarine)	Total Coliform	MPN/100mL	287	70	0.0006	39000000	7200	7200
Manila Bay (Riverine/Estuarine)	Fecal Coliform	MPN/100mL	714	460	0.0025	900000000	1600000	1600000

Manila Bay (Riverine/Estuarine)	BOD	mg/L	402	1.7	0.13	110000	9.7	9.7

Note: RQ_median - median of RQ values
RQ_min – minimum from the RQ values
RQ_max – maximum from the RQ values
RQ_p95 – 95th percentile of the computed values
RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.J.6. Computed RQs based on ASEAN Water Quality Standards for Pollution Hotspots (Post-Validation).

Pollution Hotspots	Indicator	Unit	Count	RQ_median	RQ_min	RQ_max	RQ_p95	RQ_rwc
Batangas Bay and VIP	Nitrate	mg/L	40	2.2	0.31	5.9	3.9	3.9
Batangas Bay and VIP	Phosphate	mg/L	55	0.21	0.03	2	0.89	0.89
Batangas Bay and VIP	DO	mg/L	35	0.61	0.5	1	0.72	0.72
Batangas Bay and VIP	Fecal Coliform	MPN/100mL	40	2.1	0.009	160	36	36
Batangas Bay and VIP	Chromium	mg/L	55	0.5	0.09	2.2	0.87	0.87
Coasts of Ilocos	Fecal Coliform	MPN/100mL	321	0.23	0.009	240	5.4	5.4
Lingayen Gulf	Fecal Coliform	MPN/100mL	476	0.45	0.009	160	17	17
West Coast of Palawan	Nitrate	mg/L	616	4.2	0.083	12	4.2	4.2
West Coast of Palawan	Phosphate	mg/L	679	0.067	0	3.5	0.36	0.36
West Coast of Palawan	DO	mg/L	787	0.63	0.36	9.8	1	1
West Coast of Palawan	Fecal Coliform	MPN/100mL	857	0.78	0.009	350	35	35
Manila Bay (Coastal)	Nitrate	mg/L	219	3.4	0.45	250000	28	28
Manila Bay (Coastal)	Phosphate	mg/L	225	0.94	0.2	150000	27	27
Manila Bay (Coastal)	DO	mg/L	310	0.69	0.0004	4.4	1.6	1.6
Manila Bay (Coastal)	Fecal Coliform	MPN/100mL	438	90	0.017	1.6E+11	220000	220000

Note: RQ_median - median of RQ values
RQ_min – minimum from the RQ values
RQ_max – maximum from the RQ values
RQ_p95 – 95th percentile of the computed values
RQ_rwc – Reasonable Worst-Case scenario (95th percentile)

Table 3.J.7. Summary computation of CCME WQI in Manila Bay (2011-2025).

2011

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	9	6	1	8	Fail	100	76	10	91	10	POOR
Fecal Coliform	27	100	24	3	Fail						
Total Coliform	27	1000	22	5	Fail						
Nitrate	0	10	0	0	Fail						
Phosphate	0	0.2	0	0	Fail						
TSS	8	80	7	1	Fail						

2012

Parameter	**n**	**DENR WQG***	**No. of Fail**	**No. of Pass**	**Overall**	**F1**	**F2**	**nse**	**F3**	**CCMEWQI**	**RATING**
DO	52	6	17	35	Fail	100	62	42	98	12	POOR
Fecal Coliform	52	100	46	6	Fail						

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
Total Coliform	52	1000	33	19	Fail						
Nitrate	0	10	0	0	Fail						
Phosphate	0	0.2	0	0	Fail						
TSS	26	80	16	10	Fail						

2013

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	66	6	29	37	Fail						
Fecal Coliform	65	100	61	4	Fail						
Total Coliform	50	1000	32	18	Fail	100	63	190	99	11	POOR
Nitrate	0	10	0	0	Fail						
Phosphate	20	0.2	20	0	Fail						
TSS	51	80	17	34	Fail						

2014

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	62	6	29	33	Fail						
Fecal Coliform	60	100	52	8	Fail						
Total Coliform	52	1000	30	22	Fail	83	55	160	99	19	POOR
Nitrate	15	10	0	15	Pass						
Phosphate	20	0.2	20	0	Fail						
TSS	36	80	4	32	Fail						

2015

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	63	6	38	25	Fail						
Fecal Coliform	63	100	61	2	Fail						
Total Coliform	43	1000	28	15	Fail	67	64	16,000	100	21	POOR
Nitrate	20	10	0	20	Pass						
Phosphate	20	0.2	20	0	Fail						
TSS	21	80	0	21	Pass						

2016

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	65	6	38	27	Fail						
Fecal Coliform	72	100	64	8	Fail						
Total Coliform	48	1000	35	13	Fail	83	60	120,000	100	17	POOR
Nitrate	28	10	0	28	Pass						
Phosphate	28	0.2	20	8	Fail						
TSS	28	80	4	24	Fail						

2017

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	66	6	36	30	Fail						
Fecal Coliform	68	100	60	8	Fail						
Total Coliform	1	1000	0	1	Pass	67	52	1,000,000	100	24	POOR
Nitrate	36	10	0	36	Pass						
Phosphate	36	0.2	5	31	Fail						
TSS	68	80	41	27	Fail						

2018

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	65	6	25	40	Fail						
Fecal Coliform	67	100	58	9	Fail						
Total Coliform	0	1000	0	0	Fail	83	46	1,900,000	100	20	POOR
Nitrate	36	10	0	36	Pass						
Phosphate	60	0.2	22	38	Fail						
TSS	68	80	32	36	Fail						

2019

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	108	6	60	48	Fail						
Fecal Coliform	124	100	110	14	Fail						
Total Coliform	60	1000	48	12	Fail	83	53	790,000,000	100	19	POOR
Nitrate	96	10	0	96	Pass						
Phosphate	108	0.2	30	78	Fail						
TSS	105	80	69	36	Fail						

2020

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	70	6	41	29	Fail						
Fecal Coliform	121	100	89	32	Fail						
Total Coliform	24	1000	6	18	Fail	83	50	1,800	100	19	POOR
Nitrate	67	10	0	67	Pass						
Phosphate	67	0.2	21	46	Fail						
TSS	74	80	55	19	Fail						

2021

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	106	6	74	32	Fail						
Fecal Coliform	151	100	146	5	Fail	83	62	980	100	17	POOR

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
Total Coliform	58	1000	46	12	Fail						
Nitrate	106	10	0	106	Pass						
Phosphate	106	0.2	38	68	Fail						
TSS	106	80	86	20	Fail						

2022

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	105	6	60	45	Fail	83	50	120	99	20	POOR
Fecal Coliform	131	100	122	9	Fail						
Total Coliform	12	1000	12	0	Fail						
Nitrate	108	10	0	108	Pass						
Phosphate	108	0.2	22	86	Fail						
TSS	91	80	62	29	Fail						

2023

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	115	6	66	49	Fail	100	49	2,100	100	14	POOR
Fecal Coliform	159	100	136	23	Fail						
Total Coliform	60	1000	19	41	Fail						
Nitrate	115	10	7	108	Fail						
Phosphate	115	0.2	24	91	Fail						
TSS	115	80	80	35	Fail						

2024

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	59	6	38	21	Fail	83	60	240	100	17	POOR
Fecal Coliform	113	100	102	11	Fail						
Total Coliform	12	1000	12	0	Fail						
Nitrate	59	10	0	59	Pass						
Phosphate	59	0.2	38	21	Fail						
TSS	59	80	26	33	Fail						

2025

Parameter	n	DENR WQG*	No. of Fail	No. of Pass	Overall	F1	F2	nse	F3	CCMEWQI	RATING
DO	53	6	42	11	Fail	83	40	6.3	86	27	POOR
Fecal Coliform	65	100	37	28	Fail						
Total Coliform	30	1000	4	26	Fail						
Nitrate	58	10	0	58	Pass						
Phosphate	54	0.2	10	44	Fail						
TSS	54	80	35	19	Fail						

Notes: *Class SB

DO, Nitrate and TSS follows the DENR Administrative Order 2016-08
Phosphate and Fecal Coliform DENR Administrative Order 2021-19
Total Coliform follows the DENR Administrative Order No. 34 s. 1990
n = number of data points
F1 = represents the percent of failed parameters that do not meet the guidelines at least once
F2 represents the percentage of individual tests that do not meet guidelines
nse = collective amount by which individual tests are out of compliance
F3 = represents the amount by which failed test values do not meet their guidelines