ASSESSMENT OF THE WATER QUALITY NEAR SPECIAL ECONOMIC ZONE (THILAWA)

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Abstract

This study highlights growing concerns about water pollution due to the development of the Thilawa Special Economic Zone (SEZ) and ongoing BOBLME activities, emphasizing the urgent need for action. Water samples were collected from 5 ft depth at 10 GPS-marked sites in June 2024. The analysis focuses on the physicochemical, elemental, and microbial properties of the water. The research aims to evaluate environmental impacts by analyzing various water quality parameters, such as pH, temperature, dissolved oxygen, and biological and chemical oxygen demand, to determine the aquatic environment's health. Electrical conductivity, total dissolved solids, alkalinity, hardness, chlorinity, and salinity were measured to understand ionic composition and salinity levels. Chlorophyll-*a* was analyzed to estimate the abundance of phytoplankton, and nutrient concentrations (nitrogen and phosphate) were evaluated for nutrient pollution. Total nitrogen (1.58 to 1.92 ppm) and orthophosphate (0.062 to 0.215 mg/L) contents indicated moderate nutrient levels of mesotrophic. Microbial analysis targeted coliforms and *E. coli* to assess contamination risks, while trace metals were examined to detect potential toxic elements. The results were compared to WHO, EPA, and ASEAN standards.

Keywords: Thilawa (SEZ), water quality parameters, trace metals, chlorinity, mesotrophic

Introduction

Water covers 70% of the Earth's surface and is the most abundant liquid, essential for all living things. Without water, there would be no plants, animals, or humans (Maung Kyaw, 2016). This highlights the need to study water quality and ensure access to clean water for both human health and the environment. The BOBLME is innovative with a strong focus on how fishery and management, habitats, and livelihoods interest. The project will also have a focus on marine pollution and reduction of plastics from fishing (Kyaw Naing, 2011). Thilawa Special Economic Zone (SEZ) serves as a major industrial hub and the largest port for international cargo and gas tankers, playing a key role in the transportation of gas, oil, and petroleum products. However, leaks of these substances into the river have caused environmental pollution, threatening aquatic life and human health. Such incidents raise concerns about the ecological health of the river system. As important as Myanmar's central industrial area, Thilawa SEZ requires a thorough evaluation of water quality to monitor pollution effectively. This research aims to systematically collect and analyze water samples from Thilawa SEZ, addressing issues of contamination from chemicals, waste, and bacteria. Ensuring water quality is critical for sustaining both the environment and public health (Kaly, 2004).

Materials and Methods

The research was conducted in the Thilawa Special Economic Zone (SEZ), located at 20°35'18" N latitude and 93°35'11" E longitude. Water samples were collected 5 feet from ten sampling sites (Table 1) below the surface water using a water pump in June 2024 to evaluate the physicochemical characteristics of the aquatic environment. On-site measurements for parameters like water temperature, pH, and dissolved oxygen (DO) were taken immediately after collection. The samples were stored in pre-cleaned polyethylene bottles, pre-treated by soaking in

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5 M HCl for over three days and rinsed with distilled-deionized water. After five days of incubation, the biochemical oxygen demand (BOD) was measured using a dissolved oxygen meter (Model HI-9145, Portugal). Chemical oxygen demand values were analyzed by using a COD meter (Model MD-200, Germany). Electrical conductivity and total dissolved solids of the collected water samples were determined by using EC/TDS meter (Model HI-99301, Romania). Alkalinity of water samples was determined by the titration method, and total hardness values were examined by Total Hardness Photometer (Model HI-9773, Romania). Chlorinity and salinity were determined using Mohr's titration method, and chlorophyll *a* values were determined by the Spectrophotometric method, while some mineral contents (Cr, Mn, Cd, Zn, Fe, As, and Hg) were analyzed via atomic absorption spectrophotometry. The total nitrogen content of the ten water samples was determined using the Azo dye method, while the total phosphate content was analyzed using the colorimetric molybdenum blue method. Microbial properties (total coliform and *E.coli*) of water samples were investigated by multiple tube method. The ten sampling locations are displayed in Table 1, with satellite images of Thilawa SEZ in Figure 1.

Table 1. Sampling Locations of Water Samples in Thilawa (SEZ)

No.	Sampling sites	Positions	
		Longitude (E)	Latitude (N)
1	Site 1	96° 14′ 30.9″	16° 40′ 16.9″
2	Site 2	96° 14′ 52.9″	16° 39′ 56.3″
3	Site 3	96°15′ 16.9″	16° 39′ 08.4″
4	Site 4	96° 15′ 43.5″	16° 38′ 56.5″
5	Site 5	96° 15′ 46.9″	16° 38′ 47.2″
6	Site 6	96° 15′ 48.5″	16° 38′ 26.3″
7	Site 7	96° 15′ 47.1″	16° 37′ 50.1″
8	Site 8	96° 15′ 40.5″	16° 37′ 25.6″
9	Site 9	96° 15′ 33.6″	16° 37′ 08.1″
10	Site 10	96° 15′ 29.1″	16° 36′ 32.0″

Figure 1. Satellite image of Thilawa (SEZ) and sampling location sites

Sample Preparation of Water Samples from Thilawa (SEZ)

The study was carried out in the Thilawa Special Economic Zone (SEZ), located at 20°35’18” N and 93°35’11” E. In June 2024, water samples were collected from a depth of 5 feet below the surface using a water sampler (pump) at ten sampling sites (Figure 2). These sites were selected based on their potential impact from local industrial activities. The water samples were preserved in pre-cleaned polyethylene bottles that had been soaked in 5 M HCl for more than three days and subsequently rinsed with distilled-deionized water before sampling.

Figure 2. Photograph of water sample collection in Thilawa (SEZ)

Results and Discussion

pH and Temperature of the Collected Water Samples from Thilawa (SEZ)

The pH values of the water samples ranged from 7.3 to 7.6, indicating a slightly basic nature, well within the acceptable limits set by WHO (2022) , EPA (2017), and ASEAN (2010). These values are suitable for fisheries and aquatic life. The water temperature during sampling ranged from 31.2°C to 32.4°C. This variation is typical for the region and can influence other water quality parameters, such as dissolved oxygen (Table 2).

Dissolved Oxygen, Biological Oxygen Demand and Chemical Oxygen Demand of the Collected Water Samples from Thilawa (SEZ)

Dissolved oxygen (DO) levels, which are critical for aquatic organisms, were recorded between 5.01 and 6.29 ppm (Table 2). These values align with WHO, EPA, and ASEAN standards, indicating unpolluted water that is safe for aquatic life, as DO levels below 5 ppm can harm biological communities, and levels below 2 ppm can cause fish mortality. The biological oxygen demand (BOD), measured after 5 days of incubation at 20°C, was found to be below WHO, EPA, and ASEAN standards. Since BOD levels below 2 ppm suggest unpolluted water, these results indicate the water is likely unpolluted in terms of organic matter

The chemical oxygen demand (COD) of the river water, ranging from 9.30 to14.28ppm, needs regular monitoring and pollution source mitigation to protect the aquatic ecosystem.

Electrical Conductivity, Total Dissolved Solids, Total Alkalinity and Total Hardness of the Collected Water Samples from Thilawa (SEZ)

The electrical conductivity ranged from 0.16 to 1.25 mS/cm (Table 3), showing differences in the water's ionic content, suggesting the need to investigate natural and human-related causes. The total dissolved solids (TDS) of the collected samples from Thilawa Special Economic Zone (SEZ) ranged from 0.08 to 0.63 ppt. The resulting data suggest the water quality needs further investigation and monitoring. The total alkalinity of water samples, ranging from 83 to 283 ppm, shows it can neutralize acids effectively. Its total hardness of 192 to 202 ppm indicates the water is moderately hard, which can affect mineral buildup and water quality.

Table 2. Some Physicochemical Characteristics of Collected Water Samples from-Thilawa (SEZ)

Sampling Sites	pH	Temperature (°C)	DO (ppm)	BOD (ppm)	COD (ppm)
S-1	7.3	31.8	6.02	0.89	12.94
S-2	7.3	31.2	6.29	1.20	9.57
S-3	7.4	31.7	5.59	0.98	11.34
S-4	7.5	31.3	5.26	0.78	10.87
S-5	7.5	31.5	5.80	1.40	9.30
S-6	7.5	31.5	5.87	1.37	9.57
S-7	7.6	32.2	5.67	1.07	14.28
S-8	7.5	32.3	5.39	0.54	13.30
S-9	7.5	32.4	5.01	0.71	10.51
S-10	7.6	32.3	5.20	0.66	11.43
WHO (2022)	6.5 – 8.5	30 – 32	>5	<3	<20
EPA (2017)	6.5 – 8.5	30 – 32	>5-6	<3-5	<20
ASEAN Standard (2010)	6.5 – 8.5	30 – 32	>5	<5	<20

Table 3. Electrical Conductivity, Total Dissolved Solid, Total Alkalinity, and Total Hardness of Collected Water Samples from Thilawa (SEZ)

Sampling Sites	EC (mS/cm)	TDS (ppt)	Total alkalinity (ppm)	Total hardness (ppm)
S-1	0.16	0.08	83	192
S-2	0.17	0.07	100	202
S-3	0.16	0.08	116	192
S-4	0.17	0.08	116	192
S-5	0.16	0.08	133	202
S-6	0.15	0.07	133	201
S-7	0.37	0.18	166	201
S-8	0.50	0.24	183	201
S-9	0.88	0.45	266	201
S-10	1.25	0.63	283	202
WHO (2022)	<1.5	<0.3	100 – 250	50 – 250
EPA (2017)	<1.5	<0.5	100 – 250	50 – 250
ASEAN Standard (2010)	<1.5	<0.3	100 – 250	50 – 250

Chlorinity and Salinity of the Collected Water Samples from Thilawa (SEZ)

Chlorinity values ranged from 0.063 to 0.113 ppt, i.e., 63 to 113 ppm, below the WHO limit of 0.25 ppt (250 ppm,), indicating moderate salinity. Salinity levels ranged from 0.113 to 0.204 ppt, also below the WHO standard (1-2 ppt) for freshwater. These results suggest a low to moderate level of dissolved salts, classifying the water as slightly brackish with minimal saline influence, suitable for various uses (Table 4).

Table 4. Chlorinity and Salinity of Collected Water Samples from Thilawa (SEZ)

Sampling Sites	Chlorinity (ppt)	Salinity (ppt)
S-1	0.073	0.131
S-2	0.073	0.131
S-3	0.063	0.113
S-4	0.073	0.131
S-5	0.070	0.126
S-6	0.065	0.117
S-7	0.113	0.204
S-8	0.113	0.204
S-9	0.099	0.178
S-10	0.099	0.178
WHO (2022)	0.05 – 19	1 – 2
EPA (2017)	0.05 – 19	1 – 2
ASEAN Standard (2010)	0.05 – 19	1 – 2

Chlorophyll *a* and Total Nitrogen of the Collected Water Samples from Thilawa (SEZ)

The chlorophyll-a provides valuable insight into the level of phytoplankton activity and nutrient status of the aquatic ecosystem. In this study, the chlorophyll-a levels in the water samples range from 0.749 to 2.138 µg/10 mL (Table 5), which are well below the acceptable limits set by WHO (2022), EPA (2017), and ASEAN (2010) standards. This indicates minimal algal presence and suggests that the aquatic system is not experiencing significant algal blooms

The total nitrogen concentrations in the samples range from 1.58 to 1.92 ppm, exceeding the recommended limit of 1 ppm established by WHO (2022), EPA (2017), and ASEAN(2010) standards. These elevated levels suggest nutrient enrichment in the water, potentially posing a risk of eutrophication and impacting water quality.

Table 5. Chlorophyll *a*, and Total Nitrogen of the Collected Water Samples from Thilawa (SEZ)

Sampling sites	Chlorophyll *a* (µg/10 mL)	Total nitrogen (ppm)
S-1	2.138	1.58
S-2	0.938	1.76
S-3	1.324	1.64
S-4	1.082	1.64
S-5	1.102	1.74
S-6	1.820	1.68
S-7	1.384	1.92
S-8	1.089	1.81
S-9	0.749	1.82
S-10	0.820	1.83
WHO (2022)	<10	<1
EPA (2017)	<10	<1
ASEAN Standard (2010)	<10	<1

Orthophosphate and Organic Phosphate of the Collected Water Samples from Thilawa (SEZ)

Orthophosphate levels within the range of 0.062 to 0.215 ppm are typical of healthy aquatic environments, where nutrient levels support plant growth. Organic phosphate concentrations between 5.61 and 7.83 ppm suggest substantial organic matter presence, which may indicate decomposition or pollution sources like untreated sewage or industrial waste (Table 6).

Nutrient Levels of the Collected Water Samples from Thilawa (SEZ)

Based on the medium values of DO, orthophosphate, and total nitrogen, the water samples were conclusively classified as a mesotrophic level (Tables 7 and 8), indicating moderate nutrient availability and balanced aquatic productivity. This classification highlights the importance of monitoring nutrient inputs to prevent a shift toward eutrophic conditions, which could lead to ecological imbalance and degradation of water quality.

Table 6. Orthophosphate and Organic Phosphate of the Collected Water Samples from Thilawa (SEZ)

Sampling sites	Orthophosphate (ppm)	Organic phosphate (ppm)
S-1	0.062	5.61
S-2	0.108	6.36
S-3	0.123	7.83
S-4	0.113	6.17
S-5	0.106	6.16
S-6	0.131	7.83
S-7	0.212	6.87
S-8	0.169	6.24
S-9	0.213	6.21
S-10	0.215	6.38

Table 7. Nutrient Levels of Brackish Water Samples from Thilawa (SEZ)

Sampling sites	DO (pm)	Orthophosphate (ppm)	Total nitrogen (ppm)	Nutrient enrichment
S-1	6.02	0.062	1.58	Medium
S-2	6.29	0.108	1.76	Medium
S-3	5.59	0.123	1.64	Medium
S-4	5.26	0.113	1.64	Medium
S-5	5.80	0.106	1.74	Medium
S-6	5.87	0.131	1.68	Medium
S-7	5.67	0.212	1.92	Medium
S-8	5.39	0.169	1.81	Medium
S-9	5.01	0.213	1.82	Medium
S-10	5.20	0.215	1.83	Medium

Table 8. Criteria for Evaluating Degree of Nutrient Over-Enrichment

Parameter	Low	Medium	High
Nitrogen (ppm)	≤ 0.1	> 0.1 - < 1.0	≥ 1.0
PO_4^{3-} (ppm)	< 0.03	> 0.03 - < 0.3	≥ 0.3
DO (ppm)	≥ 5	> 2 - ≤ 5	0 - ≤ 2

Low nutrient enrichment = Oligotrophic level*
Medium nutrient enrichment = Mesotrophic level
High nutrient enrichment = Eutrophic level
* Tong and Deocadiz, 1999

Some Mineral Contents of the Collected Water Samples from Thilawa (SEZ)

At various sampling sites, the concentration of metals (in ppm) varied significantly, with notable detections including chromium (Cr) up to 4.59 ppm, manganese (Mn) reaching 6.84 ppm, cadmium (Cd) peaking at 4.21 ppm, and copper (Cu) at 3.81 ppm. Zinc (Zn) and iron (Fe) were present at moderate levels, while arsenic (As) and mercury (Hg) remained undetected across all sites (Table 9).

Table 9. Some Mineral Contents of the Collected Water Samples from Thilawa (SEZ) by AAS

Sampling sites	Some mineral contents (ppm)							
	Cr	**Mn**	**Cd**	**Cu**	**Zn**	**Fe**	**As**	**Hg**
S-1	ND	2.91	ND	ND	0.61	3.14	ND	ND
S-2	ND	ND	ND	ND	ND	ND	ND	ND
S-3	ND	2.44	ND	ND	0.91	ND	ND	ND
S-4	ND	2.59	0.19	ND	0.60	1.41	ND	ND
S-5	ND	0.43	4.11	3.81	ND	ND	ND	ND
S-6	4.59	3.96	2.56	ND	0.92	1.68	ND	ND
S-7	3.63	ND	1.72	ND	2.69	ND	ND	ND
S-8	ND	5.61	4.21	ND	3.57	0.89	ND	ND
S-9	ND	6.84	ND	ND	ND	0.02	ND	ND
S-10	1.16	2.48	0.22	ND	ND	ND	ND	ND

*ND = Not Detected

Microbial Properties of the Collected Water Samples from Thilawa (SEZ)

The absence of total coliforms in all water samples and the detection of *E. coli* only at site 2 indicate overall good microbial water quality. However, the presence of *E. coli* at site 2 suggests localized contamination, highlighting the need for targeted investigation and remediation efforts in that area (Table 10).

Table 10. Total Coliform and *E.coli* Values of Brackish Water Samples from Thilawa (SEZ)

Sampling Sites	Total coliform (cfu/mL)	*E.coli* (cfu/mL)
S-1	0	0
S-2	0	100
S-3	0	0
S-4	0	0
S-5	0	0
S-6	0	0
S-7	0	0
S-8	0	0
S-9	0	0
S-10	0	0
WHO (2022)	0	0
EPA (2017)	0	0
ASEAN Standard (2010)	0	0

Conclusion

The water quality analysis indicates that the aquatic environment is generally suitable for supporting life, with parameters like pH, temperature, dissolved oxygen, BOD, salinity, and chlorinity within acceptable limits. However, certain factors require attention, including elevated COD levels indicating moderate pollution, localized contamination from metals like chromium, manganese, and cadmium, and high organic phosphate concentrations suggesting pollution from organic matter. Nutrient levels suggest a mesotrophic state without immediate eutrophication risks. The absence of total coliforms in all water samples and the detection of *E. coli* only at site 2 indicate overall good microbial water quality across the study area. Continuous microbial monitoring is needed to prevent future risks and maintain water quality standards. While the absence of arsenic, mercury, and microbial contamination is reassuring, continuous monitoring and management of potential pollution sources are crucial to maintaining water quality and protecting public health.

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