Spatial Trends and Temporal Variation Using Geographic Information Systems (GIS) in Talomo River, Davao City, Philippines

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Abstract: This study analyzes the spatial trends and temporal variability of water quality in the Talomo River Watershed, Davao City, Philippines, using Geographic Information Systems (GIS). A descriptive-quantitative approach was applied to evaluate key parameters across 14 monitoring stations from 2019-2024, including Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), fecal coliform, Total Suspended Solids (TSS), nitrate, phosphate, pH, temperature, color, and chloride. Results show that average BOD levels reached up to 9.02 mg/L (Station 7), exceeding the standard of 5 mg/L, while DO ranged from 6.31–8.37 mg/L, remaining above the minimum threshold. Fecal coliform concentrations were critically high across all stations, with values reaching 158,675.91 MPN/100 mL, far beyond the allowable 100 MPN/100 mL. TSS values peaked at 155.98 mg/L, exceeding the 65 mg/L limit in several upstream stations. Nitrate concentration reached 13.58 mg/L at Station 1, surpassing the 7 mg/L standard, while chloride peaked at 2,427.11 mg/L, indicating localized contamination. In contrast, pH (7.80–8.30), phosphate (0.06–0.27 mg/L), temperature (23.48–28.54°C), and color remained within permissible limits. Spatial analysis using IDW revealed pollution hotspots in upstream and midstream sections. The findings emphasize the need for targeted watershed management and improved wastewater control strategies.

Keyword: *GIS, Inverse Distance Weighting (IDW), Water Quality, Talomo River Watershed, Philippines.*

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I. INTRODUCTION

The United Nations Sustainable Development Goals (SDGs) highlight the interconnectedness of environmental protection, urban development, and climate resilience. SDG 6 (Clean Water and Sanitation) underscores the need to ensure the availability and sustainable management of clean water resources, emphasizing pollution reduction and the protection of aquatic ecosystems. SDG 11 (Sustainable Cities and Communities) focuses on minimizing the environmental impact of urbanization, including the improvement of water and waste management systems to foster resilient and livable cities. Meanwhile, SDG 13 (Climate Action) calls for the integration of climate-responsive strategies to mitigate and adapt to the impacts of climate change, particularly on vital freshwater resources. By determining the spatial and temporal trends while incorporating GIS in Talomo River, this study is in line with the global objectives, giving insights into sustainable water resources management specifically in a Highly Urbanized area such as Davao City in the Philippines.

Every river is an essential freshwater ecosystem that supports several functions for domestic, agricultural, and industrial purposes. In addition to these utilitarian functions, they support diverse aquatic biodiversity and enable key ecosystem processes (Md Anawar & Chowdhury, 2020). Moreover, due to increasing urbanization, land use conversion, agricultural runoff, and anthropogenic pollution have affected water quality in this ecosystem, with elevated levels of nutrients, organic material, and heavy metals (Hoang et al., 2025). Examining how the parameters of water quality vary with time is critical to documenting the seasonal and annual cycles, which further informs rational management strategies and effective policy-making decisions (Rahman et al., 2022; Hoang et al., 2025). Understanding these temporal variations can help identify pollution sources and evaluate the effectiveness of watershed protection measures, thereby contributing to sustainable water resource management.

The Talomo River in Davao City is an important water supply for domestic, industrial, and agricultural purposes

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and is most likely affected by several point and non-point sources of pollution. As a result of surrounding land use, population stress, and possible industrial discharge, water quality in the river may strongly fluctuate seasonally. With the monitoring of parameters like biochemical oxygen demand (BOD), dissolved oxygen (DO), pH, total suspended solids (TSS), and nutrients (nitrate and phosphate), significant clues about river health can be obtained (Rahman et al., 2022).

This study aims to analyze the temporal variability of selected physicochemical, microbiological, and heavy metal parameters of Talomo River for calendar years 2019–2024, across 14 monitoring stations. Through this analysis, the research seeks to characterize seasonal patterns, detect trends of pollution, compare results with relevant water quality guidelines, and provide recommendations to improve water resource management in Davao City.

Specifically, this study aims (1) to quantify the temporal variability (annual average 2019-2024) of water quality parameters (BOD, Chloride, Color, DO, Fecal Coliform, Nitrate, pH, Phosphate, Temperature, TSS) of Talomo River from CY 2019 to 2024 across 14 monitoring stations (2) and to identify spatial trends, and (3) to generate a spatial interpolation map of of the parameters' concentrations across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) technique in QGIS.

The conceptual framework of this study is framed from the work of Li et al. (2022), with a study entitled *"Linking Land Use with Riverine Water Quality: A Multi-Spatial Scale Study"* published in *Frontiers in Environmental Science*. The study shows how changes in LULC and landscape across the study area affects the water quality across varying spatial and temporal scales. Drawing from Li et al. (2022), the study considers land use and land cover (LULC) as an independent factor influencing the spatial heterogeneity of water quality across multiple monitoring stations and the temporal variability of water quality parameters between 2019 and 2024.

II. MATERIALS AND METHODS

➢ *Design and Procedure*

This study employed a descriptive-quantitative research design to investigate the spatial and temporal patterns of water quality within the Talomo River Watershed. The descriptive component was used to characterize trends, variability, and the status of selected water quality parameters, while the quantitative aspect utilized statistical analyses, including means, ranges, and comparative evaluations, to assess temporal changes and deviations from regulatory standards. This approach was appropriate, as it allowed for systematic numerical measurement and assessment of environmental parameters, providing a comprehensive understanding of the watershed's condition and dynamics.

Part of the methodology of this study is the incorporation of QGIS, specifically with the use of Inverse Distance Weighted (IDW) interpolation technique. The use of IDW in QGIS interpreted the spatial surfaces of water quality parameters from its sampling points across Talomo-Lipadas Watershed. The IDW algorithm helped estimate the values at areas that were unsampled by providing weights inversely proportional to the distance from a given point, under the assumption that the given area location closer to the sampling point that were measure were more similar that those that were farther away. With this, the visualization of spatial gradients, determining of potential hotspots, and assessment of the area of exceedances for the given parameters, providing a spatially explicit interpretation of water quality change (Lie et al., 2021). Further, the IDW process in QGIS included the importing water quality dataset, providing appropriate coordinate reference system (CRS), and raster surfaces for every parameter included in the study, that were analyzed to determine areas of concern and spatial trends.

Water quality data for the study were obtained from the Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB) for Calendar Years 2019–2024. The dataset included the following parameters: Biochemical Oxygen Demand (BOD), Chloride, Color, Dissolved Oxygen (DO), Fecal Coliform, Nitrate, pH, Phosphate, Temperature, Total Suspended Solids (TSS). These parameters were selected as key indicators of chemical, physical, and biological water quality, allowing for an integrated assessment of ecosystem health and potential anthropogenic impacts within the watershed.

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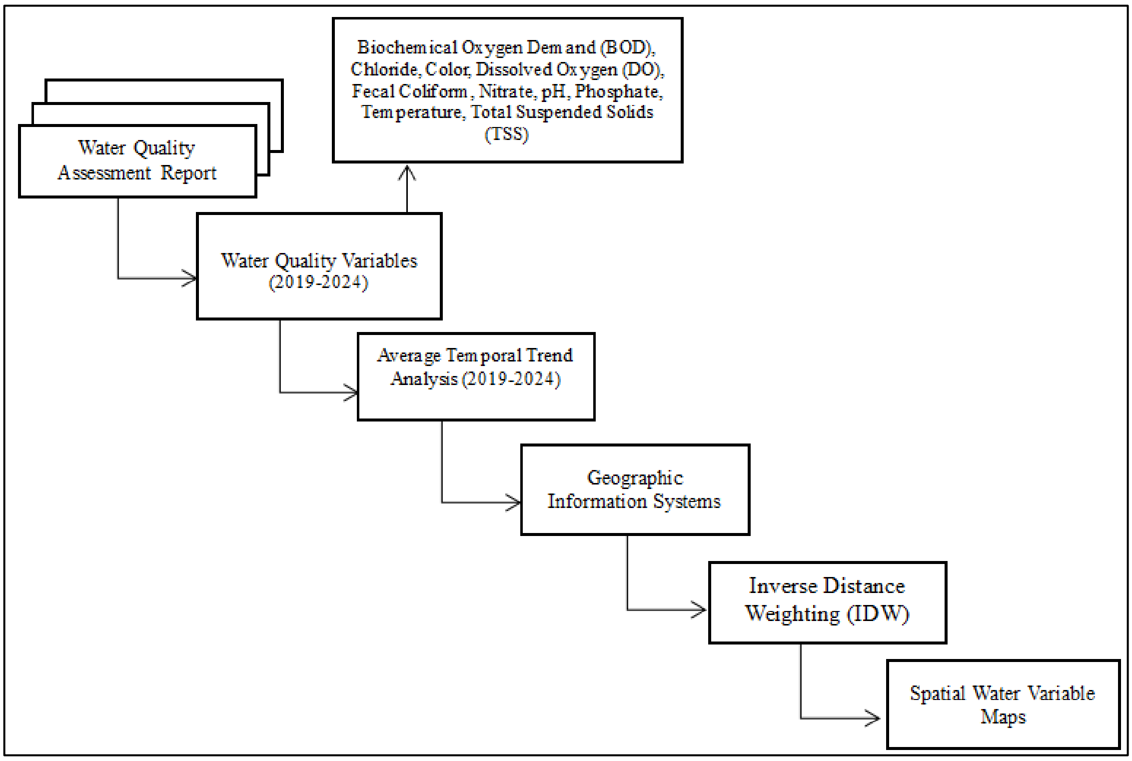

Fig 1 Conceptual Framework of the Study

➤ *Research Locale*

The study area of this paper is situated in Talomo River Watershed, Davao City, Davao Del Sur, Philippines, which is shown in Figure 3 of the paper. The largest city in the Philippines in terms of land area is Davao City, which lies in the southern part of Mindanao. This city is highly urbanized, leading in the commerce, trade, and industry hub in Mindanao (Dumdumaya & Cabrera, 2023). The Talomo River Watershed is located geographically between 7°8'4.87"N latitude and 125°26'35.66"E longitude. This watershed is where the Talomo River is situated, which is the second major drainage basin in Davao City (Acosta et al., 2019). The location has a total area of 21,578 hectares. Rapids and rocky terrain characterize this area, and canopy covers are found in its banks. According to DENR- RCBO (2017), this watershed has a drainage area of 244 km2. Talomo River Watershed experiences the Type IV climate, which indicates that it experiences equal distribution of rainfall throughout the year (Department of Agriculture, 2014).

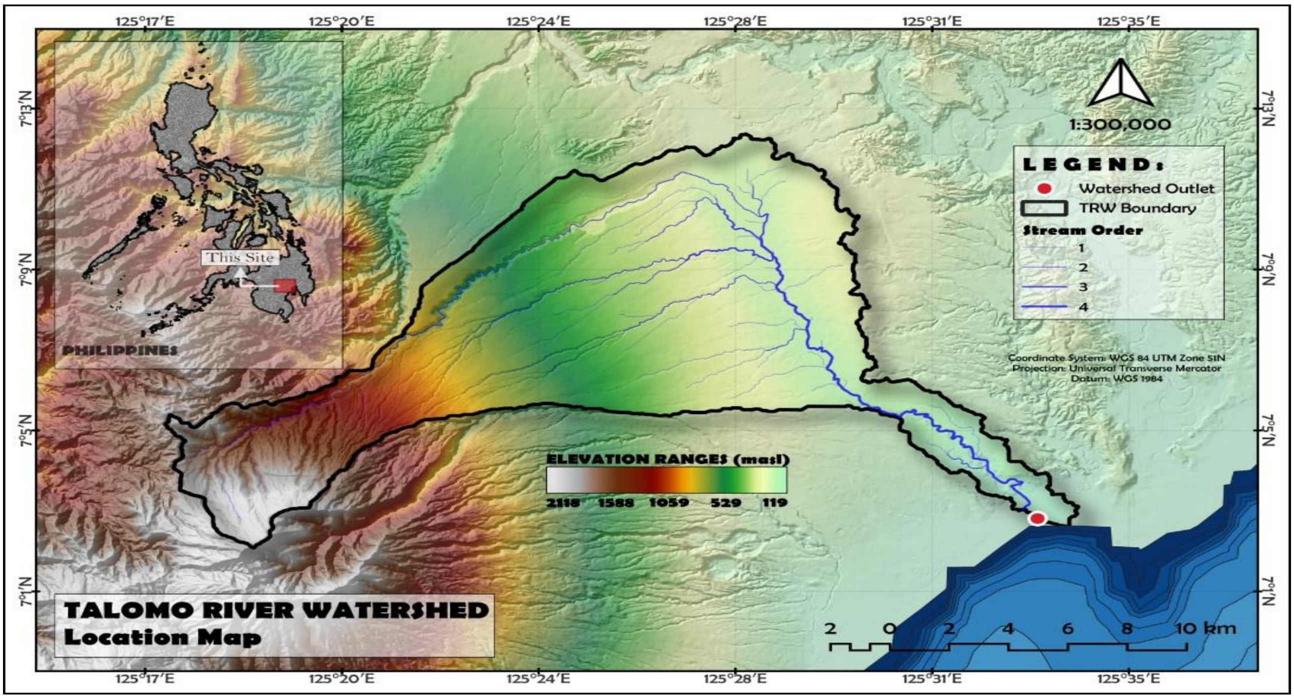

Fig 2 Location of the Study

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III. RESULTS AND DISCUSSIONS

➢ *Water Quality Spatio-Temporal Variability of Talomo River*

The physiochemical water quality of Talomo River for CY 2019-2024 is presented in the figures below for the following parameters: Biochemical Oxygen Demand (BOD), Chloride, Color, Dissolved Oxygen (DO), Fecal Coliform, Nitrate, pH, Phosphate, Temperature, and Total Suspended Solids (TSS)

- *Biochemical Oxygen Demand (BOD)*

Table 1 Average Values for CY 2019-2024 Period of BOD

Station	Year (mg/L)						Average	DAO 2016-08 5 mg/L
	2019	2020	2021	2022	2023	2024		
1	3.39	2.75	24.00	3.72	2.86	2.20	6.48	Failed
2	2.23	1.79	33.35	2.47	2.28	2.05	7.36	Failed
2a	1.64	1.56	29.38	2.23	1.48	1.82	6.35	Failed
3	1.81	1.91	37.46	2.48	1.96	2.20	7.97	Failed
3a	2.32	2.14	24.25	2.58	1.91	2.02	5.87	Failed
3b	1.85	2.16	16.97	2.61	1.83	2.03	4.58	Passed
4	2.12	2.23	13.13	2.82	2.06	1.95	4.05	Passed
4a	1.49	2.36	9.85	2.77	1.83	1.94	3.37	Passed
5	1.27	1.70	4.95	1.31	1.82	1.18	2.04	Passed
6	1.27	1.73	11.42	1.47	1.01	1.00	2.98	Passed
7	0.77	0.81	50.15	1.27	0.50	0.63	9.02	Failed
8	0.68	0.78	3.99	0.74	0.60	0.59	1.23	Passed
9	0.71	0.62	2.44	0.42	0.50	0.50	0.86	Passed
10	0.64	0.62	0.28	0.36	0.60	0.37	0.48	Failed

BOD is a standard parameter for determining the concentration of oxygen demand required by microorganisms to decompose organic matter, which occurs in a minimum period of 5 days (Aguilar-Torrejón, et al., 2023). High levels of BOD means that biodegradable organic material in a specific water is large. Thusly, the higher the oxygen consumed, the less oxygen available for aquatic organisms that would lead to stress and death of aquatic life, and thus, affects the biodiversity and degradation of the specific ecosystem in the area.

The graph below shows that only stations 5, 8, 9, and 10 did not exceed the required minimum standard based on DAO 2016-08 or the Water Quality Guidelines and General Effluent Standards of 2016.

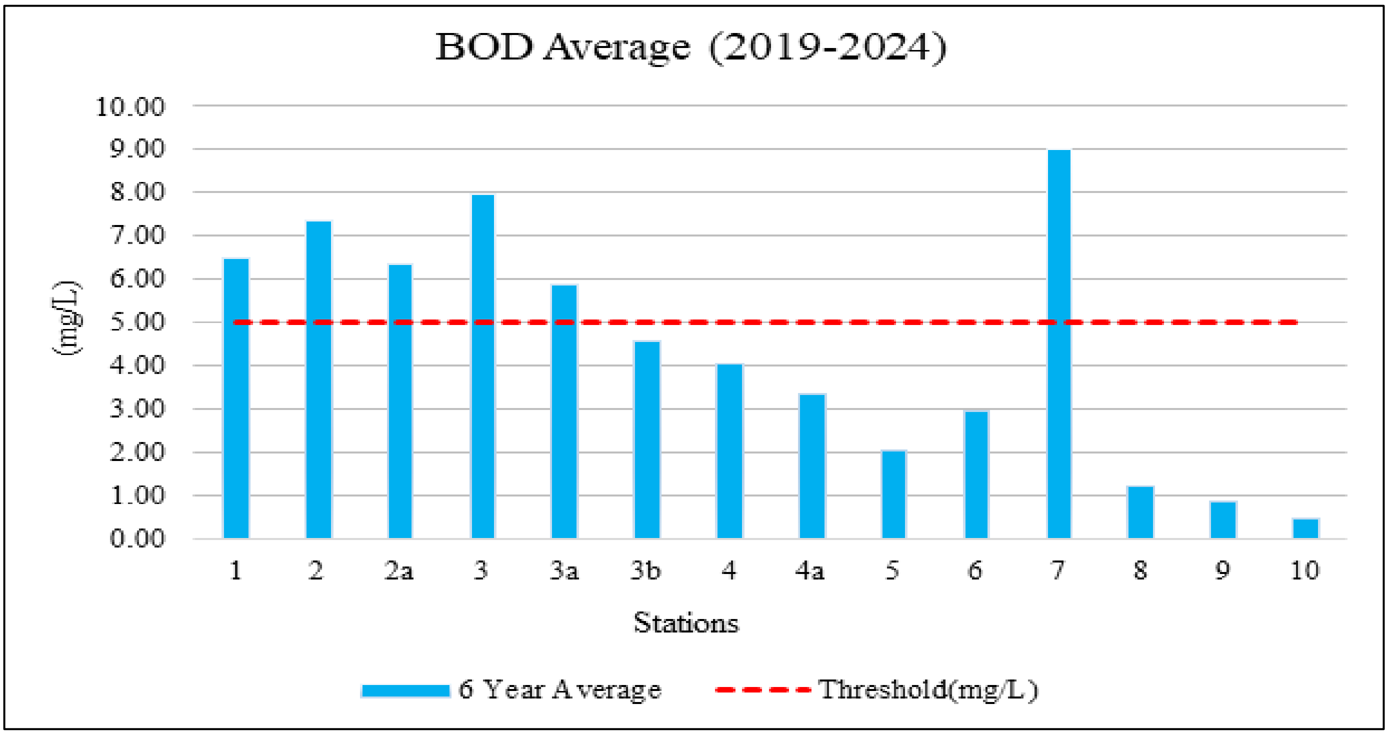

Fig 2 Average BOD of Talomo River CY 2019-2024

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Figure 3 below shows the map of Talomo-Lipadas. Using the Inverse Distance Weighting or IDW, the unknown values based on the weighted average of the known values calculate the unknown location of the values of nearby points. The figure below shows that stations 7, 3, 21,2, and 1 goes beyond the threshold based on General Effluent Standard or DA0 2016-18 for waters under Class B. Further, the figure also shows the extent of the geographical distribution (or variation in concentration/levels) of a water quality parameter across a study area.

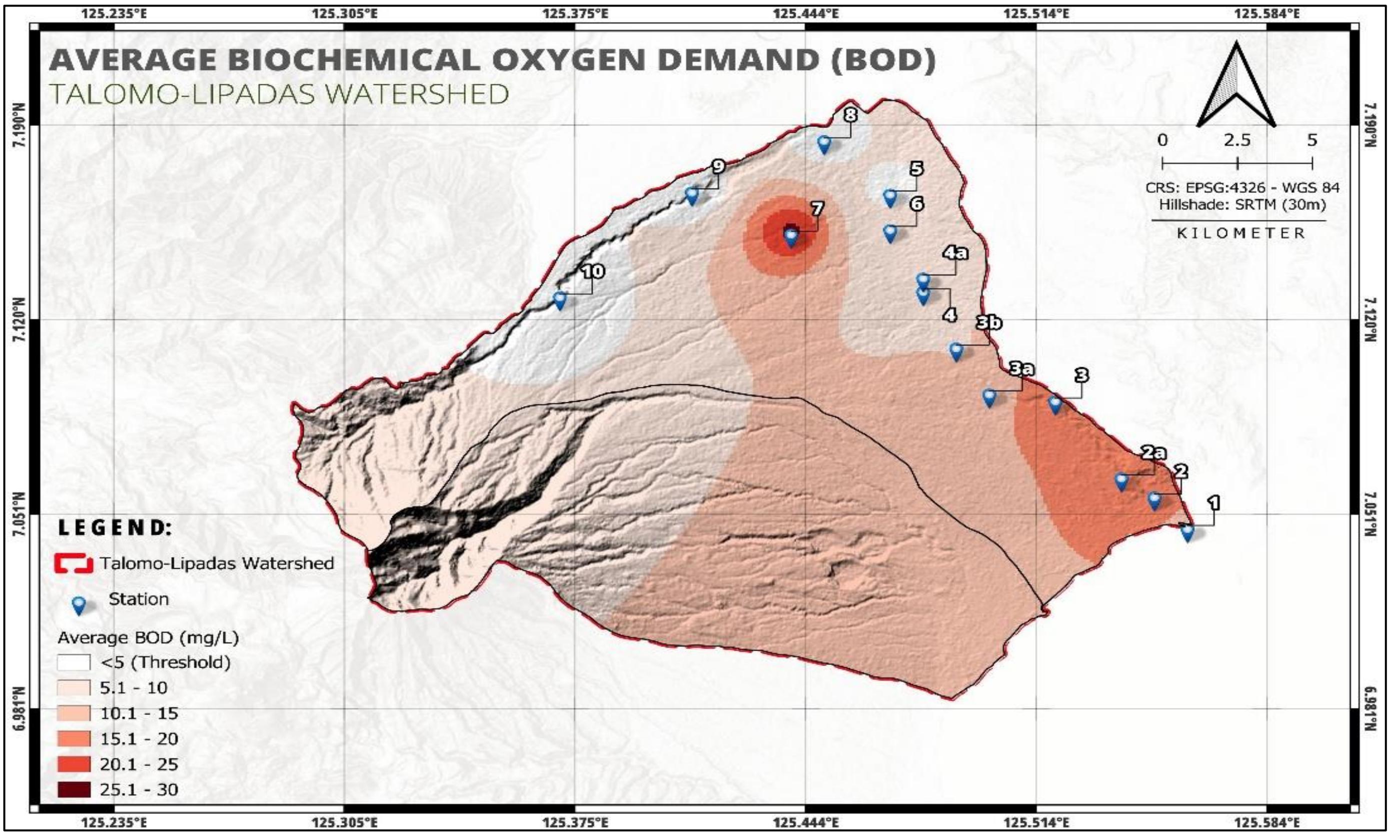

Fig 3 Map Showing the Average Concentration of BOD Along Talomo-Lipadas Watershed

- *Dissolved Oxygen (DO)*

Table 2 Average Values for CY 2019-2024 Period of DO

Station	Year (mg/L)						Average	DAO 2016-08 *5 mg/L*
	2019	2020	2021	2022	2023	2024		
1	6.32	6.08	6.00	6.50	6.13	6.84	6.31	Failed
2	7.47	7.46	7.36	7.41	7.60	7.75	7.51	Failed
2a	7.91	7.81	7.69	7.61	7.79	8.01	7.80	Failed
3	7.66	7.67	7.53	7.38	7.43	7.37	7.50	Failed
3a	7.91	7.85	7.71	8.18	7.69	7.97	7.88	Failed
3b	7.56	7.75	7.66	7.88	7.81	7.91	7.76	Failed
4	7.82	7.63	6.87	7.36	7.27	7.82	7.46	Failed
4a	7.88	7.69	7.68	7.52	7.39	7.67	7.64	Failed
5	7.89	7.86	7.75	7.88	7.66	7.66	7.78	Failed
6	7.43	7.42	7.60	7.95	7.68	7.78	7.64	Failed
7	7.81	7.82	7.75	8.22	7.68	7.87	7.86	Failed
8	8.30	8.24	8.12	8.26	8.10	8.15	8.20	Failed
9	8.60	8.40	8.30	8.36	8.23	8.23	8.35	Failed
10	8.74	8.37	8.22	8.38	8.22	8.26	8.37	Failed

The parameter, Dissolved Oxygen (DO) signals the degradation of water quality the directly affects the aquatic life (Zhao et al., 2021). In freshwater systems that is not yet polluted, DO concentration ranges from 8 to 12 mg/L. Values below 8 mg/L may potentially pose risks to organisms in aquatic ecosystems. Based on the Philippine Water Quality Standards, Class B water bodies must maintain a minimum DO of 5 mg/L to have a sustainable aquatic life and supports its beneficial uses. All stations have high Dissolved Oxygen or do not fall below 5 mg/L.

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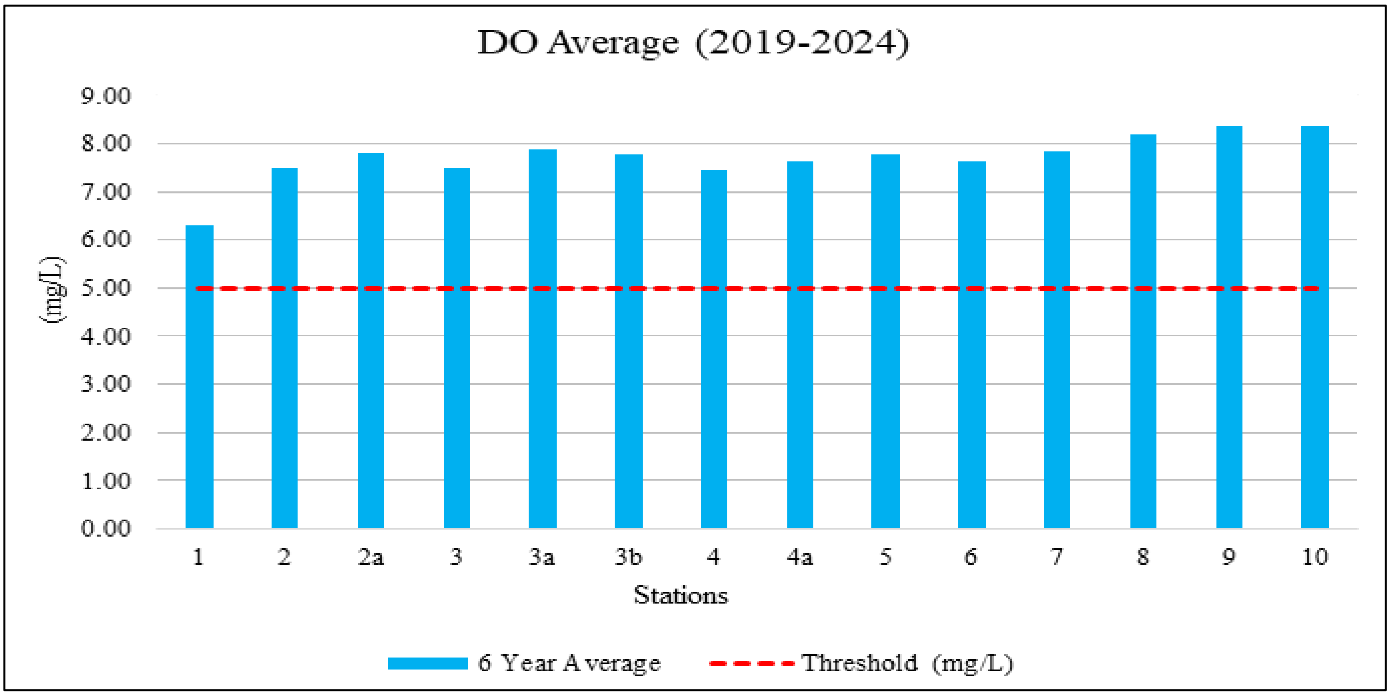

Fig 4 Average DO of Talomo River CY 2019-2024

Figure 3 below shows the map of Talomo-Lipadas. Using the Inverse Distance Weighting or IDW, the unknown values based on the weighted average of the known values calculates the unknown location of the values of nearby points. The figure below shows that all stations does not fall below the threshold for water under Class B.

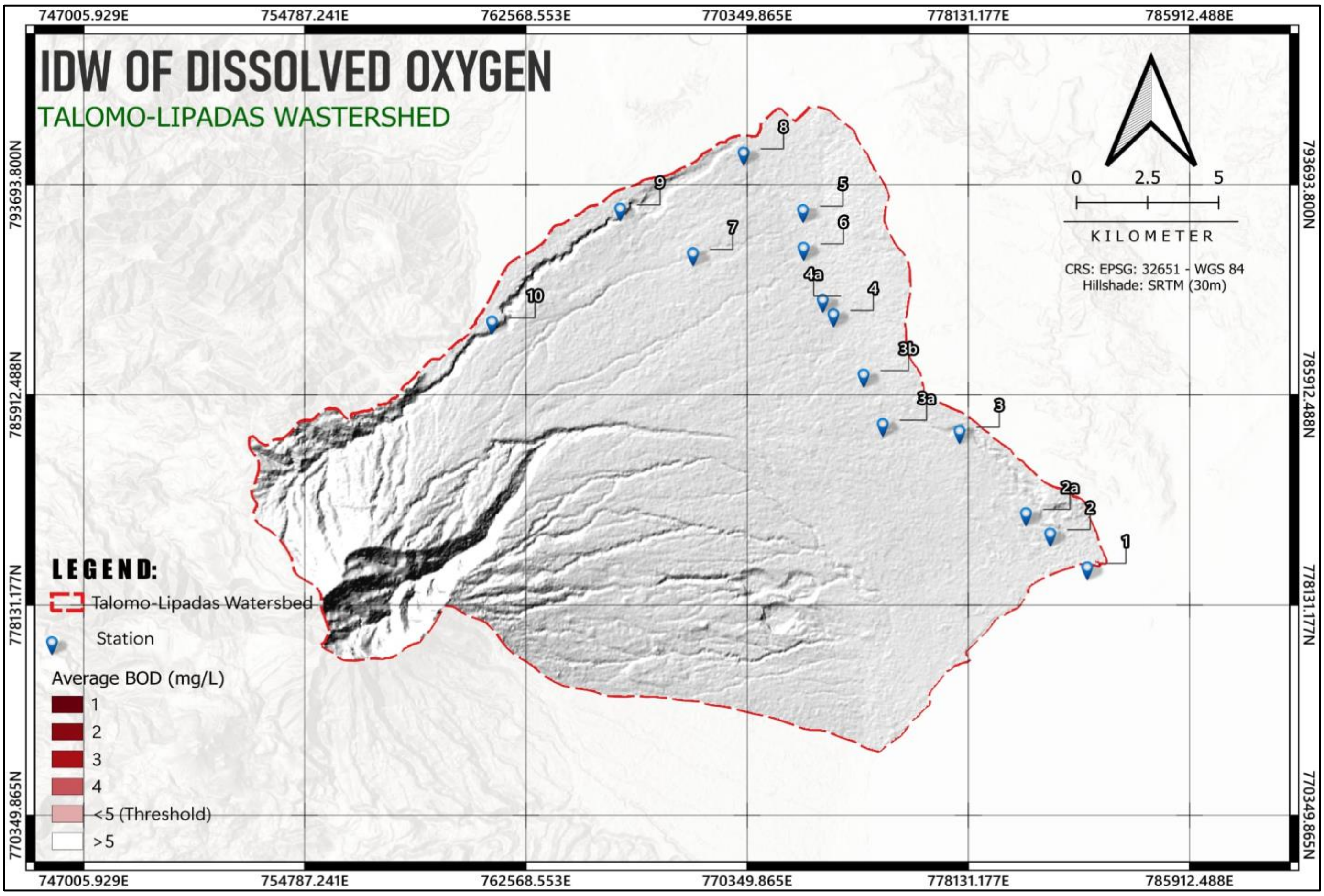

Fig 5 Map Showing the Concentration of BOD in Talomo-Lipadas Watershed

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- *Fecal Coliform*

Table 3 Average Values for CY 2019-2024 Period of Fecal Coliform

Station	Year (mg/L)						Average	DAO 2016-08 *100 MPN/100 mL)*
	2019	2020	2021	2022	2023	2024		
1	156122	67005	139179	256787	263110	162260	158675.91	Failed
2	21335	16969	27842	44815	35836	29391	27940.47	Failed
2a	4175	10646	20436	37569	22025	25229	16329.69	Failed
3	13564	8026	18085	35379	17434	18778	16839.37	Failed
3a	19740	9541	39611	30558	78056	34528	29157.25	Failed
3b	31089	13395	24516	86318	39906	44856	34118.82	Failed
4	30047	15067	49263	80620	109080	65788	48429.90	Failed
4a	25572	28197	25780	68250	41494	42421	36153.79	Failed
5	13203	12109	10111	79687	25985	26797	21157.15	Failed
6	24296	19276	39867	40337	26996	10272	24357.68	Failed
7	6518	3080	6291	8283	13982	11658	7446.67	Failed
8	1349	1899	605	1135	6011	2954	1774.93	Failed
9	266	229	635	194	274	307	292.96	Failed
10	185	135	136	152	304	519	208.09	Failed

The parameter, Fecal Coliform, indicates the presence of pathogenic microorganisms that may pose risks to human health and aquatic life, making it an essential indicator of water sanitation and contamination levels (Galera et al., 2018). For Class B water bodies, which are intended for recreational use such as swimming and other primary contact activities, the Philippine Water Quality Guidelines and General Effluent Standards prescribe a maximum allowable concentration of 100 MPN/100 mL. However, fecal coliform levels in Stations 1, 2, 2a, 3, 3a, 3b, 4, 4a, 5, 6, 7, 8, 9, and 10 all exceeded this threshold, which may indicate that Talomo River is potentially affected by the domestic wastewater discharge from nearby areas.

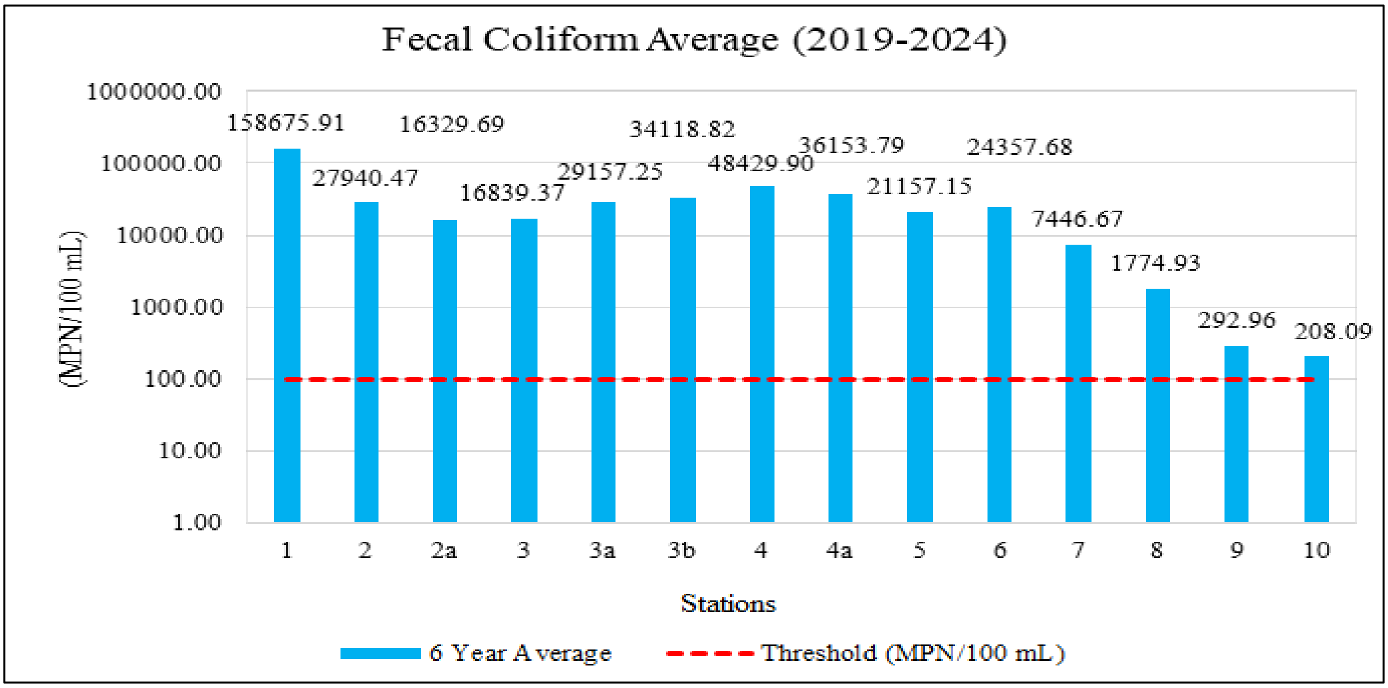

Fig 6 Average Fecal Coliform of Talomo River CY 2019-2024

Figure 7 presents the spatial distribution of fecal coliform concentrations across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique. IDW estimates the values of unsampled locations based on the weighted influence of nearby sampled points, allowing a continuous surface representation of contamination levels throughout the study area. The map clearly illustrates that all monitoring stations exceeded the allowable threshold of 100 MPN/100 mL for Class B waters as specified in the General Effluent Standards (DAO 2016-08). Similar findings were observed by Galera et al. (2018) in the Meycauayan-Marilao River System, where elevated

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fecal coliform levels were linked to domestic wastewater discharges and inadequate sanitation facilities. This spatial pattern highlights areas of potentially higher contamination influence, which may be associated with dense settlements along riverbanks and insufficient wastewater management.

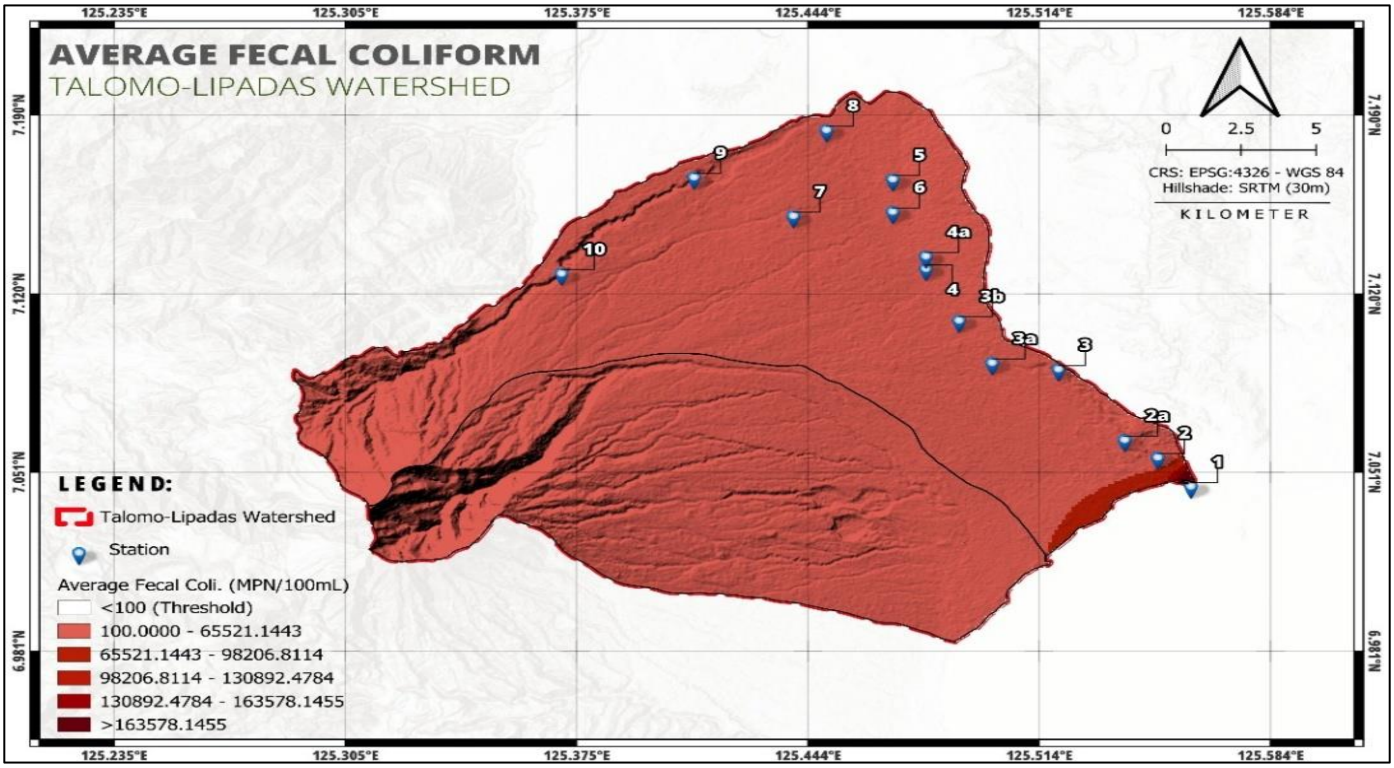

Fig 7 Map Showing the Concentration of Fecal Coliform in Talomo-Lipadas Watershed

- *Chloride*

Table 4 Average Values for CY 2019-2024 Period of Chloride

Station	Year (mg/L)						Average	DAO 2016-08 250 mg/L
	2019	2020	2021	2022	2023	2024		
1	3741.50	3210.11	2853.00	1512.69	1761.00	1484.37	2427.11	Failed
2	6.20	17.54	6.25	7.05	3.88	13.82	9.12	Passed
2a	5.88	4.84	5.09	3.55	3.22	5.19	4.63	Passed
3	5.16	4.05	5.34	3.67	2.61	10.19	5.17	Passed
3a	6.03	5.23	5.42	3.05	2.84	14.67	6.21	Passed
3b	5.33	4.23	4.86	2.90	2.62	12.48	5.40	Passed
4	4.88	4.14	4.74	2.83	3.35	5.77	4.29	Passed
4a	4.87	4.09	4.77	2.86	2.65	10.30	4.92	Passed
5	4.27	3.65	4.47	3.00	2.49	5.17	3.84	Passed
6	7.37	5.00	5.78	3.77	4.87	11.39	6.36	Passed
7	6.15	4.82	6.08	4.09	4.19	9.83	5.86	Passed
8	2.61	2.76	4.02	2.29	2.30	9.31	3.88	Passed
9	2.59	1.87	2.08	2.67	2.30	10.12	3.60	Passed
10	2.80	1.62	2.12	2.40	2.30	13.76	4.17	Passed

Figure 7 below shows that average result of Chloride from CY 2019-2024. The parameter, Chloride, is an indicator of the ionic composition of water and can reflect natural geological conditions as well as anthropogenic influences such as domestic wastewater discharge, agricultural runoff, and road salt application (Kaushal et al., 2018). For Class B waters, the allowable chloride concentration based on the General Effluent Standards is 250 mg/L. In the case of the monitoring stations assessed, only Station 1 exceeded this threshold, which would suggest that a localized source of chloride enrichment potentially linked to activities in the area or saline intrusion near the sampling area. The exceedance at this station may indicate either direct input of wastewater or increased mineral dissolution influenced by surrounding land use. In contrast, the remaining stations were within permissible limits, which would imply that chloride contamination is not widespread throughout the river system.

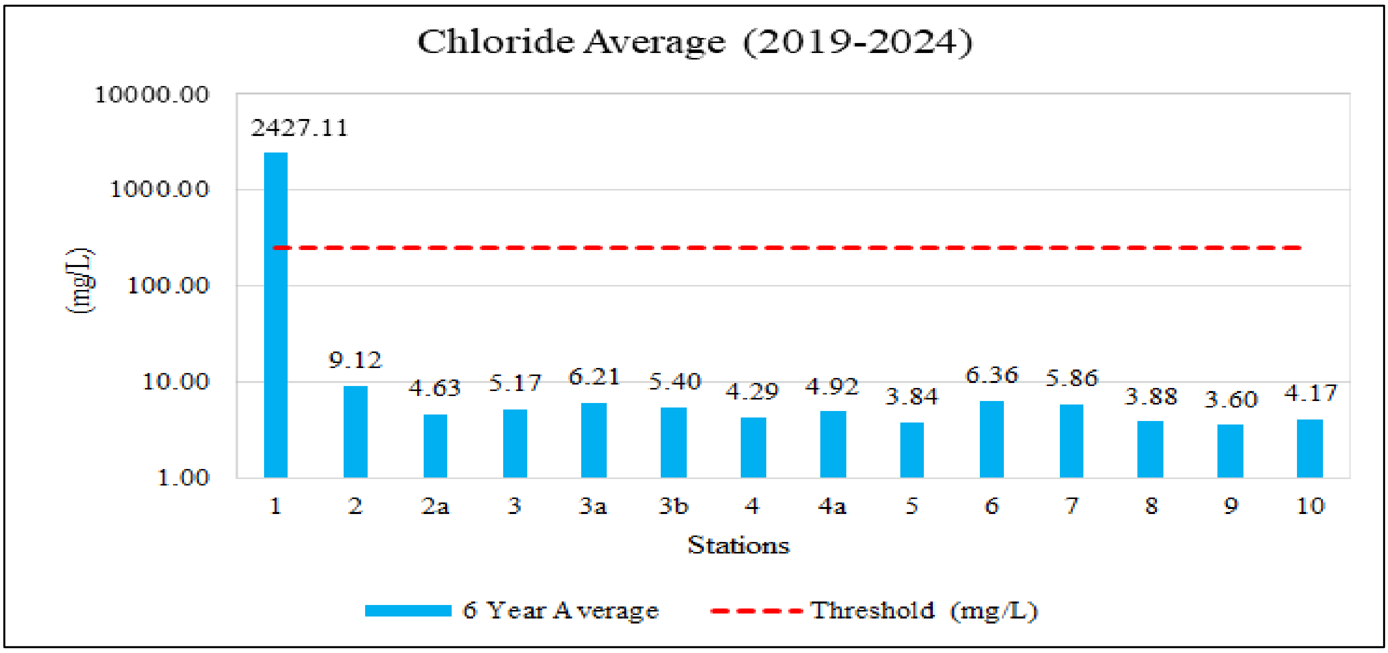

Figure 8. Average Chloride (Cl) of Talomo River CY 2019-2024

Figure 3 illustrates the spatial distribution of chloride concentrations across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique. IDW allows the estimation of chloride levels at unsampled locations based on the weighted influence of nearby sampling points, creating a continuous surface that visualizes concentration gradients. The map shows that only Station 1 exceeded the allowable threshold of 250 mg/L for Class B waters under the General Effluent Standards (DAO 2016-08), suggesting a localized source of chloride enrichment. This elevated level may be associated with domestic wastewater discharge, saline intrusion, or mineral dissolution influenced by surrounding land use. Meanwhile, the remaining stations fall within acceptable limits, indicating that chloride contamination is not widespread along the river system. Overall, the spatial visualization highlights the need for site-specific investigation and management to address the localized chloride exceedance.

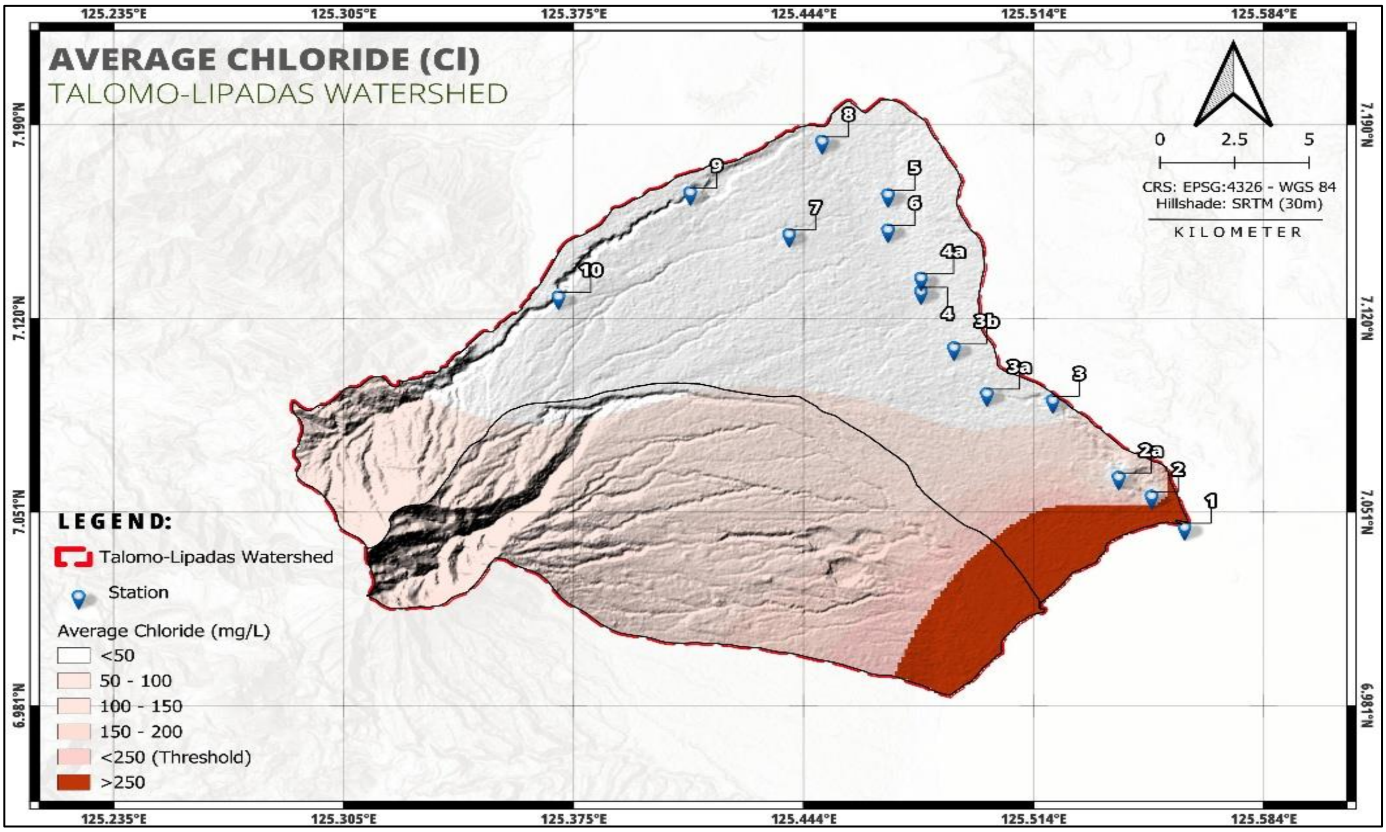

Fig 9 Map Showing the Concentration of Chloride in Talomo-Lipadas Watershed

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- *Color*

Table 5 Average Values for CY 2019-2024 Period of Color

Station	Year (TCU)						Average	DAO 2016-08 60 TCU
	2019	2020	2021	2022	2023	2024		
1	19.36	23.89	19.29	16.67	10.83	15.42	17.58	Passed
2	30.67	31.11	22.73	16.67	12.08	20.83	22.35	Passed
2a	28.50	30.56	22.73	16.67	12.08	22.50	22.17	Passed
3	28.42	30.00	22.00	15.00	11.67	21.67	21.46	Passed
3a	27.08	26.22	23.64	16.25	10.83	18.75	20.46	Passed
3b	22.17	29.44	20.91	13.33	9.58	15.42	18.48	Passed
4	22.33	20.00	21.82	15.42	8.33	15.83	17.29	Passed
4a	24.75	22.78	19.09	14.58	10.00	18.33	18.26	Passed
5	17.67	16.11	17.27	11.67	9.09	14.58	14.40	Passed
6	25.00	20.00	16.11	12.50	9.16	12.92	15.95	Passed
7	12.18	11.67	10.50	8.33	4.99	7.08	9.13	Passed
8	9.91	20.63	10.50	6.66	7.50	7.91	10.52	Passed
9	7.82	10.83	10.56	7.08	7.50	7.91	8.62	Passed
10	8.64	10.00	8.75	6.25	8.63	7.50	8.29	Passed

Figure 9 shows the average result of the parameter Color. Color is a key physical parameter used to assess the clarity and aesthetic quality of water, and it often reflects the presence of dissolved organic matter, sediments, or anthropogenic inputs (Sharma et al., 2021). For Class B water bodies under the General Effluent Standards (DAO 2016-08), maintaining color levels within the allowable threshold ensures that the water remains suitable for recreational and primary contact uses see table 5. Based on the results of the current assessment, all monitoring stations recorded color values below the prescribed limit, indicating that the river has not experienced significant discoloration or organic loading that may impair water quality. This suggests minimal influence from colored effluent discharges or excessive surface runoff at the time of sampling. Continued monitoring, however, remains essential to detect potential changes associated with seasonal shifts or land use pressures within the watershed.

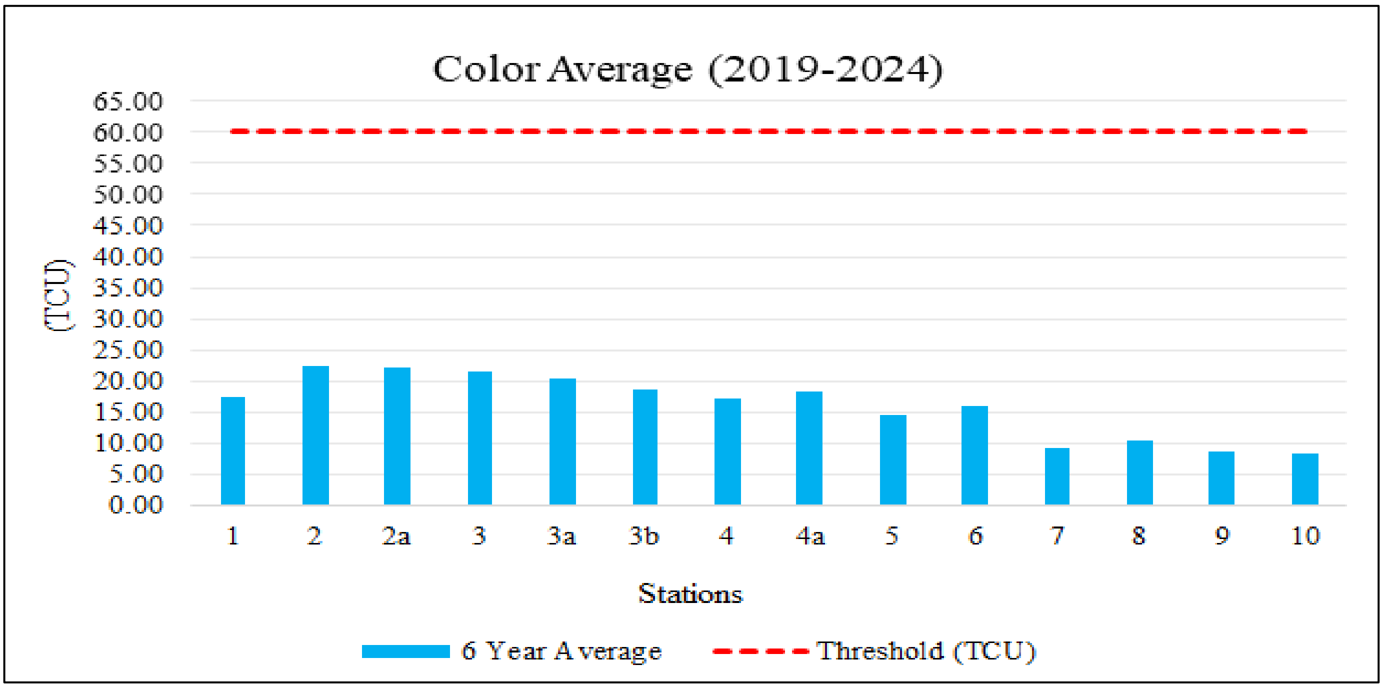

Fig 10 Average Color of Talomo River CY 2019-2024

Figure 3 illustrates the spatial distribution of color levels across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique. IDW estimates color values at unsampled locations based on the weighted influence of nearby sampling points, allowing a continuous visualization of the parameter throughout the study area. The map shows that all monitoring stations recorded color levels below the allowable threshold for Class B waters under the General Effluent Standards (DAO 2016-08), indicating that color does not currently pose a concern in this river system. This suggests minimal influence from colored effluent discharges, excessive

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organic matter, or suspended sediments that commonly contribute to increased water coloration. However, continued monitoring is essential, as changes in land use, erosion patterns, or wastewater inputs could influence color levels over time (Sharma et al., 2021).

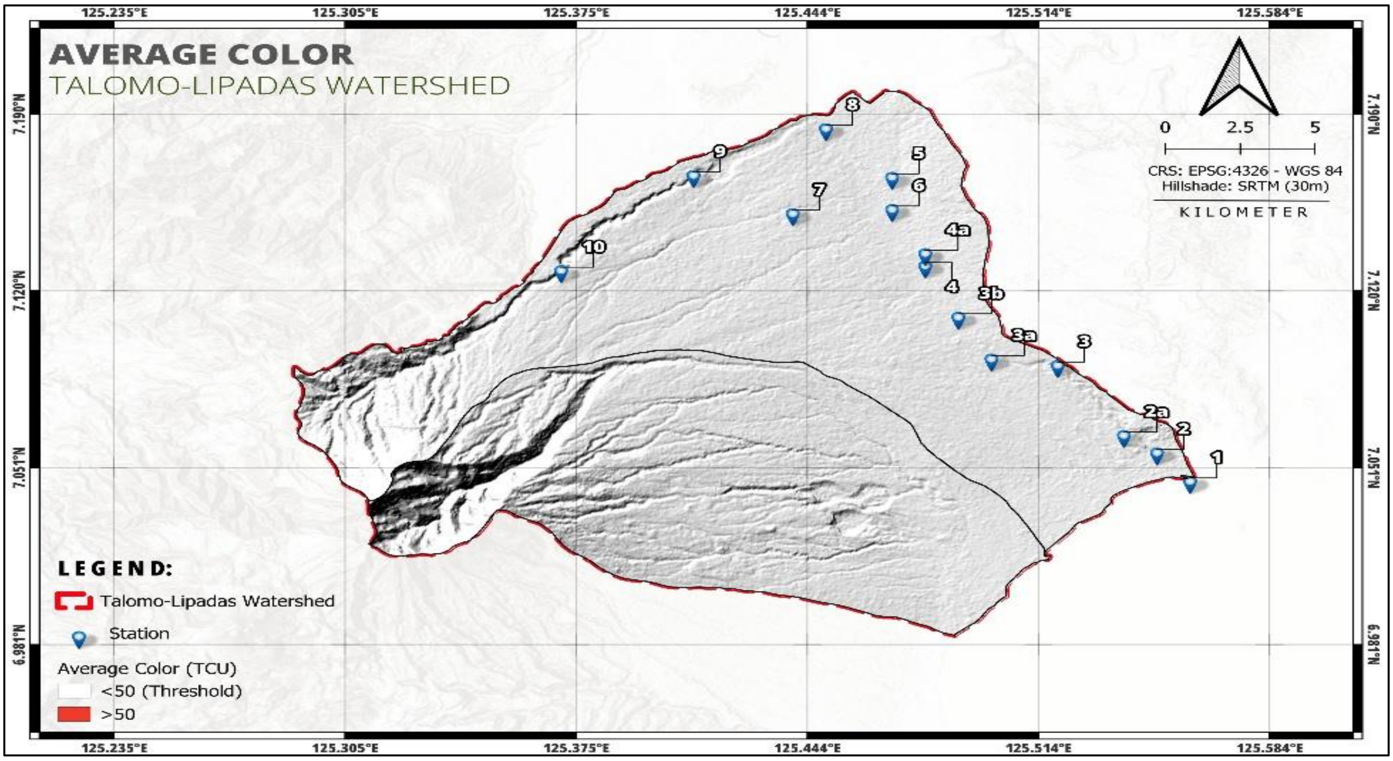

Fig 11 Map Showing the Concentration of Color in Talomo-Lipadas Watershed

- *pH*

Table 6 Average Values for CY 2019-2024 Period of pH

Station	Year						Average	DAO 2016-08 8.5
	2019	2020	2021	2022	2023	2024		
1	7.95	7.54	7.57	7.68	7.83	8.22	7.80	Passed
2	8.20	7.96	7.94	8.08	8.17	8.42	8.13	Passed
2a	8.17	7.94	8.04	8.08	8.08	8.37	8.11	Passed
3	8.03	7.82	7.90	7.88	7.89	8.34	7.98	Passed
3a	8.15	8.00	8.04	8.21	8.17	8.30	8.14	Passed
3b	8.02	7.80	7.83	8.05	8.03	8.32	8.01	Passed
4	8.01	7.80	7.81	7.93	7.87	8.28	7.95	Passed
4a	8.03	7.78	7.85	7.93	7.82	8.25	7.94	Passed
5	8.01	7.13	7.87	8.08	7.92	8.28	7.88	Passed
6	8.03	7.82	7.90	7.99	7.97	8.27	8.00	Passed
7	8.21	8.04	8.00	8.24	8.14	8.37	8.17	Passed
8	8.35	8.21	8.14	8.31	8.24	8.53	8.30	Passed
9	8.19	8.19	8.11	8.06	7.97	8.28	8.13	Passed
10	8.13	8.03	8.18	8.12	8.01	8.41	8.15	Passed

The figure below shows the average pH result for CY 2019-2024 of Talomo River Watershed. pH is a fundamental chemical parameter that reflects the acidity or alkalinity of water and plays a critical role in regulating the biological and chemical processes within aquatic ecosystems (Khan et al., 2021). Under the General Effluent Standards (DAO 2016-08), Class B water bodies are required to maintain pH levels within the acceptable range to support aquatic life and ensure suitability for recreational use. The results of the assessment indicate that all monitoring stations recorded pH values within the allowable threshold, suggesting that the river maintains a stable chemical balance with no signs of acidification or excessive alkalinity. This condition implies minimal influence from industrial discharges, acidic runoff, or other chemical contaminants that may disrupt ecological functioning. Nonetheless, sustained monitoring remains important, as shifts in land use, watershed development, or pollutant inputs could alter pH dynamics over time.

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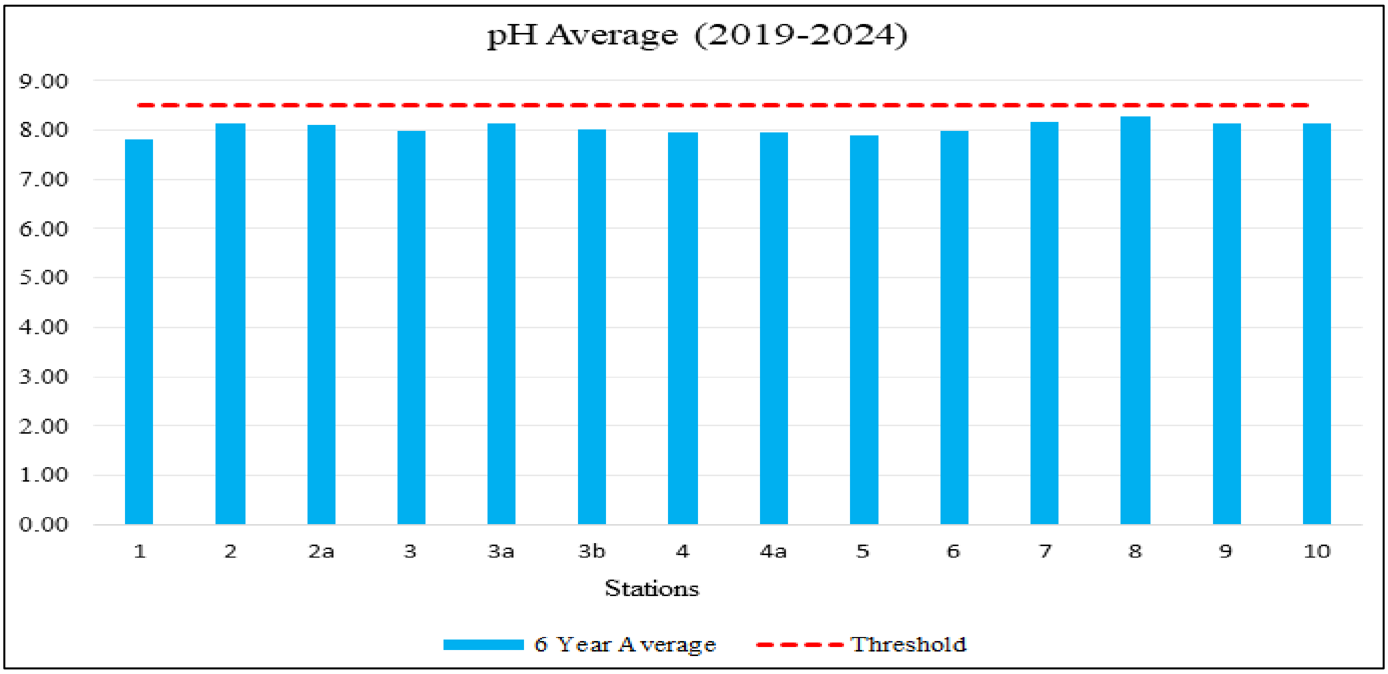

Fig 12 Average pH of Talomo River CY 2019-2024

Figure 13 illustrates the sspatial distribution of pH levels across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique. IDW provides a continuous spatial representation by estimating pH values at unsampled locations based on the weighted influence of nearby monitoring points. The map shows that all stations recorded pH levels within the allowable range for Class B waters under the General Effluent Standards (DAO 2016-08), indicating that the river maintains a stable acid–base balance suitable for aquatic life and recreational use. This suggests limited influence from industrial effluents, acidified runoff, or other sources that may alter the river's natural pH conditions. Nevertheless, ongoing monitoring remains essential, as pH is sensitive to changes in land use, watershed development, and pollutant loading, all of which may shift the chemical equilibrium of the river over time (Khan et al., 2021).

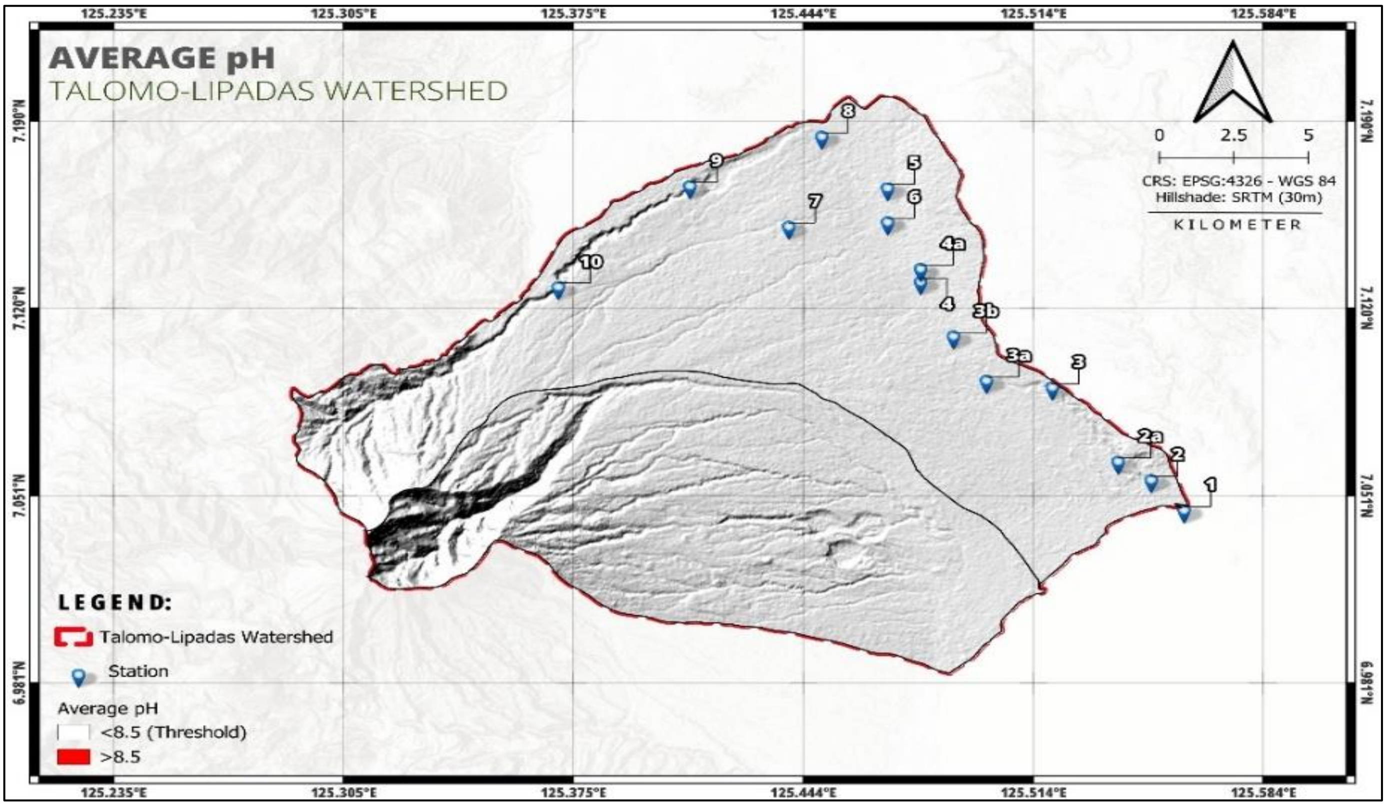

Fig 13 Map Showing the Concentration of pH in Talomo-Lipadas Watershed

- *Total Suspended Solids (TSS)*

Table 7 Average Values for CY 2019-2024 Period of TSS

Station	Year (mg/L)						Average	DAO 2016-08 65 mg/L
	2019	2020	2021	2022	2023	2024		
1	129.92	71.78	34.23	128.67	123.42	112.83	100.14	Failed
2	177.31	216.67	87.36	118.17	54.92	54.00	118.07	Failed
2a	156.75	120.22	64.06	92.42	57.58	51.33	90.39	Failed
3	74.17	56.73	53.12	595.17	95.58	61.08	155.98	Failed
3a	60.58	98.11	45.78	43.42	23.33	26.67	49.65	Passed
3b	54.17	54.67	40.05	42.83	29.83	30.08	41.94	Passed
4	44.00	49.00	71.32	73.50	42.50	40.00	53.39	Passed
4a	36.03	100.11	59.53	90.25	37.55	46.83	61.72	Passed
5	27.34	30.16	12.14	29.07	61.36	66.83	37.82	Passed
6	28.33	93.86	49.10	33.40	22.80	32.83	43.39	Passed
7	32.53	44.77	13.02	6.65	9.68	16.34	20.50	Passed
8	6.48	25.28	7.05	8.88	6.21	5.99	9.98	Passed
9	4.68	6.20	6.09	13.95	5.15	4.71	6.80	Passed
10	5.12	7.57	2.84	5.58	4.44	4.83	5.07	Passed

Total Suspended Solids (TSS) represent the concentration of particulate matter in the water column and are commonly associated with soil erosion, surface runoff, and anthropogenic disturbances within the watershed (Abbas et al., 2021). Based on the General Effluent Standards (DAO 2016-08), only Stations 3a, 3b, 5, 6, 7, 8, 9, and 10 recorded TSS levels below the allowable threshold for Class B waters see Table 7, indicating that these areas experience comparatively lower sediment loading. Meanwhile, the remaining stations exceeded the threshold, suggesting localized contributions of suspended materials potentially driven by upstream erosion, disturbed riparian zones, or domestic and agricultural runoff. The spatial pattern of TSS distribution highlights the need for targeted source control and sediment management to prevent further deterioration of water quality.

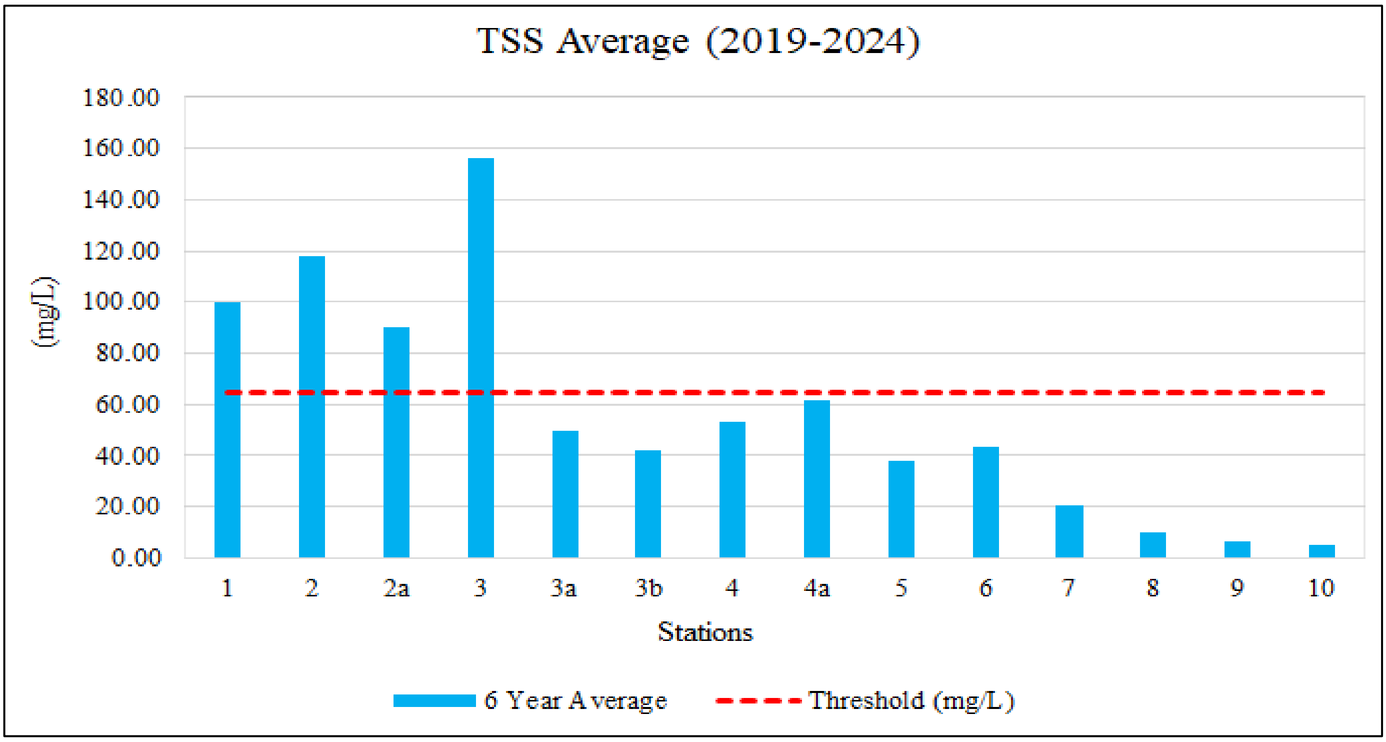

Fig 14 Average TSS of Talomo River Watershed CY 2019-2024

Figure 15 illustrates the spatial distribution of Total Suspended Solids (TSS) across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique. IDW provides a continuous spatial surface by estimating TSS concentrations at unsampled locations based on the weighted influence of nearby monitoring stations. The map shows that only Stations 3a, 3b, 5, 6, 7, 8, 9, and 10 recorded TSS levels below the allowable threshold for Class B waters under the General Effluent Standards (DAO 2016-08), indicating relatively lower sediment loading in these areas. In contrast, the remaining stations exceeded the limit, suggesting localized sources of suspended particulates likely associated with soil erosion, disturbed riparian zones, or surface runoff inputs. This spatial pattern underscores the influence of land use and watershed disturbances on sediment transport dynamics and highlights the need for targeted erosion control and watershed management strategies to mitigate elevated TSS levels (Abbas et al., 2021).

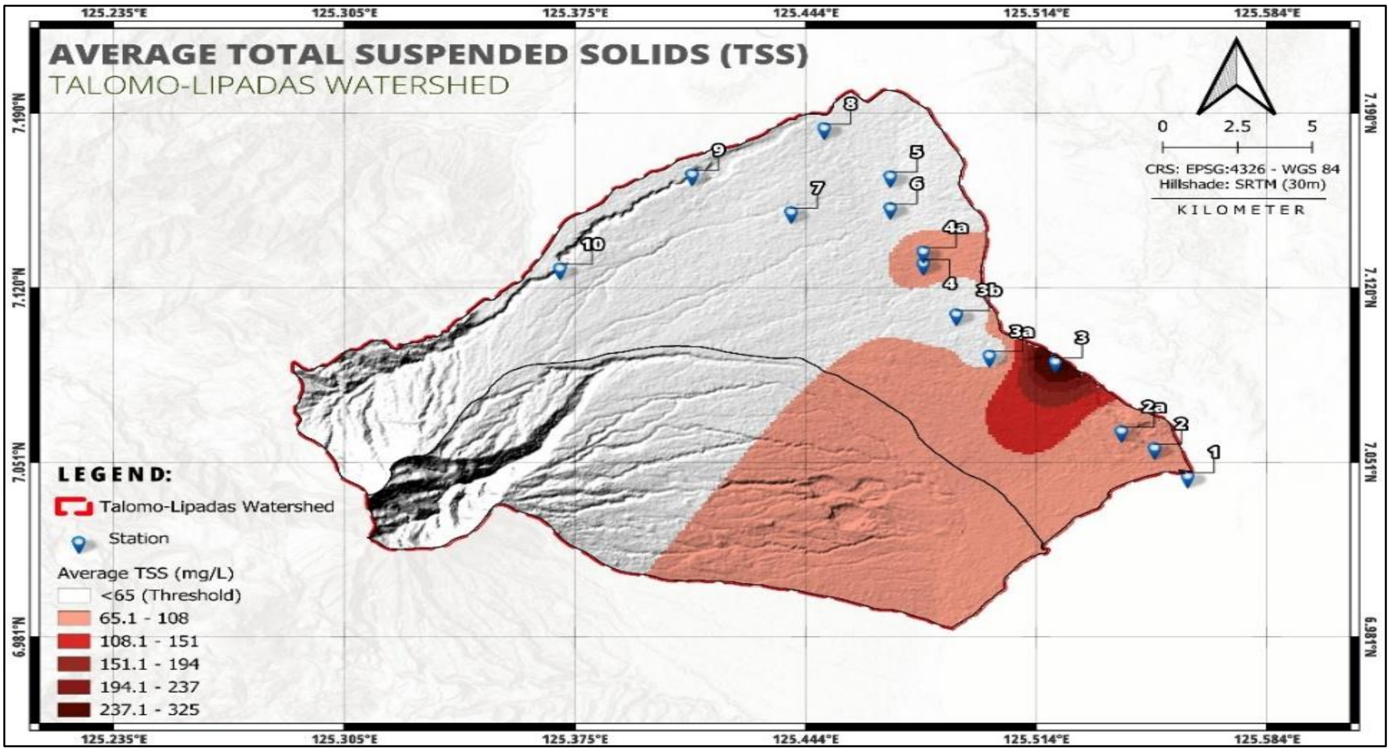

Fig 15 Map Using IDW Showing the Concentration of TSS in Talomo-Lipadas Watershed

- *Temperature*

Table 8 Average Values for CY 2019-2024 Period of Temperature

Station	Year (°C)						Average	DAO 2016-08
	2019	2020	2021	2022	2023	2024		*26 °C*
1	27.17	28.56	28.71	29.50	28.83	28.50	28.54	Failed
2	27.00	28.22	28.27	28.92	28.00	27.53	27.99	Failed
2a	26.67	27.89	27.73	28.58	28.00	26.78	27.61	Failed
3	26.33	26.89	27.30	27.92	27.50	26.57	27.08	Failed
3a	26.58	28.00	28.18	28.17	27.67	26.77	27.56	Failed
3b	26.33	27.22	27.91	27.67	27.42	26.18	27.12	Failed
4	26.00	26.67	27.82	27.50	27.17	26.33	26.91	Passed
4a	25.92	26.33	27.64	27.50	26.73	26.42	26.76	Passed
5	26.00	27.33	27.73	27.67	27.00	26.57	27.05	Failed
6	26.75	27.44	28.00	27.67	27.58	27.21	27.44	Failed
7	26.42	27.00	27.64	27.75	27.00	25.84	26.94	Passed
8	26.25	26.33	27.73	27.00	26.00	26.45	26.63	Passed
9	23.83	24.56	25.00	25.92	25.17	24.72	24.86	Passed
10	21.75	23.43	24.40	25.42	22.91	22.95	23.48	Passed

The figure below shows the average temperature of Talomo River watershed CY 2019-2024. Temperature influences the metabolic processes of aquatic organisms and affects the solubility of dissolved oxygen in the river system (Delpla et al., 2020). Based on the General Effluent Standards (DAO 2016-08), all monitoring stations recorded temperature levels within the allowable threshold for Class B waters, indicating that the river maintains a thermally suitable environment for aquatic life. The uniform compliance across stations suggests minimal thermal pollution and limited influence from industrial discharges or heated surface runoff. Continuous monitoring, however, remains necessary as temperature is highly sensitive to land cover changes, seasonal variation, and altered streamflow patterns.

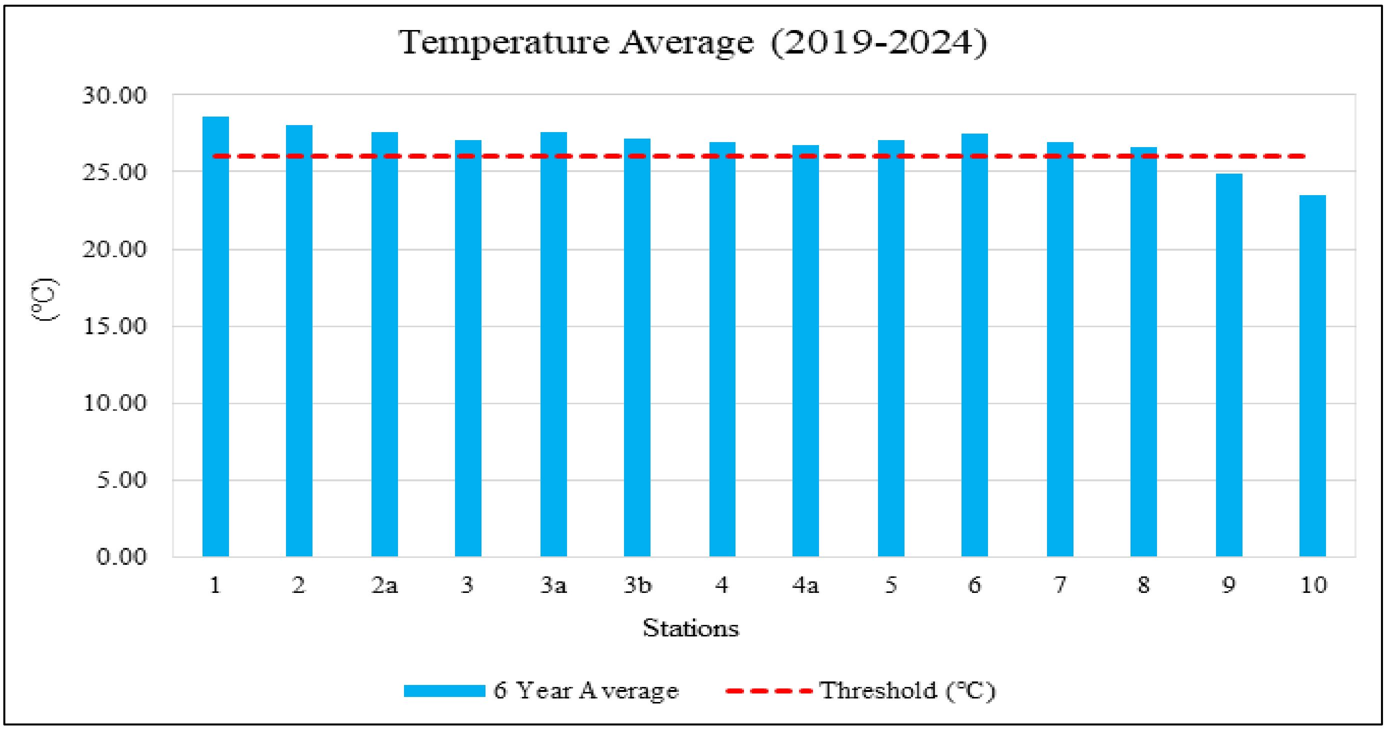

Fig 16 Average Temperature of Talomo River CY 2019-2024

Figure 17 illustrates the spatial distribution of water temperature across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique, which estimates temperature at unsampled locations based on the weighted influence of nearby stations. The map shows that all monitoring stations recorded temperature values within the allowable range of 26–30°C for Class B waters under the General Effluent Standards (DAO 2016-08), indicating that thermal conditions remain suitable for the protection of aquatic life and recreational use. This suggests limited influence from thermal pollution sources such as industrial effluents, heated runoff, or reduced riparian shading. However, because temperature is highly sensitive to seasonal variation, land cover change, and streamflow alteration, continued monitoring is essential to ensure that thermal regimes within the river remain stable over time (Zhang et al., 2021).

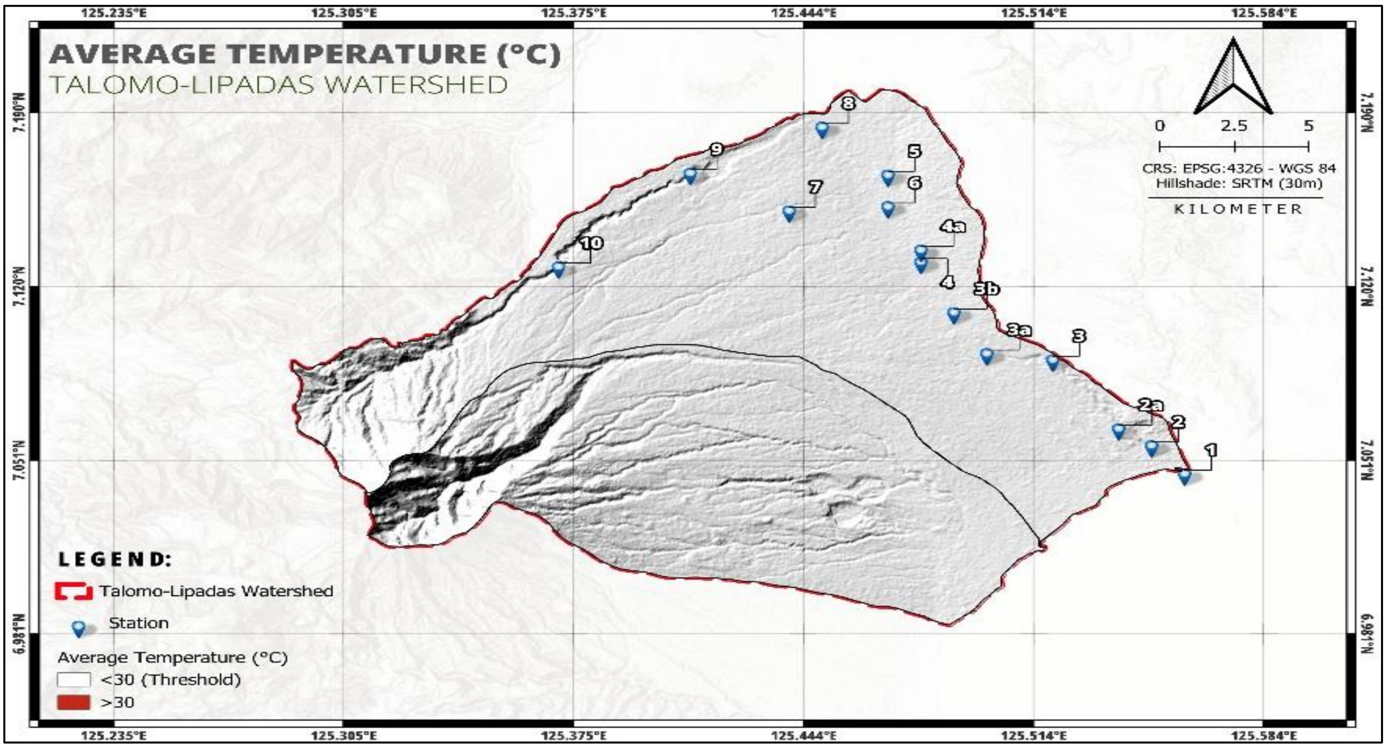

Fig 17 Map Showing the Temperature Across Talomo-Lipadas Watershed

- *Phosphate*

Table 9 Average Values for CY 2019-2024 Period of Phosphate

Station	Year (mg/L)						Average	DAO 2016-08 ***0.5 mg/L***
	2019	**2020**	**2021**	**2022**	**2023**	**2024**		
1	0.60	0.23	0.25	0.21	0.19	0.17	0.27	Passed
2	0.82	0.24	0.16	0.18	0.13	0.13	0.27	Passed
2a	0.76	0.19	0.13	0.15	0.13	0.16	0.25	Passed
3	0.66	0.14	0.12	0.16	0.12	0.12	0.22	Passed
3a	0.64	0.16	0.11	0.12	0.12	0.11	0.21	Passed
3b	0.55	0.10	0.11	0.12	0.09	0.11	0.18	Passed
4	0.55	0.11	0.09	0.11	0.09	0.10	0.18	Passed
4a	0.46	0.12	0.08	0.13	0.08	0.10	0.16	Passed
5	0.33	0.09	0.08	0.08	0.10	0.11	0.13	Passed
6	0.43	0.13	0.10	0.10	0.10	0.12	0.16	Passed
7	0.83	0.10	0.10	0.12	0.10	0.11	0.22	Passed
8	0.15	0.08	0.05	0.05	0.05	0.08	0.08	Passed
9	0.09	0.05	0.05	0.05	0.04	0.07	0.06	Passed
10	0.08	0.05	0.05	0.05	0.04	0.12	0.07	Passed

Phosphate is an essential nutrient that supports aquatic primary productivity, yet elevated concentrations may promote eutrophication and algal blooms (Said et al., 2022). Table 9 reveals that based on the General Effluent Standards (DAO 2016-08), phosphate levels across all monitoring stations were recorded below the allowable threshold for Class B waters, indicating that nutrient enrichment in the system remains within acceptable limits. The consistently low phosphate concentrations suggest minimal inputs from domestic wastewater, agricultural fertilizers, or industrial discharges within the watershed. This condition reflects favorable nutrient regulation and may contribute to maintaining ecological balance and preventing excessive algal proliferation in the river.

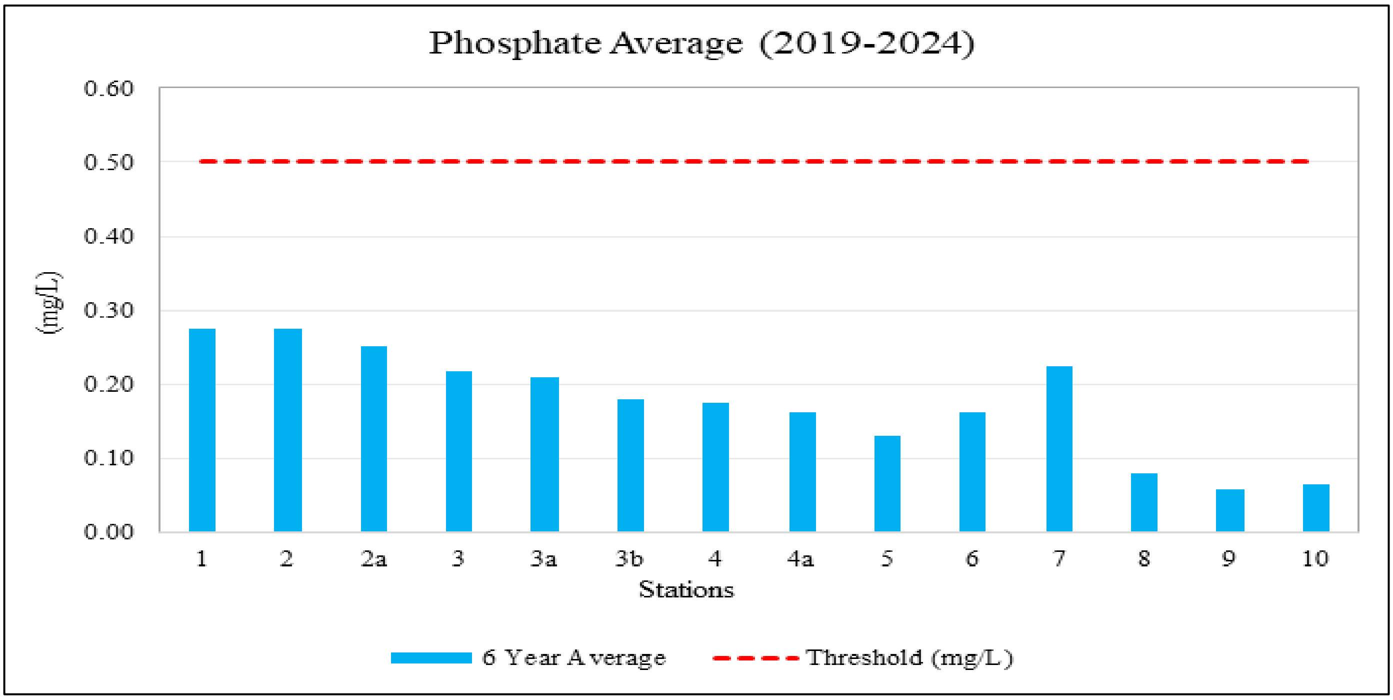

Fig 18 Average Phosphate of Talomo River CY 2019-2024

Figure 19 illustrates the spatial distribution of phosphate concentrations across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique, which estimates values at unsampled locations based on the weighted influence of nearby sampling points. The map shows that all monitoring stations recorded phosphate levels below the allowable threshold for Class B waters under the General Effluent Standards (DAO 2016-08), that may potentially indicate low nutrient within the river system. Nonetheless, sustained monitoring remains necessary, as increases in land development, fertilizer use, or sewage discharge can rapidly alter nutrient dynamics and lead to eutrophication over time (Rahman et al., 2022).

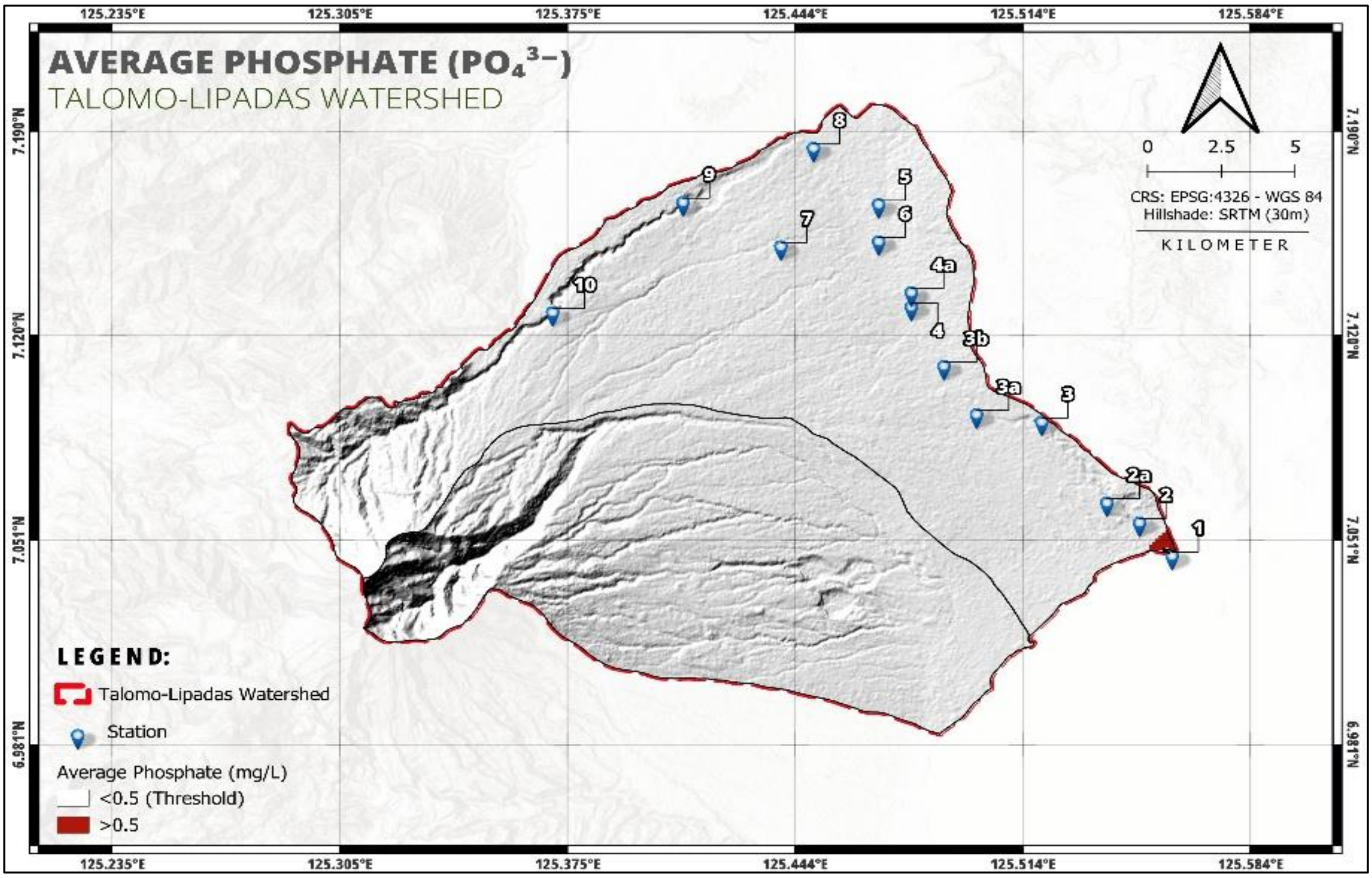

Fig 19 Map Showing the Concentration of Phosphate Across Talomo-Lipadas Watershed

- *Nitrate*

Table 10 Average Values for CY 2019-2024 Period of Nitrate

Stations	**Year (mg/L)**				**Average**	**DAO 2016-08** *7 mg/L*
	2021	**2022**	**2023**	**2021**		
1	28.85	7.78	3.46	14.22	13.58	Failed
2	4.99	4.00	1.84	2.42	3.31	Passed
2a	5.08	3.99	1.88	1.64	3.15	Passed
3	5.06	3.98	2.03	1.99	3.27	Passed
3a	5.32	4.04	1.89	2.05	3.33	Passed
3b	5.29	3.99	1.94	2.16	3.35	Passed
4	5.33	4.04	2.14	1.93	3.36	Passed
4a	5.45	3.98	1.73	1.76	3.23	Passed
5	5.45	4.05	1.64	1.43	3.14	Passed
6	4.99	4.38	2.86	2.48	3.68	Passed
7	6.66	4.51	2.71	2.93	4.20	Passed
8	5.42	3.97	2.13	2.05	3.39	Passed
9	6.26	3.93	2.36	1.67	3.56	Passed
10	8.19	3.86	1.73	1.81	3.90	Passed

Nitrate is a key nutrient in aquatic ecosystems, but elevated levels can lead to nutrient enrichment, algal proliferation, and subsequent declines in dissolved oxygen (Huang et al., 2021). Based on the General Effluent Standards (DAO 2016-08), table 10 shows only Station 1 recorded nitrate concentrations within the allowable threshold for Class B waters, while all remaining stations exceeded the limit. This pattern suggests localized sources of nitrate loading, likely associated with agricultural runoff, domestic wastewater inputs, or fertilizer leaching occurring upstream or near the affected stations. The elevated nitrate levels indicate increasing nutrient pressure on the river system, highlighting the need for targeted watershed management interventions to prevent potential eutrophication and degradation of aquatic habitat quality.

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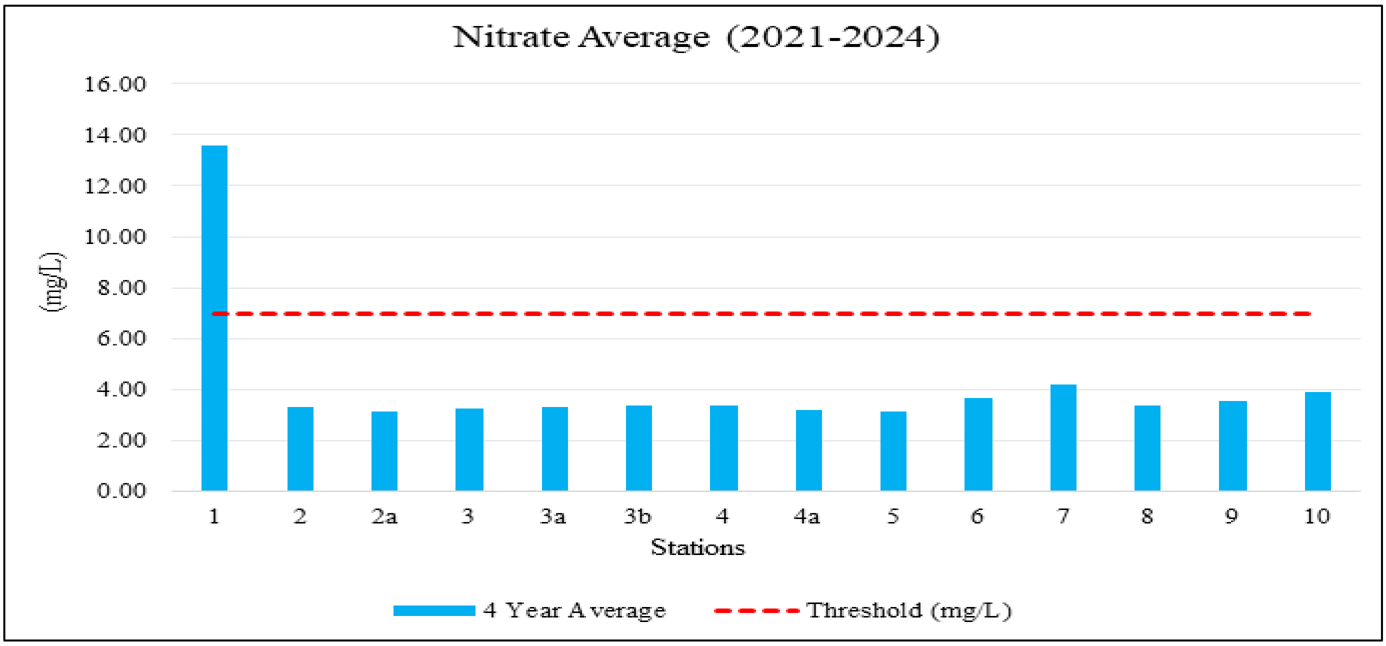

Fig 21 Average Nitrate in Talomo River CY 2021-2024

Figure 22 illustrates the spatial distribution of nitrate concentrations across the Talomo-Lipadas River using the Inverse Distance Weighting (IDW) interpolation technique, which estimates values at unsampled locations based on the weighted influence of nearby sampling points. The map shows that Station 1 recorded nitrate levels exceeding the allowable threshold for Class B waters under the General Effluent Standards (DAO 2016-08), as indicated by the prominent red coloration on the interpolated surface. This localized exceedance suggests potential nutrient inputs from sources such as agricultural fertilizer runoff, domestic wastewater leakage, or upstream settlement activities. In contrast, all other stations remained within acceptable limits, indicating that nitrate enrichment is not pervasive throughout the river system. Continued monitoring and targeted source assessment near Station 1 are recommended to prevent further nutrient accumulation and the potential risk of eutrophication (Said et al., 2022).

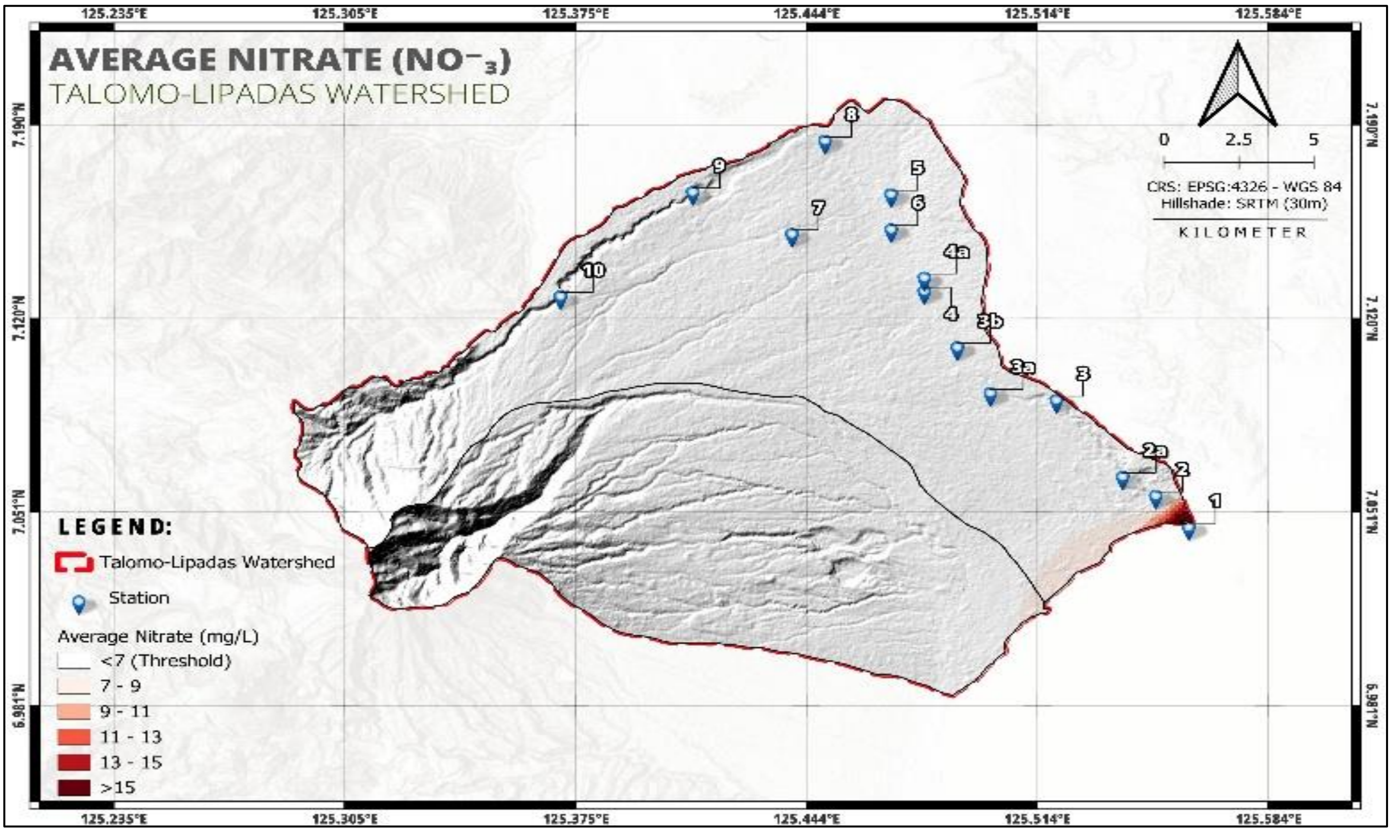

Fig 22 Map Showing the Concentration of Nitrate across Talomo-Lipadas Watershed

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IV. CONCLUSION

The water quality assessment of the Talomo River CY 2019-2024 indicated clearly distinguished spatial patterns in pollutant concentrations, both from observed values and the IDW-generated spatial interpolations. Parameters such as pH, color, temperature, and phosphate were within the allowable limits for Class B waters at all stations. Basic physicochemical conditions were stable overall. DO was likewise above the minimum limit, implying that oxygen availability remains fairly sufficient for most aquatic life.

However, IDW mapping revealed clear spatial clustering of elevated pollution in upstream and midstream sections. The BOD result exceeded the allowable limits at several stations, particularly Stations 1, 2, 2a, 3, 3a, 3b, 4, and 7, reflecting substantial organic loading likely linked to domestic wastewater discharge and decaying organic matter. Likewise, fecal coliform contamination exceeded the standard in all monitoring stations with IDW surfaces showing high concentrations extending downstream, emphasizing widespread microbial pollution throughout the watershed. Also, TSS exceeded thresholds in several stations upstream and midstream, showing erosion and runoff pressures, while only Stations 3a, 3b, 5, 6, 7, 8, 9, and 10 remained below the threshold. Site-specific ionic and nutrient enrichment was also identified: chloride and nitrate exceedances are centered at Station 1, as shown by distinct high-value zones in the IDW outputs, pointing toward site-specific anthropogenic influences such as domestic effluent, fertilizer application, or saline intrusion.

Overall, while baseline physicochemical stability is evident, the IDW spatial patterns highlight areas of concentrated pollution pressure, particularly upstream zones influenced by settlements, land conversion, and wastewater discharges.

RECOMMENDATIONS

To improve and maintain the water quality of the Talomo River Watershed, a stricter zoning regulation be enforced to limit the expansion of urban settlements, particularly in environmentally sensitive areas, in order to reduce encroachment and prevent additional pollution inputs. Reforestation projects should be prioritized in the upper areas of the Talomo River to stabilize soil, reduce erosion, and minimize the transport of sediments and nutrients into the river system. To address improper sewage issues, the city government must fast-track the development and implementation of a comprehensive sewerage management system. Regulatory bodies, must continue rigorous enforcement of water quality standards, utilize GIS-based approaches such as Inverse Distance Weighting (IDW) to spatially identify and monitor pollution hotspots, and coordinate with multi-level governance structures for watershed-scale management. Complementary to these measures, sustained community engagement and environmental education programs are critical to foster local stewardship, encourage compliance with sanitation practices, and reinforce collective responsibility for maintaining the ecological and recreational functions of the river.

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