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Research Article

Pollutant Load Assessment in the Delineated Drainage Catchment of Tagum Magugpo Creek

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Abstract
Urban wastewater pollution poses significant challenges to water quality, ecosystem integrity, and sustainable watershed management, particularly in rapidly urbanizing cities. This study assessed pollutant loads within the delineated drainage catchment of Magugpo Creek, Tagum City, by evaluating biochemical oxygen demand (BOD), nitrate, phosphate, fecal coliform, and pH to characterize wastewater pollution and identify major pollutant-contributing areas. A quantitative descriptive research design was employed using purposive sampling across five transect locations representing upstream, midstream, and downstream sections of the creek. Wastewater samples were collected during the dry season and analyzed through laboratory testing, stream discharge measurements, pollutant load estimation, and statistical analyses, including descriptive statistics, two-way analysis of variance, and Spearman's rank-order correlation. The findings indicate that pH and nitrate generally complied with national water quality standards, whereas BOD, phosphate, and fecal coliform exceeded acceptable limits across most sampling locations, reflecting substantial organic, nutrient, and microbial contamination. Significant positive relationships were observed between BOD and phosphate, and between BOD and fecal coliform, suggesting common pollution sources associated with untreated domestic wastewater. Pollutant load estimation further identified distinct spatial hotspots, with specific transect locations contributing disproportionately to organic, nutrient, and microbial pollution. The study demonstrates that integrating drainage catchment delineation with pollutant load assessment provides a comprehensive basis for identifying priority intervention areas and supports evidence-based watershed management, wastewater planning, and sustainable urban water resource protection.

Keywords
biochemical oxygen demand, drainage catchment, pollutant load assessment, urban wastewater, water quality

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This study was conducted in accordance with ethical standards.

INTRODUCTION
Urbanization and wastewater generation have emerged as critical global concerns because of their implications for water security, public health, and environmental sustainability. Rapid urban expansion, particularly in developing economies, has substantially increased the volume of domestic, commercial, and industrial wastewater generated, thereby placing considerable pressure on sanitation infrastructure and freshwater resources. It was projected that nearly two-thirds of the

global population would reside in urban areas by 2050, while global urban land expansion was estimated to increase by 60–200% between 2000 and 2030 (Delanka-Pedige et al., 2021; Seto et al., 2011). This accelerated urbanization intensified wastewater production and facilitated the transport of pollutants through urban drainage systems. Untreated wastewater commonly contained organic matter, nutrients, pathogenic microorganisms, and chemical contaminants that degraded water quality and disrupted aquatic ecosystems (Kumari et al., 2023). Excessive pollutant discharges were likewise associated with elevated biochemical oxygen demand, eutrophication, oxygen depletion, and ecological degradation in freshwater and coastal environments (Alcamo, 2019; Chakraborti, 2021). Consequently, improving wastewater management became a global priority under Sustainable Development Goal 6, which emphasized effective sanitation, pollution reduction, and the protection of water resources through evidence-based watershed management (Delanka-Pedige et al., 2021; UNESCO, 2024).

Wastewater management remained a significant environmental challenge in the Philippines because sewerage coverage was limited and most households depended on septic tanks and other on-site sanitation systems. Only a small proportion of urban wastewater was collected and safely treated before being discharged into receiving water bodies (World Bank, 2013). Consequently, untreated domestic wastewater continued to be a major contributor to water pollution nationwide (Bonilla, 2024). Previous investigations conducted in Philippine waterways documented elevated organic, nutrient, and microbial contamination associated with domestic wastewater discharges (Chounlamany et al., 2018; Damasco et al., 2024). Similar environmental conditions were observed in the Davao Region, where increasing urbanization intensified pollutant inputs into rivers and creeks (Bonilla, 2024). In Tagum City, wastewater generated from residential, commercial, and mixed-use developments was conveyed through interconnected drainage systems that discharged into eight major creeks, including Magugpo Creek, before eventually reaching the Tagum–Libuganon River. Although Republic Act No. 9275 mandated the protection and sustainable management of the country's water resources, localized scientific evidence describing pollutant transport and pollution contributions within these urban drainage catchments remained limited.

Despite considerable advances in wastewater characterization and treatment technologies, important contextual and methodological gaps remained in the assessment of pollutant loads within delineated urban drainage catchments. Existing investigations primarily focused on pollutant concentrations or treatment performance but seldom integrated hydrologically delineated drainage systems with pollutant load estimation. Pollutant load assessment provided a more comprehensive evaluation of environmental impacts because it incorporated both contaminant concentration and stream discharge, thereby quantifying the actual mass of pollutants transported within a watershed (Bello et al., 2024). However, studies applying this integrated approach to highly urbanized creek systems in the Philippines remained scarce. In Tagum City, baseline information regarding pollutant load distribution, spatial pollution hotspots, and wastewater contamination within Magugpo Creek was unavailable. This absence of catchment-scale empirical evidence limited the ability of environmental managers, planners, and policymakers to identify priority pollution sources, evaluate compliance with national water quality standards, and formulate watershed-based wastewater management strategies. Addressing these gaps was therefore essential to strengthen scientific understanding and support evidence-based environmental planning.

This study assessed pollutant loads within the delineated drainage catchment of Magugpo Creek, Tagum City, by analyzing key water quality parameters, namely biochemical oxygen demand (BOD), fecal coliform, nitrate, phosphate, and pH, across representative upstream, midstream, and downstream sampling locations during the dry-season monitoring period. The study addressed the identified contextual and methodological gaps by integrating water quality assessment with pollutant load estimation within a hydrologically delineated drainage catchment. The findings were expected to provide baseline scientific evidence for the Local Government Unit of Tagum City, the Department of Environment and Natural Resources, environmental planners, researchers, and other stakeholders involved in wastewater management and water resource protection. Furthermore, the study was expected to contribute to the advancement of drainage-based pollutant load assessment by providing a scientific basis for identifying pollution hotspots, strengthening watershed management, and supporting evidence-based environmental planning for sustainable urban water resource management.

METHODOLOGY

Design

This study employed a quantitative descriptive research design in assessing the pollutant load condition within the delineated drainage catchment of Magugpo Creek. The design enabled the systematic measurement, quantification, and characterization of existing water quality conditions and pollutant load distributions without manipulating any study variables. The study is grounded in the positivist paradigm, which emphasizes that environmental conditions and pollutant characteristics can be objectively measured, quantified, and analyzed using empirical data and scientific procedures. The study is further anchored on the Source–Pathway–Receptor (SPR) Framework, which provides the theoretical basis for understanding the generation, transport, and impacts of pollutants within a watershed system (European Environment Agency, 2016; Horrillo-Caraballo et al., 2013). Within this framework, domestic wastewater discharges serve as pollutant sources, the delineated drainage network and hydrologic processes function as pathways through which contaminants are transported, and Magugpo Creek together with its receiving water bodies act as environmental receptors. This aligns to estimating pollutant loads in assessing the current condition of the creek system.

Locale

The study was conducted in the Magugpo Creek, one of the eight major creeks of Tagum City which covers an area of 8.52 square kilometers covering 5 out of 23 barangays, namely: Barangay Mankilam, Barangay San Miguel, Barangay Magugpo Poblacion, Barangay Magugpo South and Barangay Magugpo North. In this assessment the site was chosen because this area is intensive from its existing and present land zones which comprises high-density mixed-use buildings and concentrated residential homes.

Sampling

Purposive sampling was used to identify representative wastewater sampling locations within the delineated drainage catchment of Magugpo Creek. The sampling units were deliberately selected based on predefined criteria and their capacity to provide information-rich data relevant to the research objectives (Palinkas et al., 2015). This is further strengthened, as environmental, hydrologic, and land use characteristics, as well as expert recommendations from the City Environment and Natural Resources Office (CENRO) were incorporated in the sampling locations. It consisted creek segments located within the delineated drainage area of Magugpo Creek, exhibiting observable wastewater discharge influences, accessibility for field sampling, and representation of distinct upstream, midstream, and downstream conditions. Areas located outside the delineated catchment boundary, inaccessible sections, tributaries not directly contributing to the main creek system, and locations without significant wastewater influence were excluded from the study. Guided by the transect-based planning approach (HLURB, 2014), five sampling points were strategically established to represent varying levels of urbanization, land use intensity, population concentration, and potential wastewater inputs. This approach enabled the assessment of spatial variations in pollutant loads and water quality conditions across different environmental settings while ensuring adequate representation of the creek system. To enhance sampling validity, all selected locations underwent in-situ field verification in coordination with CENRO personnel, ensuring that the sampling points accurately reflected existing wastewater discharge conditions and hydrologic characteristics within the study area.

Collection

Data gathering was conducted through a systematic sequence of field sampling, in-situ measurement, laboratory analysis, secondary data acquisition, and expert consultation. Field validation was conducted within the identified upstream, midstream, and downstream sections of Magugpo Creek to verify existing drainage conditions, creek characteristics, wastewater discharge influences, and accessibility of sampling points. Geographic coordinates were recorded using GPS devices. Wastewater samples were collected from the identified transect points using grab sampling techniques. Sampling was conducted during the dry season on the month of April at seven-day intervals, between 8:00 AM and 12:00 NN to maintain temporal consistency. The samples were collected during stable sunny weather conditions to minimize the influence of rainfall runoff, stormwater intrusion, and surface dilution. Sterile and parameter-specific containers were used: 4-liter HDPE containers for general physicochemical analysis, 1-liter amber glass bottles for phosphate analysis, 500 mL sterilized plastic bottles for fecal coliform analysis, and 250 mL plastic jars for on-site pH measurements. Containers were properly labeled according to transect code, sampling date, and time. All samples were transported within the same day to a DENR-accredited laboratory for analysis of biochemical oxygen demand, nitrate, phosphate, and fecal coliform. Stream depth, and streamflow measurements were conducted at each transect point. Stream depth was measured using a graduated measuring pole at the center and both lateral sides of the creek channel, and the readings were averaged to obtain a representative mean depth. Stream discharge was estimated using the float method by establishing a three-meter stream reach, releasing a floating ball, and recording travel time using a stopwatch. Three trials were conducted per transect point, and the mean surface velocity was adjusted using a correction coefficient of 0.9 to estimate stream discharge. These hydraulic measurements supported pollutant load computation and interpretation of pollutant transport within the creek system. Expert and specialist consultations were conducted using a guide questionnaire administered to environmental planners, a sanitary engineer, GIS specialists, and wastewater management practitioners. The consultation focused on validating the methodological framework, field observations, pollutant load assessment procedures which supplemented the empirical field and laboratory data strengthening technical reliability.

Analysis

Descriptive and inferential statistical methods were employed to evaluate wastewater conditions, pollutant load contributions, and relationships among water quality parameters within the delineated drainage catchment of Magugpo Creek. Statistical analyses were performed using IBM SPSS statistical software to ensure systematic data processing, reproducibility, and transparent interpretation of results. The mean and standard deviation, were computed to summarize the concentration levels and variability of the primary water quality parameters, namely BOD, pH, nitrate, phosphate, and fecal coliform. These measures provided an overall characterization of wastewater conditions and facilitated comparisons of pollutant concentrations across upstream, midstream, and downstream sections of the creek. The summarized values were subsequently compared with the water quality criteria prescribed under DENR Administrative Order No. 2016-08, as amended by DAO 2021-19, to assess compliance and identify potential pollution concerns. Two-Way Analysis of Variance (ANOVA) is analyzed to determine whether significant differences existed among the five transect locations and among the measured water quality parameters. Statistical significance was evaluated at the 0.05 probability level ($p \leq 0.05$). When significant differences were detected, Tukey's Honestly Significant Difference (HSD) post hoc test was performed to identify specific groups or sampling locations that differed significantly from one another. This procedure enhanced analytical rigor by providing detailed comparisons beyond the overall ANOVA results. Emphasizing the relationship analysis and pollutant load estimation, Spearman's rank-order correlation coefficient (ρ) was used to determine the strength and direction of associations among the measured water quality parameters. This non-parametric statistical technique was appropriate because environmental water quality datasets often exhibit non-normal distributions and varying levels of measurement variability. Correlation analysis provided insights into potential interactions among pollutants and helped identify patterns associated with wastewater contamination sources. Subsequently, pollutant loads were estimated by integrating laboratory-derived pollutant concentrations with measured stream discharge values following established pollutant loading equations (Bello et al., 2024; Haeruddin et al., 2025). This approach quantified the mass of pollutants transported through the creek in kilograms per day, thereby providing a more comprehensive assessment of environmental impact than concentration measurements alone.

Ethical Considerations

The study adhered to the established ethical standards throughout the conduct of field sampling, laboratory analyses, and data collection activities. Prior to the commencement of the study, necessary permissions and coordination with the local government unit of Tagum and stakeholders were established to ensure that all field activities were conducted in accordance with institutional and environmental regulations. Data integrity was maintained through standardized sampling protocols, accurate measurement procedures, proper labeling and handling of samples, and systematic documentation of field and laboratory records. All laboratory examinations were performed by a DENR-accredited laboratory to ensure the reliability, validity, and accuracy of analytical results. Furthermore, the study complied with institutional research guidelines by ensuring responsible data management, objective reporting of findings, and the transparent presentation of results without fabrication, falsification, or misrepresentation of information.

Limitations and Rigor

The wastewater assessment was limited to five purposively selected transect points within the delineated drainage catchment of Magugpo Creek, representing upstream, midstream, and downstream conditions influenced by varying levels of anthropogenic activities and point-source pollution. While the sampling locations do not encompass every section of the creek system, the transect-based approach ensured that the selected sites captured the variability of wastewater conditions across distinct land use and population density settings. Data collection was conducted exclusively during the dry season of April. Consequently, the findings reflect baseline wastewater conditions under relatively stable hydrologic conditions and do not account for seasonal variations associated with rainfall runoff, stormwater inflow, or wet-season pollutant transport dynamics. However, this approach is consistent with established water quality monitoring practices that separately evaluate dry- and wet-season conditions to obtain representative environmental assessments. To maintain methodological rigor despite these limitations, the study employed triplicate sampling at seven-day intervals, standardized field and laboratory procedures, in-situ validation, calibrated instruments, and analyses conducted by a DENR-accredited laboratory. These measures enhanced data reliability, minimized measurement variability, and ensured that the results provide a scientifically sound baseline assessment of pollutant loads and wastewater conditions within the Magugpo Creek system.

RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of the water quality parameters across the five sampled areas. The pH levels ranged from 7.54 to 8.44, with a mean of 7.89 (SD = 0.22), indicating that the water is generally neutral to slightly alkaline and within acceptable environmental ranges as per the Water Quality Guidelines for Primary Parameter from Department of Environment and Natural Resources. This relatively low standard deviation suggests that pH values across the sampling sites are consistent. In terms of BOD, values ranged widely from 10.20 to 250.00 mg/L, with a mean of 55.53 mg/L (SD = 71.14). The high standard deviation indicates substantial variability among sampling sites, suggesting uneven organic pollution loading. This means that some areas are experiencing significantly higher organic contamination, from domestic wastewater discharge and decomposing organic matter (Chan et al., 2016; Clemente, 2020). Nitrate concentrations on the other hand ranged from 1.00 to 2.20 mg/L, with a mean of 1.72 mg/L (SD = 0.37). These values indicate relatively low spatial variation and suggest that nitrate pollution is moderately uniform across the sampling locations. Phosphate levels ranged from 0.83 to 2.10 mg/L, with a mean of 1.37 mg/L (SD = 0.50). The moderate variability suggests intermittent or localized inputs of phosphorus, linked to household wastewater discharge (Bunce et al., 2018). These elevated phosphate levels contribute to eutrophication in the receiving water body (Al-Islmi, Amiri & Malakootian, 2021). Fecal coliform counts exhibited extremely high variability, ranging from 4,200 to 9,200,000 CFU/100 mL, with a mean of 1,579,547 CFU/100 mL (SD = 2,783,260) which indicates severe microbial contamination.

Table 1
Descriptive Statistics of the Water Quality Parameters across the five Transect Points in Magugpo Creek

Parameter	Minimum	Maximum	*M*	*SD*
pH	7.54	8.44	7.89	0.22
Biochemical Oxygen Demand (BOD; mg/L)	10.20	250.00	55.53	71.14
Nitrate (mg/L)	1.00	2.20	1.72	0.37
Phosphate (mg/L)	0.83	2.10	1.37	0.50
Fecal Coliform (CFU/100 mL)	4,200	9,200,000	1,579,547	2,783,260

Note. M = mean; *SD* = standard deviation; CFU = colony-forming units.

Table 2 presents the Spearman's rank-order correlation analysis which determined the strength and direction of relationships among the measured water quality parameters. The results reveal several statistically significant associations, indicating interrelated patterns of water quality variation across the sampling sites. A statistically significant moderate positive correlation was found between biochemical oxygen demand (BOD) and phosphate levels ($\rho = 0.541$, $p = 0.037$). This finding implies that higher phosphate concentrations are associated with increased BOD levels. This agrees to the report of Bhat & Qayoom (2021) that domestic wastewater contains not only organic matter measured as BOD but also significant concentrations of nitrogen and phosphorus. This relationship reflects nutrient enrichment conditions, where elevated phosphorus promotes algal growth and subsequent organic matter decomposition, thereby increasing oxygen demand in the water system.

Furthermore, a moderate positive and statistically significant relationship was also identified between BOD and fecal coliform counts (ρ = 0.515, p = 0.049). This means that sites with higher organic pollution, as reflected by BOD, also tend to exhibit higher microbial contamination levels. This finding strongly agrees to the report of Fulke et al. (2024) that the statistical correlation between BOD and coliforms showed a direct positive relationship indicating BOD levels partially imitate the amount of organic pollution which is associated with fecal bacteria. This pattern suggests that both organic waste and pathogenic contamination may originate from similar pollution sources, such as untreated domestic wastewater or improper sanitation practices. Among all the parameters, BOD appears to be the most influential in the changes of the water quality of the sampling sites. Its significant associations with both phosphate and fecal coliform suggest that it reflect combined nutrient enrichment and microbial pollution processes.

Table 2
Spearman's Rank-Order Correlation Analysis of the Water Quality Parameters

Variable	pH	BOD	Nitrate	Phosphate	Fecal Coliform
pH	—	−0.075 (.791)	−0.532 (.041)*	−0.189 (.501)	0.007 (.980)
BOD		—	0.501 (.057)	0.541 (.037)*	0.515 (.049)*
Nitrate			—	0.437 (.104)	−0.110 (.697)
Phosphate				—	0.275 (.320)
Fecal Coliform					—

Note. Values represent Spearman's rho (ρ); p values are shown in parentheses. $p < .05$.

Table 3 shows the computed pollutant load estimates and the percent contribution respectively across the five sampling stations (T1-T5). This analysis provides a more comprehensive assessment of contamination because it reflects both the concentration of pollutants and the amount of water transporting them. As shown on Figure 1, the results of the study imply that T2 and T4 are critical pollution-contributing stations, with T4 has the highest organic pollution load (BOD) and T2 contributing the greatest microbial and phosphate load. The analysis revealed substantial variation in pollutant loads among the monitoring stations. For BOD, T4 recorded the highest load (1227.63 kg/day) accounting to 47.22% pollutant load contribution, followed by T3 (634.14 kg/day) with 24.39%, whereas T1 exhibited the lowest load (198.80 kg/day) with 7.65% pollutant load contribution. Although T5 had the highest BOD concentration (118.43 mg/L), its lower discharge value (Q = 24.77 L/s) resulted in a comparatively smaller pollutant load. This finding demonstrates that pollutant transport is influenced not only by contaminant concentration but also by streamflow volume. The elevated BOD load at T4 indicates a greater contribution of organic matter at this station, which increase microbial decomposition and reduce dissolved oxygen availability in the receiving water body (Chan et al. 2016). The nitrate load results showed a relatively minor differences among stations, ranging from 3.78 kg/day at T5 (3.68%) to 25.51 kg/day at T4 (24.82%). Transect points T1, T2, T3, and T4 exhibited comparable nitrate loads, suggesting a relatively consistent input of nitrogenous compounds throughout the creek system. Elevated nitrate transport in downstream or higher-flow stations indicate runoff contributions from domestic wastewater, and agricultural activities from neighboring municipalities discharging in the river system (Zhang et al., 2015).

For phosphate load, T2 exhibited the highest load (22.15 kg/day) with 28.06% pollutant load contribution, followed by T1 (19.37 kg/day) with 24.47% and T3 (18.61 kg/day) with 23.58% pollutant load contribution. Phosphate loading was comparatively lower at T5 (3.45 kg/day) with 4.36% due to reduced discharge despite relatively elevated phosphate concentration. High phosphate loads are environmentally significant because they can accelerate nutrient enrichment and contribute to eutrophication, promoting excessive algal growth and subsequent oxygen depletion in aquatic ecosystems (Al-Islmi, Amiri & Malakootian, 2021; Ana & Espino, 2020). The most obvious differences were observed in fecal coliform load, where T2 recorded the highest microbial load (approximately 4.58 × 1011 MPN/day) accounting 50.22% pollutant load contribution, followed by T3 (3.07 × 1011 MPN/day) with 33.68% load contribution and T4 (1.00 × 1011 MPN/day) with 10.97%. In contrast, T1 showed the lowest fecal coliform load (5.07 × 109 MPN/day) with 0.56%. These findings indicate that microbial contamination was most severe at T2, potentially reflecting direct sewage discharge, livestock waste, or surface runoff containing fecal matter (Swistock et al., 2022). Despite T5 having a high fecal coliform concentration, its relatively low discharge reduced the total microbial load transported.

Table 3
Estimated Pollutant Load Contribution Across the Five Transect Points

Sampling Site	BOD Load (kg/day)	%	Nitrate Load (kg/day)	%	Phosphate Load (kg/day)	%	Fecal Coliform Load (MPN/day)	%
T5	253.44	9.75	3.78	3.68	3.45	4.36	4.17×10^{10}	4.57
T4	1,227.63	47.22	25.51	24.82	15.46	19.53	1.00×10^{11}	10.97
T3	634.14	24.39	23.81	23.12	18.61	23.58	3.07×10^{11}	33.68
T2	285.83	10.99	24.35	23.74	22.15	28.06	4.58×10^{11}	50.22
T1	198.80	7.65	25.36	24.64	19.37	24.47	5.07×10^{9}	0.56

Figure 1 illustrates the percentage contribution of pollutant loads across the five transect points in Magugpo Creek, demonstrating pronounced spatial variability in the transport of organic, nutrient, and microbial contaminants. The results indicate that Transect 4 contributed the largest proportion of biochemical oxygen demand (BOD) load, whereas Transect 2 accounted for the highest phosphate and fecal coliform loads. These findings suggest that pollutant transport within the creek is governed not only by contaminant concentrations but also by stream discharge and hydrologic conditions, resulting in distinct pollution hotspots within the delineated drainage catchment. This observation is consistent with previous studies demonstrating that pollutant load estimation provides a more comprehensive assessment of watershed contamination than concentration-based monitoring because it integrates contaminant levels with flow characteristics to quantify the actual mass of pollutants transported through aquatic systems (Bello et al., 2024; Haeruddin et al., 2025).

The elevated BOD load observed at Transect 4 indicates substantial organic matter inputs, likely originating from untreated domestic wastewater and densely developed urban areas, which increase microbial decomposition and oxygen demand within the receiving water body (Chakraborti, 2021). Conversely, the predominance of phosphate and fecal coliform loads at Transect 2 suggests localized inputs from household wastewater, inadequate sanitation infrastructure, and other anthropogenic activities that contribute to nutrient enrichment and microbial contamination (Bunce et al., 2018; Fulke et al., 2024). These spatial differences emphasize the influence of land use, drainage connectivity, and wastewater discharge patterns on pollutant distribution within urban creek systems.

The identification of critical pollutant-contributing areas has important implications for watershed management and environmental planning. Prioritizing interventions in Transects 2 and 4, including improved septage management, stricter wastewater discharge control, and targeted water quality monitoring, would likely produce greater reductions in overall pollutant loading than uniform management strategies. Moreover, the integration of pollutant load estimation with drainage catchment delineation provides a robust scientific framework for identifying pollution hotspots, supporting evidence-based decision-making, and strengthening sustainable urban wastewater management.

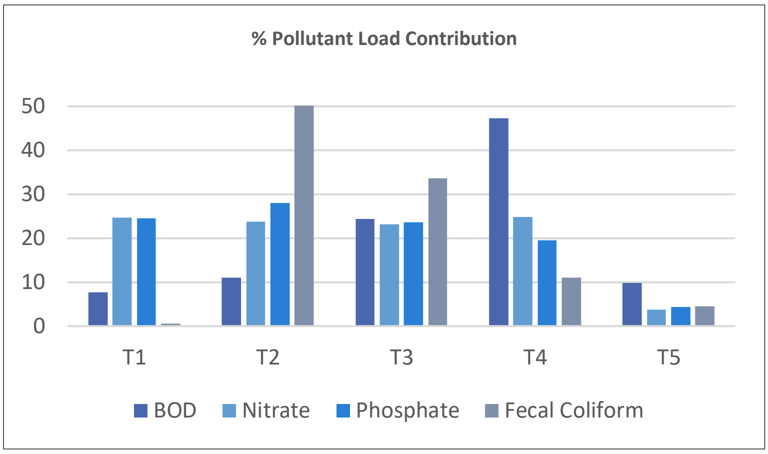

Figure 1. Percent Pollutant Load Contribution on the Transect Points

Conclusion and Recommendations

The study demonstrated that Magugpo Creek is experiencing considerable wastewater-related environmental stress characterized by elevated organic, nutrient, and microbial pollution associated with domestic wastewater discharges and urban land-use activities. While pH and nitrate concentrations generally remained within regulatory standards, biochemical oxygen demand (BOD), phosphate, and fecal coliform levels exceeded acceptable thresholds across most transect locations, indicating substantial impairment of water quality. Pollutant load assessment revealed that contamination patterns are influenced not only by pollutant concentrations but also by stream discharge and watershed characteristics, resulting in distinct spatial variations across the creek system. The identified positive relationships among BOD, phosphate, and fecal coliform further suggest that domestic wastewater serves as a common source of multiple pollutants. Through the integration of pollutant load estimation, spatial analysis, and drainage catchment assessment, the study addressed the absence of localized baseline information on wastewater pollution within Magugpo Creek and provided a more comprehensive understanding of pollutant generation, transport, and distribution. The findings contribute to existing knowledge on urban wastewater management by demonstrating the value of combining water quality assessment with pollutant load and spatial hotspot analyses to support watershed-based environmental planning and decision-making.

The findings underscore the need for proactive wastewater management interventions to reduce pollutant inputs and protect the ecological condition of Magugpo Creek and its receiving water bodies. It is recommended that the Local Government Unit of Tagum City, in partnership with DENR-EMB and other concerned agencies, institutionalize a long-term water quality monitoring program for Magugpo Creek and the city's remaining major creek systems to support regulatory compliance, environmental monitoring, and evidence-based planning. Strengthening the implementation of septic tank inspection, maintenance, and desludging programs, together with the development of an integrated septage management system, is likewise recommended to address the primary sources of domestic wastewater contamination. The identified pollution hotspots should be prioritized for intervention and future wastewater infrastructure planning. Future studies should expand monitoring efforts to include wet-season conditions, incorporate additional parameters such as Total Suspended Solids (TSS), and examine seasonal pollutant transport dynamics to further improve pollutant load estimation and support comprehensive urban water resource management strategies.

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