ANALYZING SPATIAL AND TEMPORAL VARIATIONS OF WATER QUALITY PARAMETERS IN OGUNPA RIVER WATERSHED

BY

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HND/23/CEC/FT/0052

A PROJECT SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING INSTITUTE OF TECHNOLOGY, KWARA STATE POLYTECHNIC, ILORIN.

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF HIGHER NATIONAL DIPLOMA(HND) IN CIVIL ENGINEERING.

July, 2025

CERTIFICATION

This is to certify that this research study was conducted by SALIU Mashood Olawale (HND/23/CEC/FT/0052) and had been read and approved as meeting the requirements for the award of Higher National Diploma (HND) in Civil Engineering of the Department of Civil Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

I dedicate this project to Almighty Allah my creature, my source of inspiration, wisdom, knowledge and understanding.

ACKNOWLEDGEMENTS

All glory, honour, praise and adoration be to Almighty Allah for giving me the strength, knowledge and understanding to complete this project.

I sincerely express my deep sense of gratitude to my project supervisor Engr. Mansur Wopa, for his valuable support, patience, time and guidance in seeing me to the end of this project.

I also want to express my profound gratitude to the Head of Civil Engineering Department Engr. A. Naallah, for his fatherly advice and support.

I appreciate all my lecturers who have impacted me throughout my Higher National Diploma. Thanks and God bless you all.

I also wish to appreciate the effort, love, care and support of my dear parents Mr. and Mrs. Saliu, family and friends who have graced me with their prayers, financial supports and encouragements till the end of my program.

Finally, I also wish to appreciate the support, care, and encouragement of my friends during the course of my Higher National Diploma (HND), I pray God Almighty lifts them higher in all their future endeavours.

ABSTRACT

The degradation of surface water quality due to anthropogenic and natural influences has become a major environmental concern in urban watersheds. This study examines the spatial and temporal variations of water quality parameters within the Ogunpa River watershed in Ibadan, Oyo State, Nigeria. The Ogunpa River, which flows through a densely populated urban region, has been subjected to severe pollution from domestic, industrial, and agricultural sources. The aim of the study was to analyze how spatial and temporal factors influence the variation of key water quality indicators along different subbasins of the river. To achieve this, the Soil and Water Assessment Tool (SWAT) was employed for hydrological and water quality modeling. Input datasets included Digital Elevation Model (DEM), land use/land cover maps, soil characteristics, and weather data. The model simulated pollutant transport processes and predicted values for organic phosphorus (ORGP_IN), nitrate (NO_3_IN), and sediment (SED_IN) loads across multiple subbasins. Results revealed that subbasins 1, 2, 3, 4, and 6 exhibited significantly higher pollutant loads, with total estimates of 23,095.35 kg of organic phosphorus, 263,741.95 kg of nitrate, and 712,072.62 tons of sediment. These high levels were attributed to intensive land use activities and inadequate waste management. Conversely, other subbasins recorded lower values due to better land cover and reduced anthropogenic pressure. The study concludes that spatially targeted watershed management practices such as buffer zones, erosion control, and fertilizer management are crucial for improving water quality. The findings serve as a decision-making tool for urban water resource planning and highlight the need for continuous monitoring and sustainable land use policies in the Ogunpa watershed.

Word Count: Spatial And Temporary Variation of Water Quality Parameters in Ogunpa River Watershed

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CHAPTER ONE

INTRODUCTION

Water as a valuable component of the environment is important for human, economic and social development. Rivers serve as one of the sources of public drinking water and private wells. Others may include streams, lakes, reservoirs, springs, and ground water. Therefore, when these sources are polluted, wildlife is endangered, drinking water becomes unsafe, and by implication threatens the health of the users, due to its poor-quality status. The World Health Organization (WHO) estimated that up to 80 % of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. There are various criteria for water quality standards, i.e., safety of drinking water, acceptability of water quality for industrial use such as cooling water for boilers, water used for agriculture, fish farming, fishery, and for sustaining natural aquatic ecosystems. (Adeyefa *et al*., 2023).

Thus, information on water quality and pollution sources in such water bodies is important for the implementation of sustainable water use management strategies, have opined that for effective maintenance of water quality through appropriate control measures, continuous monitoring of a large number of quality parameters is essential. In addition, due to seasonal and regional characteristics of river water, assessing spatial variations has become an important aspect of river water quality at a watershed level as an important aspect for the physical and chemical characterization of aquatic environments. Unethical disposal habits and activities around river bodies have been largely responsible for the deteriorating nature of river water quality. Although, deterioration of river water quality can result from natural processes, but more recently, it's due to anthropogenic activities through the discharge of industrial and domestic wastewater as well as agricultural drainage to the rivers. (Adeyefa *et al.*, 2023).

In Nigeria, the problem of water pollution is largely a result of an interplay of high population growth, accelerated urbanization and industrialization, and has become a complex issue due to a lack of a solid waste management approach.

As observed by Ayatomuno and Gobo 2004), estimation shows that each Nigerian generates about 0.85 kg of waste per day totaling about 119 million tons of municipal and industrial waste per annum. A substantial amount of this eventually found its way to the rivers. The activities of the people in waste generation and disposal at the upper course and even around Ogunpa River in Oyo state, are not different. As a result, the quality status of the river is unsafe for domestic purposes (cooking, washing of clothes, bathing, and recreation, amongst others) due to the unpleasant waste dumping habits.

The problem of how to manage these wastes is reaching a critical proportion. In the recent past, the government had gone extra the mile to invest in the services of waste management companies, especially in urban areas which has led to improvements in the level of urban cleanliness. But unfortunately, solid waste dumps keep on emerging and proliferating in different parts of the urban landscape. The choice of rivers and streams as dumpsites particularly in areas of proximity is becoming a major concern that merits special attention. This is essential because most of these surface water bodies still serve as sources of water supply to many urban and rural communities down-stream and are expected to maintain a certain level of quality for sustainable use by these populations.

Several studies have been undertaken generally on water quality assessments and environmental-related issues. River water quality assessments, specifically are also numerous among others. The rate at which the residents along the various points through which the river flows dispose faeces, domestic and industrial wastes, is alarming. This may have led to the pollution and contamination of the river. More importantly, many of the users of the river at the lower course assume they are not affected by the hazardous activities occurring at the upper course of the stream. This requires that knowledge of what is operational, and the quality status of the river at various points is made known.

Thus, the need for investigating, identifying and understanding the extent to which the menace has affected the river's water-quality status. Given the alarming rate at which Ogunpa River is mismanaged in terms of quality, quantity and utilization at different points as observed above, and the dearth of information on water quality assessments on the river, the knowledge of the spatial and temporal variations of the physicochemical properties of the river water is required. Apart from the examination of the variations in the river water properties, computation of the water quality index (WQI) for reaches along River Ogunpa should also be of consideration. All this is to ascertain its quality status.

Rivers come in contact with different types of rocks in their pathway which are weathered by physical, chemical and biological processes. The weathered elements by the natural processes add directly in to the river system. Various types of chemicals also added in the rivers by anthropogenic activities which contribute in changing the physical, chemical, and biological properties of the rivers water. Besides these human influences, river water quality is also affected by other natural activities viz. geological, hydrological and climatic factors. (Harendra & Shukla 2016).

The concentration of pollutants in water samples only indicate the situation at the time of sampling, while concentrations in the organism are the result of past as well as current pollution levels in the environment in which the organism lives (Ravera *et al.*, 2001). A previous study indicated that potential sources of elevated levels of heavy metals were sewage wastes, wastes from metal processing industries and other household refuse. Generally, the main natural source of heavy metals in water is weathering of minerals. Industrial effluents and non-point pollution sources, as well as changes in atmospheric precipitation can lead to local increase in heavy metals concentration water.

Also, total heavy metals concentrations in aquatic ecosystem can mirror the present pollution status of these areas. Tannery industry contributes significantly towards exports, employment generation and occupies an important role in Indian economy. Heavy metals released from tanneries are kept under environment pollutant category due to their toxic effects on plants, animals and human beings. They interfere with physiological activities of plants such as photosynthesis, gaseous exchange and nutrient absorption and cause reduction in plant growth, dry matter accumulation and yield. They cause direct toxicity, both to human and other living beings due to their presence beyond specified limits. The metals present in the soil can enter in the aquatic system by weathering, percolation, and surface runoff from agricultural land. Soil can also be polluted by wastewater irrigation. These contaminated soils may have an impact on water quality. Therefore, protection of the soil around the industrial region is of prime importance for the quality of soil and water. Temporal variations in precipitation, surface runoff, interflow, groundwater flow, and pumped in and outflows have a strong effect on river discharge and subsequently on the concentration of pollutants in river water (Haiyan and Stuanes, 2003).

The quantity of the river water may determine how well it is able to sustain its application for these services as well as the diversity and richness of its freshwater biota. This study was carried out to determine the general status of the physical and chemical water quality parameters of the river from its headwaters to the lower reach before discharge into the sea (Omoniyi *et al.,* (2017).

The outcome of this study therefore, will be useful in creating awareness, and educating the society at large as well as the appropriate authorities on the best way, manner and approach to manage water bodies within a given environment.

1.1 AIM AND OBJECTIVES

AIM

The aim is to investigate the impact of spatial and temporary variation of water quality parameters in Ogunpa, Oyo State.

OBJECTIVES

The objectives are to:

i. Analyze spatial variations in water quality parameters across different locations within the Ogunpa river watershed
ii. Estimate the water quality parameters in Ogunpa river watershed.

1.2 SCOPE OF THE STUDY

The study will be focused on the impact of spatial and temporal variation of water quality parameters in Ogunpa River, Oyo State, including sources of pollution, seasonal influences, and implications for ecosystem health and human usage with the surrounding.

1.3 JUSTIFICATION OF STUDY

The study offered information on the impact of spatial and temporary variation of water quality parameters in Ogunpa river watershed. The outcome was useful for the sustainable management of the river and the protection of public health.

1.4 PROBLEM STATEMENT

The quality of water in Ogunpa River has been a major concern due to pollution from various sources. However, spatial and temporary variation of water quality parameters in ogunpa river has not been adequately investigated.

CHAPTER TWO

2.0 LITERATURE REVIEW

Omoniyi *et al.,* (2017) examine the Seasonal and Spatial Variations in Physico-Chemical Water Quality. This study was carried out at six selected sampling stations over the three reaches of River along its main axis to determine seasonal and spatial variations in the general physico-chemical water quality parameters of the river water. From each sampling station, surface water samples were collected bi-monthly for an annual cycle, the samples were treated and analyzed for physico-chemical water quality parameters using applicable standard procedures. The river showed an increasing clarity from its headwaters to the lower reach with regard to mean transparency, turbidity and colour and was also clearer in the dry season than in the rainy season. The mean values of most parameters determined were within permissible limits making the river water suitable for most probable domestic and industrial uses and livestock support.

Li, M. *et al.,* (2016) conducted a longitudinal study to assess the temporal variability of water quality parameters within delineated watersheds over multiple years. Their research provided insights into the dynamic nature of pollutant transport processes and the implications for long-term watershed management strategies. The result showed that fluctuations in water quality parameters such as nutrient concentrations, pollutant levels, and sedimentation rates over time, influenced by seasonal variations, weather patterns, land use changes, and human activities. Additionally, they have identified trends or patterns in the temporal variability of water quality parameters, highlighting periods of improvement or degradation in water quality within the studied watersheds. Their study likely provided valuable information for understanding the dynamics of water quality over time and guiding long-term watershed management and conservation efforts

Fatai *et al.,* (2024). Examine effect of watershed delineation on water quality parameter, This study assessed the impact of watershed delineation on the estimation of water quality parameters in the Omi River in Osun state, Nigeria. MAP Window GIS interfaced with Soil and Water Assessment Tools (SWAT) and was used to pre-process the spatial data. The model was used to simulate water quality parameters such as organic phosphorus and nitrate at subbasin level of the study area.

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Abel. *et al.,* (2023) carried out an investigation on study of seasonal changes in Quality Parameters, Physico-chemical parameters of River were investigated to determine its quality characteristics and establish seasonal effects on the water. Water from the river was collected at five different points in dry season (March, 2008 and 2009) and rainy season (July, 2008 and 2009). Quality evaluation for irrigation revealed that the water was suitable for all irrigation purposes. River Oluwa water was soft, low mineralized, chemically potable, suitable for irrigation but with lower ionic concentrations in rainy season.

Johnson, D.W. *et al.,* (2020) investigated the influence of watershed delineation on the identification of critical source areas for sediment and nutrient transport in agricultural landscapes. By comparing different delineation methods, the researchers highlighted how variations in boundary definition can impact the spatial distribution of pollutant hotspots. The result indicated that watershed delineation significantly influences the identification of critical source areas for sediment and nutrient transport in agricultural landscapes. They have found that variations in watershed boundaries can lead to differences in the spatial distribution and magnitude of sediment and nutrient loads, affecting the prioritization of management practices and resources. They have recommended approaches to improve the accuracy of watershed delineation methods to better target conservation efforts and mitigate water quality impacts in agricultural areas.

Adeyefa *et al.,* (2023) investigate on Spatial and Temporal Variations in Water Quality of River Ogun" The water quality of River Ogun is contaminated largely through the activities of the population by the latter purpose. Several studies have been carried out on water quality assessment with little or no information on the River Ogun portion of Abeokuta, a fundamental water source for densely populated area. Standard analytical methods were undertaken to determine the physical (salinity, temperature, Electrical Conductivity (EC) and Total Dissolved Solids (TDS)), and the chemical parameters (pH, hardness, ammonia, chloride, nitrate, alkalinity, dissolved oxygen, and biochemical oxygen demand). Graphs, tables, T-test, and ANOVA, were employed for the statistical analyses.

2.1 EFFECT OF SPATIAL AND TEMPORARY VARIATION

Spatial and temporal variations significantly impact water quality parameters, affecting the suitability of water for various uses.

2.1.1 SPATIAL VARIATION

i. Geographical Location: Water bodies in different regions exhibit varying water quality due to differences in climate, geology, and human activities. For example, urban areas with high pollution levels may have poorer water quality compared to rural areas.

ii. Distance from Pollution Sources: Water quality deteriorates closer to pollution sources like industrial discharges or agricultural runoff.

iii. Depth: Water quality parameters can vary with depth due to factors like sunlight penetration, temperature stratification, and sediment deposition.

iv. Flow Rate: Water bodies with higher flow rates tend to have better water quality as pollutants are diluted and dispersed more rapidly.

2.1.2 TEMPORAL VARIATION

i. Seasonal Changes: Water quality can fluctuate seasonally due to factors like rainfall, temperature, and vegetation cover. For example, nutrient levels may increase during spring runoff, leading to algal blooms.
ii. Diurnal Variations: Water quality parameters can vary throughout the day due to factors like photosynthesis, respiration, and human activities. For example, dissolved oxygen levels may decrease at night due to reduced photosynthesis.
iii. Long-term Trends: Water quality can change over longer time periods due to climate change, urbanization, and changes in land use. For example, increased temperature can lead to decreased dissolved oxygen levels.

2.1.3 COMBINED EFFECTS

Spatial and temporal variations can interact to further complicate water quality patterns. For example, a pollutant discharged into a river may have a greater impact during low-flow periods when dilution is reduced.

2.1.4 IMPLICATIONS

Understanding the spatial and temporal variations in water quality is crucial for:

i. Effective Water Management: Implementing appropriate strategies to mitigate pollution and conserve water resources.
ii. Public Health: Ensuring safe drinking water and preventing waterborne diseases.
iii. Environmental Protection: Protecting aquatic ecosystems and biodiversity.
iv. Sustainable Development: Balancing economic growth with environmental sustainability.

2.2 WATER QUALITY PARAMETERS

Water quality parameters are used to evaluate the quality of water. Some of the main parameters include:

i. pH: A measure of water's acidity or alkalinity. pH levels outside the acceptable range can harm aquatic life and water treatment systems.

ii. Temperature: A measure of the average energy of water molecules. Temperature affects water chemistry and the functions of aquatic organisms.

iii. Turbidity: A measure of how particles suspended in water affect water clarity. Turbidity increases after rainfall when sediment is carried into the water.

iv. Conductivity: A measure of water's ability to conduct electricity. Water with a lot of salt can be dangerous to crops.

v. Hardness: A measure of the presence of certain salts in water, such as carbonate, bi-carbonates, chlorides, and sulphates of Ca and Mg.

vi. Alkalinity: A measure of water's ability to neutralize acids. Alkalinity is often measured to determine how much soda and lime to add to water to soften it.

vii. Biological: A measure of whether water meets set standards. Biological parameters include bacteria and algae.

viii. Nitrogen: Water can contain four forms of nitrogen: organic, ammonia, nitrite, and nitrate.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

The Ogunpa River system is a third-order stream with a channel length of 21.5 kilometres (13.4 mi) and a drainage basin covering 73.3 square kilometres (28.3 sq mi) draining the densely populated eastern part of Ibadan, Nigeria. The city of Ibadan in southwestern Nigeria (7º23’ N, 3º5’ E) is the largest urban centre in Africa south of the Sahara, Ogunpa River is known to contain 49 species of zooplankton, Western part.

Two seasons are distinguishable in the Ogun River Basin, a dry season from November to March and a wet season between April and October. Mean annual rainfall ranges from 900 mm in the north to 2000 mm towards the south, a reflection of the dichotomy in the ecological zones of the savanna and the forest. The total annual potential evapotranspiration is estimated at between 1600 and 1900 mm.

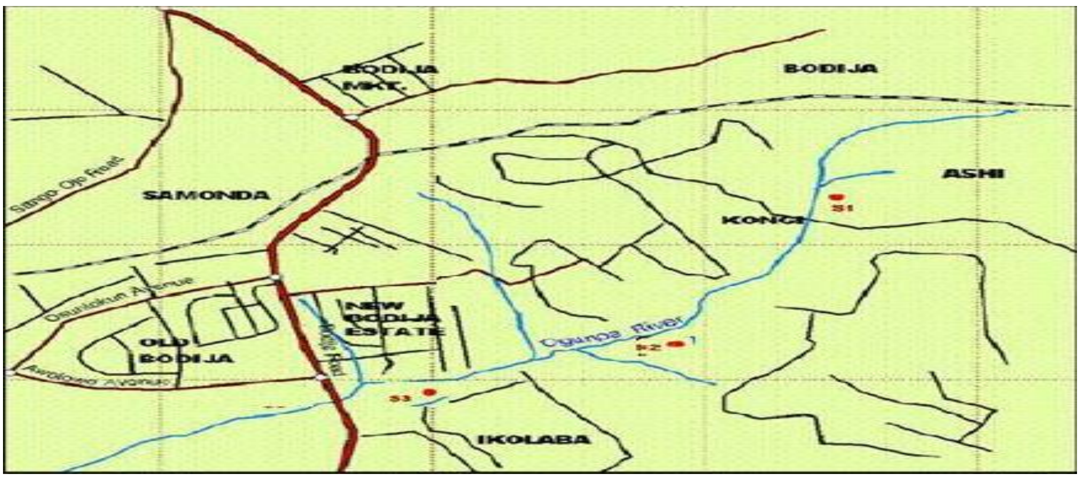

Figure 3.1: Map of Ogunpa River, Ibadan, Oyo State (Source: Goggle)

3.2 MODEL SELECTION AND DESCRIPTION

Selecting an appropriate model is crucial for accurately assessing the effect of Spatial and temporal variations on water quality parameters. In this study, the Soil and Water Assessment Tool (SWAT) was chosen due to its capability to simulate the hydrological processes and water quality dynamics within a watershed. SWAT is widely used for watershed-scale assessments, offering comprehensive features for simulating various land management practices and their impacts on water resources.

3.3 MODEL DATA REQUIREMENT

3.3.1 DIGITAL ELEVATION MODEL (DEM):

A Digital Elevation Model (DEM) is a digital representation of the Earth's surface topography. It provides elevation data for each grid cell within a study area, typically in the form of a raster dataset. DEMs are essential for delineating watershed boundaries, estimating slope and aspect, and modeling surface water flow. They are 15 commonly derived from remote sensing technologies such as satellite imagery or airborne LiDAR (Light Detection and Ranging) systems.

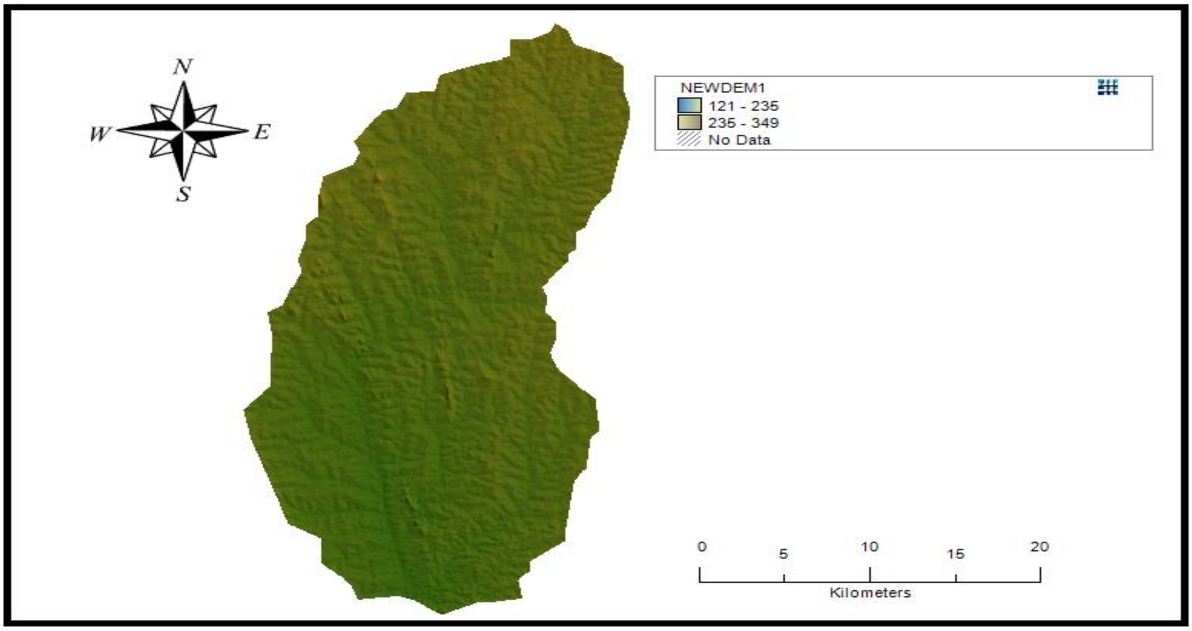

Figure 3.2: Dem Map of showing the Study Area (Source: Goggle)

3.3.2 LAND USE/LAND COVER (LULC):

Land use/land cover data classify the types of land cover and land use activities within a geographic area. This dataset categorizes land into classes such as forest, agriculture, urban, water bodies, etc. Land use/land cover data are crucial for characterizing the spatial distribution of human activities and their impacts on hydrological processes and water quality. They are typically derived from satellite imagery, aerial photography, or field surveys.

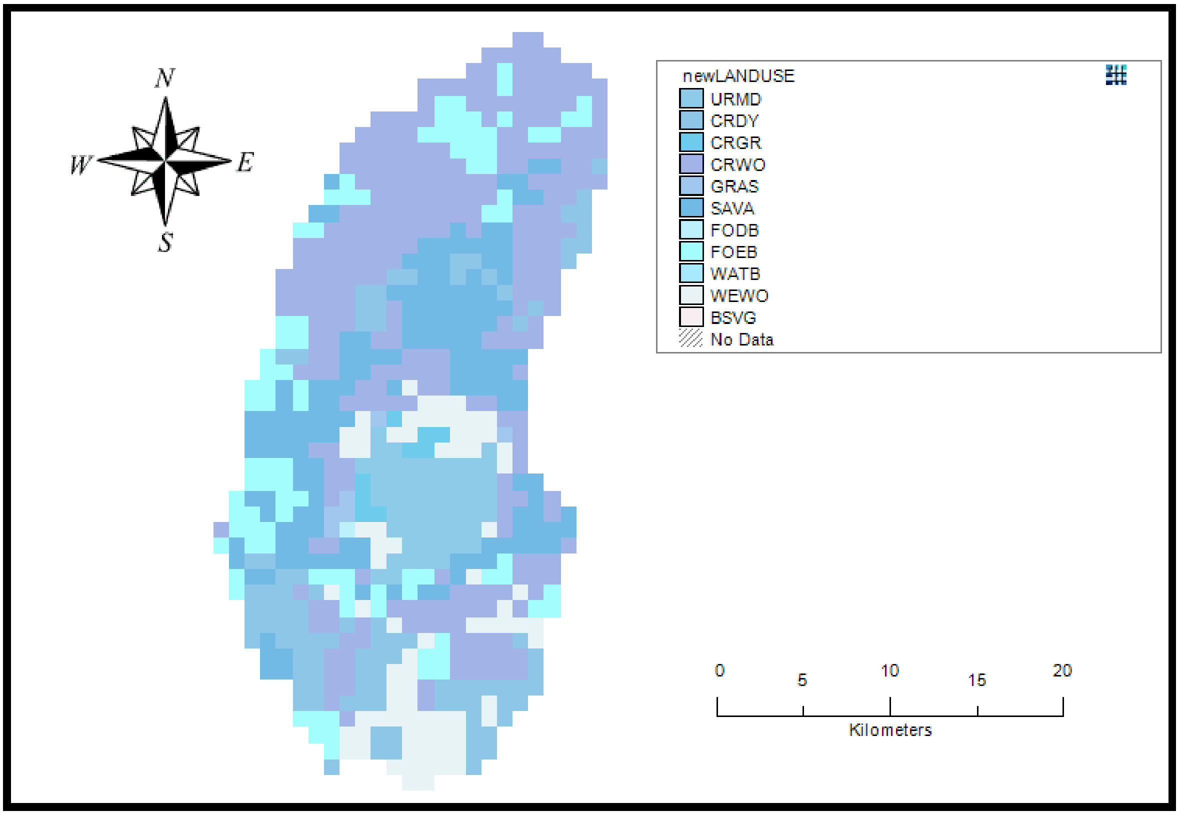

Figure 3.3: Land Use Map of the Study Area (Source: Goggle)

3.3.3 SOIL MAP

A soil map provides information on the spatial distribution of soil types, properties, and characteristics within a study area. It delineates soil units based on factors such as texture, drainage, depth, and fertility. Soil maps are essential for understanding soil-water interactions, infiltration rates, and nutrient cycling processes. They are typically derived from soil surveys conducted on the ground and are represented as polygonal or raster datasets.

3.3.4 WEATHER DATA

Meteorological data including temperature, rainfall, humidity, solar radiation, and wind speed were collected from weather stations within or near the study area. These data were used as input for SWAT to simulate hydrological processes and water quality parameters.

i. Temperature: Temperature refers to the degree of hotness or coldness of the atmosphere. In the context of hydrological modeling, temperature data is essential as it influences various processes such as evaporation, snowmelt, and vegetation growth. Temperature data is usually measured in degrees Celsius (°C) or Fahrenheit (°F) and is recorded at regular intervals (e.g., daily, hourly). It provides insights into seasonal variations and climate patterns, which are crucial for understanding hydrological processes.

ii. Rainfall: Rainfall represents the amount of precipitation, typically in the form of rain, which falls over a specific area during a given period. Rainfall data is measured using rain gauges or radar systems and is expressed in units such as millimeters (mm) or inches. It is a primary driver of surface runoff, infiltration, and groundwater recharge within watersheds. Temporal patterns of rainfall, including intensity, frequency, and duration, influence hydrological response and water quality dynamics.

iii. Humidity: Humidity measures the amount of water vapor present in the air. It is an important meteorological parameter that affects evaporation rates, plant transpiration, and atmospheric stability. Relative humidity, expressed as a percentage, indicates the moisture content of the air relative to its maximum capacity at a given temperature. High humidity levels can enhance evapotranspiration rates, while low humidity levels can lead to increased water stress in vegetation.

iv. Solar Radiation: Solar radiation refers to the electromagnetic radiation emitted by the sun. It includes both direct radiation from the sun and diffuse radiation scattered by the atmosphere. Solar radiation plays a crucial role in driving various environmental processes, including photosynthesis, evaporation, and temperature regulation. Solar radiation data is typically measured in watts per square meter (W/m^2) and is influenced by factors such as time of day, season, cloud cover, and atmospheric conditions.

v. Wind Speed: Wind speed measures the rate at which air moves horizontally across the Earth's surface. It is an important meteorological parameter that affects evaporation, dispersion of pollutants, and wind-driven erosion. Wind speed data is usually recorded in meters per second (m/s) or kilometers per hour (km/h) and is measured using anemometers or weather stations. Wind direction, in conjunction with wind speed, influences the distribution of pollutants and the transport of airborne particles within the atmosphere.

3.4 MODEL PARAMETERIZATION AND PREDICTION OF WATER QUALITY PARAMETERS

Model Parameterization

SWAT Model Setup: Configure the Soil and Water Assessment Tool (SWAT) by defining model parameters, land use categories, soil types, and management practices. Calibrate model parameters such as curve number, soil hydraulic properties, and crop coefficients using observed data to improve model performance.

Hydrological Components: Specify parameters related to hydrological processes such as evapotranspiration, infiltration, surface runoff, and groundwater flow. Ensure that these parameters accurately represent the physical characteristics of the study area and hydrological processes within the watershed.

Prediction of Water Quality Parameters

Water quality parameters such as nutrient concentrations (e.g., nitrogen, phosphorus), sediment yield, and pollutant loads were predicted using the calibrated SWAT model. The model incorporated algorithms to simulate the transport and transformation of pollutants within the watershed, accounting for factors such as land use, soil properties, and hydrological processes. Prediction of water quality parameters enabled the assessment of how changes in watershed declination affect the overall water quality status of the Ogunpa River in Oyo State.

3.5 VISUALIZATION OF THE RESULT

Visualization of the results is a critical component of any research project, including watershed and hydrological analysis. Effective visualization techniques enable researchers and stakeholders to interpret complex datasets, identify spatial patterns, and communicate findings in a clear and concise manner. In the context of watershed management, visualization tools can enhance understanding of hydrological processes, watershed characteristics, and the impacts of management interventions on water resources.

One commonly used visualization tool is geographic information systems (GIS), which enable researchers to integrate, analyze, and visualize spatial data layers within a geospatial framework. GIS software provides a range of visualization techniques, including overlay analysis, 3D visualization, and interactive mapping, to explore relationships between different datasets and extract meaningful insights (Fisher & Tate, 2006). For instance, researchers can use GIS to overlay results with land use maps, soil maps, and hydrological modeling outputs to assess the impacts of land use changes on water resources and ecosystem services.

Visualization of the results is important in watershed management by enhancing understanding, facilitating communication, and guiding decision-making processes. By employing a combination of thematic mapping, GIS analysis, and remote sensing techniques, researchers can effectively visualize hydrological processes, watershed characteristics, and the impacts of management interventions, contributing to informed and evidence-based decision-making for sustainable water resource management.

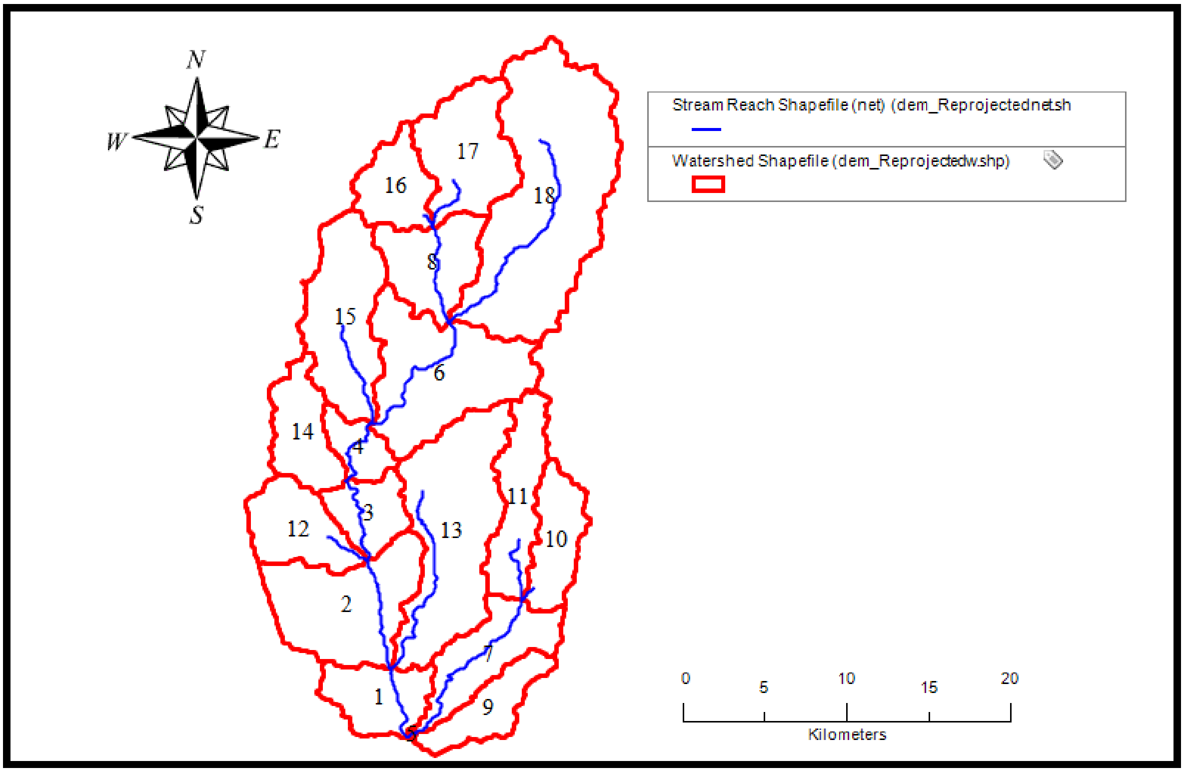

Figure 3.4: Watershed Delineation of the Study Area (Source: Goggle)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 SPATIAL VARIATIONS IN WATER QUALITY PARAMETERS ACROSS THE OGUNPA RIVER WATERSHED

4.1.1 ORGANIC PHOSPHORUS (ORGP_IN)

Organic phosphorus inputs vary widely across the watershed, reflecting differences in land use intensity and anthropogenic activities. Subbasins 6, 4, and 2 recorded the highest organic phosphorus inputs, with values of 3158.14 kg, 2588.27 kg, and 2383.40 kg respectively. These elevated inputs suggest significant agricultural activities or urban runoff contributing to phosphorus loading in these areas. In contrast, Subbasins 0 and 5 recorded minimal organic phosphorus inputs, likely due to their very small area or limited land use impact.

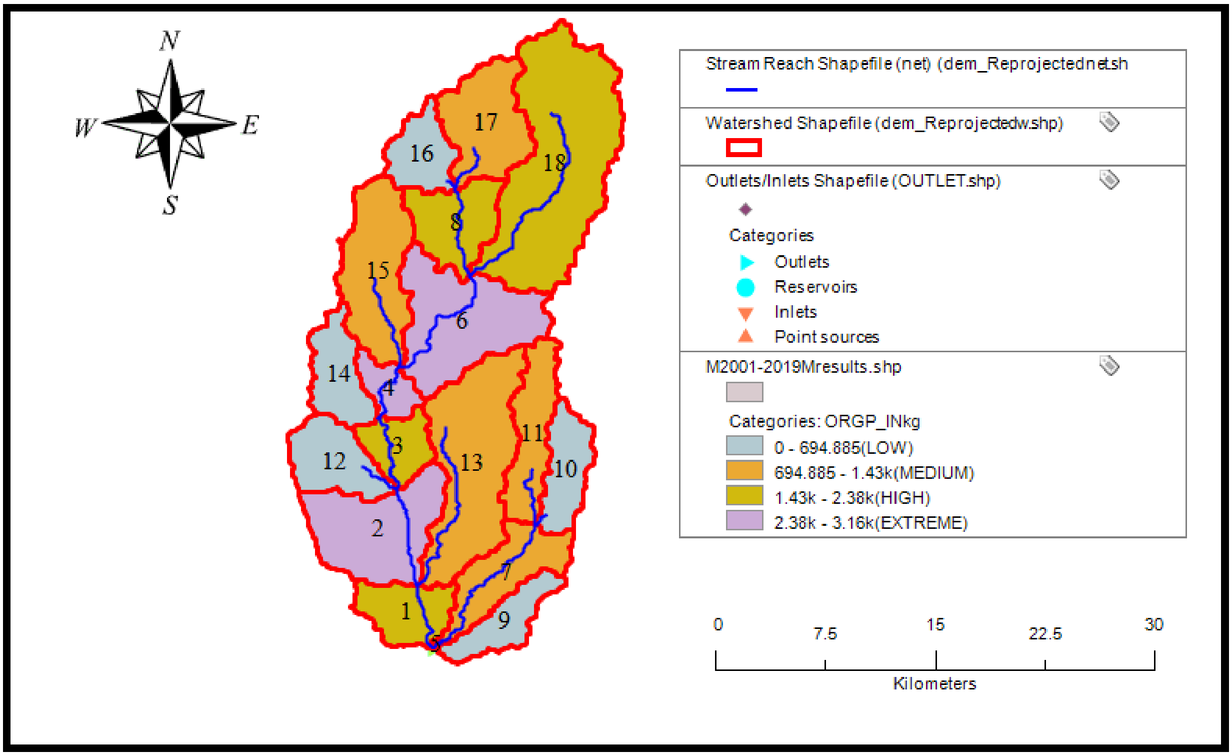

Figure 4.1: Spatial Variation of Organic Phosphorus in the Study Area

4.1.2 NITRATE (NO3_IN)

Nitrate input exhibits a highly variable spatial pattern, indicating localized sources of nitrate pollution within the watershed. The highest nitrate concentration was recorded in Subbasin 1 (51,237.68 kg), followed by Subbasin 2 (44,138.54 kg) and Subbasin 4 (32,077.85 kg). These subbasins are likely influenced by intensive fertilizer application, sewage discharge, or urban runoff. In contrast, Subbasins 12, 14, and 16 recorded much lower nitrate inputs, suggesting less intensive land use or more natural vegetation cover that limits nitrate runoff.

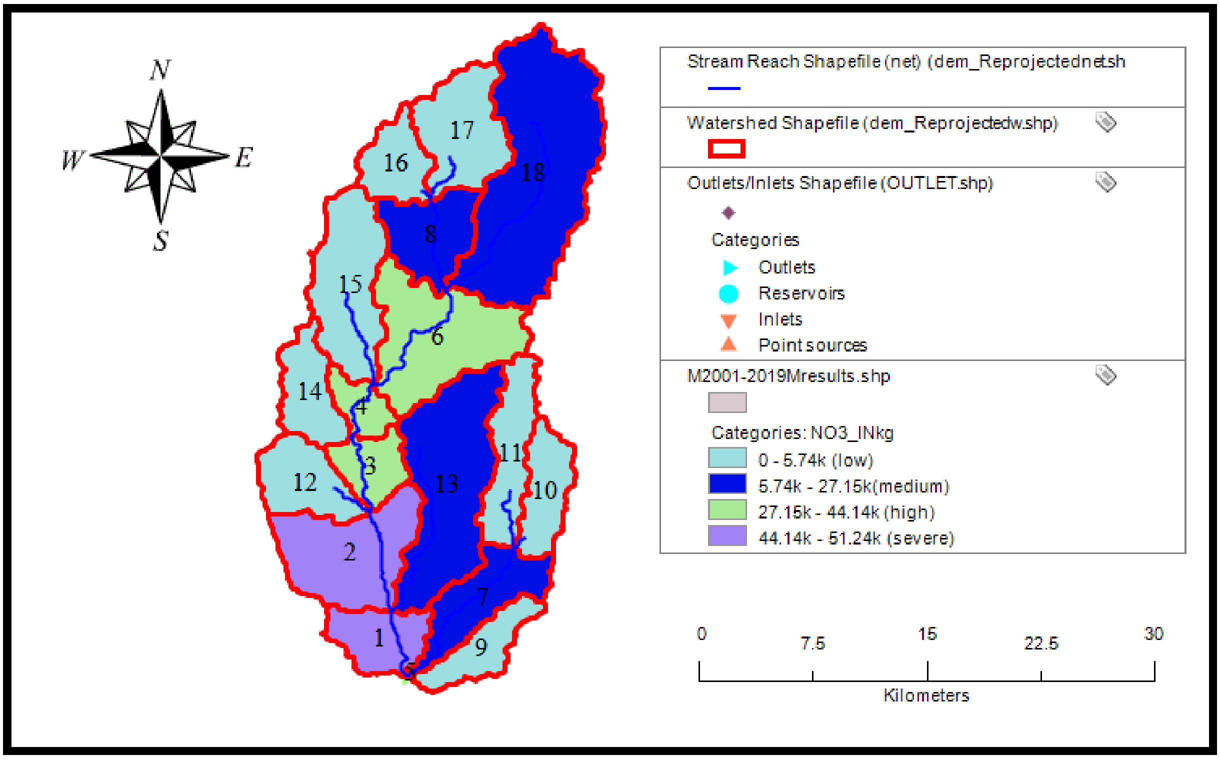

Figure 4.2 Spatial Variation of Nitrate in the Study Area

4.1.3 SEDIMENT (SED_IN)

Sediment load also varied significantly across the subbasins, pointing to differences in erosion rates and land cover conditions. Subbasin 1 showed the highest sediment yield at 144,087.05 tons, followed by Subbasins 2 (121,649.55 tons), 4 (88,633.26 tons), and 3 (99,020.29 tons). These results suggest that these areas are highly prone to soil erosion, likely due to factors such as bare soil surfaces, steep slopes, or poorly managed land uses. Subbasins with lower sediment inputs, such as Subbasins 9 and 14, indicate better vegetation cover or less disturbance.

4.1.4 OVERALL SPATIAL PATTERNS

From the analysis, it is evident that the northern and central subbasins, particularly Subbasins 1, 2, 3, 4, and 6, are the major contributors to organic phosphorus, nitrate, and sediment loading within the Ogunpa River watershed. These subbasins represent critical zones where water quality is most at risk and where management interventions should be prioritized.

Conversely, subbasins with smaller areas and lower input values, such as Subbasins 5, 9, 12, and 14, contribute less significantly to the overall pollutant load. However, ongoing monitoring is recommended to prevent potential degradation due to future land use changes.

This spatial analysis highlights the uneven distribution of water quality issues within the Ogunpa watershed and emphasizes the need for targeted management practices such as buffer zone establishment, erosion control measures, improved agricultural practices, and urban runoff management in the most impacted subbasins.

Table 4.1 Shows the Spatial And Temporal Variations Of Water Parameters Water Quality Parameters Across The Study Area

Subbasin	AREAkm2	ORGP_INkg	NO3_INkg	SED_INtons
0	0.00	0.00	0.00	0.00
5	0.25	694.89	13498.38	26210.96
1	23.70	2012.91	51237.68	144087.05
9	20.21	311.54	1964.73	3656.28
7	31.45	1014.00	11623.35	24027.92
2	51.84	2383.40	44138.54	121649.55
12	27.46	313.72	1403.27	4882.62
3	18.36	1823.39	34081.26	99020.29
10	23.25	489.74	3292.77	8478.96
4	12.66	2588.27	32077.85	88633.26
13	73.67	1170.59	5742.00	25577.90
11	30.52	705.42	3619.82	11640.16
14	23.94	349.11	1053.11	6815.23
6	61.55	3158.14	27148.92	69291.02
8	30.43	1430.02	8212.57	28908.81
15	48.61	1253.09	4066.80	19956.10
16	21.19	558.33	1954.52	6049.04
17	39.36	724.94	4048.31	6467.21
18	110.66	2113.84	14578.08	16720.26
	649.09	23095.35	263741.95	712072.62

4.2 ESTIMATION OF WATER QUALITY PARAMETERS IN OYUN RIVER WATERSHED

In addition to hydrological assessments, the study examined the transport of key water quality parameters across the Ogunpa River Watershed, focusing on organic phosphorus (ORGP_IN), nitrate (NO_3_IN), and sediment inflow (SED_IN). These constituents are significant indicators of watershed health, influencing aquatic ecosystem integrity and informing land and water management decisions.

The analysis was conducted across selected subbasins, with each subbasin contributing varying loads of pollutants depending on its area, land use, soil characteristics, and hydrologic behavior.

4.2.1 ORGANIC PHOSPHORUS (ORGP_IN)

Organic phosphorus inputs across the watershed totaled 23,095.35 kg, with notable contributions from Subbasins 6 (3,158.14 kg), 4 (2,588.27 kg), and 2 (2,383.40 kg). These elevated values are likely associated with intensive agricultural activity, livestock waste, or unbuffered surface runoff from fertilized fields. Subbasins with lower ORGP loads, such as Subbasins 12 and 14, suggest less nutrient-enriched runoff or more vegetative buffering.

4.2.2 NITRATE (NO_3_IN)

The total nitrate inflow across all subbasins was estimated at 263,741.95 kg, with the highest concentrations recorded in Subbasin 1 (51,237.68 kg), Subbasin 2 (44,138.54 kg), and Subbasin 3 (34,081.26 kg). These subbasins may be receiving excess nitrogen from fertilizers, wastewater discharge, or surface leaching. The spatial disparity in nitrate loads highlights the need for nutrient management strategies in critical source areas.

4.2.3 SEDIMENT INFLOW (SED_IN)

Sediment transport is a major concern in watershed management due to its impact on reservoir siltation, aquatic habitats, and pollutant loading. The total estimated sediment inflow was 712,072.62 tons, with Subbasins 1 (144,087.05 tons), 2 (121,649.55 tons), and 3 (99,020.29 tons) accounting for the highest contributions. These values suggest severe soil erosion and surface runoff intensity, possibly due to poor land cover, steep slopes, or unprotected farmlands.

Table 4.2 Shows the Summary Values

Subbasin	Area (km^2)	ORGP_IN (kg)	NO_3_IN (kg)	SED_IN (tons)
1	23.70	2,012.91	51,237.68	144,087.05
2	51.84	2,383.40	44,138.54	121,649.55
3	18.36	1,823.39	34,081.26	99,020.29
4	12.66	2,588.27	32,077.85	88,633.26
6	61.55	3,158.14	27,148.92	69,291.02

These findings emphasize the pressing need for integrated nutrient and sediment management in high-load subbasins. The variation in pollutant loading among subbasins also supports targeted interventions, rather than a uniform watershed-wide approach.

4.2.4 IMPLICATIONS FOR WATERSHED MANAGEMENT

- **High nutrient zones** (Subbasins 1–4, 6) are susceptible to eutrophication risks downstream and should be prioritized for best management practices (BMPs) such as buffer strips, reduced fertilizer application, and cover cropping.
- **Critical erosion zones** may require structural measures like check dams, terracing, and gully plugging.
- **Monitoring programs** should be established in high-impact subbasins to track long-term trends in nutrient and sediment loading.

This comprehensive water quality assessment provides actionable insights into pollutant dynamics in the watershed, serving as a foundation for designing sustainable land and water conservation measures.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study assessed the spatial variations of key water quality parameters—organic phosphorus, nitrate, and sediment loads—across different subbasins within the Ogunpa River watershed.

The findings reveal a highly uneven distribution of pollutant inputs across the watershed. Subbasins 1, 2, 3, 4, and 6 emerged as critical areas contributing the highest loads of organic phosphorus, nitrate, and sediment. These elevated pollutant levels are largely attributed to intensive agricultural activities, urban runoff, improper land management, and possible point-source pollution such as sewage discharge. In contrast, subbasins such as 5, 9, 12, and 14 recorded relatively low pollutant inputs, indicating areas with lower land use intensity or more effective natural buffering processes.

The cumulative pollutant loads—23,095.35 kg of organic phosphorus, 263,741.95 kg of nitrate, and 712,072.62 tons of sediment—underscore the urgent need for effective watershed management strategies. The spatial analysis conducted highlights the importance of targeting high-risk subbasins to improve water quality and protect the ecological health of the Ogunpa River system.

Ultimately, the study provides a scientific basis for implementing sustainable land and water management practices within the watershed, ensuring long-term environmental protection and better water resource management for the surrounding communities.

5.2 RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

i. Targeted Intervention Programs

Management efforts should focus primarily on subbasins 1, 2, 3, 4, and 6, where pollutant loads are highest. Interventions such as improved agricultural practices, fertilizer management, and urban runoff controls are essential.

ii. Implementation of Erosion Control Measures

Subbasins with high sediment yields should adopt soil conservation techniques, such as reforestation, terracing, cover cropping, and the construction of check dams, to reduce erosion and sediment transport.

iii. Establishment of Riparian Buffer Zones

Protecting and restoring natural vegetation along riverbanks, especially in high-risk subbasins, would help filter pollutants before they reach the river and stabilize riverbanks against erosion.

iv. Strengthening of Regulatory Policies

Strict enforcement of land use and waste management regulations is needed to control point and non-point source pollution within the watershed.

v. Promotion of Sustainable Agriculture

Farmers within the watershed should be encouraged to adopt nutrient management plans, use organic fertilizers, and apply precision agriculture techniques to minimize fertilizer runoff into nearby waterways.

vi. Continuous Monitoring and Evaluation

A watershed-wide water quality monitoring program should be established to track changes over time, identify emerging pollution sources, and evaluate the effectiveness of management strategies.

vii. Community Engagement and Education

Raising awareness among local communities about the impact of human activities on water quality and involving them in watershed management initiatives will enhance the sustainability of interventions.

viii. Further Research

Additional studies are recommended to investigate seasonal variations in water quality, groundwater-surface water interactions, and the specific contributions of different land use types to pollutant loads.

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