Pan Africa Science Journal
ISSN 2709-1473 | Open Access

RESEARCH ARTICLE: Environmental Ecology, Technology & Engineering
Volume 02 – Issue 03

Assessment of Chemosit River pollution with urbanization of Chemosit Centre, Kericho County, Kenya

Cherotich Langat Emily[1], Nyabaro Obed Mainya[1], Rayori Douglas Mosoti[2*], Kenanda Okemwa Evans[3]

[1] Department of chemistry, School of Pure and Applied Sciences, Kisii University, P.O. Box 408-40200, Kisii, Kenya.

[2] Department of Biological Sciences, School of Pure and Applied Sciences, Kisii University, P.O. Box 408-40200, Kisii, Kenya.

[3] Department of Research and Extension, Kisii University, P.O. Box 408-40200, Kisii, Kenya.

* **Correspondence:** Rayori Douglas Mosoti, drayori @kisiiuniversity.ac.ke

Received: 16th April 2023; Accepted: 16th June 2023; Published: 7th July, 2023

DOI: https://doi.org/10.47787/pasj.v3i02.19

Abstract: Water that is free of contaminants is necessary for life. River Chemosit passes through Chemosit Centre. The centre population is increasing due to numbers of learning institutions, medical facilities, businesses, industries and social facilities. This population has put pressure on the available clean water resources and waste management facilities. Inadequate waste management has led to environmental pollution including river Chemosit. The river pollution is negatively impacting the water quality presenting threats to the public's health and aquatic ecosystem. The study assessed the contribution of Chemosit Centre to pollution of river Chemosit. The study was carried out from August, 2021 to January, 2022. Water samples were collected and analysed for physico-chemical parameters. pH, temperature, Electrical conductivity, DO, and TDS measured *in situ* using calibrated portable professional series (YSI) multi-parameter meter model 35C, and UV-VIS spectrophotometer for sulphates, phosphates, and nitrates. The data was analysed using the statistical package SPSS, version 22. The software was used for computing descriptive statistics, ANOVA, and correlation coefficients. Spatially, the mean values for parameters were 7.0 ± 0.05 (pH), 24.15 °C ± 0.18 (temperature), 1187.94 μScm^{-1} ± 30.84 (electrical conductivity), 8.99 mgL^{-1} ± 0.06 (DO), 1460.06 mgL^{-1} ± 69.14 (TDS), 0.08 mgL^{-1} ± 0.005 (sulphates), 0.40 mgL^{-1} ± 0.01 (phosphates), and 1.6 mgL^{-1} ± 0.09 (nitrates). Seasonally, the means of pH, temperature, EC, and TDS, sulphates, and phosphates were significantly different between the two seasons except for DO, and nitrates. The means for pH, EC, sulphates and nitrates were within the WHO guidelines for domestic water use. The Correlation coefficient analysis for physico-chemical parameters indicates strong positive and negative relationship. In conclusion, river Chemosit is receiving pollutants from diffuse sources in addition from Chemosit Centre. The sources include effluent discharge from domestic and industrial sources and other human activities in the riparian zones along the river path. Therefore, preventing further pollution and complying with the NEMA and WHO standards for water usage, there is need for water quality monitoring.

Keywords: Chemosit Centre, River Chemosit, Water quality, Physico-chemical parameters, NEMA and WHO standards

1. INTRODUCTION

Water pollution has become a major environmental increasing concern to man leaving him with little access to clean and safe water for drinking, domestic, agricultural and industrial applications. In the low-income countries, majority of the people do not have access to safe drinking water and lack proper sanitation facilities. Thus, United Nations Sustainable Development Goals, specifically SDG 6 aim at ensuring sustainable management of water and sanitation thus improving water quality by reducing pollution through the discharge of partially or untreated wastewater. However, most water resources are still being contaminated with effluents released from domestic, industrial and other man-made activities which has resulted to degradation of aquatic ecosystems, outbreak of food and water-borne diseases, and environmental pollution [1, 2, 3, 4, 5]. Therefore, fresh water resources are diminishing and becoming costly due to increasing demand for diverse uses by man as a result of population increase in the world. As a result, there is need for sustainable use and management of the available freshwater resources. Moreover, wastewater needs to be treated to provide a reliable alternative source of water to be used for domestic purposes, agricultural uses, industrial operations in the advent of the ever-growing demand for clean water [6, 7].

In developing countries, rivers, streams, boreholes and wells serve as the main source of water. They are prone to contamination by inorganic, organic and biological pollutants from point and non-point sources [8, 9, 10]. Industries have been associated with discharge of effluents rich with heavy metals. Heavy metals are of great concerns due to their nature of toxicity, and persistence in the environment [11, 12, 13]. In Kenya, the National Environment Management Authority (NEMA) and Kenya Bureau of Standards (KEBS) are the national organizations mandated by law to provide guidelines on water quality requirements and World health organization (WHO) also do provides water quality standards [14, 15]. River Chemosit provide water source for domestic, agricultural and industrial uses to the Chemosit centre residents. The current pattern of industrial activities alters the natural flow of materials and introduces novel chemicals into the environment posing health hazards. Therefore, there is need to ascertain the water quality of the river for sustainable use and management.

2. MATERIALS AND METHODS

2.1 Study area

The study was carried out along Chemosit river in south west Mau complex forest in Kericho County and covers an area of 1023km^2. It lies at 0.14^0-0.78^0 south. Chemosit river flows through Kimulot, Itare and Nyakach before entering Lake Victoria. The river provides several benefits to local community that include source of water for domestic, industrial and agricultural uses. It is also a source of livelihood as majority of the population along the river relies on domestic activities (car wash business, and water vending) as their main source of income.

Chemosit river was chosen for this study as it passes through Chemosit centre. The three sampling stations were strategically selected so as to enable us determine the role of the centre in the river water pollution. The sampling stations were; Upstream (at Kipkerieny sampling station) Middle stream (that's at Chemosit shopping Centre sampling station), then Downstream (at Kabitungu sampling station) (Figure 1). The distance between the sampling stations were three kilometres apart. The upstream station was from part of the river with minimal human activities and with better forest cover thus acted as the control station. The middle station was within the town and acted as experimental area. In this location, there was automobile washing, discharge point of effluent from domestic and industrial sources among other activities. The downstream station was after the town. In this location, there were minimal human activities and it also acted as experimental station and assessment of the river self-purification capacity of the pollutants.

Pan Africa Science Journal
ISSN 2709-1473 | Open Access

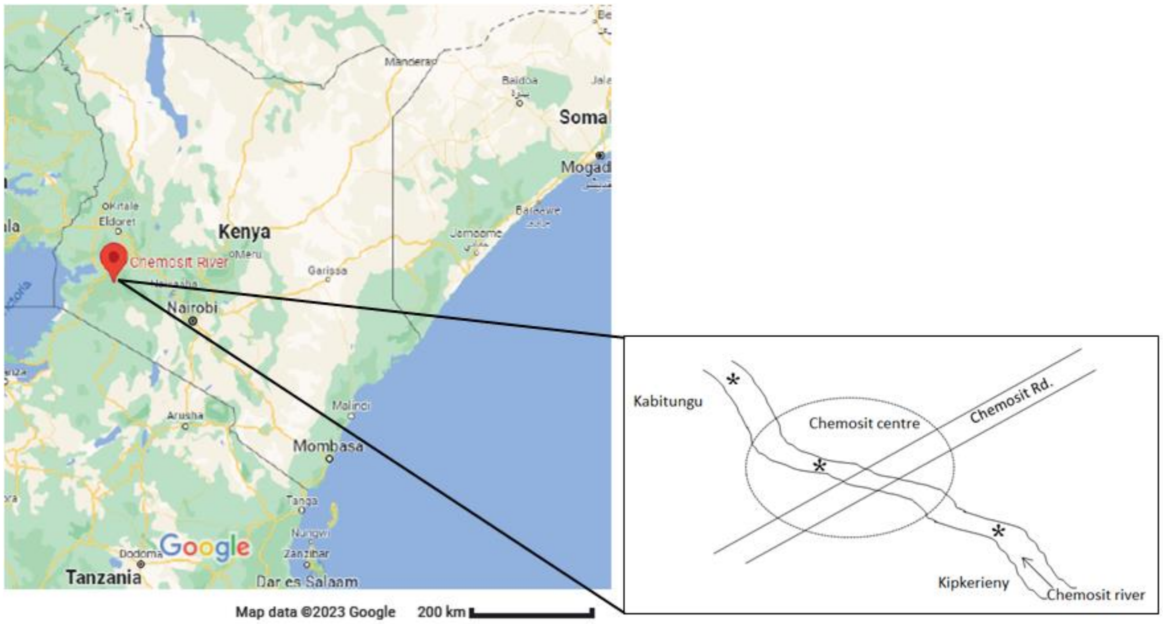

Figure 1: Location and the sampling points (*) along Chemosit river in Kericho county, Kenya

2.2 Sampling

Samples were collected once every month in the period of August, 2021 up to January, 2022. The wet season sampling was done during the month of August to October, while the dry season was from November to January. Sampling was carried out during morning hours following the standard methods for examination of water and wastewater. During sampling, the containers used were cleaned by soaking in 10% HNO_3 and rinsed with distilled water. At each sampling point, 500 ml of water was collected in triplicate. The water samples were collected in sterile containers dully labelled with place of collection and stored at ambient temperatures then transported to the laboratory for analysis.

2.2.1 *In situ* measurements

pH, Temperature ($^{\circ}$C), electrical conductivity (μScm^{-1}), TDS (mgL^{-1}), and DO (mgL^{-1}) were measured *in situ* using calibrated portable professional series (YSI) multi-parameter meter model 35C. At each level of measurement, the probes were rinsed thoroughly using deionized water before and after each reading lowered to 1.25 inch into the sample and stabilized readings were taken. The readings were taken in triplicate.

2.2.2 Chemical parameters

2.2.2.1 Sulphate

Sulfaver 4 turbidimetric method was used. A clean sample cell was filled with 10ml of the sample followed by contents of one sulfaver 4 reagent powder pillows and swirled to mix. The blank was prepared by filling one sample cell with 10ml of distilled water and contents in one sulfaver 4 reagent pillow; this was used to zero spectrophotometer. The samples were placed into the cell holder and the results were read in mgL^{-1}.

2.2.2.2 Phosphate

Amino acid method was used. Solutions of 2, 4, 6 and 8 mgL^{-1} were prepared by appropriate dilution of 10 mgL^{-1} of phosphate standard solution. These solutions together with molybdate and amino acid reagents were used to calibrate the UV-VIS spectrophotometer. A 25ml mixing cylinder was filled with 25ml of the sample followed by 1.00ml of molybdate reagent using 1.00ml calibrated dropper. 1.00ml of amino acid reagent solution was added and inverted several times to mix. A spectrophotometer with wavelength 530nm was allowed to run for 10 minutes after which it was zeroed using the blank. The prepared sample was then placed in the sample cell holder and the results were read in mgL^{-1}.

2.2.2.3 Nitrate

The method that was used it based on the complexation between 4-phenylpyryliumperchlorate (ppp) and nitrate and then extraction of the resulted complex from aqueous solution by microcrystalline naphthalene. The solid mass consisting of the nitrate complex and naphthalene was then dissolved in dimethyl formamide (DMF) and absorption of the resulted solution was obtained at 328nm.

2.3 Data analysis

Microsoft Excel version 2010 was used to organize the physico-chemical data from the different sampling stations. Spatial and temporal differences in the physico-chemical parameters were determined by Analysis of Variance (ANOVA) at a pre-determined *alpha* value of 0.05 to test for significant differences. Where the variations in means were significant, *post hoc* analysis was done using the Tukey pairwise comparisons under SPSS version 22 to establish where the differences existed between the sampling stations and months. For seasonal variations, independent sample *t-test* was performed to determine variation in the mean values of the physico-chemical parameters between the wet and dry seasons. The significance differences were determined at $p < 0.05$.

3. RESULTS

3.1 Spatial variations of the physico-chemical parameters

Table 1 is a summary of the mean and standard error (± S.E) and ANOVA comparisons of the measured parameters of the different sampling stations along river Chemosit in Kericho County during the study period.

For temperature, the mean value recorded was 24.15 °C ± 0.18 with a minimum value of 22 °C and a maximum value of 26 °C. A single-factor ANOVA indicated there was no significant difference in temperature between the sampling stations ($p > 0.05$). The recorded mean DO for this study was 8.99 mgL^{-1} ± 0.06 with a minimum value of 8.1 mgL^{-1} and a maximum value of 9.9 mgL^{-1}. The least amount of DO was recorded at Kipkerieny (8.922 ± 0.12) station. One-way ANOVA showed that dissolved oxygen concentrations were not statistically significant between the sampling stations ($p > 0.05$).

The mean (± SE) pH value recorded was 7.0 ± 0.05 and the values ranged was from 6.1 to 7.85 and the Kabitungu recorded pH value was lower compared with the mean pH of the Kipkerieny. One-way ANOVA test showed that pH was not statistically significant ($p > 0.05$) among the sampling stations. The measured pH values for the three sampling stations were within the NEMA and World Health Organization (WHO) standards for both irrigation and domestic uses.

Table 1: Mean (± SE) spatial variations in the measured physico-chemical parameters along river Chemosit in Kericho County, Kenya. Means within a row followed by different letters (a, b, c) are significantly different ($p < 0.05$) with respect to the measured parameter and stations.

Parameter	**Sampling station**			**NEMA standards**	**WHO standards**
	Upstream (Kipkerieny)	**Middle (Chemosit Centre)**	**Downstream (Kabitungu)**		
pH	7.1133 ± 0.04^{a}	6.9494 ± 0.11^{a}	6.915 ± 0.08^{a}	6.5 – 8.5	6.5 – 8.5
Temperature (°C)	24.133 ± 0.27^{a}	24.006 ± 0.37^{a}	24.306 ± 0.29^{a}	-	15
DO (mgL^{-1})	8.922 ± 0.12^{a}	9.006 ± 0.10^{a}	9.039 ± 0.12^{a}	-	-
EC (mgL^{-1})	1023.89 ± 18.83^{b}	1380.17 ± 56.24^{a}	1159.78 ± 39.69^{b}	1200	1500
TDS (mgL^{-1})	1244.33 ± 153.12^{b}	1760.39 ± 46.90^{a}	1375.44 ± 102.95^{b}	-	1000
Sulphates (mgL^{-1})	0.0709 ± 0.01^{a}	0.0696 ± 0.01^{a}	0.0942 ± 0.01^{a}	-	400
Phosphates (mgL^{-1})	0.3986 ± 0.02^{a}	0.3818 ± 0.03^{a}	0.4179 ± 0.03^{a}	-	0.5
Nitrates (mgL^{-1})	2.2828 ± 0.12^{a}	0.9301 ± 0.06^{c}	1.5889 ± 0.05^{b}	10	45

Where: - denotes non-existence of a NEMA and WHO standard for the concentration levels of the corresponding parameter.

The mean (± SE) conductivity value recorded was 1187.94 µScm^{-1} ± 30.84 and the recorded values ranged between 900 µScm^{-1} and 1630 µScm^{-1} with the Chemosit Centre sampling station recording the highest mean value of 1380.17 µScm^{-1} ± 56.24. Single-factor ANOVA showed that conductivity was statistically significant between the sampling stations ($p < 0.05$). *Post hoc* Tukey Pairwise comparisons revealed that the Chemosit Centre station mean conductivity was significantly higher compared with the mean conductivity of Kipkerieny station but the latter station did not differ significantly with Kabitungu. Although the maximum value recorded for electrical conductivity exceeded the WHO standards, the measured averages for the three sampling stations were below the WHO standards for domestic water use.

The recorded mean TDS was 1460.06 mgL^{-1} ± 69.14 with a minimum value of 517 mgL^{-1} and a maximum value of 2010 mgL^{-1}. The least amount of TDS was recorded at Kipkerieny (1244.33 ± 153.12) station. One-way ANOVA showed that TDS concentrations were statistically significant between the sampling stations ($p < 0.05$). *Post hoc* Tukey Pairwise comparisons revealed that the Chemosit Centre station mean TDS was significantly higher compared with the mean conductivity of Kipkerieny station which was the least but the latter station did not differ significantly with Kabitungu. In terms of compliance, the TDS mean values for the three sampling points were below the WHO guidelines for domestic water use.

The mean (± SE) level of sulphate concentration that was recorded was 0.08 mgL^{-1} ± 0.005 with minimum and maximum values of 0.01 mgL^{-1} and 0.16 mgL^{-1} with Chemosit Centre recording the least value of 0.0696 mgL^{-1} ± 0.01. A single factor ANOVA showed that the mean sulphate values were not significantly different among the sampled stations ($p > 0.05$). On the other hand, the mean (± SE) value of nitrates concentration recorded was 1.6 mgL^{-1} ± 0.09 with a minimum value of 0.52 mgL^{-1} and a maximum value of

2.93 mgL^{-1}. A single factor ANOVA showed that the mean nitrates values were significantly different among the sampled stations ($p < 0.05$). *Post hoc* Tukey Pairwise comparisons revealed that the Kipkerieny station mean nitrates was significantly higher compared with Chemosit Centre which recorded the least nitrate concentrations. For phosphates, the mean value recorded was 0.40 mgL^{-1} ± 0.01 with minimum and maximum mean values of 0.15 mgL^{-1} and 0.56 mgL^{-1}. However, One-way ANOVA showed that phosphate was not significant among the sampled stations ($p > 0.05$).

3.2 Temporal variations

3.2.1 Temporal variations of the physico-chemical parameters

Table 2 shows the summary of the mean and standard error (±S.E) and ANOVA comparisons of the measured parameters of the different sampling months along river Chemosit in Kericho County during the study period.

Table 2: Mean (± SE) Temporal variations in the measured physico-chemical parameters along river Chemosit in Kericho County, Kenya. Means within a row followed by different letters (a, b, c, d) are significantly different (p < 0.05) with respect to the measured parameter and months.

Parameter	Sampling months					
	August,2021	**September, 2021**	**October, 2021**	**November, 2021**	**December, 2021**	**January, 2022**
pH	6.53 ± 0.11^{b}	6.93 ± 0.07^{a}	6.95 ± 0.09^{a}	7.29 ± 0.11^{a}	7.15 ± 0.06^{a}	7.10 ± 0.13^{a}
Temperature (°C)	25.59 ± 0.112^{a}	$25.41 \pm 0.164^{a,b}$	24.86 ± 0.159^{b}	23.37 ± 0.269^{c}	$23.17 \pm 0.162^{c,d}$	22.50 ± 0.100^{d}
DO (mgL^{-1})	$9.06 \pm 0.080^{a,b}$	$9.18 \pm 0.180^{a,b}$	8.67 ± 0.190^{b}	$8.91 \pm 0.116^{a,b}$	$8.78 \pm 0.146^{a,b}$	9.34 ± 0.114^{a}
EC (μScm^{-1})	$1282.33 \pm 93.496^{a,b}$	$1280.78 \pm 86.185^{a,b}$	1370.22 ± 76.100^{a}	1015.44 ± 27.390^{b}	1053.33 ± 32.867^{b}	$1125.56 \pm 34.686^{a,b}$
TDS (mgL^{-1})	1032.89 ± 157.400^{b}	1057.56 ± 131.060^{b}	1053.00 ± 136.503^{b}	1879.22 ± 22.993^{a}	1874.89 ± 25.411^{a}	1862.78 ± 27.171^{a}
Sulphates (mgL^{-1})	0.09 ± 0.011^{a}	0.08 ± 0.019^{a}	0.08 ± 0.009^{a}	0.09 ± 0.007^{a}	0.09 ± 0.012^{a}	0.05 ± 0.010^{a}
Phosphates (mgL^{-1})	0.36 ± 0.051^{a}	0.39 ± 0.034^{a}	0.45 ± 0.021^{a}	0.38 ± 0.050^{a}	0.44 ± 0.028^{a}	0.37 ± 0.010^{a}
Nitrates (mgL^{-1})	1.83 ± 0.227^{a}	1.85 ± 0.208^{a}	1.86 ± 0.245^{a}	1.39 ± 0.225^{a}	1.45 ± 0.207^{a}	1.21 ± 0.135^{a}

Temporally, the mean pH value recorded was 6.99 ± 0.05 with a minimum value of 6.1 and a maximum value of 7.85 with the month of November recorded the highest mean (± SE) pH of 7.29 ± 0.11, followed by the month of December which recorded a mean of 7.15 ± 0.06 while the month of August had the lowest mean of 6.53 ± 0.11. The results obtained indicate a steady increase in the mean pH from August to November then a decline in the month of December to January. One way ANOVA showed that pH was significantly different between the sampling months ($p < 0.05$). *Post hoc* Tukey Pairwise Comparisons revealed that the mean pH of August (6.53 ± 0.11) was significantly lower compared with the other months which in turn they did not differ significantly between each other (Table 2).

For temperature, the mean (± SE) value recorded was 24.15 ˚C ± 0.18 with a minimum value of 22 ˚C and a maximum value of 26 ˚C with the month of August recorded the highest mean temperature of 25.59 ˚C ± 0.11 while the month of January had the lowest mean of 22.50 ˚C ± 0.100. One way ANOVA showed that temperature was significantly different between the sampling months ($p < 0.05$). *Post hoc* Tukey Pairwise Comparisons revealed four groups of months which their mean temperatures did not differ significantly from each other (Table 2).

The recorded mean DO was 8.99 mgL^{-1} ± 0.06 with a minimum value of 8.1 mgL^{-1} and a maximum value of 9.9 mgL^{-1}. The least amount of DO was recorded during the month of October (8.67 ± 0.19). One-way ANOVA showed that dissolved oxygen concentrations were statistically significant between the sampling months ($p < 0.05$). *Post hoc* Tukey Pairwise Comparisons revealed two groups of months which their mean temperatures did not differ significantly from each other. The first group comprises the months of August to December while the second group being the month of September to January (Table 2).

The mean (± SE) conductivity value recorded was 1187.94 μScm^{-1} ± 30.84 and the recorded values ranged between 900 μScm^{-1} and 1630 μScm^{-1} with the month of October recording the highest mean value of 1370.22 μScm^{-1} ± 76.1. Single-factor ANOVA showed that conductivity was statistically significant between the sampling stations ($p < 0.05$). *Post hoc* Tukey Pairwise Comparisons revealed two groups of months which their mean electrical conductivity did not differ significantly from each other (Table 2).

The recorded mean TDS was 1460.06 mgL^{-1} ± 69.14 with a minimum value of 517 mgL^{-1} and a maximum value of 2010 mgL^{-1}. The least amount of TDS was recorded during the month of August (1032.89 ± 157.4) followed by the month of September. One-way ANOVA showed that TDS concentrations were statistically significant between the sampling stations ($p < 0.05$). *Post hoc* Tukey Pairwise Comparisons revealed two groups of months which their mean TDS did not differ significantly from each other. The first group comprises the months of August to October while the second group being the month of November to January (Table 2).

The mean (± SE) level of sulphate concentration that was recorded was 0.08 mgL^{-1} ± 0.005 with minimum and maximum values of 0.01 mgL^{-1} and 0.16 mgL^{-1} with the month of January recording the least value of 0.05 mgL^{-1} ± 0.01. A single factor ANOVA showed that the mean sulphate values were not significantly different among the sampled months ($p > 0.05$). On the other hand, the mean (± SE) value of nitrates concentration recorded was 1.6 mgL^{-1} ± 0.09 with a minimum value of 0.52 mgL^{-1} and a maximum value of 2.93 mgL^{-1}. A single factor ANOVA showed that the mean nitrates values were not significantly different among the sampled months ($p > 0.05$). For phosphates, the mean value recorded was 0.40 mgL^{-1} ± 0.01 with minimum and maximum mean values of 0.15 mgL^{-1} and 0.56 mgL^{-1}. One-way ANOVA showed that phosphate was not significant among the sampled months ($p > 0.05$) (Table 2). With regard to the WHO guidelines for domestic water use, the amounts of nitrates, sulphates and phosphates in the water samples from the three sampling stations all were within the guidelines.

3.2.2 Seasonal variations

The wet season was comprised of August to October, while the dry season was comprised of November to January. The mean (± SE) of seasonal variations of the physico-chemical parameters along river Chemosit in Kericho County during the study period are summarized in Table 3. The means of physico-chemical parameters measured were compared to reveal whether there was a significant difference between the dry and wet seasons. The calculated independent sample *t*-test showed that the means of pH, temperature, EC, and TDS values were significantly different between the two seasons except for DO ($t_{(52)} = -0.344$; $p = 0.73$). The means of sulphates and phosphates values were significantly different between the two seasons except for nitrates ($t_{(52)} = 0.13$; $p = 0.9$). The measured mean values during wet and dry seasons for the pH, electrical conductivity, sulphates, and nitrates were within the WHO guidelines for domestic water use.

Table 3: Mean (± SE) seasonal variations in the measured physico-chemical parameters along river Chemosit in Kericho County, Kenya

Parameter	Season	Mean ± SE	*t*- value
pH	Wet	6.8 ± 0.06	$t_{(52)} = -4.424$; $p = 0.0$
	Dry	7.2 ± 0.06	
Temperature (°C)	Wet	25.3 ± 0.1	$t_{(52)} = 13.89$; $p = 0.0$
	Dry	23.0 ± 0.1	
EC (μScm^{-1})	Wet	1311.1 ± 48.2	$t_{(52)} = 4.731$; $p = 0.0$
	Dry	1064.6 ± 19.8	
TDS (mgL^{-1})	Wet	1047.8 ± 78.9	$t_{(52)} = -10.29$; $p = 0.0$
	Dry	1872.3 ± 14.1	
DO (mgL^{-1})	Wet	9.0 ± 0.1	$t_{(52)} = -0.344$; $p = 0.73$
	Dry	9.0 ± 0.1	
Sulphates (mgL^{-1})	Wet	0.08 ± 0.01	$t_{(46)} = 0.72$; $p = 0.48$
	Dry	0.08 ± 0.01	
Phosphates (mgL^{-1})	Wet	0.40 ± 0.02	$t_{(52)} = 0.13$; $p = 0.9$
	Dry	0.40 ± 0.02	
			$t_{(52)} = 2.983$; $p = 0.004$
Nitrates (mgL^{-1})	Wet	1.85 ± 0.13	

3.3 Correlation between physico-chemical parameters

By carrying out Pearson's correlation analysis we determined the linear relationship between the different 9 parameters along river Chemosit in Kericho County. Table 4 shows the obtained linear correlation matrices at 5% level of significance and only those parameters with Pearson coefficients equal or higher than 0.50 ($r = 0.50$) were significant. There was a significant very strong negative correlation between temperature and TDS ($r_{(54)} = -.712$, $p < 0$), and TDS with nitrate ($r_{(54)} = -.715$, $p < 0$). There was a significant strong positive correlation between temperature and EC ($r_{(54)} = .449$, $p = .001$). In contrast, there was a significant strong negative correlation between pH with temperature ($r_{(54)} = -.47$, $p < 0$), and EC ($r_{(54)} = -.521$, $p < 0$), and EC with nitrate ($r_{(54)} = -.413$, $p = .002$). Lastly, there was a significant moderate positive correlation between temperature and nitrate ($r_{(54)} = .37$, $p = .006$).

Pan Africa Science Journal
ISSN 2709-1473 | Open Access

Table 4: Pearson Correlation coefficients (*r*) between the physico-chemical parameters along river Chemosit in Kericho County, Kenya

	pH	**Temperature (°C)**	**EC (μScm^{-1})**	**TDS (mgL^{-1})**	**DO (mgL^{-1})**	**Sulphates (mgL^{-1})**	**Phosphates (mgL^{-1})**	**Nitrates (mgL^{-1})**
pH	1							
Temperature (°C)	-0.470**	1						
EC (μScm^{-1})	-0.521**	0.449**	1					
TDS (mgL^{-1})	0.254	-.712**	-0.017	1				
DO (mgL^{-1})	-0.182	-0.075	-0.033	0.041	1			
Sulphates (mg/L)	0.042	0.22	0.062	-0.022	-0.2	1		
Phosphates (mgL^{-1})	0.01	-0.052	0.023	-0.064	0.016	-0.067	1	
Nitrates (mgL^{-1})	-0.005	.370**	-.413**	-.715**	-0.123	-0.086	0.089	1

**** Correlation is significant at the 0.01 level (2-tailed).**

4. DISCUSSIONS

Low pH values at Chemosit shopping Centre could be attributed to detergents (used in washing automobiles, washing clothes), bedrock and soil composition of the area, decomposing organic materials from plants and animal wastes, and effluents from the shops, and the lower pH values could be attributed to effluents containing acid from the car wash. The study conducted by Gupta [16], they found pH range between 7.7 and 8.48 which was within the WHO standards and observed that it was due to annual variation in free carbon (IV) oxide. Therefore, the pH of water rises and the water becomes alkaline. The pH also decreases with increase in rainfall due to dilution during rainy seasons [17].

Temperature mean value recorded was 24.15 ˚C ± 0.18 and it was above the WHO set standards of 15 ˚C. A study carried out by Oseji [18] recorded high temperature values ranging between 22 ˚C and 30 ˚C citing low vegetation cover and degree of exposure to solar heat to be a major contributor. This also differed with the values recorded in Chemosit river as the area is covered with vegetation. Similar studies done in India by Banjara [19] in river Kharun, they obtained 24 ˚C - 32 ˚C and attributed this high temperature values to low level and clear atmosphere since it was during summer. These values differed with the values obtained in river Chemosit as Banjara`s study was done during summer period. Jannat [9] in a similar study recorded 23.3 ˚C - 30.8 ˚C and they associated with decreasing water level and increasing number of insoluble pollutants during summer which made water hotter as well as the discharge of pollutants could have increased the temperature of water in river Mokeshbeel in Bangladesh.

The DO mean concentration ranges were 9.36 mgL^{-1} and 8.67 mgL^{-1} during wet and dry season respectively and were within the acceptable values of WHO standards. The DO concentrations were found to be higher during the wet season as compared to dry season. This could be due to increased water volume during wet season hence higher aeration. Studies by Olubanjo and Adeleke [10] obtained mean values of 0.35 mgL^{-1} and observed that the values are low and attributed them to increase in organic matter which results in high biological and chemical demands in river Osse, Kogi state in Nigeria.

The high electrical conductivity recorded at Chemosit shopping Centre was attributed to surface runoff, domestic and industrial effluent discharge into the river which increases the concentration of ions. This is findings are similar to Khalik [20]. Gershom [21] observed that the EC values in the rivers of; Chesogon, and Murunyi in Sigor division West Pokot County were high during dry season (221.83 μScm^{-1}) compared to wet season (163 μScm^{-1} - 194 μScm^{-1}) citing high temperature and turbidity to be major causes. High temperature increases the ionization of compounds in water leading to higher EC. During dry season there is less precipitation and movement of water. The ions in rivers thus have a higher concentration enabling to be detected leading to higher EC values during the dry season. It was also attributed to low volume of water in the region resulting from its arid nature, more influx of agrochemical and detergents from the local residents. These values differed with the values of Chemosit river because it passes through nutrient-rich agricultural lands of tea plantations.

The high levels of TDS in Chemosit centre could be attributed to domestic effluents from the shops and washing of vehicles and other automobiles. Jannat [9] in his study, they recorded TDS values in river Mokeshbeel ranging from 686 mgL^{-1} to 952 mgL^{-1} which surpassed the maximum allowable limit of 500 mgL^{-1} of WHO but within the allowable limit of Bangladesh Environmental quality standard 1000 mgL^{-1}. They also attributed the high levels of TDS to anthropogenic activities such as washing of motorcycles, clothes, bathing and runoffs from the surrounding farmlands. Seasonally, the values of TDS in rivers are high during the wet season compared to the dry season. This is due to the increased discharge of materials rich with organic and inorganic substances into the rivers during wet seasons as a result of erosions and flash floods. Water movement during wet seasons is also quite higher leading to erosion of the river walls and thus adding more particulates [22].

The elevated levels sulphates, phosphates and nitrates in river Chemosit during the sampling period can be associated with human activities, effluent discharge from domestic and industrial sources within the centre. Seasonally, the calculated independent sample *t*-test showed that the means of sulphates and phosphates were significantly different between the two seasons except for nitrates ($t_{(52)} = 0.13$; $p = 0.9$). In terms of compliance, sulphates and nitrates were within the WHO standards for domestic water use. The variation of their concentration in seasonality can be associated with the presence of fertilizer, and organic matter in the river at that particular time. Previous studies have shown that effluent discharge into rivers leads to elevated levels in nutrient concentrations resulting to eutrophication and negatively impacting the aquatic ecosystem. Nevertheless, phosphates and nitrates are essential for growth of organisms. Elevated levels of phosphate and nitrate concentrations in water can be used as indicators of the presence of pollution [3, 23, 24, 25].

5. CONCLUSIONS

In conclusion, the levels of the physico-chemical parameters along river Chemosit varied spatially and seasonally. Moreover, pollutants loading into the river emanates from the surrounding due to human activities. This is evident from the concentration variance between upstream and downstream. In addition, effluent discharge from domestic and industrial sources led to increase of TDS, sulphates and phosphates, indicating Chemosit centre is acting as their point-source into the river. Therefore, an effective management of possible soil erosion from land use change of urban development, agricultural activities and domestic waste in the vicinity of river Chemosit should be planned and enforced. Moreover, good agricultural scheme practices like rain shelter cultivation, limitation of fertilizer and pesticide usage should be considered in this area. Therefore, main purposes of freshwater ecosystem such as drinking, irrigation and other domestic essential can be continuously contributed by river Chemosit, thus, need for continuous water quality monitoring towards attaining the NEMA and WHO standards for water usage.

Acknowledgements: The authors acknowledge National Commission for Science Technology and Innovation (NACOSTI) and Kericho County for the permissions to carry out this research. We sincerely thank Kenya Plant Health Inspectorate services (KEPHIS) for the laboratory facilities.

Author Contributions: Conceptualization, Methodology, Validation, and formal analysis C.E., N.O; data curation, R.D.; writing original draft preparation, R.D., C.E., K.O.E, and N.O.

Conflict of Interests: The authors declare no conflict of interest.

REFERENCES

1. Karimi, R. D. (2015). The Bacterial Flora of Tilapia (*Oleochromis Niloticus*) and Catfish (*Clarias Gariepinus*) From Earthen Ponds in Sagana fish farm and Masinga dam.
2. Njue, N., Koech, E., Hitimana, J. and Sirmah, P. (2016). Influence of Land Use Activities on Riparian Vegetation, Soil and Water Quality: An Indicator of Biodiversity Loss, South West Mau Forest, Kenya. Open Journal of Forestry, **6**, 373-385. doi: 10.4236/ojf.2016.65030.
3. Rayori, D., Getabu, A., Omondi, R., Orina, P., Gisacho, B., & Omondi, A. (2021). Phytoplankton diversity in Gusii wastewater treatment plant in Kisii county, Kenya. International Journal of Fisheries and Aquatic Studies, 9(3), 299–306.
4. Unesco. (2017). Wastewater the untapped resource. The United Nations World Water Development report. https://doi.org/10.1016/j.apcbee.2013.05.059.
5. Omoko Bochaberi Janes, Onyatta John, Nyabaro Obed, Kenanda Okemwa Evans (2015). Level of metal pollutants in water from Nyakomisaro stream through Kisii Town. International Journal of Science and Research (IJSR).
6. Bannerji, S. (2014). Sewage-fed fisheries under private ownership in the East Kolkata Wetlands: A Case study. International Journal of Advancements in Research and Technology, 3(6), 24–34.
7. Kumar, D.; Hiremath, A. M.; Asolekar, S. R. (2014). Integrated management of wastewater through sewage fed aquaculture for resource recovery and reuse of treated effluent: A case study. Elsevier, 10, 74–78. Retrieved from https://doi.org/10.1016/J.Apcbee.2014.10.019.
8. OS, E., & Udongwo, A. M. (2021). Physical and chemical characteristics of water from Okamini Stream, Obio/Akpor, Rivers State, Niger Delta, Nigeria. GSC Advanced Research and Reviews, 8(1), 175–182. https://doi.org/10.30574/gscarr.2021.8.1.0157
9. Jannat N., Mottalib M.A., Alam M.N. (2019). Assessment of physico-chemical properties of surface water of Mokeshbeel, Gazipur, Bangladesh. J Environ Sci Curr Res 2: 014.
10. Olubanjo, O.O., & Adeleke, E.B. (2020). Assessment of physico-chemical properties and water quality of River Osse, Kogi State. Applied Research Journal of Environmental Engineering.
11. Nyabaro, O. M., Muthoka, T. M., Mosoti, D., & Onyancha, E. (2013). Determination of the pollution levels of waste water from Nakuru Tanners, Kenya. African Journal of Education, Science and Technology, 1(3), pp 193-206. https://doi.org/https://doi.org/10.2022/ajest.v1i2.182.
12. Douglas, R., Albert, G., Reuben, O., Paul, O., Hellen, N., Boniface, G., Obed, N., Omondi, A., and Job, O. (2022). Assessment of heavy metal concentrations (Cu, Cd, Pb, and Zn) in wastewater from Gusii Treatment Plant in Kisii County, Kenya. Pan Africa Science Journal, 1(02), 122–138. https://doi.org/10.47787/pasj.v1i02.12.
13. Wasike Peter Wekesa (2015). Analysis of selected heavy metals in water from river Kuywa and adjacent wells in Bungoma Central Sub county- Kenya, Kenyatta University.
14. Water Services Regulatory Board (wasreb, 2018). Guidelines on drinking water quality and effluent monitoring.
15. World Health Organization (2017). World health organization guidelines for quality drinking water
16. Gupta N, Pandey, P and Hussain, J, (2017). Effect of physicochemical and biological parameters on the quality of river water of Narmada, Madhya Pradesh, India. Environmental Protection Agency (EPA) NOV 2019.Environmental Chemistry.2:146–160.
17. O. E. Atobatele & O. A. Ugwumba (2010). Distribution, abundance and diversity of macrozoobenthos in Aiba Reservoir, Iwo, Nigeria, African Journal of Aquatic Science, 35:3, 291-297, DOI: 10.2989/16085914.2010.543121
18. Julius Otutu Oseji, James Chucks Egbai, Emmanuel Chukwuemeka Okolie, Etebefia Chris Ese (2018). Investigation of the aquifer protective capacity and groundwater quality around some open dumpsites in Sapele Delta State, Nigeria. Applied and Environmental Soil Science, vol. 2018, Article ID 3653021. https://doi.org/10.1155/2018/3653021.
19. Bhumika Banjara, Singh, R.K. and Dr. Banjara, G.P. (2019). A study on physico chemical parameters of river,

urban and rural ponds of Raipur District", International Journal of Fisheries and Aquatic Studies, 5(6), 23–27

20. Wan Mohd Afiq Wan Mohd Khalik, Md Pauzi Abdullah, Nur Amirah Amerudin, Norfaizan Padli (2013). Physicochemical analysis on water quality status of Bertam River in Cameron Highlands, Malaysia. Journal of Mater and Environmental Science 4 (4) (2013) 488-495. Development Research, 9, (01), 24986-24989.
21. Gershom, N. A., Kirui, S., Maingi, J., & Kebira, A. (2019). Effects of seasonality on physico-chemical properties and selected ligands on Rivers in Sigor Division, West Pokot County, Kenya. Journal of Aquademia, 3(1), ep19012.
22. Kosgey, J., Koech, J., Bunyasi, S., Kipkemoi, B., Muthoka, T.M., & Nyabaro, O. (2015). Determination of heavy metals pollutants in sediments along the banks of Athi River Machakos County, Kenya. International journal of Science and Technology.
23. Were KJ, Adhiambo P. (2017). Status of phytoplankton community of Kisumu Bay, Winam Gulf, Lake Victoria, Kenya. Int. J. Eng. Sci. 6 (5):22-28.
24. Chapman, D. (1996). Water quality assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring.
25. Wang, H., Tao, W., Zhang, B., Brahima, T., Omosa, I. B., Chiramba, T. & Pradhan, M. (2013). Water and Wastewater Treatment in Africa – Current Practices and Challenges. Clean-Journal, 1029–1035. https://doi.org/10.1002/clen.201300208