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# Multivariate analysis of water quality of ‘omi-omo’ stream Ikole Ekiti, Nigeria.

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**Abstract -** The multivariate Principal Component Analysis (PCA) was used to assess the variations in the water quality of the "Omi Omo" Stream. This allowed for the identification of temporal and spatial variations in the water quality caused by contamination by analysing the similarities and differences between the sampling points. For three months, four sampling locations along the streamline provided data on the quality of the water. Temperature and other physicochemical parameters were used to analyse the samples. Turbidity, alkalinity, Electrical Conductivity (EC), Total hardness TH, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological oxygen demand (BOD), heavy metals (Cadmium - Cd, Copper - Cu, Lead - Pb, Iron - Fe, Manganese - Mn), sulphate, phosphate, nitrate, and chloride were also determined. For the months under study, PCA helped identify and extract the factors causing variations in water quality. The important factors influencing the variation in water quality for the three months of study were turbidity, TDS, alkalinity, electrical conductivity, nitrate, calcium, and chloride. The comparison of the stream’s physicochemical parameters with the World Health Organization (W.H.O) standards shows an acceptable correlation except for the turbidity and the EC which for some periods were higher than the acceptable level of the W.H.O standard. The study's findings will assist pertinent authorities in determining how to improve the declining water quality caused by pollution from various human activities.

***Keywords:*** *Contamination, Multivariate, Physicochemical, Principal Component Analysis, W.H.O., Water management, Water quality*

## 1.0 Introduction

Water is now one of the main environmental issues and is impacted by both natural and man-made disturbing factors, such as land recovery, overflows, and wastewater, with great competition for access to it increasing [1]. Surface waters are helpless against contamination because of common techniques, namely, disintegration, precipitation, weathering of crustal materials and anthropogenic exercises such as industrial, horticultural, and urban activities [2]. Due to its significance for human prosperity, surface water quality management has received increased attention in recent years. When surface water becomes polluted, it usually brings about an imbalance in the ecosystem, this, in turn, affects the beneficial interactions that are essential between living organisms and the environment [3].

Pollution causes the natural harmony in the world to be disturbed. Water quality management programmes increasingly include the identification of the factors controlling the behavioural properties of aquatic systems in addition to the assessment of the aquatic systems' quality. But in order to have accurate data about water quality, ongoing and frequent monitoring programmes are needed because hydro chemical and biological characteristics vary over time and space [4].

The Omi-Omo Stream needs to have its capacity to carry pollutants evaluated because the riparian population, particularly those who use the water for domestic and agricultural uses, depends on it. In nature, the human need for water is important and it's required in both premium quality and quantity [5].

In water quality monitoring, the concern is centred on keeping impurities within safe limits. [6] described the pollution of water as the biofouling of the aquatic environment in a way that prevents water from being used for its intended purpose. Thus, while water may contain certain pollutants, it may not be described as polluted provided it meets the intended use for which it was designated. The source of the pollution may be dispersed randomly throughout the water body or concentrated at one location. When the former is the case, it is described as a point source. When the latter is the case, it is called a non-point source [7].

Proper management usually goes hand in hand with getting quality from our natural resources and the same goes for our water resources [8]. Only within a legal framework is it possible to manage water quality, and for a while, many nations had antiquated, rudimentary water laws that limited the efficacy of water quality management [9]. Although there have been observations of water quality for over a century, the understanding that hydrologic processes have an impact on water quality has made the need for systematic management of water quality imperative. Due to this, there is now a need for a more thorough comprehension of the procedure and its application within an organised programme for managing water quality [10; 11]. For any water quality management programme to be successful, all stakeholders must be involved in the identification of discharges to receiving waters [12; 13; 14]. Similar to this, [9] claimed that better decisions about water quality management result from the integration of indigenous knowledge with scientific knowledge. Having access to current, high-quality, and trustworthy data is crucial for effectively managing the quality of the water [15; 16]. Climate change is increasing the frequency and intensity of extreme weather events that may have an impact on the safety of drinking water [17]. However, the cost and duration of on-site water quality assessments frequently act as a barrier to data availability [18; 19].

A well-thought-out and implemented water quality management programme yields results that support prompt, important management decisions that are grounded in comprehensive, reliable data [19]. Every component of the programme offers vital and relevant solutions to issues pertaining to water [18]. River discharges have been widely used as a covariate in the evaluation of water quality and in the development of water quality standards for rivers that are considered for wastewater disposal, provided that the discharge conditions are low. Nonetheless, different rivers have different constituent concentrations, stream discharges, and parameter interactions [14]. This is explained by the fact that a number of variables, such as drought or the dry season, affect the water in streams and rivers and cause variations in the quality of the water [20]. This variance is evident in the way that different loading volumes have different effects on rivers or other water bodies that receive wastewater. There might be none or very little effect at a given discharge, but the same loading volume can have a greatly degrading effect at low discharges [21]. The needs and goals of the assessment determine which parameters should be used for the water quality assessment [22]. For this investigation, among other parameters, the ones below were examined.

Temperature, pH, Alkalinity, Turbidity, Total Alkalinity, Ammonia, Phosphorus, Dissolved Oxygen, Biological Oxygen Demand, Total Suspended Solids, Total Dissolved Solids, and few Heavy metals.

The above parameters were also considered by [23] in the water quality assessment of a river in Nigeria. Characteristics of temporal variation are crucial and according to [24], the degree of the pollutant's temporal and spatial variation determines the risk associated with it.

## 2. Methods

### 2.1 Area of study

Omi-Omo Stream in 6˚15N7˚10E was the focal water body for the study. This stream has its source from the stream flows from Fesola River which is located at oke orin, Ikole local government area, and Omi Iru in Ikole, the streams then converge at Omi Omo Street and flows through Omi Omo stream. The riparian population uses the stream for domestic, ponding and irrigation purposes.

### 2.2 Collection of water samples

For three months (July to September 2021), water samples were taken once a month from four sampling locations. Grab samples were taken at various locations by carefully dipping sample containers that had already been cleaned into the water and the temperature was recorded immediately at the various sampling points.

**2.2.1 Sampling Points:** The points at which water samples were collected were labelled A to D.

**Point A**: Stream source.

**Point B**: The point of major contamination

**Point C**: 2m downstream from the point of major contamination.

**Point D**: 100m downstream from the major contamination point.

The samples collected were taken to the laboratory for analysis on the same day. Below are the method and means applied in detecting the levels of parameters considered for this research; the research applied standard laboratory procedures as described by the American Public Health Association's Standards methods for examination of water and wastewater [25].

Table 1: Techniques for calculating physicochemical parameters.

| Parameter | Method of determination |
|---|---|
| pH | HANNA Hi208 pH meter. |
| Temperature ($^{o}$C) | Thermometer |
| EC (us/cm) | DDS-307 Conductivity meter. |
| Alkalinity (mg/l) | Titration method |
| TH (mg/l) | EDTA Titration method |
| TDS (ppm) | HM TDS-3 TDS Meter |
| DO | Winkler's method |
| BOD | Winkler's method |
| TSS | Filtration method |
| Lead (ppm) | Spectronic 20 machine |
| Chloride (mg/l) | Argentometric method |
| Sulphate (mg/l) | Turbidimetric method |
| Phosphate (mg/l) | Spectronic meter |
| Nitrate (mg/l) | UV spectrophotometric method |
| Turbidity (NTU) | Labtech AVI-654 Turbidity meter. |
| Ca | EDTA Titration method |
| Cd, Mn, Fe, Cu | Buck Scientific 210VGP atomic absorption spectrophotometer (AAS). |

*Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Hardness (TH), Cadmium (Cd) (ppm), Manganese (Mn) (ppm), Iron (Fe) (ppm), Calcium (Ca) (ppm), Copper (Cu) (ppm)*

## 2.3 Statistical Analysis

Factor Analysis (FA) which is similar to Principal Component analysis, an extremely potent method was used. With the least amount of information loss and maximum preservation of the variability found in the dataset, this method lowers the dimensionality of a dataset made up of numerous interconnected variables (Equation 1).

$$F_i = a_1 x_1 j + a_2 x_2 j + \cdots + a_m x_m j$$ (1) [26]

Given that $F_i$ is the factor; a is the loading; x is the measured value of variable; i is the factor number; j is the sample number; and m is the total number of variables.

## 2.4 Principal Component Analysis (PCA)

The PCA method was used to conduct the analysis and determine the most important parameters in the assessment of water quality. In order to determine significant water quality parameters, PCA was used in this study to analyse 19 variables from four separate sampling locations during the water quality monitoring months of July, August, and September 2021. A factor's significance can be gauged by its eigenvalues, and the most significant factors are those with the highest eigenvalues. Significant eigenvalues are those that are 1.0 or higher [27]. Principal components are thus classified as "Strong," "Moderate," and "Weak," with absolute loading values of >0.75, 0.75-0.50, and 0.50-0.30, respectively [28].

## 3 Results and Discussions

### 3.1 The relationship between the variables (Correlation)

Finding the parameter correlation matrix is the first stage in the factor analysis process. It is employed to take into consideration the extent to which individual pairs of water quality variables share variability with one another. We were able to obtain the correlation matrix, which allows us to see the relationship between the parameters (Table 2 – 4).

Studies that examine the correlation between various variables are a very useful tool for advancing research and discovering new areas of knowledge. The range of uncertainty related to decision-making is decreased by the study of correlation. Most of the anions and cations have inverse relationships with pH. There is a highly significant ($p<0.01$) positive correlation between EC and TDS and SO4-, two water quality parameters. Additionally, there is a noteworthy positive correlation ($p<0.05$) with TH. This suggested that the hydrochemical properties of these parameters are comparable in the studied region. Due to their low concentrations, DO do not considerably increase conductivity. At a highly significant level, alkalinity and TH have a positive correlation ($p<0.05$). TH exhibits a highly significant ($p<0.05$) positive correlation with TDS, Ca, and sulphate, as well as a highly significant ($p<0.01$) positive correlation with sulphate. TDS has a significant positive correlation ($p<0.5$) with calcium and a significant positive correlation ($p<0.01$) with sulphate. At a highly significant level, DO and BOD have a positive correlation ($p<0.01$). At a highly significant level, manganese and lead had a negative correlation ($p<0.01$). At a highly significant level, calcium exhibits a positive correlation with both sulphate and chloride ($p<0.05$). Phosphate and iron had a highly significant negative correlation ($p<0.01$). Lead and Nitrate have a highly significant positive correlation ($p<0.01$).

Table 2: Correlation coefficients for Nineteen Physicochemical parameters for the of July

| | **pH** | **Temp.** | **EC** | **Alk.** | **TH** | **TDS** | **DO** | **BOD** | **TSS** | **Mn** | **Ca** | **Fe** | **Cu** | **Pb** | **Cl$^-$** | **SO$_4^-$** | **PO$_4^-$** | **NO$_3$** | **Turb** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1.000 | | | | | | | | | | | | | | | | | | |
| **Temp** | -.407 | 1.000 | | | | | | | | | | | | | | | | | |
| **EC** | -.593 | .360 | 1.000 | | | | | | | | | | | | | | | | |
| **Alk.** | -.218 | .149 | .912 | 1.000 | | | | | | | | | | | | | | | |
| **TH** | -.495 | .169 | **.979**$^{*}$ | **.951**$^{*}$ | 1.000 | | | | | | | | | | | | | | |
| **TDS** | -.596 | .337 | **1.000**$^{**}$ | .912 | **.983**$^{*}$ | 1.000 | | | | | | | | | | | | | |
| **DO** | -.465 | .777 | -.124 | -.448 | -.321 | -.140 | 1.000 | | | | | | | | | | | | |
| **BOD** | -.333 | .663 | -.320 | -.615 | -.503 | -.335 | **.980**$^{*}$ | 1.000 | | | | | | | | | | | |
| **TSS** | -.170 | -.827 | .047 | .062 | .200 | .074 | -.609 | -.579 | 1.000 | | | | | | | | | | |
| **Mn** | .714 | .156 | -.758 | -.611 | -.806 | -.774 | .287 | .418 | -.647 | 1.000 | | | | | | | | | |
| **Ca** | -.509 | .032 | .944 | .915 | **.987**$^{*}$ | **.952**$^{*}$ | -.397 | -.567 | .352 | -.878 | 1.000 | | | | | | | | |
| **Fe** | -.589 | .400 | -.255 | -.628 | -.400 | -.259 | .866 | .885 | -.145 | .060 | -.396 | 1.000 | | | | | | | |
| **Cu** | -.002 | -.895 | -.281 | -.255 | -.134 | -.256 | -.511 | -.419 | .944 | -.383 | .025 | -.016 | 1.000 | | | | | | |
| **Pb** | -.842 | .132 | .857 | .643 | .848 | .866 | -.053 | -.216 | .414 | **-.958**$^{*}$ | .882 | .071 | .132 | 1.000 | | | | | |
| **Cl$^-$** | -.452 | -.138 | .874 | .873 | .948 | .886 | -.515 | -.664 | .498 | -.906 | **.985**$^{*}$ | -.442 | .186 | .861 | 1.000 | | | | |
| **SO$_4^-$** | -.591 | .276 | **.996**$^{**}$ | .916 | **.991**$^{**}$ | **.998**$^{**}$ | -.190 | -.381 | .136 | -.807 | **.969**$^{*}$ | -.281 | -.195 | .881 | .914 | 1.000 | | | |
| **PO$_4^-$** | .550 | -.195 | .341 | .695 | .451 | .340 | -.743 | -.787 | -.047 | -.010 | .414 | **-.977**$^{*}$ | -.195 | -.064 | .424 | .349 | 1.000 | | |
| **NO$_3$** | -.836 | .250 | .912 | .701 | .886 | .918 | -.003 | -.181 | .289 | -.916 | .897 | .050 | -.006 | **.990**$^{**}$ | .855 | .925 | -.013 | 1.000 | |
| **Turb** | -.831 | .638 | .893 | .641 | .790 | .887 | .324 | .131 | -.139 | -.659 | .738 | .192 | -.407 | .844 | .629 | .866 | -.072 | .905 | 1.000 |

Table 3: Correlation coefficients for Nineteen Physicochemical parameters for the of August

| | pH | Temp | EC | Alk. | TH | TDS | DO | BOD | TSS | Mn | Ca | Fe | Cu | Pb | $Cl^-$ | $SO_4^-$ | $PO_4^-$ | $NO_3$ | Turb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1.000 | | | | | | | | | | | | | | | | | | |
| **Temp** | .367 | 1.000 | | | | | | | | | | | | | | | | | |
| **EC** | -.701 | -.045 | 1.000 | | | | | | | | | | | | | | | | |
| **Alk.** | -.735 | .067 | **.985**$^{*}$ | 1.000 | | | | | | | | | | | | | | | |
| **TH** | -.410 | -.853 | -.231 | -.265 | 1.000 | | | | | | | | | | | | | | |
| **TDS** | -.712 | -.029 | **1.000**$^{**}$ | **.990**$^{*}$ | -.232 | 1.000 | | | | | | | | | | | | | |
| **DO** | -.293 | -.915 | .278 | .131 | .571 | .255 | 1.000 | | | | | | | | | | | | |
| **BOD** | .241 | -.483 | .198 | .030 | -.019 | .167 | .764 | 1.000 | | | | | | | | | | | |
| **TSS** | -.464 | .621 | .351 | .507 | -.325 | .379 | -.702 | -.821 | 1.000 | | | | | | | | | | |
| **Mn** | .738 | .846 | -.193 | -.163 | -.908 | -.194 | -.644 | .002 | .116 | 1.000 | | | | | | | | | |
| **Ca** | -.310 | -.681 | -.415 | -.411 | **.960**$^{*}$ | -.410 | .327 | -.248 | -.193 | -.803 | 1.000 | | | | | | | | |
| **Fe** | -.503 | .088 | **.969**$^{*}$ | .942 | -.431 | **.965**$^{*}$ | .219 | .309 | .280 | .030 | -.616 | 1.000 | | | | | | | |
| **Cu** | -.585 | .528 | .492 | .634 | -.287 | .519 | -.580 | -.742 | .986$^{*}$ | .022 | -.197 | .408 | 1.000 | | | | | | |
| **Pb** | -.803 | -.787 | .257 | .242 | .869 | .260 | .585 | -.075 | -.009 | **-.994**$^{**}$ | .771 | .026 | .088 | 1.000 | | | | | |
| **$Cl^-$** | .315 | .054 | .404 | .287 | -.563 | .380 | .345 | .828 | -.438 | .448 | -.748 | .592 | -.377 | -.477 | 1.000 | | | | |
| **$SO_4^-$** | .178 | -.444 | -.802 | -.797 | .759 | -.800 | .094 | -.236 | -.344 | -.429 | .875 | -.915 | -.419 | .371 | -.682 | 1.000 | | | |
| **$PO_4^-$** | .203 | -.636 | -.731 | -.777 | .807 | -.737 | .358 | .058 | -.591 | -.489 | .850 | -.824 | -.637 | .410 | -.466 | **.955**$^{*}$ | 1.000 | | |
| **$NO_3$** | -.317 | -.685 | .573 | .427 | .221 | .549 | .914 | .844 | -.553 | -.416 | -.058 | .570 | -.409 | .379 | .627 | -.316 | -.042 | 1.000 | |
| **Turb** | -.686 | -.918 | .231 | .172 | .888 | .226 | .771 | .177 | -.258 | -.984$^{*}$ | .743 | .031 | -.151 | .965$^{*}$ | -.291 | .375 | .487 | .562 | 1.000 |

Table 4: Correlation coefficients for Nineteen Physicochemical parameters for the of September

| | **pH** | **Temp** | **EC** | **Alk.** | **TH** | **TDS** | **DO** | **BOD** | **TSS** | **Mn** | **Ca** | **Fe** | **Cu** | **Pb** | **$Cl^-$** | **$SO_4^-$** | **$PO_4^-$** | **$NO_3$** | **Turb** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 1.000 | | | | | | | | | | | | | | | | | | |
| **Temp** | .858 | 1.000 | | | | | | | | | | | | | | | | | |
| **EC** | .711 | .322 | 1.000 | | | | | | | | | | | | | | | | |
| **Alk.** | -.093 | -.579 | .382 | 1.000 | | | | | | | | | | | | | | | |
| **TH** | -.771 | -.709 | -.226 | .023 | 1.000 | | | | | | | | | | | | | | |
| **TDS** | .658 | .184 | .942 | .625 | -.347 | 1.000 | | | | | | | | | | | | | |
| **DO** | $\mathbf{-.956^{*}}$ | -.848 | -.524 | .079 | .924 | -.545 | 1.000 | | | | | | | | | | | | |
| **BOD** | -.265 | .222 | -.851 | -.732 | -.137 | -.878 | .085 | 1.000 | | | | | | | | | | | |
| **TSS** | .433 | -.074 | .683 | .856 | -.412 | .888 | -.438 | -.766 | 1.000 | | | | | | | | | | |
| **Mn** | .920 | .916 | .387 | -.258 | -.924 | .379 | $\mathbf{-.981^{*}}$ | .096 | .262 | 1.000 | | | | | | | | | |
| **Ca** | -.664 | -.670 | -.055 | .092 | $\mathbf{.985^{*}}$ | -.188 | .854 | -.292 | -.300 | -.878 | 1.000 | | | | | | | | |
| **Fe** | -.075 | .049 | -.591 | .008 | -.576 | -.352 | -.223 | .612 | .023 | .281 | -.696 | 1.000 | | | | | | | |
| **Cu** | .514 | .018 | .717 | .804 | -.477 | .909 | -.517 | -.749 | $\mathbf{.996^{**}}$ | .346 | -.361 | .024 | 1.000 | | | | | | |
| **Pb** | .591 | .796 | .354 | -.728 | -.143 | .058 | -.429 | .095 | -.376 | .506 | -.084 | -.484 | -.302 | 1.000 | | | | | |
| **$Cl^-$** | .847 | .454 | .914 | .428 | -.580 | $\mathbf{.955^{*}}$ | -.769 | -.702 | .816 | .638 | -.432 | -.216 | .861 | .225 | 1.000 | | | | |
| **$SO_4^-$** | .368 | .106 | .132 | .546 | -.772 | .423 | -.570 | -.109 | .723 | .492 | -.768 | .696 | .732 | -.496 | .496 | 1.000 | | | |
| **$PO_4^-$** | -.080 | -.312 | .582 | .274 | .659 | .424 | .357 | -.753 | .154 | -.457 | .779 | $\mathbf{-.951^{*}}$ | .129 | .195 | .216 | -.569 | 1.000 | | |
| **$NO_3$** | .791 | .392 | .765 | .523 | -.717 | .895 | -.798 | -.591 | .888 | .668 | -.599 | .065 | .927 | .008 | $\mathbf{.956^{*}}$ | .730 | -.022 | 1.000 | |
| **Turb** | -.772 | -.494 | -.498 | -.365 | .909 | -.670 | .877 | .264 | -.754 | -.796 | .843 | -.402 | -.800 | .043 | -.806 | -.873 | .386 | -.930 | 1.000 |

### 3.2 Present Water Quality

Table 5 and Figure 1 display the findings of the heavy metals and physicochemical parameters of the samples that were taken at various times.

Table 5: Physicochemical parameters and heavy metals of samples collected at different points**.**

| **PARAMETERS** | **Point of sampling** | | | |
|---|---|---|---|---|
| | **A** | **B** | **C** | **D** |
| Ph | 6.86 | 7.04 | 6.95 | 6.66 |
| Temperature (°C) | 21.63 | 21.57 | 21.73 | 21.23 |
| Electrical conductivity (µs/cm) | 230.00 | 342.67 | 208.67 | 287.67 |
| Alkalinity (mg/l) | 103.33 | 94.00 | 83.00 | 108.00 |
| Total Hardness (mg/l) | 54.96 | 66.91 | 71.84 | 89.23 |
| Total dissolved solid (ppm) | 194.67 | 218.00 | 180.33 | 242.67 |
| Dissolved oxygen | 7.40 | 7.02 | 7.48 | 7.62 |
| Basic oxygen demand | 2.17 | 1.92 | 2.21 | 2.05 |
| Total suspended solid | 58.64 | 60.61 | 52.29 | 58.26 |
| Cadmium (ppm) | 0.01 | 0.01 | 0.01 | 0.01 |
| Manganese (ppm) | 9.74 | 9.62 | 9.66 | 8.46 |
| Calcium (ppm) | 22.90 | 27.41 | 27.08 | 32.02 |
| Iron (ppm) | 2.88 | 1.69 | 2.06 | 2.11 |
| Copper (ppm) | 0.06 | 0.07 | 0.03 | 0.05 |
| Lead (ppm) | 0.01 | BDL | BDL | 0.02 |
| Chloride (mg/l) | 28.40 | 35.51 | 19.41 | 21.67 |
| Sulphate (mg/l) | 14.63 | 14.89 | 15.17 | 18.02 |
| Phosphate (mg/l) | 1.00 | 1.19 | 1.17 | 1.16 |
| Nitrate (mg/l) | 2.87 | 2.65 | 2.39 | 3.32 |
| Turbidity (NTU) | 1.48 | 1.40 | 1.70 | 1.99 |

*BDL – Below detected limit.*

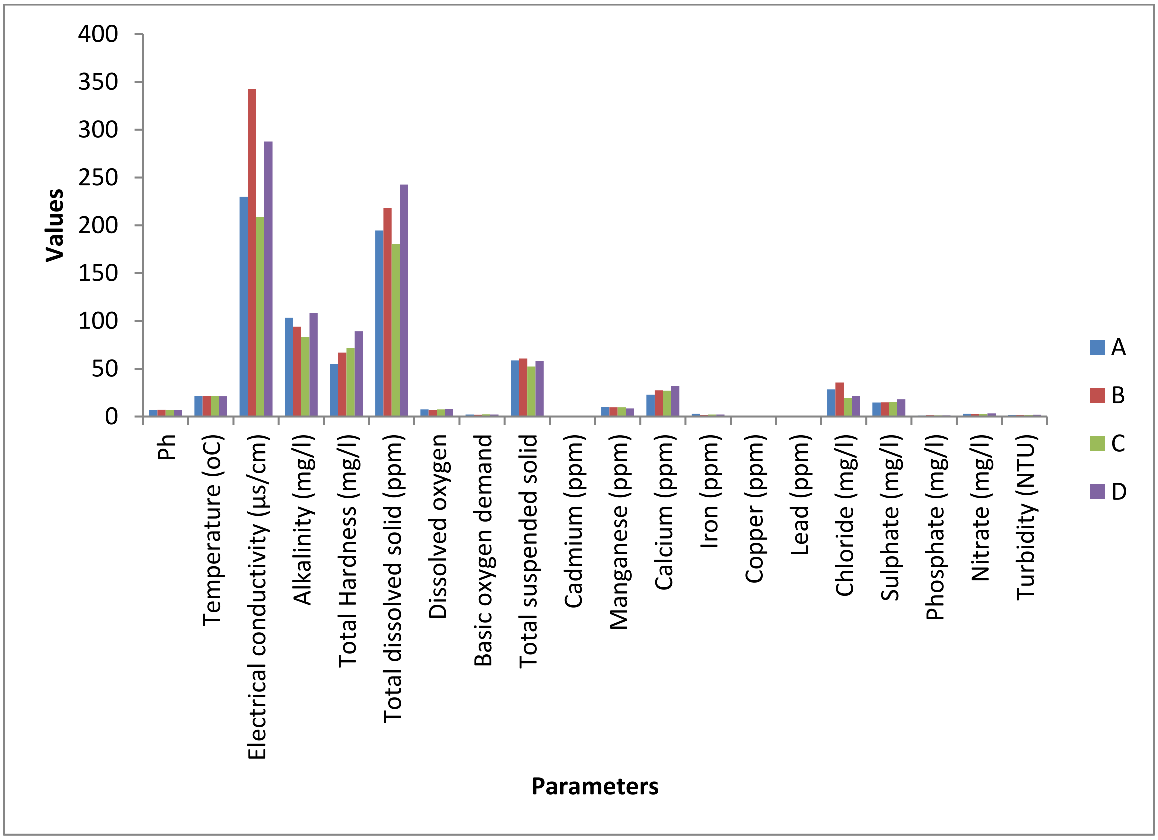

Fig 1. Heavy metals and physicochemical parameters water sample at points A, B, C and D

The PCA is summarised in Tables 6, 7, and 8, along with the loadings, eigenvalues of each PC, total variance explained, cumulative variance, and strong loading values that are indicated.

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Table 6: PCA of water quality parameters of the Stream in July

| Variables | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Nitrate | **.987** | -.146 | -.073 |
| Sulphate | **.974** | .201 | .100 |
| TDS | **.969** | .184 | .163 |
| EC | **.965** | .182 | .189 |
| Pb | **.962** | -.176 | -.209 |
| Total Hardness | **.947** | .318 | .035 |
| Ca | **.945** | .303 | -.123 |
| Turbidity | **.905** | -.251 | .342 |
| Chloride | **.896** | .342 | -.283 |
| Mn | **-.886** | .055 | .460 |
| Alkalinity | **.806** | **.570** | .157 |
| pH | **-.747** | **.664** | .035 |
| Fe | -.091 | **-.993** | .073 |
| Phosphate | .142 | **.981** | .135 |
| BOD | -.270 | **-.831** | .487 |
| DO | -.083 | **-.823** | **.562** |
| Cu | -.087 | -.049 | **-.995** |
| TSS | .229 | .053 | **-.972** |
| Temperature | .266 | -.361 | **.894** |
| Eigen values | 10.366 | 4.752 | 3.882 |
| % Variance Explained | 54.556 | 25.011 | 20.433 |
| % Cumulative Variance | 54.556 | 79.567 | 100 |

*Principal Component Analysis was used as the extraction method, and Varimax with Kaiser Normalisation was used as the rotation method. Bold figures denote absolute values >0.5 of parameters with strong loading values.*

Three PCs, or 100% of the variance, were revealed by the PCA of the July data (Table 6). The first PC, which was best represented by nitrate, sulphate, TDS, EC, lead (Pb), calcium (Ca), turbidity, total hardness, chloride (Cl), manganese, alkalinity, and pH, explained 54.556% of the total variance. Iron, alkalinity, pH, phosphate, BOD, and DO account for 25.011% of the variance in PC 2. PC 3 significantly increased the load on DO, copper, TSS, and temperature and explained 20.433% of the total variance (Figure 2).

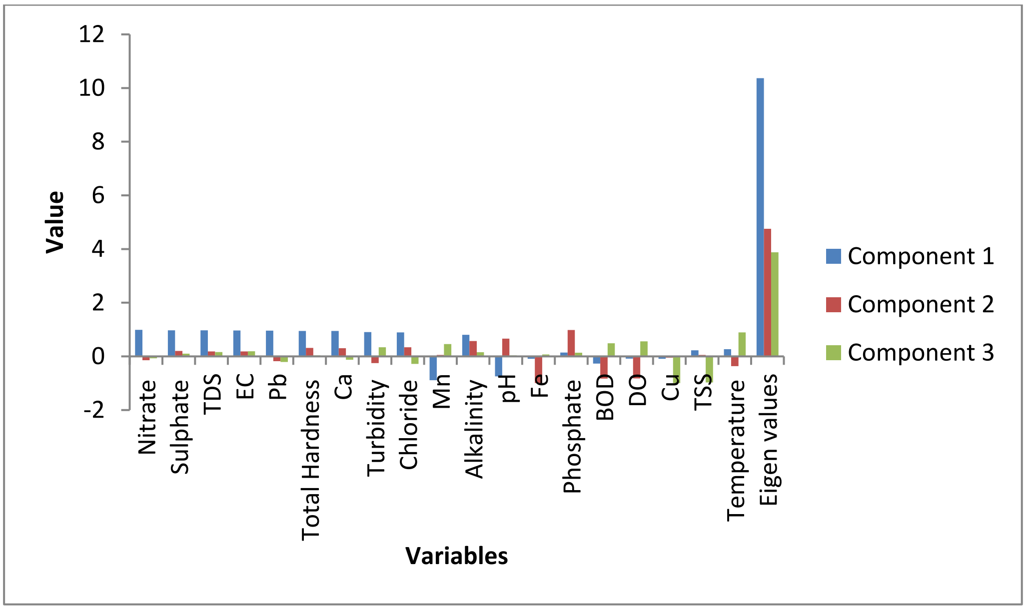

Figure 2: Component Analysis of water quality variables in July

Table 7: PCA of water quality parameters of the Stream in August

| Variables | Component | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| TDS | **.992** | .121 | .036 |
| EC | **.991** | .119 | .067 |
| Alkalinity | **.990** | .097 | -.104 |
| Fe | **.980** | -.108 | .169 |
| Sulphate | **-.864** | .496 | -.089 |
| Phosphate | **-.816** | **.540** | .204 |
| Mn | -.072 | **-.996** | -.045 |
| Pb | .143 | **.989** | -.040 |
| Turbidity | .101 | **.970** | .220 |
| Total Hardness | -.351 | **.933** | .083 |
| Ca | **-.512** | **.849** | -.131 |
| Temperature | .092 | **-.831** | **-.549** |
| pH | **-.643** | **-.707** | .295 |
| BOD | .139 | -.056 | **.989** |
| TSS | .429 | -.107 | **-.897** |
| Cu | **.556** | -.025 | **-.831** |
| Nitrate | .482 | .346 | **.805** |
| DO | .155 | **.600** | **.785** |
| Chloride | .418 | **-.513** | **.749** |
| Eigenvalues | 7.104 | 7.041 | 4.856 |
| % Variance Explained | 37.387 | 37.056 | 25.556 |
| % Cumulative Variance | 37.387 | 74.444 | 100 |

*Principal Component Analysis was used as the extraction method, and Varimax with Kaiser Normalisation was used as the rotation method. Bold figures denote absolute values >0.5 of parameters with strong loading values.*

Three components that accounted for 100% of the variance overall were extracted from the PCA of the August data (Table 7). PC 1 loaded heavily on sulphate, TDS, EC, and Alkalinity, iron, sulphate, phosphate, pH, copper, and calcium, and it explained 37.387% of the variance. Phosphate, manganese, lead, calcium, temperature, DO, pH, turbidity, total hardness, and lead accounted for 37.056% of the variance in PC 2. PC 3 provided the best explanation for 25.556% of the variation and included BOD, TSS, Copper, Nitrate, DO, and Chloride (Figure 3)

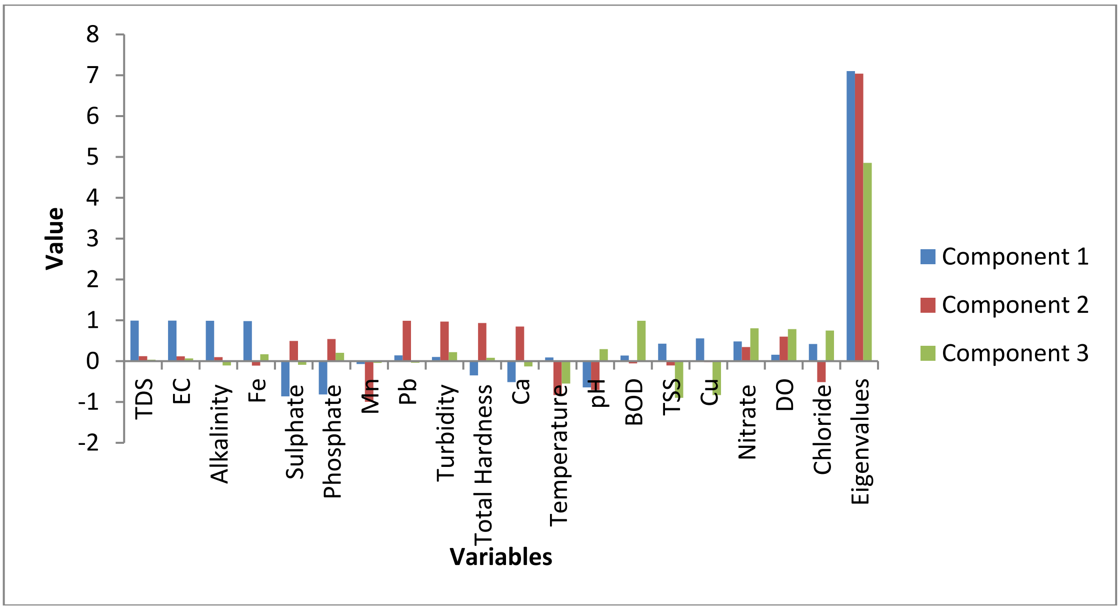

Figure 3: Component Analysis of water quality variables in August

Table 8: PCA of water quality parameters of the Stream in September

| Variables | Component<br>1 | <br>2 | <br>3 |
|---|---|---|---|
| TSS | **.984** | -.007 | -.179 |
| Cu | **.979** | .085 | -.186 |
| TDS | **.939** | .288 | .188 |
| BOD | **-.867** | .097 | -.489 |
| Nitrate | **.863** | .447 | -.234 |
| Alkalinity | **.847** | **-.521** | -.107 |
| Chloride | **.842** | **.537** | .048 |
| EC | **.779** | .440 | .446 |
| Turbidity | **-.670** | **-.500** | **.549** |
| Temperature | -.087 | **.991** | -.104 |
| Mn | .204 | **.903** | -.379 |
| pH | .437 | **.898** | -.055 |
| DO | -.388 | **-.854** | .346 |
| Pb | -.288 | **.828** | .481 |
| Fe | -.157 | -.067 | **-.985** |
| Phosphate | .324 | -.190 | **.927** |
| Sulphate | **.589** | .074 | **-.805** |
| Ca | -.169 | **-.610** | **.775** |
| Total Hardness | -.300 | **-.670** | **.679** |
| Eigenvalues | 7.855 | 6.187 | 4.958 |
| % Variance Explained | 41.343 | 32.565 | 26.092 |
| % Cumulative Variance | 41.343 | 73.908 | 100 |

*Principal Component Analysis was used as the extraction method, and Varimax with Kaiser Normalisation was used as the rotation method. Bold figures denote absolute values >0.5 of parameters with strong loading values.*

Three components that accounted for 100% of the variance overall were identified in the PCA of the September data (Table 8 and Figure 4). PC 1 loaded heavily on nitrate, TSS, copper, EC, chloride, alkalinity, and turbidity and explained 41.343% of the variance. Manganese, lead, calcium, turbidity, total hardness, temperature, DO, and pH accounted for 32.565% of the variance in PC 2. The variables that best accounted for PC 3's explanation of 26.092% of the variance were iron, phosphate, sulphate, calcium, and total hardness.

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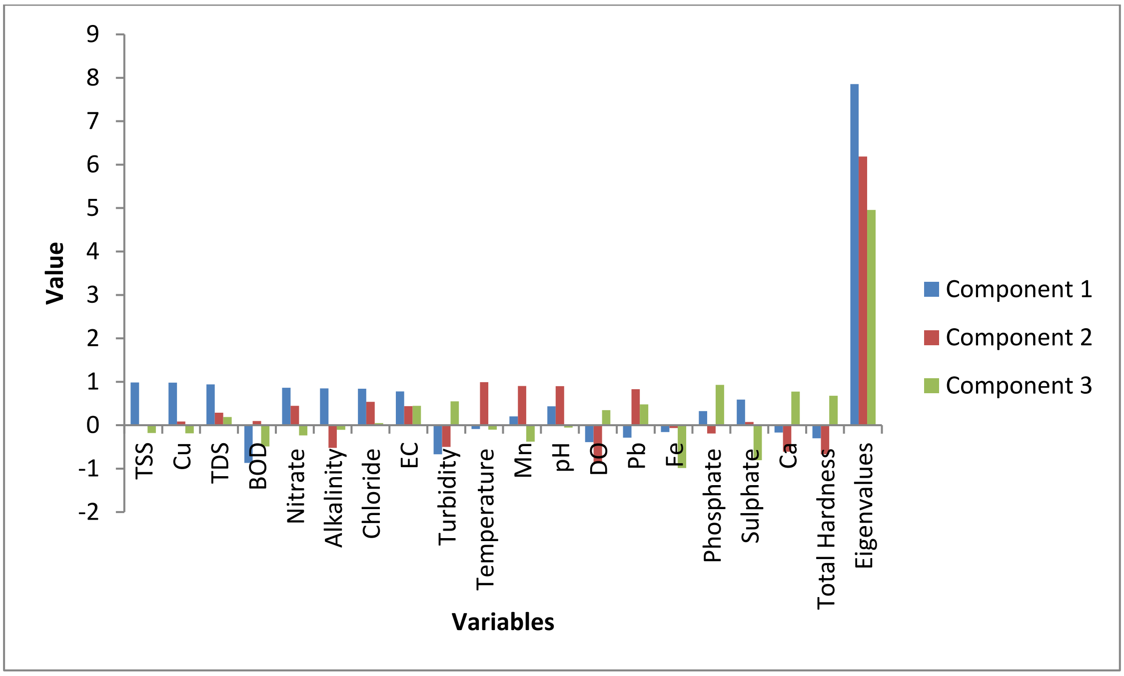

Figure 4: Component Analysis of water quality variables in September

The comparison of the stream quality with the W.H.O standard shows that the pH is within the acceptable range (Figure 5). The electrical conductivity increased above the W.H.O standard value. This relatively higher value could be attributed to the discharge of dirt and suspended inorganic matter and automobile effluent from the carwash close to the streamline because of the location of the stream. The high value of TDS may be an indication of increased runoff water from excess rainfall. Increased dissolved solids in irrigation water have an impact on crop yield, growth, and soil efficiency and the amount of copper content is within the W.H.O. standard range. There also is no deviation from the W.H.O. standard in the dissolved oxygen (DO). Because of the stream's comparatively low total hardness level, soft water is present. Total hardness brought on by calcium and magnesium was typically indicated by the build-up of soap scum and the requirement for excessive soap use in order to clean.

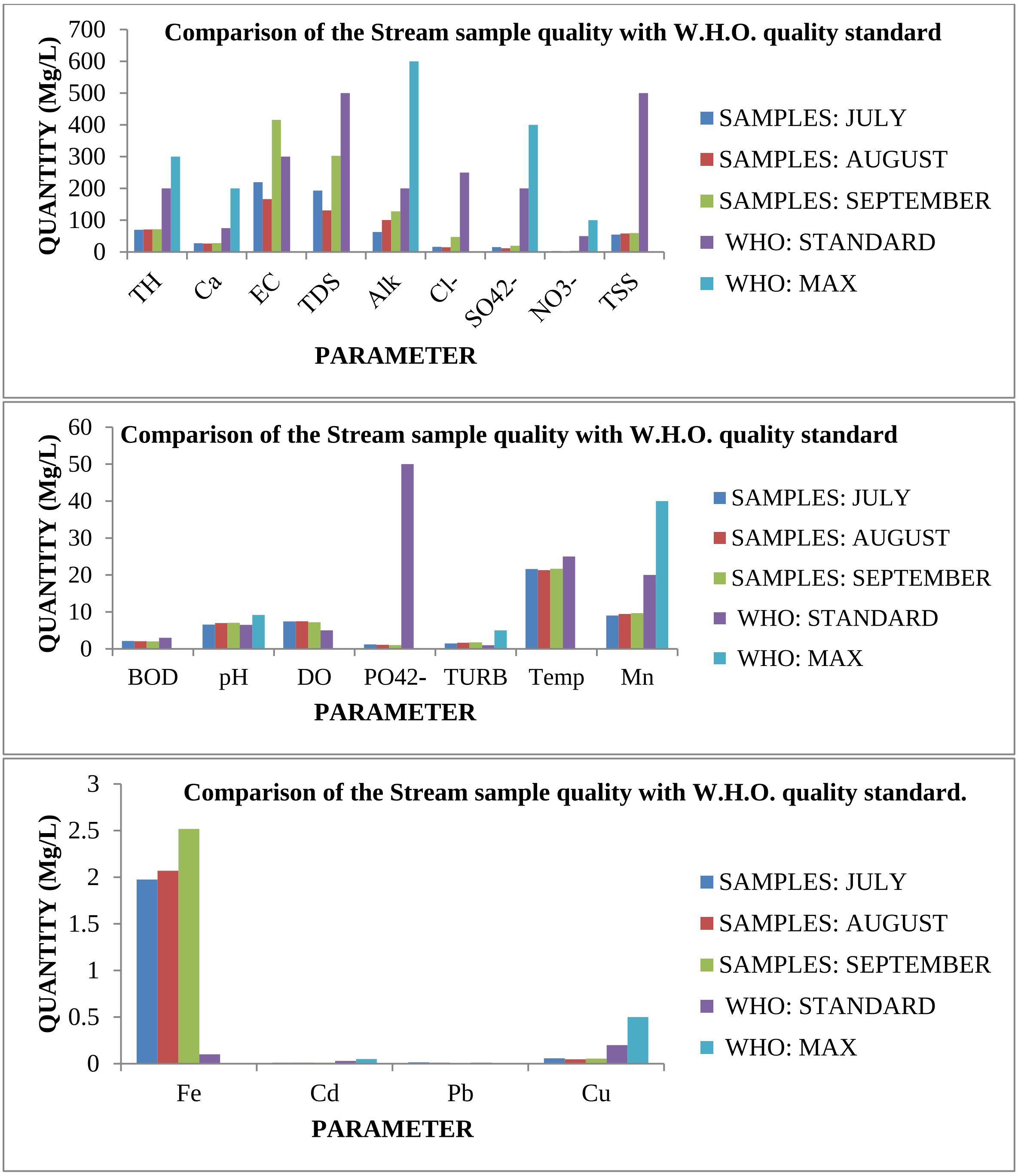

Figure 5: Comparison of detection levels with WHO Standard

## 4. CONCLUSION

The PCA results demonstrated the factors influencing variations in water quality, the most and significantly significant factors that were found to have an impact on the study's water qualities, and the correlation between the parameters affecting water quality. Finding the variables that regularly or consistently cause the water quality to fluctuate was also helpful. Furthermore, it might serve as a guide for choosing preventive actions for the appropriate management of surface water. With the exception of turbidity and EC, which were higher than the W.H.O. standard's acceptable level, the comparison of the stream's physicochemical parameters with the standards demonstrates an acceptable correlation. As a result, the study's findings will support the pertinent authorities in developing policies that will help them effectively manage the water quality, which has declined as a result of pollution from numerous human activities. This research did not work on the microbial parameters of this river, therefore future research can explore working on analysing the microbiological parameters of “Omi Omo” Stream and more water quality parameters and heavy metals like Chemical oxygen demand, nickel and zinc.

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