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Correlation between Total Dissolved Solids and Electrical Conductivity of Water in Ubeji and Iffie Environs of Delta State

ONIFADE, Y. S.[1,*], *OKWUNJOR, O.*[2]

[1,2]*Department of Physics, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria*

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ABSTRACT

Water is an inorganic Compound that is crucial to the sustenance of life on earth. The negative impact of contaminated water to life and other activities of man cannot be over emphasized. Total Dissolved Solids and Electrical conductivity of water are two parameters that determine the quality of water. They provide a lot of information on the quality of water. This research seeks to find the correlation between these parameters; Total Dissolved Solids (TDS) and Electrical Conductivity (EC) of water sources within Ubeji and Iffie environs. A total of fifty-six (56) locations which comprises of Sixteen (16) samples of surface water from recipient water bodies (rivers), Eleven (11) wastewater from fish pond and creeks, and twenty-nine (29) ground water samples from bore holes used for drinking and other domestic activities were identified and samples collected. The samples were analysed under room temperature and pressure using the Mettler meter to determine their Total Dissolved Solids and Electrical conductivity. The relationship between Total Dissolved Solids and Electrical Conductivity was analysed using the Pearson's regression analysis. The coefficient of correlation (r) of surface water, waste water and Borehole water was 1. This indicates a strong correlation and the correlation ratio (k) for these water types were 0.66, 0.73, and 0.67 respectively.

1. INTRODUCTION

Two Hydrogen atoms (H) and one Oxygen atom (O) combine to form the inorganic molecule known as water. H_2O is the chemical formula and a primary element of the Earth's hydrosphere, water is a chemical substance that is clear, tasteless, odorless, and virtually colorless (Zumdahl, 2023). Both solid and gaseous forms of it are possible states in which water can exist, it is a peculiar substance. In contrast to comparable substances like hydrogen sulfide and ammonia, water is very complex and exhibits unique physical and chemical characteristics (Akporode, 2012). Ice cubes frequently float in a glass of water, but other compounds cannot exhibit this behavior because they typically have a solid state that is denser than their liquid state, causing the solid to sink to the bottom to the bottom of the liquid. Whereas, the solid state of water is less dense than its liquid state. This characteristic of water is crucial to nature because it preserves marine life underneath when ice forms on ponds and lakes in arctic regions. The ice that forms in the pond will sink to the bottom if the ice is denser than the water. This will expose

*Corresponding author, e-mail:onifade.yemi@fupre.edu.ng @fupre.edu.ng
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more water to the cold, causing the pond to eventually freeze over and destroy any aquatic life that may have been present (Zumdahl, 2023). Another peculiar phenomenon that waters displays is called anomalous expansion. When water is heated from 0°C to 4°C, it initially shrinks before starting to expand. Contrary to this, analogous compounds begin to expand right away at 0°C. Water is essential to the survival of life on earth it is essential to every life on earth in order to exist. Water is essential for photosynthesis in plants as well as the transfer of nutrients from roots to leaves and fruits. According to Matthews (2004), water makes up about 60% of the human body, including bodily fluids like perspiration and blood. Water is used in the majority of vital bodily activities. Therefore, it should come as no surprise that people can go longer without food than without water. Rusydi (2018) analyzed the physicochemical components of his three satellite streams (Nuwori, Otamiri, and Oramilikwa) in the Owerri Municipality region of Imo State using World Health Organization (WHO) criteria and compared the findings. With the exception of the pH and PO_4^{3-} of the Nworie and Oramirika rivers, the three rivers were found to be largely acceptable for ingestion by humans. Similar results were found by Rhoades et al. (1992), who found that total hardness was higher than total carbonate during the wet season and conductivity was higher than total dissolved solids during the dry season, with the two parameters being almost equal. In Kano State, Nigeria, Tody and May. (2005) investigated a number of physicochemical aspects of the Watari Reservoir. The efficacy of the treatment procedure is shown by average TDS, conductivity, turbidity, and total suspended solids hardness values of 14 Biochemical Oxygen Demand (BOD), Cl-, NO_2, NO_3, CO_2, and PO_4^{2-}. The usage of nitrogen-based fertilizers in the field may have contributed to the elevated levels of nitrates that were found. The concentrations of the studied parameters in the water samples were found to be within the World Health Organization's tolerances in Selvaraj and Kurian 2009's study of water electrical conductivity in several chosen regions of Delta State, Nigeria. However, given that all of the streams studied were acidic and had similarly significant amounts of conductivity and iron, the pH values of our river water samples provide cause for concern. In order to prevent health hazards related to these characteristics, water pH, total iron content, and electrical conductivity should be frequently evaluated.

According to Bear et al. (1999) study of the regional variability of physicochemical parameters in the eastern Obolo Estuary, all stations had TDS and BOD levels that were higher than the advised limits, indicating that the area is a reliable source of drinking water. There have been hints that it might not be the source. Water quality assessments of the Great Kwa River were made using physical and chemical methods, according to Mattews. (2004). It was discovered as a result that, with the exception of BOD, the water temperature, clarity, salinity, and dissolved Oxygen values were all much greater in the dry season than in the wet season. The Nkisi River's mean anions concentration (mg/L) was reported by Rhoades et al., (1992). The concentrations of these physicochemical characteristics complied with the acceptable drinking water guidelines set by the World Health

Organization (WHO). Physical-chemical analyses of the Orashi River in the river provinces' Mbiama and Ogbema cities revealed a temperature of 29.2 °C at two sampling places, according to Dibofori-Orji and Clark (2022). The transitory hardness that has been noticed in water samples is caused by bicarbonate and is rather mild. The amount of sulfate in river water, however, reveals the water's organic matter concentration. This may be from industrial waste or human waste. Zhumdahl (2023) examined the physico-chemical characteristics of the Niger River on the Onitsha Riverbank in Nigeria to ascertain the degrees of contamination of the soil and water along the riverbank. Water quality has been observed to be negatively impacted by metallic and nonmetallic ions, alkalinity, total solids, sulfate, chloride, hardness, and other physicochemical factors, rendering it unfit for human consumption. Todd and May (2005) also evaluated the pond water quality at the University of Jos in Nigeria. It was advised that the water was suitable for irrigation and that the values found fell within permissible unit ranges. Before and after a sewage treatment plant was sanitized, Clark (2022) reported on average physicochemical and bacteriological analyses of Asa treated water where all samples tested negative. Similar to this, Mattews. (2004) evaluated the quality of drinking water sources in the Abba South and Abayi regions of Abia State and discovered that all physicochemical parameters of the water analyzed were within the range of pH, with the exception that the World Health Organization (WHO) reported that it met the criteria for 5.20-5.80), as opposed to the WHO range of 6.5-8.5. To varied degrees, all samples contained (Staphylococcus sp. Streptococcus, Escherichia coli, etc.). Selvaraj and Kurian. (2009) evaluated the water from his three springs in Bende LGA, Abia, and found that the average pH was 5 and the average temperature was 28.3 °C, which is below the WHO-recommended temperature of 25 °C. Selvaraj and Kurian. (2009) combined various water quality attributes into a single number to provide an easy-to-understand indicator and provide a tool for management and decision-making. Based on a set of water quality factors, water quality is displayed as overall water quality at a specific location and time. The purpose of this indicator was to simplify complex water quality data so that it could be used and understood by the general public.

1.1. The Study Area

In Delta State, Nigeria's Warri South Municipal Region, Ubeji community is an Itsekiri community. Due to its proximity to the Warri Refinery and Petrochemical Company (WRPC or Wari Refinery) in Ekpan, Uvwie province, the Ubeji hamlet is severely polluted. It is situated on the outskirts of Warri City and is the residence of many Itsekiri. It is close to the communities of Iffie, Aja Etan, Ijala Ikenren, Ekpan, and others. The monarch of the Warri Kingdom, Olu of Wari, is in charge of all the districts in the Warri Kingdom as well as his own community Ubeji.

The research area (the settlements of Ubeji and Iffie) is situated in the Delta Province's Warri South Municipal Area. It spans a roughly 66 km^2 region and is situated between latitudes 5°30' and 5°38'N and longitudes 5°38' and 5°45°E. The two settlements are situated in the oil-rich Niger

Delta region of Nigeria. According to its climatology, the research area has 3200 millimetres of annual rainfall on average and average temperatures of roughly 28 °C. With an average elevation of 13 meters, the landscape is level. Flooding following rains frequently prefers flat, low relief. Dendritic drainage is present, with the Forcados River receiving substantial tributaries. This region has tropical rainforest-style vegetation with lots of trees and grasses. It consists of freshwater swamp forests in locations outside the tidal range, mangrove swamps in the intertidal zone, and coastal freshwater forests atop seawalls. The Someiro Delta Plain, a Quaternary to Recent alluvial deposit, underlies the region geologically. This formation is made up primarily of unconsolidated fine, medium, or coarse sand with traces of gravel, peat, or plastic clay lenses. It has a high-water content. The three stratigraphic units that make up the Niger Delta, the Benin, Agbada, and Akata formations, are located beneath the Someiro Delta Plain sands, which are ordinarily more than 100 m thick. The research area's soils display a wide variety of hues, ranging from milky white to brown to very dark brown. The United States Department of Agriculture (USDA) classifies them as having a range of types and textures, including loamy, sandy, and clayey. The presence of luxuriant trees and grasses typical of the study area demonstrates how nutrient-rich the soils in this area are. Networks of well-kept minor roads that connect to the Warri Port Expressway provide access to the area. To the location where the samples were gathered, there are many off-road trails.

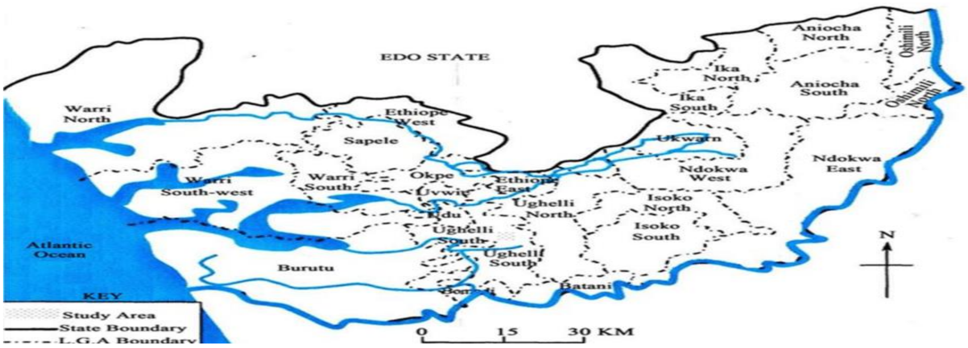

Figure1: Map of Delta Showing the Study Area *(Ministry of lands and survey and urban development, Asaba, 2002.)*

2. METHODOLOGY

The cross-section descriptive design of the study looked at the correlation of Total Dissolved Solids (TDS) and Electrical Conductivity (EC) in Ubeji and Iffie environs in Warri South Local Government Area of Nigeria. Water samples were taken and preserved according to standard to avoid loss of characteristics. Processed results from the laboratory were analyzed using Microsoft Excel and SPSS (version 28).

Details of Sampling Location

Sampling locations are situated in and around Ubeji and Iffie communities in Warri South Local Government Area. A total of fifty-six (56) sample location were identified within Ubeji and Iffie environs. Sixteen (16) samples were colleted from surface water which included recipient water bodies such as rivers and streams, Eleven (11) waste water samples were collected from fish pond and creeks, and twenty-nine (29) water samples were collected from bore holes for domestic use were sampled. Their details are given below in Table 1, 2, 3.

Determination of Electrical Conductivity.

This was done at room temperature with a Mettler Toledo MC 226 Conductivity Meter. Data was gathered at room temperature.Three different buffer configurations were used to calibrate and standardize the Mettler Toledo MC 226 Conductivity Metter pH meter. To do this, the anodes were cleaned with ethanol, the control was turned on, and the three buffer arrangements were presented one at a time after pressing the calculation button.The tests were gently shaken, and then the conductivity meter was inserted into the test's container and exchanged to be examined. The reading was started once an unwavering opinion had been reached. This method was repeated for all 56 tests, and after each test, the cathodes were washed with distilled water.

Determination of Total Dissolved Solids

After being certain that the meter has been standardized, press mode to select TDS to start browsing. Display test and key in mode A record is made. For all fifty-six (56) experiments, the same approach was used. After each test, the cathodes were flushed.

3. RESULTS AND DISCUSSIONS

3.1. Result Presentation

Based on the physical investigation done on the tests as stated in Tables below, the results for the water tests collected from different locations are reported in the Tables 1, 2 and 3 below

Table 1. TDS-EC In Borehole Water

Sample code	pH	Electrical Conductivity (EC) (µS/cm)	Total Dissolved Solids (mg/l)
BHW1	7.4	497.91	333.6
BHW2	7.89	412.02	276.05
BHW3	6.67	37.95	25.43
BHW4	5.6	30.56	20.48
BHW5	5.79	50.88	34.09
BHW6	4.38	111.97	75.02
BHW7	4.17	165.68	111.01
BHW8	6.42	328.5	220.1
BHW9	4.48	122.56	82.12
BHW10	4.57	81.18	54.39
BHW11	6.57	196.99	131.98
BHW12	6.12	287.74	192.79
BHW13	5.65	69.56	46.61
BHW14	5.5	22.78	15.26
BHW15	4.86	36.07	24.71
BHW16	4.83	34.88	23.37
BHW17	4.42	136.03	91.14
BHW18	4.12	107.02	71.7
BHW19	4.08	166.27	111.4
BHW20	6.4	233	156.11
BHW21	4.66	34.94	23.41
BHW22	5.22	21.41	14.34
BHW23	5.06	24.03	16.1
BHW24	5.41	18.33	12.28
BHW25	4.18	127.77	85.61
BHW26	5.12	189.07	126.68
BHW27	5.09	58.11	38.93
BHW28	5.63	214.86	144
BHW29	5.65	185.96	124.6

The graphs of Total dissolved Solid against the Electrical Conductivity are shown in Figures 2, 3 and 4.

Table 2. TDS-EC In Surface Water

Sample Code	Ph	Electrical Conductivity (EC) (µS/cm)	Total Dissolved Solids (mg/L)
SWS1	6.98	82.53	55.30
SWS2	6.89	84.93	56.90
SWS3	6.67	89.07	59.68
SWS4	6.68	95.06	63.70
SWS5	6.52	114.6	76.42
SWS6	6.41	133.27	89.29
SWS7	6.49	133.27	89.29
SWS8	5.85	85.01	57.00
SWS9	6.62	148.59	99.56
SWS10	6.72	79.31	53.14
SWS11	6.73	79.39	53.19
SWS13	6.48	95.55	131.02
SWS14	6.73	96.77	64.84
SWS15	6.17	99.88	66.92
SWS16	6.80	52.88	35.43
SWS17	7.04	55.70	37.32

Table 3. TDS-EC In Waste Water

	pH	Electrical Conductivity (EC) (µS/cm)	TOTAL Dissolved Solids (mg/l)
WWS1	6.21	65.09	43.61
WWS2	6.63	83.79	56.14
WWS3	6.61	136.35	86.41
WWS4	6.61	128.97	86.41
WWS5	6.57	141.29	94.67
WWS6A	6.73	209.22	140.18
WWS6B	5.64	25.83	17.31
WWS7	7.29	351.66	253.61
WWS8	6.71	115.56	77.42
WWS9	6.45	110.42	73.98

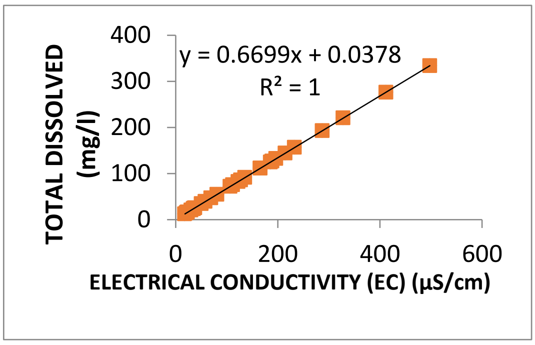

Figure 2: Correlation of TDS-EC In Borehole Water

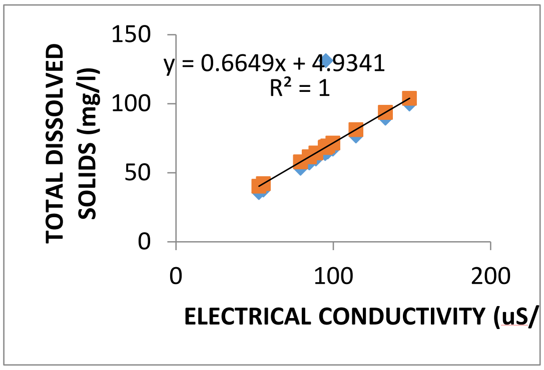

Figure 3: Correlation f TDS-EC in surface water

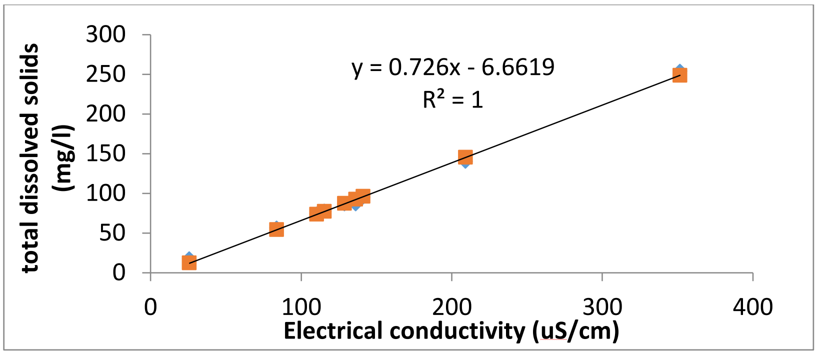

Figure 4: Correlation of TDS-EC in waste water

3.2. Discussion of Results

3.2.1. Correlation of TDS-EC in Surface Water

Table 2 above shows the P^H of the surface water of the study area ranges between 5.85 to 7.04. Only one sample point, SWS17 that has a P^H greater or equal to 7 all other sample points has a P^H less than 7. Sample point SWS8 has the lowest P^H 5.85. The Surface water in Study area has a generally low P^H and this can be a sign of chemical or heavy metal pollution. The Electrical Conductivity of the Surface water of the area of study ranges between 52.88 µS/cm to 148.59 µS/cm with an average was 95.36 µS/cm. Based on Rhodes water classification, the surface water in the study area is non-saline. Total Dissolved Solids were in the range 35.43 – 131.02 mg/L. The average was 68.06 mg/L. Based on Walton Classification of water, the surface water in the area of study can be termed Fresh water. From Figure 3 above, the correlation ratio (k) of TDS-EC in Surface water was 0.6649, ($R^2 = 1$). Where R^2 = correlation coefficient = 1, this signifies a strong positive correlation between Total Dissolved Solids, and Electrical Conductivity of surface water in the study area. Therefore, the equation that shows the relationship between TDS and EC will become;

$$TDS\left(\frac{mg}{l}\right) = 0.6649 \times EC\left(\frac{\mu S}{cm}\right) \quad (1)$$

3.2.2. Correlation of TDS-EC in Waste Water

As shown in Table 3, the Electrical Conductivity of the Surface water of the area of study ranges between 52.88 µS/cm to 148.59 µS/cm with an average was 95.36 µS/cm. Based on Rhodes water classification, the surface water in the study area is non-saline. Total Dissolved Solids were in the range 35.43 – 131.02 mg/L. The average was 68.06 mg/L. Based on Walton Classification of water, the surface water in the area of study can be termed Fresh water. The P^H of the Waste water of the study area ranges between 5.64 to 7.29. Only one sample point, WWS7 that has a P^H greater or equal to 7 all other sample points has a P^H less than 7. Sample point WWS6B has the lowest P^H 5.64. The waste water in Study area has a generally low P^H and this can be a sign of chemical or heavy metal pollution. From Figure 4 above, the correlation ratio (k) of TDS-EC in Waste water was 0.0.726, ($R^2 = 1$). Where R^2 = correlation coefficient = 1 this signifies a strong positive correlation between Total Dissolved Solids, and Electrical Conductivity of surface water in the study area. Therefore, for waste water equation that represents the relationship between TDS and EC will become as thus;

$$\text{TDS}\left(\frac{\text{mg}}{\text{l}}\right) = 0.726 \times \text{EC}\left(\frac{\mu\text{S}}{\text{cm}}\right) \quad (2)$$

3.2.3. Correlation of TDS-EC in Borehole Water

Table 1 shows the P^H of the Borehole water of the study area ranges between 4.08 to 7.89. Only two sample point, BHW1 and BHW2 that has a P^H greater or equal to 7 all other sample points has a P^H less than 7. Sample point BHWS19 has the lowest P^H 4.08. The Borehole water in Study area has a generally low P^H and this can be a sign of chemical or heavy metal pollution. The Electrical Conductivity of the Borehole water of the area of study ranges between 21.41 µS/cm to 497.91 µS/cm with an average was 138.07 µS/cm. Based on Rhoades, et al, 1992's water classification, the Borehole water in the study area is non saline. Total Dissolved Solids were in the range 14.34mg/l – 333.60 mg/L. The average was 92.54 mg/L. Based on Walton Classification of water, the Borehole water in the area of study can be termed Fresh ground water. From Figure 2 below, the correlation ratio (k) of TDS-EC in Borehole water was 0.6699, ($R^2 = 1$). Where R^2 = correlation coefficient = 1 this signifies a strong positive correlation between Total Dissolved Solids, and Electrical Conductivity of surface water in the study area. Therefore, equation that depicts the relationship between TDS and EC will become as thus:

$$TDS\left(\frac{mg}{l}\right) = 0.6699 \times EC\left(\frac{\mu S}{cm}\right) \quad (3)$$

4. CONCLUSION

Water quality measures such as Electrical Conductivity (EC) and Total Dissolved Solids (TDS) reveal the presence of toxins in the water. These toxins could be either chemical or physical toxins. Additionally, it appears to be the effect of water interruption entering the aquifer. Even though Add up to broken down solids provides thorough information on the solutes that have been broken down in water, it is more difficult to assess than Electrical Conductivity estimation. Our results show that there is a link (k) between EC and TDS that spans from 0.66 to 0.72, the relationship between TDS and EC is not always linear and the higher the material content dissolved in water; the more complex mathematical equations needed in describing those parameters. The values of p^H obtained for the various types of water around Ubeji and Iffie Environs, indicates signs of heavy chemical pollution hence the need to apply gravimetry for analysis deeper analysis of TDS concentrations.

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