

Estimation of the Salinity of Choba River, Port Harcourt Using a Self Constructed Electrical Conductivity Meter

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Abstract

In line with the Federal Government of Nigeria's policy on local production and University of Port Harcourt's entrepreneurial disposition, we went into local production of conductivity meter which can effectively measure water salinity. This meter was constructed using, 10 V ac to dc power supply, resistors, vero board, copper electrodes and multi meter. The electrical connections were strictly carried out following circuit illustrations. The meter was used to measure the conductivity of 20 water samples collected from Choba River in Port Harcourt, and five tap water samples from the same community. The salinity or total dissolved salts (TDS) of the samples was computed from the sample conductivities. The results showed that the TDS ranged between 11.36 mg/l and 24.85 mg/l and were found to be high when compared to the measured average conductivity of tap water (5.19 mg/l) from the same surveyed area. These results are in the same range with previous measurements. Also, both the measured conductivity and TDS of the samples are low compared to the standard limits of 1000 $\mu\text{S}/\text{cm}$ and 500 mg/l respectively, indicating that the surveyed river may not be highly mineralised since the conductivity and thus TDS of water depend on its mineral content. The measured results using constructed meter when compared with the results using standard meter showed percentage deviation range of between - 0.35 % and 0.19 %. The close agreement in the 2 sets of results is an indication that the constructed conductivity meter can serve as an effective meter for the measurement of salinity of water bodies.

Keywords: Salinity, Choba river, Self- constructed, Conductivity meter.

1.0 Introduction

One of the fundamental environmental problems confronting the local communities is lack of free accessibility to portable water. Public water corporations are no longer in vogue and house owners (landlords and ladies) have resorted to providing water for their households and tenants through drilled boreholes. However, most landlords cannot afford to drill their own boreholes and such landlords and their tenants resort to the local rivers for their domestic and economic sources of water.

Water from the local Choba River may likely contain some contaminants because it is not protected from external pollutants due to its openness. Also, so many activities go on within the river such as fishery, ships are anchored within the river for drilling purposes, white sand is mined from the river using excavators and even some industries within the locality release their industrial effluents into the river and all these contribute to the degradation of the quality of water body outsourced from this river.

Among the physicochemical parameters needed to access the quality of water from a source is water conductivity and total dissolved salt and the duo are inter-related because dissolved ions increase salinity as well as conductivity. Conductivity of water is the ability of water to conduct an electrical current, due to the action of dissolved ions such as sodium (Na^+), calcium (Ca^{+2}), potassium (K^+), magnesium (Mg^{+2}), chloride (Cl^-), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), bicarbonate (HCO_3^-), Nitrates (NO_3^-) and phosphates (PO_4^{-3}) [1]. The term *salinity* refers to the amount of total dissolved salts (TDS) that are present in water. Sodium and chloride are the major ions in seawater that contribute to its salinity. The concentrations of magnesium,

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calcium, and sulfate ions are also substantial. Naturally occurring waters vary in salinity from the almost pure water, devoid of salts, in snowmelt to the saturated solutions in salt lakes such as the Dead Sea [2].

Soil minerals such as calcite (CaCO_3) and feldspars (sodium-, calcium-, or potassium-rich silicates) have low solubilities and contribute to water only small increases in salinity. Highly soluble minerals such as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) have higher solubility and may contribute significant concentrations of Ca^{2+} and SO_4^{2-} ions. The solubility of gypsum in pure water is about 2,600 mg/L; in the presence of sodium and magnesium ions, it can range even higher [3]. The level of salinity of a water body influences its water quality and affects aquatic plants and animals.

Most conductivity measurements are made at or corrected to 25°C and referred to as specific conductance. This is the standardized method of reporting conductivity because the temperature of water will affect conductivity readings as well as calculated total dissolved salt (TDS). Reporting conductivity at 25°C allows data to be easily converted from conductivity to salinity (TDS) [4]. In streams and rivers, normal conductivity levels come from the surrounding geology. Clay soils will contribute to conductivity as the minerals in clay will ionize as they dissolve. Likewise, groundwater inflows will contribute to the conductivity of the stream or river depending on the geology that the groundwater flows through. Groundwater that is heavily ionized from dissolved minerals will increase the conductivity and consequently the salinity of the water into which it flows [4].

With the dwindling oil revenue in Nigeria and consequent decline in the value of the naira, the federal government's economic policies are now hinged on local production in order to create employment and boost the value of the naira. In line with this policy, University of Port Harcourt (our institution) has presently emphasized entrepreneurship which has lured staff and students into local production of laboratory equipment in order to support human capacity, save cost and boost productivity.

It is based on this principle that we went into local production of conductivity meter which can effectively be used to measure water salinity. This conductivity meter has been adopted to measure TDS within Choba river, to ascertain the suitability of the river for domestic usage.

2.0 Materials and Methods

2.1 Study Area

The water body understudied in this research work is Choba River. Choba town with a population of about 12000 is located in the mangrove belt in Eastern Niger Delta in Rivers State, Nigeria. Its geographical location is latitude $4^\circ 48'$ N and longitude $7^\circ 00'$ S, covering a land mass of approximately 1.3 square kilometres [5]. This town plays host to Federal University of Port Harcourt, Nigeria, University of Port Harcourt Teaching hospital, Willbros Oil Exploration Company (not fully in operation again), Dufil PrimaFoods PLC (otherwise called Indomie Company) and so many other cottage industries that tap from the vast economic activities that go on within this environment.

The source and sink of Choba River are Rumuakparali and Emoha Rivers respectively. The river is a combination of fresh water and salt water. It is used mainly by inhabitants for fishing, transportation, mining of sharp sand for construction work and other domestic and industrial purposes.

2.2 Method of Construction of Conductivity Meter

The components used in the construction of this conductivity meter are as listed below and were connected as shown in the electrical circuit of Figure 1;

- (i) Battery/10 V ac to dc power supply
- (ii) Battery snap connector
- (iii) Jumper and wire/ clips
- (iv) Resistors (1 k Ω , 470 Ω , 10 k Ω and 3.3 Ω)
- (v) Bread board and Vero board
- (vi) Light Emitting Diode (LED)
- (vii) Copper Electrodes and
- (viii) Multi meter

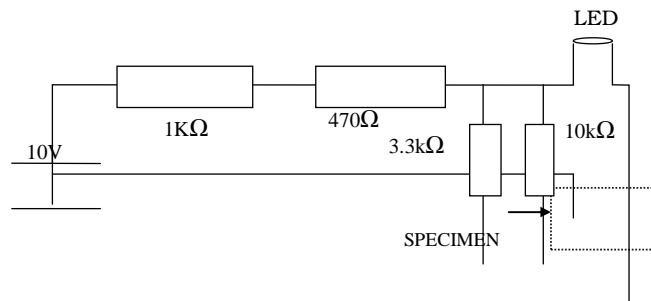


Figure 1: Electric Circuit Diagram of the Conductivity Meter

2.3 Mathematical Formulations for the Operation of the Conductivity Meter

Let the relationship between the resistance ‘R’ of a body and its resistivity ‘ρ’ be given as;

$$R = \rho l / A \tag{1}$$

Let conductance, $G = A / \rho l$ (2)

Also, $G = k A / l$ (3)

Therefore, the cell constant ‘C’ which is the geometric parameter on which the electrical conductivity of a material depends is deduced as,

$$C = l / A = k / G = kR \tag{4}$$

Where k, l and A are conductivity, length and resistivity of the specimen.

2.4 Method of Calibration of the Conductivity Meter

In order to effectively calibrate the conductivity meter, a standard potassium chloride (KCl) solution, 0.01 M was prepared by dissolving 745.6 mg of anhydrous KCl in distilled water and diluted to 1000 ml in volumetric flask at 25^oc and stored in a CO₂ – free atmosphere. This standard solution when measured gave a standard resistance (R_s) of 132 Ω at 25^oC with corresponding standard conductivity (K_s) of 1412 μS/cm.

This enabled us to calculate the cell constant of the conductivity meter using the expression;

$$C = K_s \cdot R_s \tag{5}$$

$$C = 1412 \times 132 = 186384 \mu S\Omega/cm \tag{6}$$

2.5 Method of Sample Collection

The surveyed river was divided into 3 segments with the first segment as the river bank, the second as the midway of the river and the third as towards the far end of the river. A total of 20 samples were collected from the river (7 samples from the river bank, seven samples from midway of the river and 6 samples from the far end of the river). Also, five samples were collected from tap waters within the Choba locality for the purpose of comparison. These samples were collected in 1.5 litres containers. Prior to sample collection, the containers were properly washed with detergent and rinsed three times with the sample to be tested to reduce contamination to a very minimal level.

2.6 Sample Measurement

100 ml of each water sample was poured into the measuring cylinder. The two electrodes of the conductivity meter were immersed into the cylinder at opposite ends. The meter was connected to an ac to dc power supply with an output voltage of 10 volts and the corresponding resistance of each measured sample recorded using a Multi-meter. The measurements were taken with the samples maintained at a temperature of 25^oC for easy conversion to total dissolved salt (TDS). The experimental set-up for the laboratory measurement is as shown in Figure 2.

The TDS (in mg/l) was computed using the formula in [6],

$$TDS = 0.64 \cdot K_s \tag{7}$$

The computed results were compared with standard measurements.



Figure 2: Picture showing the experimental set-up for the laboratory measurement of sample conductivity

3.0 Results and Discussion

3.1 Results of Measured Resistance, the Corresponding Conductivity and TDS for the three Segments of Choba River

The results of measured resistance, the corresponding conductivity and TDS for the bank, mid-way and far- end of Choba River have been presented in Tables 1 to 3. The results showed that the TDS ranged between 11.36 mg/l and 16.12 mg/l, 12.97 mg/l and 23.86 mg/l and; 19.88 mg/l and 24.85 mg/l for the three portions of the river respectively. These results were found to be high compared to the measured average conductivity of tap water (5.19 mg/l) from the same surveyed area. These results when compared with previous measurements in Table 4 showed that they are in the same range. Also, both the measured conductivity and TDS of the samples are low compared to the standard limits of 1000 μ S/cm and 500 mg/l respectively, indicating that the surveyed river may not be highly mineralised since the conductivity and thus TDS of water depend on its mineral content.

Table 1: Resistance (R), Conductivity (K) and Total Dissolved Salt (TDS) of Samples from Bank of Choba River Compared with Standard Limits

Sample ID	R (Ω)	K (μ S/cm)	TDS (mg/l)
A	8601.0	21.67	13.87
B	10500.5	17.75	11.36
C	9199.6	20.26	12.97
D	7399.1	25.19	16.12
E	8499.0	21.93	14.04
F	8499.0	21.93	14.04
G	9499.7	19.62	12.56
Tap Water	23000.0	8.10	5.19
Standard Limit [7]		1000	500
Standard Limit [8]		1000	500

Table 2: Resistance (R), Conductivity (K) and Total Dissolved Salt (TDS) of Samples from Mid- Point of Choba River Compared with Standard Limits

Sample ID	R (Ω)	K (μ S/cm)	TDS (mg/l)
H	6800.0	27.41	17.54
I	5000.0	37.28	23.86
J	6900.6	27.01	17.29
K	6200.4	30.06	19.24
L	8400.0	22.19	14.20
M	8800.0	21.18	13.56
N	9199.6	20.26	12.97
Tap Water	23000.0	8.10	5.19
Standard Limit [7]		1000	500
Standard Limit [8]		1000	500

Table 3: Resistance (R), Conductivity (K) and Total Dissolved Salt (TDS) of Samples from Far End of Choba River Compared with Standard Limits

Sample ID	R (Ω)	K ($\mu\text{S}/\text{cm}$)	TDS (mg/l)
O	5400.0	34.52	22.09
P	4800.0	38.83	24.85
Q	5799.1	32.14	20.57
R	5701.6	32.69	20.93
S	5799.1	32.14	20.57
T	6000.8	31.06	19.88
Tap Water	2299.0	8.10	5.19
Standard Limit[7]		100	500
Standard Limit [8]		1000	500

Table 4: Comparison of Maximum and Minimum Values of Present Results Using Constructed and Standard Conductivity Meter (Janeway- 4040 model) with Previous Results. (Alphabets for sample ID's represent the maximum and minimum TDS for the 3 portions of the river).

Sample ID	Present Result (Using Constructed Meter) (mg/l)	Present Result (Using Standard Meter) (mg/l)	% Deviation from Standard	Previous Result (Same Study Area) (mg/l)
B	11.36	11.32	-0.35	5.1- 28.9[5] 20 – 80 [9]
D	16.12	16.08	-0.25	
N	12.97	12.93	-0.30	
I	23.86	23.82	-0.17	
T	19.88	19.90	0.08	
P	24.85	24.88	0.12	
Tap Water	5.19	5.20	0.19	

The measured results using constructed meter when compared with the results using standard meter (refer to Table 4) showed a range of percentage deviation of between – 0.35 % and 0.19 %. The close agreement in the 2 sets of results (using constructed meter and standard meter) is an indication that the constructed conductivity meter can serve as an economic and effective meter for the measurement of salinity (TDS) of water bodies. The present results fall within the same range as previous measurements within the surveyed area.

4.0 Conclusion

A conductivity meter has been constructed and utilised in the laboratory for the measurement of conductivity and salinity of Choba River. The results obtained are in agreement with previous measurements. When the TDS of the samples were measured using standard conductivity meter, there was reasonable agreement between the results using the constructed and standard meters.

This constructed meter can be improved upon and mass-produced to encourage local production of equipment used in the laboratory, enhance local earnings and save cost.

5.0 References

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