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ASSESSMENT OF RAINWATER QUALITY OBTAINED FROM A SUBURBAN AREA IN NIGERIA BASED ON THE PHYSICO-CHEMICAL PROPERTIES

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ABSTRACT

Water is important in the daily activities of living things. The sources could be from the surface or ground. Rainwater is known to be pure, but its use could be reduced due to contaminants due to industrial, agricultural, traffic activities and other natural sources. Many research works have been undertaken on water pollution to provide information on the outcome for use in policymaking and monitoring. The location of this study has little or no information with regards to environmental safety. Therefore, the aim of this study was to assess the rainwater quality (July 2015 - June 2016) with reference to the physicochemical parameters. Standard methods were used in the assessment process. The results showed the mean results as follows: Total Dissolved Solids (TDS - 22.92 mg/L), Temperature (28.58°C), pH (6.83), Electrical Conductivity (EC - 45.3 µS/cm), and Free CO_2 (22.0 mg/L). Statistical analyses (coefficient of variation (%)) depicted high variations in TDS, EC, and Free CO_2.The only pH was skewed to the left. The results compared well with WHO standards and other references used. The present situation at the study location revealed a safe environment, but it is recommended that constant monitoring should be put in place by relevant stakeholders.

1. INTRODUCTION

No doubt water is important in living things man inclusive [1]. Water is obtained in different forms – one of them is rainwater and regarded as pure water with no harmful effects on the environment. For the rainwater to be useful, it has to be devoid of impurities which cause its contamination. Therefore, according to Al Aizari et al., (2017), the quality of water is of profound importance [2]. The quality of water from ground or surface can be influenced at any point by the lithology of the basin, atmospheric, climatic, and anthropogenic inputs [2, 3]. Contaminations of water are from anthropogenic inputs that are man-made from urban, industrial and agricultural activities, traffic, and increasing consumption of water resources) and also from natural processes which include changes in precipitation inputs, erosion, weathering of crustal materials. Contamination of rainwater impairs its use for drinking, industrial, agricultural, recreation or other purposes [4].
Contamination of water is associated with gastrointestinal illness in humans, with nausea, vomiting, and/or diarrhea, pneumonia [5,6], morbidity among young children [7] ,typhoid fever, cholera, hepatitis A, influenza, dengue, and leptospirosis [8].
Part of the 2030 Agenda is Good Health and Well-being (Goal 3) and Clean Water and Sanitation (Goal 6) [9] .These mean that there must be water available for use every time of the year and must be clean and healthy for use. This agenda cannot be achieved if rainwater is not harvested and kept hygienic. Not all waters can be stored especially if contaminated (physically, chemically, and microbiologically) and constant monitoring must be ensured. There are no traces of information on the rainwater obtained in this study area and so before the water here can be harvested and kept for future use, the quality must first be ascertained. It is on this premise our research was based on the harvest of rainwater and thereafter determines the quality based on the physicochemical properties.

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2. MATERIALS AND METHODS

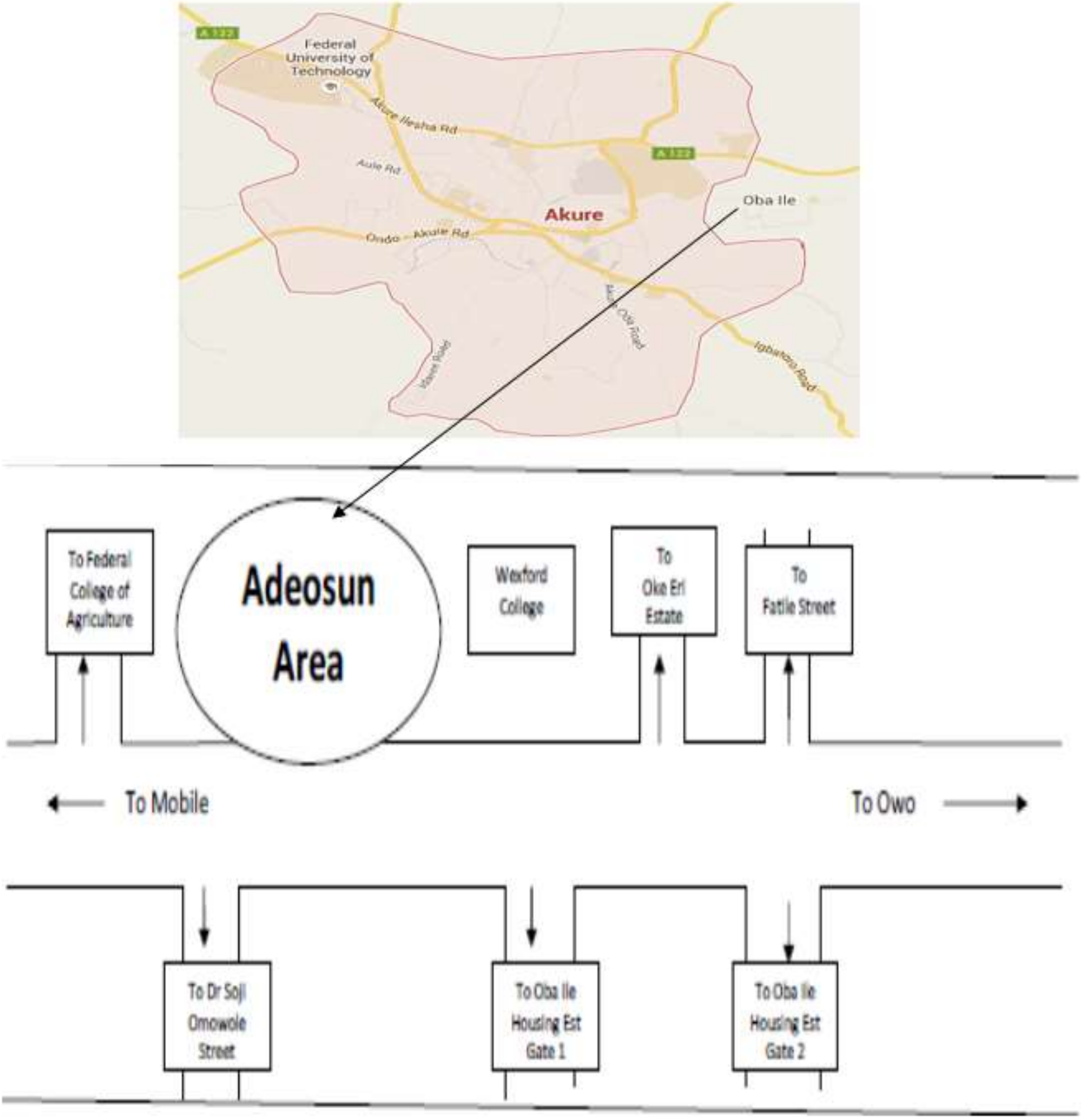

Fig 1. Study Location

The samples were collected in Adeosun area, Oba-Ile, Akure, Ondo State, Nigeria (N07º 15' 42.4' E005º 14' 39.5 ± 9ft). The weather in this area is a tropical climate which is made of rain (April-October) and dry (November-March) seasons. The sampling site was located near a tarred road with medium traffic flow. Adeosun area is located in a suburban area surrounded by agricultural fields, trees, residential buildings, untarred roads for vehicular activities (low traffic), welder workshop, and farms. Samples were collected for a period of twelve (12) months (from July 2015 to June 2016). The rainwater samples were collected once a month, using the sampler, fashioned after the Australian model gauge which was made of high-density polyethylene (HDPE) plastic container (5L), connected to an HDPE funnel. The set-up was placed on the sampling stand 2.0 m above the ground in order to prevent lichen-formation during the sampling period. After a month, the rainwater sample collected was filtered, using quartz filter (47 mm) [10, 11].

The collected sample was subjected to immediate analyses before treatments and storage. The pH was determined using a pen-type pH meter (PH-009 (I)) made in China, TDS, Temperature, and EC were obtained using a pen-type TDS and EC meter (EZ-1) made in China, and free CO_2 and acidity of rainwater samples were subjected to appropriate determinations, using standard methods of analyses [12].
Data obtained (basic descriptions and multivariate analyses) were generated in triplicates and analyzed, using Minitab 16 Statistical Software.

3. RESULTS AND DISCUSSION

Table 1. Basic Description of results

	TDS (mg/L)	Temp (°C)	pH	EC (μS/cm)	Free CO_2 (mg/L)
WHO	20 – 32		6.5-9.5		6-60
Mean	22.92	28.58	6.83	45.3	22.00
SE Mean	8.05	0.36	0.12	15.7	2.30
StDev	27.90	1.24	0.43	54.4	7.95
CoefVar	121.73	4.34	6.31	120.24	36.16
Minimum	2.00	27.00	5.90	4.00	8.00
Maximum	75.00	31.00	7.40	146.00	40.00
Q1	5.00	28.00	6.53	10.00	18.50
Q3	47.75	29.75	7.25	95.5	24.00
Skewness	1.24	0.63	-0.61	1.22	0.49
Kurtosis	-0.16	-0.34	0.42	-0.24	2.07

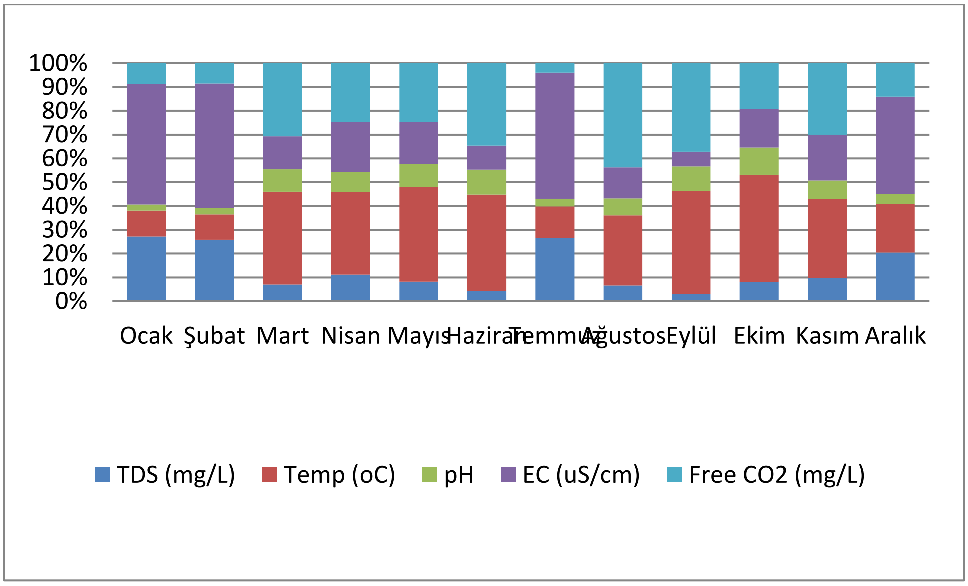

Fig 2. Results of the physico-chemical parameters

The basic description of the results is shown in Table 1 and Fig 2. The mean Total Dissolved Solids (TDS) in mg/L was 22.92 with a standard error of 8.05. The results compared with the results of 0.7-45.00 mg/L obtained for harvested rainwater samples in Abeokuta, Nigeria [13]. The reason for the comparison is because the climates of the two areas are the same. Also, it could be because the two areas are surrounded by mountains and hills. However, the two results were within the WHO limit [14]. July (20%) and December (11%), 2015 had the highest percentage of TDS and the same applied in January (27%) and February (26%), 2016 (Fig 3). The high concentration of TDS can have an influence on the taste and hardness of water. It is an indicator of the presence of contaminants (Fe, Mn, Br, As, and SO_4) [15]. The temperature values were between 27 and 31°C. Although the values obtained varied with time of water collection, there were not many variations in the results as shown by the coefficient of variation (4.34). The dry seasons showed high results due to little or no rainfall. The temperatures within these periods were normal for farming and human activities. A temperature higher than this could lead to heat exhaustion, fainting, heat swelling, and heatstroke. WHO has recommended 20-32°C (Kumar 2016). The pH ranged between 5.90 and 7.40 with an average of 6.83. Out of the 12 rain events, one event was obtained in acidic medium (< 5.9) which happened in December. The results obtained in this study were in agreement with those other research works conducted in Turkey [17] and Ireland [18]. The pH values depicted that the prevailing activities of the surrounding did not have any significant effect on the pH of the water samples. Budiwati et al. (2016) reported pH of 3.57 to 6.55 during 2000-2010 in Indonesia. During these periods the mean value was above 5.6 and a region suffered acid rain, the main reason was the forest fire which occurred in 2006 [18,20]. Electrical conductivity (EC (µS/cm)) was generally low ranging from 4-146 µS/cm with a mean value of 45 µS/cm, the skewness 1.22, and Kurtosis -0.24. The skewness showed that the mean was higher than the median. For comparison, the conductivity of the Brisbane municipal supply is approximately 400 µS/cm which was higher [21] than our values, but the two countries' results were low. The implication of this could be that the presence of positive ions (inorganic dissolved solids) in the water samples may not be much in terms of quantity, but the samples will conduct electricity. July (20%) and December (11%), 2015 had the highest percentage of the EC and the same applied in January (26%) and February (27%), 2016 (Fig 2). Free CO_2 is known to be the carbon dioxide that is present in the environ. When this comes in contact with rainwater, carbonic acid is formed. It is good to note that the Free CO_2 obtained in this worked was lower than 6-60 mg/L set by WHO. The presence of Free CO_2 in the study area could due to the traffic. Fear of acid rain is eliminated, but constant monitoring of the area should be ensured. August (15%) and November (11%), 2015 had the highest percentage of Free CO_2 and the same applied in January (9%) and February (9%), 2016 (Fig 3).

Table 2. Correlation matrix of results

	TDS	Temp	pH	EC	Free CO_2
TDS	1				
Temp	0.256	1			
pH	0.877	0.146	1		
EC	0.000	0.264	0.863	1	
Free CO_2	0.575	0.647	0.870	0.558	1

Table 2 depicted the Pearson correlation coefficient analysis of the parameters determined. There are strong correlations between pH and TDS (R=0.87), EC and pH (R=0.86), and Free CO2 and pH (R=0.87), while weaker correlation was observed for Free CO2 and Temperature (R=0.64). CO_2, pH, alkalinity, and hardness have effects on rainwater quality [22]. Carbon dioxide rarely causes direct toxicity, but the acid formed when in contact with water lowers the pH of the surroundings. Wurts and Durborow, (1992) showed that high CO_2 concentrations are almost always accompanied by low dissolved oxygen concentrations [22].

Table 2. The Principal Component Analysis (PCA) results

Variable	PC1	PC2	PC3
TDS	**0.629**	-0.209	0.169
Temp	0.399	**0.529**	-0.007
pH	0.186	**0.625**	**-0.527**
EC	**0.628**	-0.212	0.158
Free CO_2	-0.128	0.492	**0.818**
Eigenvalue	2.276	1.383	0.890
Variance (%)	45.5	27.7	17.8
Cumulative (%)	45.5	73.2	91.0

The Principal Component Analysis (PCA) results are shown in Table 3. The number of principal components (PC) was determined by the size of the eigenvalue greater than 0.8. The PC1 component was strongly correlated with TDS and EC. The meaning of this is that TDS and EC varied together. The second (PC2) increased with Temperature (0.529) and pH (0.625). PC3 increased with Free CO_2 (0.818), while the opposite pH (-0.527). The percentage of the total variance of PC1 is 45.5%, PC2 accounted for 27.7%, and PC3 had 17.8%. The variances could have been due to anthropogenic, biomass burning, and agricultural activities respectively in the surrounding area.

The time trend plots of the parameters within the study year (2015-2016) are shown in Fig 4. There is no primary standard for TDS set by the WHO, but it has its secondary standards to be 500mg/L. Over the time frame of the study, the annual mean recorded was 22.92mg/L. This value was lower than the WHO standards. The trend in this study showed that January 2016 had the highest value, while September 2015 had the least. Free CO_2 highest value occurred in August 2015 while the same year had the least. The two values were well above and below (respectively) the fits line. The same behavior occurred to pH, EC and temperature parameters. These observations were influenced by the anthropogenic, burning of biomass and agricultural activities.

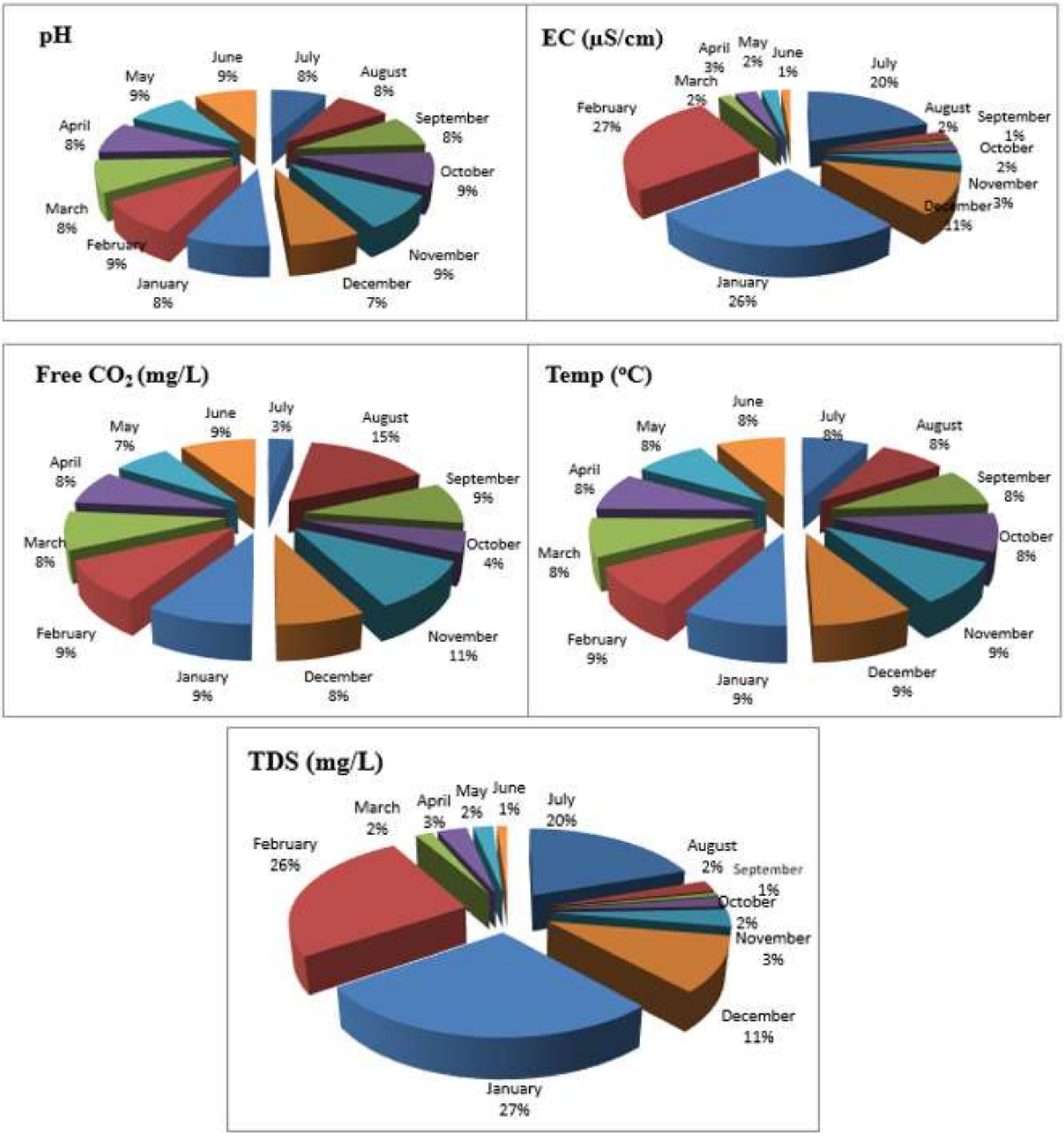

Fig 3. The percentages of parameters for the months

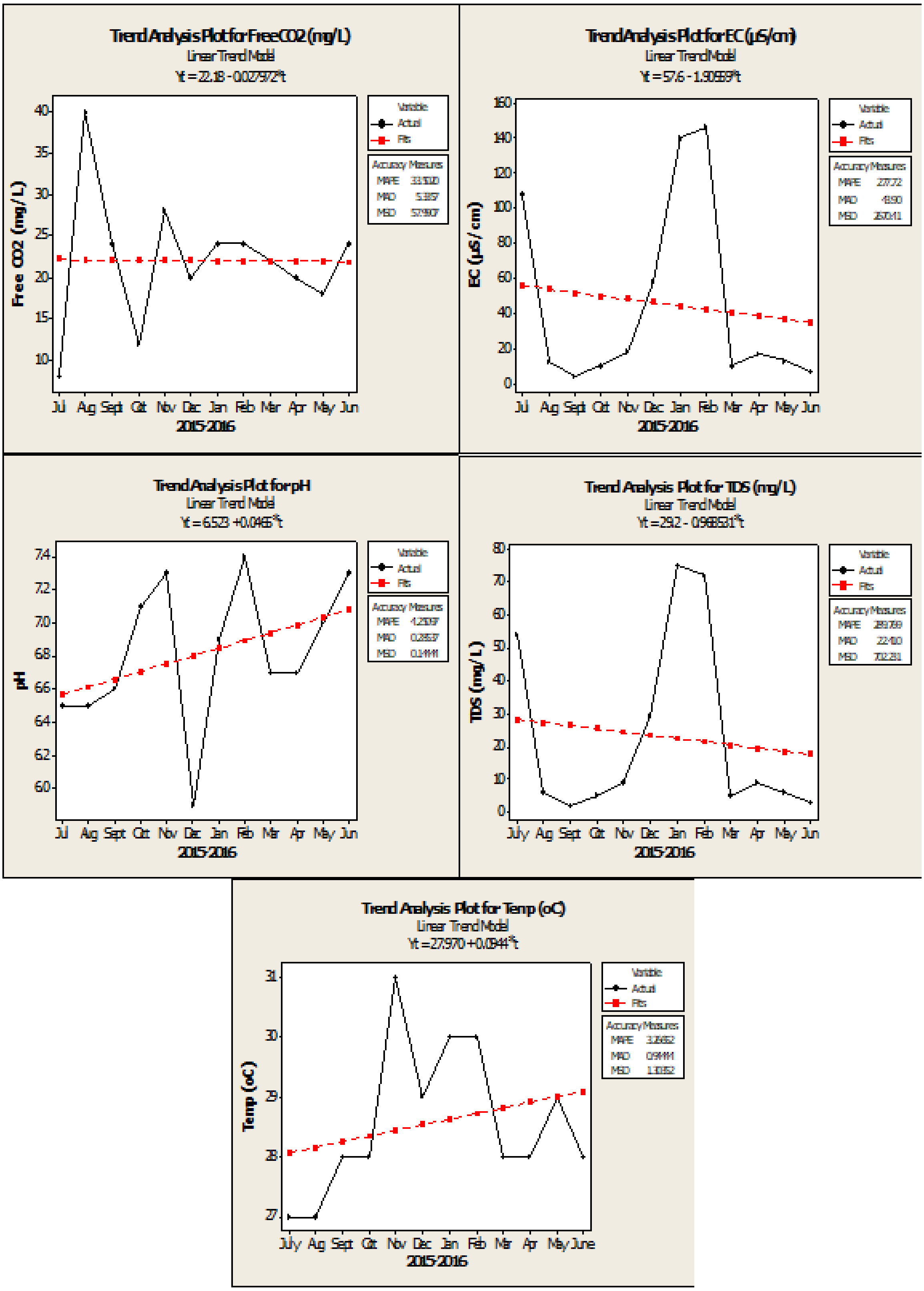

Fig 4. Trend Analysis results of the parameters

4. CONCLUSIONS

The samples were collected for twelve months at a monthly interval. The analyses were performed using standard methods. The results obtained showed that the parameters were within the recommended limits. The highest results for Free CO_2, pH, and temperature recorded in 2015 may be due to the little rainfall recorded. Anthropogenic, biomass burning and farming activities could have influenced the results. From the results, there may be no cause for alarm with regards to pollution of the study location.

Though the results obtained were within the standard limits, but it is recommended that constant checks should be made within the vicinity so as to avoid environmental contaminations or pollution.

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