Contribution of Physico-Chemical Parameters of Water Bodies to Taxonomy, Distribution and Diversity of Phytoplankton within Kaduna Metropolis, Nigeria

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Abstract
The physico-chemical parameters in Nigerian Defence Academy (NDA) stream, Government Technical College (GTC) stream and school of agriculture, Ahmadu Bello University (ABU) dam, Mando in Kaduna State, Nigeria were studied for a period of six months (November 2012 to April 2013) using standard sampling methods. The research is aimed at assessing the physico-chemical parameters of some micro environments within Kaduna metropolis. Temperature, transparency and pH were recorded *in-situ*. Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Total dissolved solids (TDS), electrical conductivity (EC), phosphate and nitrate. The study showed remarkable variations of physico – chemical parameters and significant difference in the sampling sites ($p < 0.05$). The values obtained fell within permissible range for domestic and pisciculture.
Keywords: Physico-chemical parameters, water bodies, Kaduna, Nigeria.

1. Introduction

Water quality can be monitored either by direct measurement of both the physical and chemical parameters of water or by analyzing the inhabiting biota. The quality of an aquatic ecosystem is dependent on the physico - chemical qualities of water and the biological diversity of the system (Irfanullah, 2006).

Many studies have been carried out on the physico-chemical parameters of Northern waters by Ibrahim *et al.,* 2009 on Kontagora reservoir ; Kemdirim , (2001), on Shendam Reservoir in Plateau state. Other works on physico-chemical parameters include Idowu *et al.,* 2013 on Ado-Ekiti reservoir; Davies *et al*, 2009, on Elechi creek, Niger Delta; Zakariya *et al*., 2013, on Lower Niger River and Akoma (2007) on Imo River estuary. The present study was conducted to determine the physicochemical parameters of some aquatic environments within Kaduna metropolis and reveal the state of the water bodies in terms of domestic use and animal activities.

2. Materials and Methods

2.1 Study Area

This research was carried out within areas in Kaduna metropolis, Kaduna State, Nigeria. Kaduna metropolis is located within the Guinea savannah of Latitude 10°31′23″N and Longitude 7°26′25″E with distinct seasons. Kaduna occupies a central position in Northern Nigeria.

2.2 Sampling Sites

Water samples were collected from three sampling collection sites (Figure 1) monthly from November 2012 – April 2013, with corked specimen bottles.

- Site A (N 10^{O}36.225'E 007^{O}23.025') – Nigerian Defence Academy (NDA) Stream, Afaka is on agrarian FADAMA used for farming particularly rice. This is because of rice padding; pesticides and herbicides are used as fertilizers. It is a lotic ecosystem with the stream following a meandering course which leads to the slow speed of the stream.
- Site B (N 10^{O}33.145'E 007^{O}28.142')- within Government technical college (GTC), Malali is an urbanized stream serving as run-offs to the major river Kaduna and collector domestic wastes from houses in adjoining communities. It is also a lotic ecosystem.
- Site C (N 10^{O}35.521'E 007^{O}25.362') – ABU , school of Agric dam, Mando is a lake created by impoundment of the flowing stream by earth dam. It is a lentic ecosystem used primarily for irrigation and cattle rearing.

2.3 Determination of Physico-Chemical Parameters

The Surface water pH and water temperature were measured in degree Celsius (^{O}C) using portable HANNA instrument model HI 8424. The meter probe was inserted into the water at each sampling station. The values were read and recorded as displayed on the calibrated meter. The transparency of water was measured using a Secchi disc. (Temperature, secchi disc transparency, pH were measured *in-situ*).

The TDS and conductivity of the water samples was measured in µS/cm by using the conductivity meter (model pHOX 52). The Azide Modification of the Winkler method as described by American Public

Health Association (APHA, 1985) was used to determine the dissolved oxygen.

Dissolved Oxygen (DO) & Biochemical Oxygen Demand (BOD): 3 light bottles and 3 dark bottles were needed monthly for DO and BOD parameters for the sampling stations following the Azide Modification of the Winkler method as described by American Public Health Association (APHA, 1985). All samples in the light bottles were immediately fixed (DO). To 300ml of the water sample collected, 2ml of Manganous chloride solution was added followed by addition of 2ml of alkali-iodide-azide reagent

The mixture was stoppered carefully to exclude air bubbles and mixed by inverting the bottle a few times. Two (2ml) of concentrated tetraoxosulphate(vi) acid was added, restoppered and mixed by inverting several times until dissolution was completed. 100mL of the treated sample was titrated with sodium thiosulphate (0.025N) to a light yellow colour. Then 1ml of 1% Starch (indicator) was added turning the sample dark blue. Titration continued until the disappearance of the blue colour. The volume of the thiosulphate used is equivalent to the milligram of the dissolved oxygen per litre.

The (five- day) BOD of water is the amount of dissolved oxygen taken up by bacteria in degrading oxidizable matter in the sample, measured after 5 days incubation in the dark at 20°C. The BOD is simply the amount by which the DO level has dropped during the incubation period and also gives a direct measure of primary productivity. (EPA 2001)

Nitrate NO_3^- (mg/l) and phosphate PO_4^{3-}(mg/l) were analyzed at the National Water Resources Institute (NWRI), Water Quality Laboratory, Mando, Kaduna. Water samples were measured in mg/l by using the Wagtech photometer model 7100.

2.4 Statistical Analysis

The physicochemical parameters determined were subjected to Pearson's correlation coefficient which was calculated to determine a relationship among the physico - chemical characteristics of water of the three sampling sites as seen on Table 2.

3.0 Results

Maximum and minimum values of the physico – chemical parameters of sampling sites are presented on Table 1.

pH - pH is a measure of whether the water bodies are acidic or alkaline. The maximum value of pH was recorded as 8.35 in the month of January at the NDA stream and minimum 6.73 in month of November at the GTC sampling site.

Conductivity - Also referred to as *electrical conductivity*. It is an expression of its ability to conduct an electric current. It is also the best indicator of water pollution as conductivity is the indirect measure of total dissolved solids or nutrients (Pandey *et al,* 2012). The maximum value was found to be 6.5×10^2 µS/cm in March at site C and minimum value of 0.8×10^2 µS/cm in April at site C.

Secchi Transparency - This is a reflection of the overall quality of water, indicating the presence or absence of suspended matter, living or inert. The water was found most turbid at 0.825m in November at sampling site A while minimum turbidity was 0.00m in December, February and March; December to March at sampling sites A and B respectively.

Temperature - Water plays an important role in governing the growth of organisms ultimately the water quality (Pandey et al, 2012). The maximum temperature recorded was 31.3 °C in April at the sampling site A and minimum 20.2 °C in December at the same sampling site, during the period of harmattan in Kaduna.

DO (Dissolved Oxygen) - The maximum value recorded 16.85 mg/l in November at the NDA site and minimum 3.90mg/l in March at GTC sampling station. The sanitary significance is critical for the survival of animal life (fish), but generally true that if water quality is suitable for fish it will also meet the criteria for most other beneficial uses and be of good ecological status.

BOD - Biological Oxygen Demand is the amount of oxygen utilized by microorganisms in stabilizing organic matter. In the NDA site, BOD was recorded maximum 10.1mg/l in November and minimum 0.1mg/l in April at the GTC site.

Total Dissolved Solids - showed highest value of 4.5×10^1 mg/l in month of March at the impounded lake and minimum with 0.5×10^1 mg/l in April at the same sampling site.

Nitrate (NO_3^-) - nitrates and phosphates are good indicators of eutrophication. During this study, the minimum and maximum values of nitrate are 0.088mg/l in March at site C and 346.7mg/l in January at sampling station B respectively.

Phosphate (PO_4^{3-}) -. The minimum and maximum values of Phosphate are 0.00mg/l in most of the months throughout the sampling sites and 531mg/l in April at site C respectively.

Pearson's Correlation

The correlations indicate the degree of similarity or dissimilarity in conditions of the variables.

DAM and GTC – Positive correlation is observed with pH, DO, TDS, BOD, TEMP, NO_3^- and PO_4^{3-} but negatively correlated to EC and SDT. The correlation was equally highly significant to Temp (r = 0.9317), PO_4^{3-}

(r = 0.874), DO (r = 0.7886) and pH (r = 0.7769). These correlations are not statistically significant. TDS (r = 0.2206), BOD (r = 0.0236), EC (r = -0.6395) and SDT (r = -0.5181).
DAM and NDA – Positive correlation is observed with NO_3^- , EC, SDT, pH, TEMP, DO and BOD while correlating negatively with TDS and PO_4^{3-} . These correlations are statistically significant, with DO (r = 0.9218) and BOD (r = 0.9581) while these are not statistically significant, NO_3^- (r = 0.665), SDT (r = 0.7260), EC (r = 0.2595), pH (r = 0.6379), TEMP (r = 0.7412), TDS (r = -0.6252) and PO_4^{3-} (r = 0.4160).
GTC and NDA – Positive correlation is observed with TEMP, BOD, NO_3^-, DO and pH and correlated negatively with SDT, TDS, PO_4^{3-} and EC. A highly statistical difference was observed with DO (r = 0.9354), pH (r = 0.9148), TDS (r = -0.8575) and EC (r = -0.8632) but no statistical significance with TEMP (r = 0.7415), BOD (r = 0.0737), NO_3^- (r = 0.1650), SDT (r = -0.0559) and PO_4^{3-} (r = -0.611).

4.0 Discussions

The variation and significant differences in physicochemical parameters of the water bodies indicate different environmental conditions. These variations may be related to temperature, rainfall (Ayoade et al 2006, Oso and Fagbauro, 2008 and Idowu *et al* 2013). Water temperature plays an important role in governing the growth of organisms ultimately the water quality (Pandey et al, 2012).

In this study, the maximum temperature recorded was in April and can be attributed probably to low relative humidity, high atmospheric temperature and reduction in the amount of suspended particles. Lowest values recorded in December, during the period of harmattan in Kaduna for that year. This can be attributed to the cooling effect of harmattan and high relative humidity. Adebayo (1993) made similar observation of recording lowest temperature during harmattan in Ado- ekiti. The excessive amount of nutrients in water bodies along with higher temperature favors the growth of algae and aquatic weeds. This result agrees with previous reports that temperatures in tropics vary between 21^{o}c and 32^{o}c (Idowu *et al* 2013; Ayoade et al 2006; kamran et al., 2003).

Water pH recorded were found between 6.73- 8.35, indicating that the water is near neutral and alkaline range. The values fell within suitable range of 6.5-9.0 for fish production (EPA, 2001) and within the range for inland water, (6.5-8.5) as reported by Antoine and Al-saadi (1982). Boyd and Lichtkoppler (1979), reported the pH range of 6.09 – 8.45 as being ideal for supporting aquatic life including fish. The result corroborates with reports by Idowu *et al* 2013 and kamran et al., 2003 which pose no health / sanitary consequences to humans as well.

Secchi Transparency of water was found most turbid in November. It could be due to decrease in sunlight intensity due to presence of heavy cloud in the atmosphere, which in turn reduced the quantity of light reaching the water (Anetekhai, 1986; Oso & Fagbuaro 2008) thereby decreasing light penetration. Minimum turbidity was observed in December, February and March (a higher transparency) which could be due to reduction in allochthonous substances that find their ways into the reservoir (Ikom *et al.,* 2003, Kemdirim (1990) and Ibrahim *et al* 2009). Similar observations were made by Adebisi (1981) in Upper Ogun River, Egborge (1981) in Asejire Reservoir.

Conductivity and accumulation of minerals varied considerably depending on the season and on the water body (Baijot *et al*., 1997). The maximum value was found to be in March. The higher conductivity value obtained could be as a result of reduced water volume and the rich nutrient content of the lake which is consistent with Ibrahim *et al* 2009, Chia et al., 2011 and minimum value in April high water value. Values falling within acceptable limits of EPA, 2001 and NIS 2007 standards, there are no direct significance or health impacts of the results obtained. Monthly variations in Conductivity at the different sampling sites may have been due to the types of human activities in the catchment, and to the extent of usage of the ponds for irrigation. Electrical conductivity is dependent on the nature of substances dissolved, not necessarily their amount (Chapman and Kramer 1991, Akin-Oriola 2003, Chindah and Braide 2004).

The highest value for dissolved oxygen was recorded in November. The high oxygen value for the period coincides with periods of lowest turbidity and temperature. The amount of dissolved oxygen in water has been reported not constant but fluctuates, depending on temperature, depth, wind and amount of biological activities such as degradation (Adeniji, 1973; Ibe, 1993). In the cool harmattan wind which increases wave action, and decrease in surface run offs might have contributed to the increase in oxygen concentration while the torrential rains, creates increased turbidity and decreased oxygen concentration during the rainy season. Oniye *et al*., (2002), made similar observation for Zaria dam and Kemdirim (2005) in kangimi reservoir. The lowest value was recorded in March which fell below the acceptable limit stipulated by EPA 2001. Concentrations below 5mg/l adversely affect aquatic life (DFID, 1999).

Biological Oxygen Demand is the amount of oxygen utilized by microorganisms in stabilizing organic matter. For WHO, 2002 and EPA, 2001, the stipulated guidelines are 5 and $\leq$ 5 respectively. The BOD levels observed in the sampling sites are below the acceptable limits although the month of November in two of the sampling stations are above the limits. Samples with high values might have direct health implications (EPA, 2001), but it's an important indicator of overall water quality. Consequently, the generally low BOD values observed may be as a result of the nature of the effluent discharged into the water system that places low demand for oxygen present in the water system. Israel (2008) made similar observations.

In natural water, dissolved solids are composed mainly of solutes like carbonates, chlorides, iron, manganese, sodium, calcium etc (Esmaeili, 2005). In present study, TDS showed highest in the dry season which is similar to the work of Chia *et al* 2011. The excess amount might principally have organoleptic implications, disturb ecological balance and cause suffocation to aquatic fauna (Pandey *et al*, 2012).

Nitrates and phosphates are good indicators of eutrophication. Phosphorus along with Nitrogen causes explosive growth of algal species (Pandey *et al* 2012. During this study, the highest value of nitrate was recorded in January and lowest in March. This allows us to notice that the minimum rates of nitrate obtained is lower than the standard required which are in the order of 50mg/l (chergui *et al*, 2013) and maximum higher than the standard limit. This agrees with Ibrahim *et al,* 2009; Ufodike *et al* 2001) stating that high nitrate concentrations in lake is related to oxidation of ammonia, agricultural run- offs, decomposition of organic matter. The maximum value for Phosphate was recorded in April. A number of authors have reported that inorganic fertilizers are washed into standing water bodies from the farms that surround them (Branco and Senna 1996, Brenner et al. 1999, Butzler 2002, Dublin-Green et al. 2003). This agrees with our findings, as higher values for the nutrient was recorded in the month with rainfall and farming activities. Farmers use inorganic fertilizers to fertilize their farms. Some of these fertilizers are highly likely to be washed into the pond whenever there is a heavy downpour.

The correlations indicate the degree of similarity or dissimilarity in conditions of the sites. Positive correlation was observed between sampling sites *ABU* and *GTC* with $_{P}$H, DO, TDS, BOD, TEMP, NO_3^- and PO_4^{3-} but negatively correlated to EC and SDT. The correlation was equally highly statistically significant ($p < 0.05$) to Temp, PO_4^{3-} , $_{P}$H and DO while TDS, BOD, EC, NO_3^- and SDT are correlations not statistically significant. *ABU* and *NDA* sites showed a positive correlation with $_{P}$H, EC, SDT, TEMP, and DO, BOD and NO_3^- while correlating negatively with TDS and PO_4^{3-} . The correlations highly statistically significant ($p < 0.05$) to the sampling sites are DO and BOD while pH, EC, SDT, TEMP, TDS , PO_4^{3-} and NO_3^- are not statistically significant. Sites *GTC* and *NDA* showed a positive correlation with pH, TEMP, DO, BOD, NO_3^- , PO_4^{3-} and correlated negatively with EC, SDT and TDS. A highly statistical difference ($p < 0.05$) was observed with $_{P}$H, EC, DO and TDS and but no statistical significance with SDT, TEMP, BOD, NO_3^- and PO_4^{3-}. Sampling sites showing statistical differences indicates the degree of dissimilarity between the sites as regards the physicochemical parameters while sites with no statistical significance indicate the similarity between the different water bodies.

Conclusion

This study shows remarkable variations of physico – chemical parameters and significant difference in the sampling sites ($p < 0.05$) which can influence living organism especially phytoplanktons. It can be concluded that the water bodies might pose threat to the health of both aquatic life and individuals coming into contact with it. It is recommended that controlling nutrient loading through reduced fertilizer use, improved animal waste control, and improved sewage treatment may reduce the number of toxic substances. Careful monitoring and early detection of water characteristics could allow time to initiate actions to prevent or reduce mortality.

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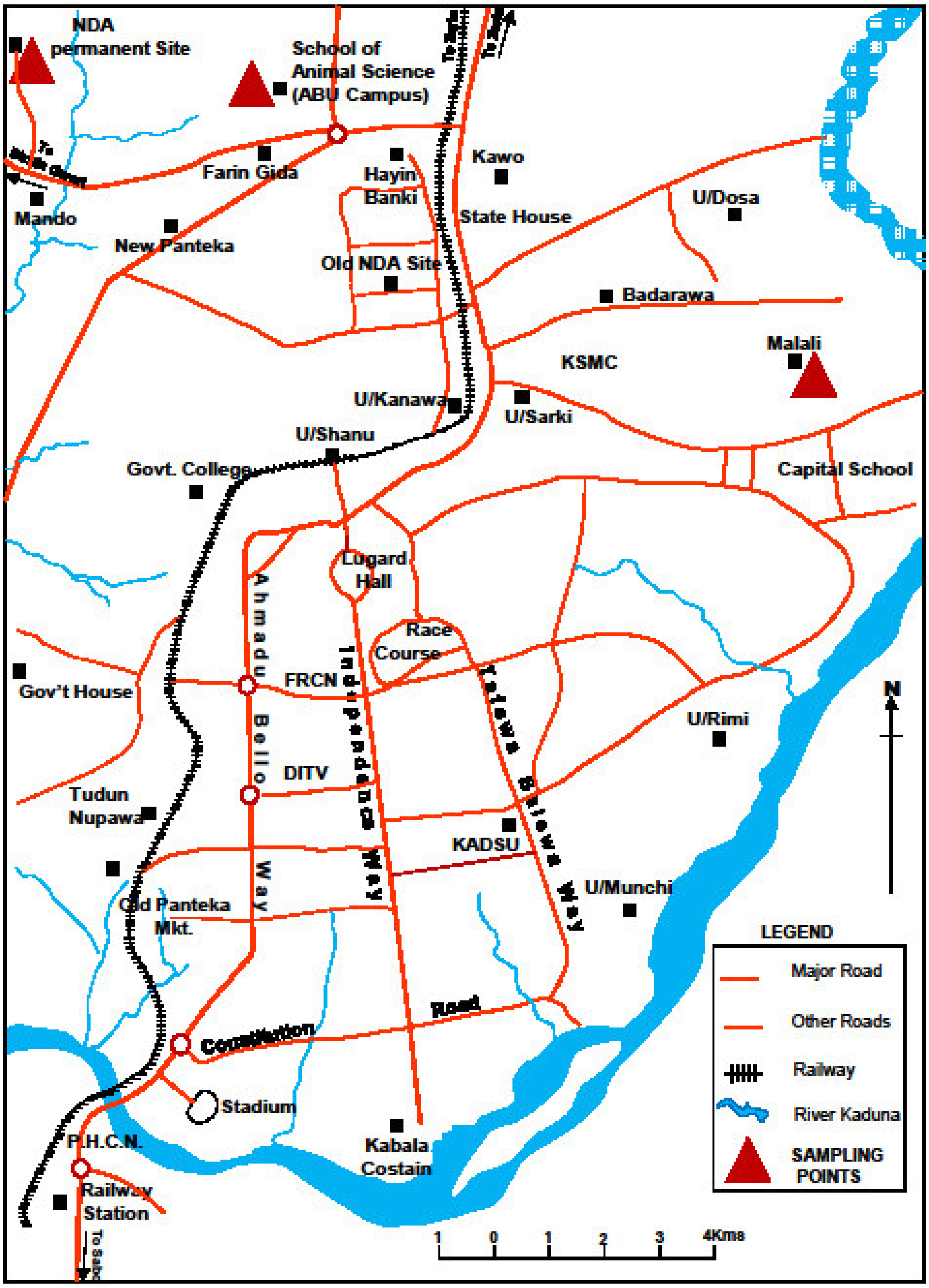

FIG. KADUNA NORTH LOCAL GOVERNMENT AREA SHOWING THE LOCATION OF SAMPLING POINTS
Source: Geo. Dept. NDA Kaduna, 2013.

Table 1: Physico – Chemical Characteristics of Water of NDA, GTC and ABU Sampling Sites.

Physico chemical characteristics	Statistical summary					Standard limits		
	Min	Max	Ave	Var	SD	NIS	EPA	WHO
NDA								
1. pH	6.74	8.35	7.50667	0.435947	0.660263	6.5 – 8.5	5.5 -9.0	6.5 – 8.5
2. EC (µs/m)	130.0	580.0	425.0	25390.0	159.342	1000	1000	180 - 1000
3. SDT (m)	0.0	82.5	17.9167	1101.04	33.1819	NA	≥ 1	NA
4. T (°C)	20.2	31.3	24.6	24.092	4.90836	NA	25	25 – 30
5. DO (mg/l)	5.5	16.85	9.25	17.272	4.15596	NA	≤ 7	5
6. BOD (mg/l)	0.6	10.1	3.10	12.257	3.501	NA	≤ 5	5
7. TDS	9.0	40.0	29.333	120.667	10.9848	500	NA	500
8. NO_3(mg/l)	1.584	156.6	52.327	3366.256	58.019	50	50	50
9. PO_4^{3-} (mg/l)	0	81.1	33.883	1592.634	39.9078	NA	0.5-0.7	0.2
GTC								
10. pH	6.73	7.75	7.305	0.10887	0.329955	6.5 – 8.5	5.5-9.0	6.5 – 8.5
11. EC (µs/m)	290.0	480.0	343.333	5306.67	72.8469	1000	1000	180 - 1000
12. SDT (m)	0.0	35.2	22.15	150.151	12.2536	NA	≥ 1	NA
13. Temp (°C)	21.8	28.9	25.9833	6.73367	2.59493	NA	25	25 – 30
14. DO (mg/l)	3.9	9.05	6.2	2.84	1.68523	NA	≤ 7	5
15. BOD (mg/l)	0.1	4.45	1.86667	2.21167	1.48717	NA	≤ 5	5
16. TDS	20.0	34.0	24.0	28.4	5.32917	500	NA	500
17. NO_3(mg/l)	33.9	346.7	145.676	181789.9	426.3684	50	50	50
18. PO_4^{3-} (mg/l)	0	405.0	101.866	28856.51	169.872	NA	0.5-0.7	0.2
ABU								
19. pH	7.01	8.25	7.68333	0.228947	0.478484	6.5 – 8.5	5.5 -9.0	6.5 – 8.5
20. EC (µs/m)	80.0	650.0	456.667	40706.7	201.759	1000	1000	180 - 1000
21. SDT (m)	37.5	48.0	42.3833	14.1937	3.76745	NA	≥ 1	NA
22. Temp (°C)	20.6	29.5	25.3833	14.0537	3.74882	NA	25	25 – 30
23. DO (mg/l)	7.5	13.5	10.1667	4.14567	2.03609	NA	≤ 7	5
24. BOD (mg/l)	2.9	8.25	4.29167	3.98142	1.99535	NA	≤ 5	5
25. TDS	5.0	45.0	31.8333	204.167	14.2887	500	NA	500
26. NO_3(mg/l)	0.088	192.7	61.936	5850.243	76.487	50	50	50
27. PO_4^{3-} (mg/l)	0	531	88.5	46993.5	216.78	NA	0.5-0.7	0.2

Key; SDT – Secchi Disc Transparency, EC- Electrical Conductivity, NA- Not Available, NIS- Nigerian Industrial Standards, EPA- Environmental Protection Agency, WHO- World Health Organization.

Table 2: Pearson's Correlation P – Values for the Pairs of Variables (Sampling Sites)

Physico chemical characteristics	Sampling sites		
	NDA	GTC	DAM
1. **pH** - NDA	--------	0.0106 **(0.9148)**	0.1729 (0.6379)
- GTC	0.0106 **(0.9148)**	----------	0.0691 **(0.7769)**
- DAM	0.1729 (0.6379)	0.0691 **(0.7769)**	----------
2. EC - NDA	…………..	0.0268 **(-0.8632)**	0.6196 (0.2595)
- GTC	0.0268 **(-0.8632)**	…………..	0.1715 (-0.6395)
- DAM	0.6196 (0.2595)	0.1715 (-0.6395)	…………….
3. **SDT** - NDA	…………….	0.9163 (-0.0559)	0.1023 (0.7260)
- GTC	0.9163 (-0.0559)	…………..	0.2924 (-0.5181)
- DAM	0.1023 (0.7260)	0.2924 (-0.5181)	…………….
4. **TEM** - NDA	………….	0.0916 (0.7415)	0.0918 (0.7412)
- GTC	0.0916 (0.7415)	………….	0.0068 **(0.9317)**
- DAM	0.0918 (0.7412)	0.0068 **(0.9317)**	……………
5. **DO** - NDA	…………….	0.0061 **(0.9354)**	0.0089 **(0.9218)**
- GTC	0.0061 **(0.9354)**	…………..	0.0623 **(0.7886)**
- DAM	0.0089 **(0.9218)**	0.0623 **(0.7886)**	…………
6. **BOD** - NDA	……………	0.8897 (0.0737)	0.0026 **(0.9581)**
- GTC	0.8897 (0.0737)	……………	0.9645 (0.0236)
- DAM	0.0026 **(0.9581)**	0.9645 (0.0236)	………….
7. **TDS** - NDA	……………..	0.0290 **(-0.8575)**	0.1844 (-0.6252)
GTC	0.0290 **(-0.8575)**	……………..	0.6744 (0.2206)
DAM	0.1844 (-0.6252)	0.6744 (0.2206)	………………
8. **NO_3^-** - NDA	………………	0.7450 (0.1650)	0.1490 (0.6650)
GTC	0.7450 (0.1650)	……………….	0.1030 (0.7250)
DAM	0.1490 (0.6550)	0.1030 (0.7250)	………………..
9. **PO_4^{3-}** - NDA	……………….	-0.6110 (0.1980)	0.4120 (-0.4160)
GTC	-0.6110 (0.1980)	………………..	0.0230 **(0.8740)**
DAM	0.4120 (-0.4160)	0.0230 **(0.8740)**	………………….

r – Values in bold parentheses are statistically different ($p < 0.05$).