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Seasonality Assessment of Abattoir Waste Impact on Water Quality of Anwai River in Nigeria

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ABSTRACT Water is a very important environmental resource to all organisms. Therefore, guiding against the influx of pollutants into it is necessary. This study assesses the environmental and seasonality impact of abattoir waste on water quality of Anwai River in Nigeria. Experimental design was adopted, while systematic sampling technique was employed to divide the river into downstream (DS) and upstream (US) for samples collection. 24 samples were collected for 6 different months and analysed for physico-chemical properties (PCP) using standard laboratory procedures. Statistical analyses of data involved graphs, mean (μ), standard deviation (S^2), standard error of mean (SEM) and t-test statistics. Findings show that PCP of water varied across months and seasons, as well as between the DS (with μ, S^2, SEM =16.21, 26.58, ±6.10; and 18.40, 26.80, ±6.15 for rainy and dry seasons) and US (with μ, S^2, SEM =10.69, 13.59, ±3.12; and 13.61, 18.39, ±4.22 for rainy and dry seasons). In both rainy and dry months, DS recorded higher temperature, acidity, electrical conductivity (EC), total dissolve solid (TDS), total suspended solids (TSS), nitrate, phosphate, calcium (Ca), sodium (Na), magnesium (Mg), ammonia (NH_3), potassium (K) and total coliform (TC). There is no significant difference in the water quality between the rainy and dry seasons for both DS and US sections at 5% confidence level. Therefore, abattoir waste should be properly treated before disposal into rivers, while river waters should not be consumed directly without treatment.

KEY WORDS Abattoir waste; physico-chemical properties; seasonal variation; water resources.

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INTRODUCTION

Water pollution is becoming a continuous concern within the developing regions of the world. As a problem, it is becoming complex in the face of rapidly increasing human population, poor implementation of environmental laws guiding human existence, as well as understanding of the trends and patterns of climatic change (Ukoji & Ndakara, 2021). Rivers, seas and oceans being major parts of the environment may vary in their water qualities and component characteristics because of the presence of foreign bodies in the water. Aside the presence of foreign bodies in the water, seasonality may cause changes in the contents of water basic components (Kosamu et al., 2011; Barakat et al., 2016). For instance, water pH and turbidity can vary and constantly change as the water body is exposed to change in temperature due to time variation (Ohwo & Abotutu, 2014; Ndakara & Eyefia,

2021) and varying solar radiation received by the water body (Elemile et al., 2019).

Undoubtedly, abattoir waste (AW) represents an important and direct source of both surface and groundwater contamination in developing countries, especially in Nigeria since abattoirs are mainly sited near river bodies, in attempts to have near and close access to water for the processing activities. Terrumun & Oliver (2015), Njoku-Tony et al. (2018) reported that AWs are dangerous because they contain heavy metals, viruses, bacteria, organic matter and several micro organisms and sediment.

All over the world, abattoirs are known to pollute the environment either directly or indirectly from their various processes (Adelegan, 2002; Elemile et al., 2019). Direct pollution occurs when the waste is emptied into water and land surfaces without pre-treatment due to absence of facilities; while indirectly, pollution occurs when the waste is carried from the abattoirs' dumpsite by run off into the water bodies or the neighbouring environment (Ukoji & Ndakara, 2021). Like any other wastes, AW, when not properly managed and disposed, can pose environmental and human health hazards (Ohwo & Ndakara, 2022).

At the rates meats are being processed in abattoir, several parts like blood, flesh, fat, etc are lost as waste which are channelled into waste ground within the abattoir, or directly flushed into river (Bello & Oyedemi, 2009; Magaji & Chup, 2012; Ojekunle & Lateef, 2017). The wastes are not treated and easily become toxic to the environment (Ekpetere et al., 2019). The processes of adsorption of waste and its contents into the soil through the different particles attract the pathogenic organisms which are detrimental to organisms (Ndakara, 2012a). However, if there is too high departure of conditions from normalcy beyond the limit which the natural process can hold, diversity of autochthonous species could diminish while count of individual species which can survive may increase with possibility of grave consequences on groundwater (Osemwota, 2010; Augustyn et al., 2016).

In Nigeria contest, AWs are more indiscriminately dumped thereby leading to both health and environmental problems. Akanni et al. (2019) emphasized that facilities for waste recovery treatment and reuse are either inadequate or non existent in most Nigerian abattoirs. Leachates from abattoirs pollute nearby land and water and even contaminate underground water and wells. The non-scientific ways of disposing the AW have led to high environmental hazards which have affected both aquatic and humans globally. This problem started long back but intensified during the last few decades, and now the situation has become alarming in Nigeria (Akanni et al., 2019; Ekpetere et al., 2019). In the study of a natural ecosystem, many variables simultaneously changed with time and location with little opportunity to control them all systematically or otherwise (Ndakara, 2016). By measuring as many parameters as possible that define the system, it may be possible to understand their interactions and to assess the sustainability of the environment (Atuanyaet al., 2012; Ndakara, 2012a; 2016). AW is quite detrimental to the environment. Studies by Nwanta et al. (2011); Odoemalan & Ajunwa (2008) revealed that abattoir activities contaminate both surface and underground water, reduce air quality and health of inhabitant organisms in the environment.

Several studies investigated how AW affect water quality (Masse & Masse, 2000; Omole & Longe, 2008; Abebe, 2009; Kosamu et al., 2011; Fearon et al., 2014; Augustyn et al., 2016; Ojekunle & Lateef, 2017; Njoku-Tony et al., 2018; Akanni et al., 2019; Bakume et al., 2019; Ekpetere et al., 2019; Elemile et al., 2019; Ukoji & Ndakara, 2021). However, from the studies, the aspect of seasonal variations in water quality in response to AW has not been adequately documented. Therefore, this study is focused on seasonality assessment of how AW affects water quality of the Anwai River. This is with a view to ascertain the period and season where AW impact more the river's water quality, and as well aid sustainability in the approaches towards managing the river water for human, agriculture and aquatic lives.

MATERIAL AND METHODS

This research took place at Anwai River (AR), a fresh water ecosystem within southern Nigeria. This region falls within the humid equatorial climate, with mean annual temperature and rainfall of 31 °C and >3500 mm respectively (Ndakara, 2012b; Ndakara & Eyefia, 2021; Ukoji & Ndakara, 2021). The relief of the environment is a plain with gentle slope, and well drained by the AR into the river Niger. Experimental design approach was adopted in the course of this study, while systematic sampling technique was employed in the collection of water samples. The sampling points were established at 5 m distance from where AW enters the river (downstream), while 50 m away was established as control (upstream).

Two water samples each were collected with plastic containers (washed with de-ionized water) from the DS and US sections respectively for 6 different months (February to July, 2021), being parts of drier and rainy months within the study area. The samples were collected on only days that animals were slaughtered in the abattoirs, and at the time that AW were already in contact with the river water. Standard methods (APHA, 2005) were adopted in laboratory analysis of the samples for temperature, pH, nitrate, electrical conductivity (EC), total dissolve solid (TDS), phosphate, dissolve oxygen (DO), sodium (Na), iron (Fe), ammonia (NH_3), calcium (Ca), sulphate, magnesium (Mg), chloride, biochemical oxygen demand (BOD), potassium (K), turbidity, total suspended solids (TSS) and total coliform (TC). Analysis of data generated involved the use of graph, μ, S^2, SEM and t-test statistics.

RESULTS AND DISCUSSION

Variations in Monthly Concentrations of Physico-Chemical Properties (PCP) of Water between the DS and US Sections of Anwai River

Variations in the characteristics of seasons can have influence on environmental components (Ndakara, 2012a, b). Rivers, seas and oceans being major environmental components, vary in their qualities and component characteristics because of foreign bodies introduced into the water. The amount of PCP of water in the AR varied across months and seasons, as well as between the DS and US sections (Table 1).

Aside the presence of foreign bodies in the water, seasonality may cause changes in the water basic components. For instance, water pH and turbidity can vary and constantly change as the water body is exposed to changes in temperature due to time variation and varying solar radiation received by the water body. Figures 1 to 19, present the amount of PCP of water in the AR between the DS and US sections across months.

Within rainy months the DS section recorded higher temperature, EC, TDS, TSS, nitrate, phosphate, Ca, Na, Mg, NH_3, K and TC than the US section; while pH, sulphate, DO, turbidity, chloride, Fe and BOD were higher within the US section than the DS section within the rainy months. Conversely, within the dry months, temperature, EC, TDS, TSS, nitrate, phosphate, Ca, Na, Mg, NH_3, K and TC were higher within the DS section; while pH, sulphate, DO, turbidity, chloride, Fe and BOD were higher within the US section. Studies by Ojekunle & Lateef (2017) and Ekpetere et al. (2019) reported variations in the amount of PCP of water in response to season.

Seasonal Variation in Water Quality between the DS and US Sections of Anwai River

Water qualities within the DS and US sections of AR varied in response to the seasons (rainy and dry) of the year. While some PCP parameters varied between the DS and US sections respectively, the seasonality influence shows that within each of the sections of the AR as defined by this study, the amount of many parameters varied between the rainy and dry months. Within rainy months, the DS section recorded higher temperature (28 °C), EC (112.00 us/cm), TDS (46.25 mg/l), TSS (22.48 mg/l), nitrate (2.20 mg/l), phosphate (1.98 mg/l), Ca (16.16 ppm), Na (7.00 ppm), Mg (10.24 ppm), ammonia (4.63 mg/l), K (6.29 ppm) and TC (34.16 count/100) than the US section; while pH (6.40), sulphate (3.16 mg/l), DO (6.98 mg.l), turbidity (12.11NTU), chloride (5.08 mg/l), Fe (1.96 ppm) and BOD (5.68 mg/l) are higher within the US section than the DS section during rainy months.

On the other hand, within the dry months, temperature (29.86 °C), EC (112.48 us/cm), TDS (46.29 mg/l), TSS (32.54 mg/l), nitrate (2.28 mg/l), phosphate (2.74 mg/l), Ca (16.24 ppm), Na (11.04 ppm), Mg (12.28 ppm), NH_3 (4.67 mg/l), K (10.35 ppm) and TC (42.20count/100) were higher within the DS section; while pH (6.46), sulphate (5.26 mg/l), DO (7.04 mg/l), turbidity (12.15NTU), chloride (11.18 mg/l), Fe (4.06 ppm) and BOD (5.74 mg/l) were higher within the US section.

However, in both rainy and dry months, the DS section recorded higher concentrations of temperature, acidity, EC, TDS, TSS, nitrate, phosphate, Ca, Na, Mg, NH_3, K and TC respectively. This finding is in line with Ukoji and Ndakara (2021) which reported higher concentrations of PCP in the DS section of river. This is a reflection of how AW affects water quality as earlier reported by Kosamu et al. (2011), Magaji & Chup (2012), and Deborah et al. (2017).

The DS section recorded higher temperature, EC, TDS, TSS, nitrate, chloride, phosphate, Fe, sulphate, DO, turbidity, Ca, Na, Mg, BOD, NH_3, K and TC during the dry season than in the rainy season. Only pH concentrations increased during the rainy season, which implies a marked decrease in acid content within the DS section during the rainy season (Table 2).

From Table 2, the observed seasonal variation could be seen from the μ, S^2, and SEM values of 16.21, 26.58, ±6.10; and 18.40, 26.80, ±6.15 for the rainy and dry seasons respectively. The difference in water quality of the DS section between the rainy and dry season months was tested with the T-Test statistics at the 5% level of significance.

From Table 3, t= -0.252, F= 0 023 with significant value of 0.880; the mean difference is therefore not significant at the 5% level. Therefore, there is no significant difference in water quality in the DS section of AR between the rainy and dry seasons. This further confirms the significant effect of the AW on the Anwai River's water quality at the DS section. But in terms of seasonality, the differences in the mean values of the effect of the discharge are not significant between the rainy and dry seasons respectively. This means that AW has marked effects on water quality of AR at the DS section irrespective of seasons.

The upstream section recorded higher concentrations of all the parameters which are the tem-

Parameters	February		March		April		May		June		July	
	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US
Temperature	30.04	28.02	29.68	27.34	29.12	27.12	29.00	27.01	27.76	22.08	27.64	18.19
pH	4.98	6.42	4.94	6.50	5.07	6.46	5.07	6.47	5.09	6.42	5.09	6.26
EC	112.64	78.54	112.32	78.44	112.28	75.38	112.01	74.06	111.99	46.00	111.72	38.20
TDS	46.64	33.30	45.94	33.10	45.98	31.12	46.00	30.18	46.54	16.24	48.48	14.78
TSS	32.68	16.80	32.40	16.76	28.02	16.78	22.14	16.76	20.18	16.72	19.58	16.70
Nitrate	2.27	1.20	2.26	1.12	2.25	1.04	2.24	1.00	2.20	0.78	2.17	0.70
Phosphate	2.86	1.02	2.62	0.90	2.10	0.91	2.04	0.94	2.19	0.82	1.59	0.77
Sulphate	1.92	5.41	1.88	5.12	1.87	4.88	1.87	4.62	1.85	2.01	1.85	1.13
DO	5.10	7.10	5.02	6.99	1.12	6.99	1.04	6.98	0.90	6.98	0.86	6.97
Turbidity	9.62	12.18	9.42	12.12	6.14	12.12	6.04	12.11	5.16	12.10	4.42	12.10
Chloride	1.27	11.28	1.25	11.08	1.24	10.86	1.22	9.60	1.22	0.16	1.20	0.10
Fe	0.46	4.10	0.46	4.02	0.41	3.14	0.39	2.96	0.36	1.00	0.36	0.74
Ca	16.30	4.80	16.18	4.70	16.18	4.70	16.16	4.70	16.16	4.70	16.14	4.70
Na	11.06	6.30	11.02	6.24	10.82	6.24	9.46	6.23	4.86	6.18	2.86	6.11
Mg	12.36	5.20	12.20	5.16	11.64	5.16	10.54	5.15	9.81	5.14	8.97	5.11
BOD	3.48	5.98	3.30	5.74	2.66	5.72	2.00	5.70	0.36	5.20	0.30	5.10
NH_3	4.70	0.92	4.64	0.88	4.64	0.88	4.64	0.87	4.62	0.88	4.62	0.81
K	10.38	4.06	10.32	4.00	8.14	4.00	6.82	3.99	5.50	3.99	4.70	3.98
TC	42.40	27.48	42.00	27.24	38.60	25.62	34.64	24.30	32.00	10.21	31.40	9.23

Table 1. Monthly Concentration of Physico-Chemical Parameters of DS and US Sections of Anwai River.

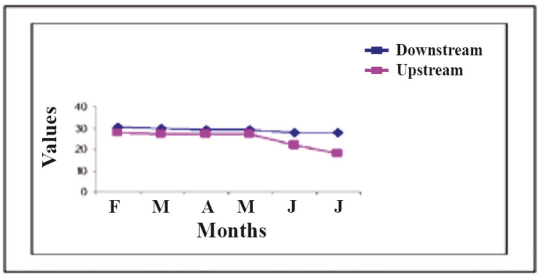

Figure 1. Monthly temperature for DS and US.

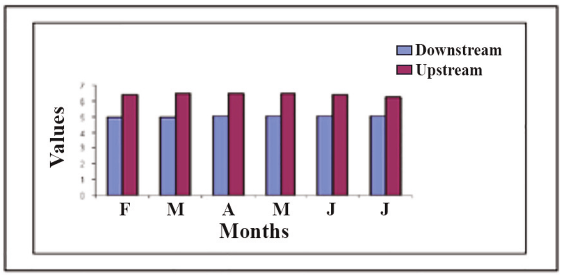

Figure 2. Monthly pH for DS and US.

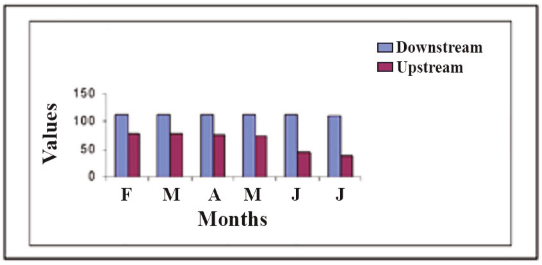

Figure 3. Monthly EC for DS and US.

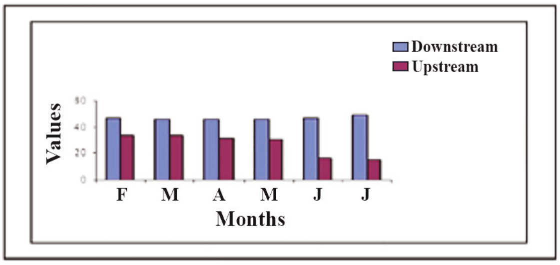

Figure 4. Monthly TDS for DS and US.

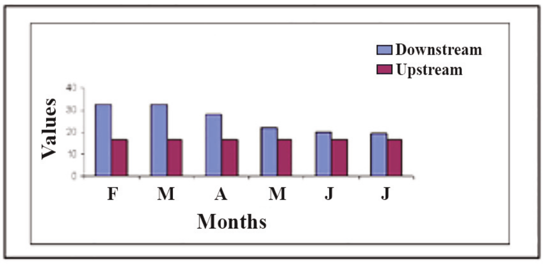

Figure 5. Monthly TSS for DS and US.

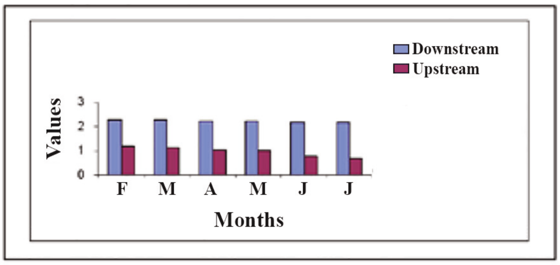

Figure 6. Monthly nitrate for DS and US.

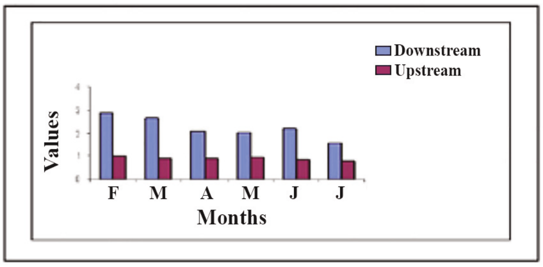

Figure 7. Monthly phophate for DS and US.

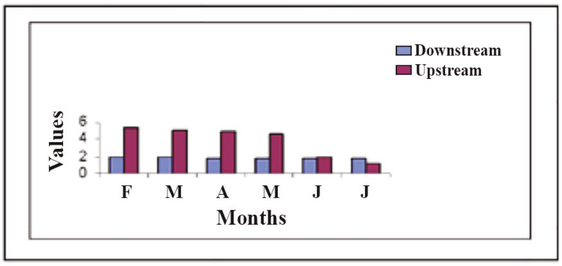

Figure 8. Monthly sulphate for DS and US.

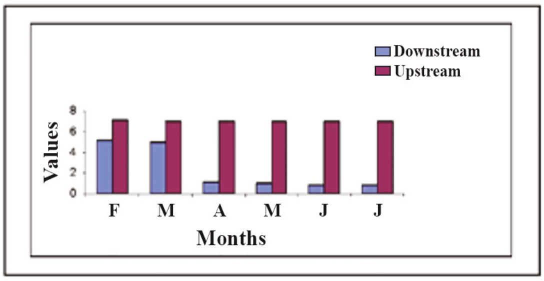

Figure 9. Monthly DO for DS and US.

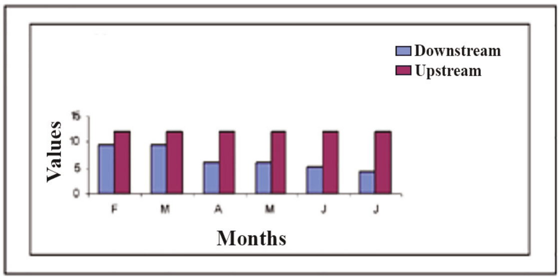

Figure 10. Monthly turbidity for DS and US.

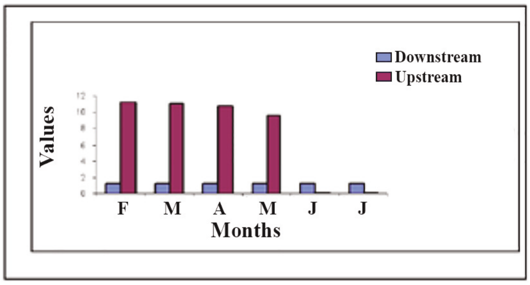

Figure 11. Monthly chloride for DS and US.

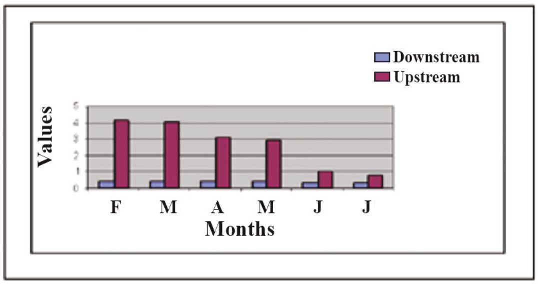

Figure 12. Monthly Fe for DS and US.

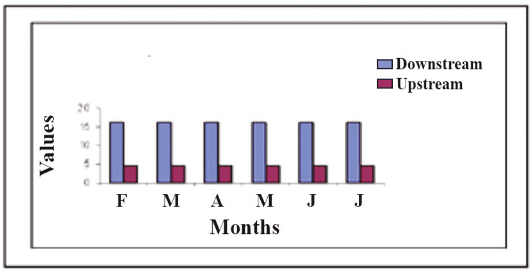

Figure 13. Monthly Ca for DS and US.

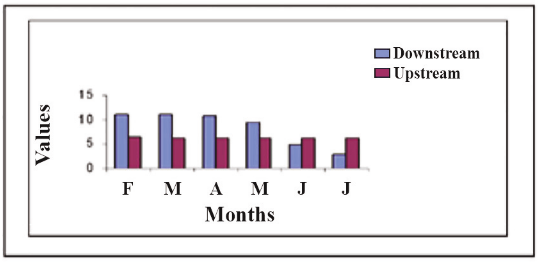

Figure 14. Monthly Na for DS and US.

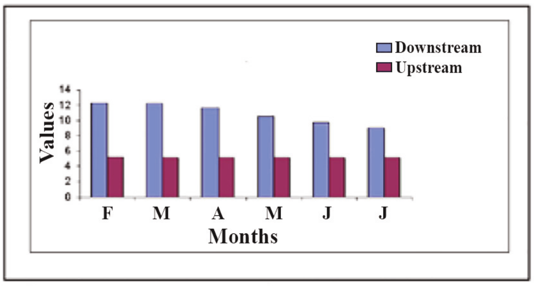

Figure 15. Monthly Mg for DS and US.

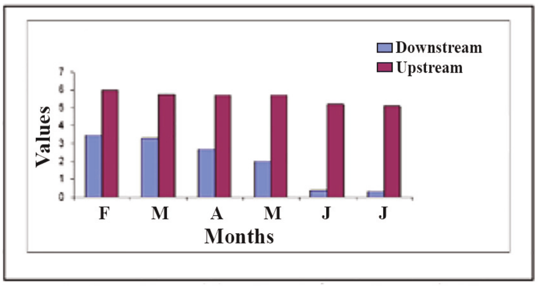

Figure 16 Monthly BOD for DS and US.

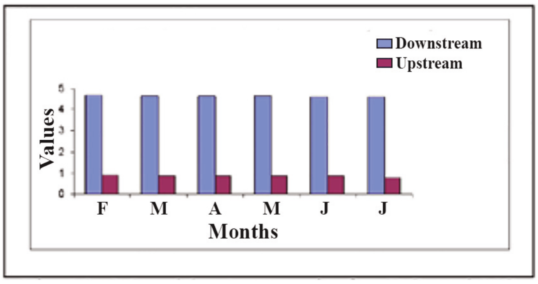

Figure 17. Monthly Ammonia for DS and US.

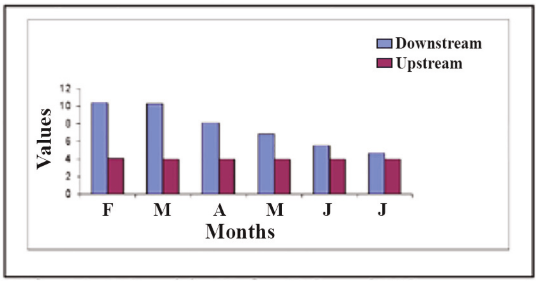

Figure 18. Monthly K for DS and US.

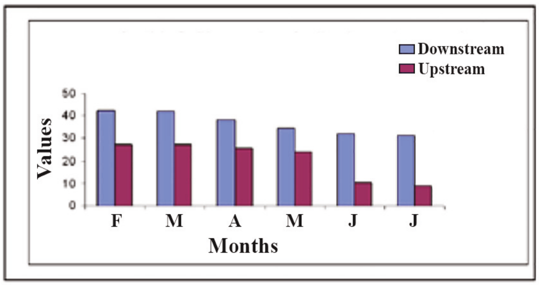

Figure 19. Monthly TC for DS and US.

Parameters	Rainy Season		Dry Season	
	Downstream	Upstream	Downstream	Upstream
Temperature (ºC)	28.38	23.60	29.86	27.68
pH	5.08	6.40	4.96	6.46
E.C (us/cm)	112.00	58.41	112.48	78.49
TDS (mg/l)	46.25	23.08	46.29	33.20
TSS (mg/l)	22.48	16.74	32.54	16.78
Nitrate (mg/l)	2.20	0.88	2.28	1.16
Phosphate (mg/l)	1.98	0.86	2.74	0.96
Sulphate (mg/l)	1.86	3.16	1.90	5.26
DO (mg/l)	0.98	6.98	5.06	7.04
Turbidity (NTU)	5.44	12.11	9.52	12.15
Chloride (mg/l)	1.22	5.08	1.26	11.18
Fe (PPM)	0.38	1.96	0.46	4.06
Ca (PPM)	16.16	4.70	16.24	4.76
Na (PPM)	7.00	6.19	11.04	6.27
Mg (PPM)	10.24	5.14	12.28	5.18
BOD (mg/l)	1.33	5.68	3.39	5.74
NH_3 (mg/l)	4.63	0.86	4.67	0.90
K (PPM)	6.29	3.99	10.35	4.03
TC (count/100)	34.16	17.34	42.20	27.36

Table 2. Seasonal Variation in PCP of water in the DS and US sections of Anwai River.

perature, EC, TDS, TSS, nitrate, Fe, phosphate, DO, sulphate, turbidity, chloride, Ca, Na, Mg, BOD, NH_3, K and TC during the dry season than during the rainy season. The observed seasonal variation could be seen from the μ, S^2 and SEM values of 10.69, 13.59, ±3.12; and 13.61, 18.39, ±4.22 for the rainy and dry seasons respectively. The difference in water quality of the US section between the rainy and dry season months was tested with the T-test statistics at the 5% level of significance.

From Table 4, t = -0.55, F= 0.607, while significant value =0.441; the observed mean difference is therefore not significant at the 5% level of confidence. Therefore, there is no significant difference in water quality between the rainy and dry seasons in the US at the 5% level of confidence. This shows that the observed differences in the PCP at the US are not significant at the 5% level between the rainy and dry seasons.

CONCLUSIONS

Water quality in AR varied at both DS and US sections in response to the seasons. While some of the parameters varied between the DS and US sections respectively, the seasonality influence shows that within each of the sections as defined by this study, the amount of many parameters differed between rainy season and dry season. The observed mean difference in amount of the different parameters during the two seasons could be accounted for by seasonality influence.

Within the DS section, the seasonal variation in water quality is not significant at the 5% level of confidence. Thus, there is no significant difference in the quality of water in the DS section of AR between the rainy and dry seasons. Within the US section, concentrations of all the parameters were higher during the dry season than during the rainy season. However, the observed seasonal variation was also not significant at the 5% level of confidence. Therefore, there is no significant difference in the quality of water within the US section of AR between the rainy and dry seasons. The findings show that AW affects water quality in AR; the PCPs are higher within the DS section than the US section; while seasonality did not have significant impact on the water quality.

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