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Physico-Chemistry Quality of Trans-Amadi (Woji) Creek Port Harcourt, Niger Delta, Nigeria

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Abstract: The Trans-amadi (Woji) Creek of the Upper Bonny Estuary in Port Harcourt, Nigeria has received little attention regarding its physico-chemistry quality. The creek is a sink receiving multiple organic anthropogenic effluents from its surroundings. This study was conducted to assess the physico-chemical properties of the surface water and the impact of municipal wastes on these parameters. Surface water samples were collected for physico-chemistry analyses from May 2004 to April 2006 from 4 stations according to standard methods. Turbidity, dissolved oxygen, alkalinity, magnesium, hardness, nitrate, phosphate and sulphate demonstrated significant spatial and seasonal variations. Total dissolved solids, total organic carbon, total organic matter, phosphate and ammonia exceeded United States Environmental protection Agency acceptable levels for natural water bodies. The presence of these organic pollutants indicates organic pollution and stress in this creek. Concerted surveillance of this environmental is advocated to restore its integrity.

Key words: Physico-chemistry, quality, trans-amadi creek, sink, Nigeria

INTRODUCTION

The physico-chemistry quality of water is very vital for the life of aquatic organisms. Environmental variables (pH, temperature, salinity, dissolved oxygen, biological oxygen demand, turbidity, transparency, etc.) have effects on organisms and vice-versa. Natural surface waters are of importance to man: Domestic uses, industrial development, navigation, boating, fishing, dredging, wastes disposal to mention but a few. These parameters are used to detect any perturbation in the aquatic environment.

The explosion in population density, urbanization and industrialization had profound impact on human life and aquatic environment in terms of quantity and quality (Herschy, 1999). Also, seasonal and climatic changes affect the quality and physico-chemistry of surface water. According to Vega *et al*. (1998), the flow in surface waters is a function of many factors including precipitation, surface runoff and interflow. Seasonal variations of these factors have strong effects on flow rates and on the concentration of pollutants in surface waters.

Trans-amadi Creek is a sink, receiving municipal wastes from anthropogenic and domestic sources in its environment. Obire *et al.* (2003) recommended the need for an acute societal and global monitoring of water quality characteristics of some waters in the Niger Delta region. Trans-amadi is of industrial development, human settlement and fish resources importance in the Rivers State. And due to its strategic location, there is urgent need to conserve this environment to ensure sustainable resources and development at the local and international levels. Some studies on the water physico-chemical characteristics of the Niger Delta region include: Ajayi and Osibanjo (1981), Adeniyi (1986) IPS (1990, 1991), Erondu and Chindah (1991a, 1991b), Obire *et al.* (2003), Hart and Zabbey (2005) and Davies *et al.* (2007). However, little attention has been given to this creek. This study was conducted to provide additional information to that of Hart and Zabbey (2005) on the physico-chemical characteristics of Woji Creek and the impact of various human activities on its chemistry. Hart and Zabbey (2005) only determined 6 physico-chemical parameters viz; pH, salinity, dissolved oxygen, biological oxygen demand, total suspended solids and temperature of Woji Creek. This study examined twenty parameters namely: Turbidity, transparency, temperature, salinity, conductivity, pH, dissolved oxygen, biological oxygen demand, total dissolved solids, total organic carbon, total organic matter, alkalinity, chloride, calcium, magnesium, hardness, ammoma, nitrate, phosphate and sulphate.

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MATERIALS AND METHODS

Study area: The Woji Creek is a typical estuarine tidal water, located between longitudes 7°00'' and 7°15''N and latitudes 4°28''E and 4°40''N. It is a tributary of the Upper Bonny Estuary in Port Harcourt, Niger Delta, South-South of Nigeria (Fig. 1). The vegetation is dominated by Nypa palm *(Nypa fructican)* and mangroves, red *(Rhizophora racemosa)* and white *(Avecennia nitida)*. Nypa palm is becoming a resilent plant in this creek. It passes through many communities namely: Oginigba, Woji, Azubiae, Okujagu, Okuru-ama, Abuloma, Ojimba, Oba, Kalio and Okrika. Many human activities going on within and around this creek include fishing, boating, navigation, laundry, disposal of excreta, bathing, swimming to mention but a few. This aquatic body receives effluents discharges from many industries, residential buildings and the main Port Harcourt abattoir sited along the bank.

Sampling stations: A total of 4 stations were chosen at least 500 m apart along the main creek course. All the stations were tidal environments they are: Oginigba (upstream) Trans-amadi by Schlumberger, Trans-amadi by slaughter and Azubiae (downstream).

Surface water sample collections: Samples were collected for 24 months covering 2 dry seasons and two wet seasons between May 2004 and April 2006. One-litre sterilized containers were used to collect water samples for physico-chemical parameters at each station. All the

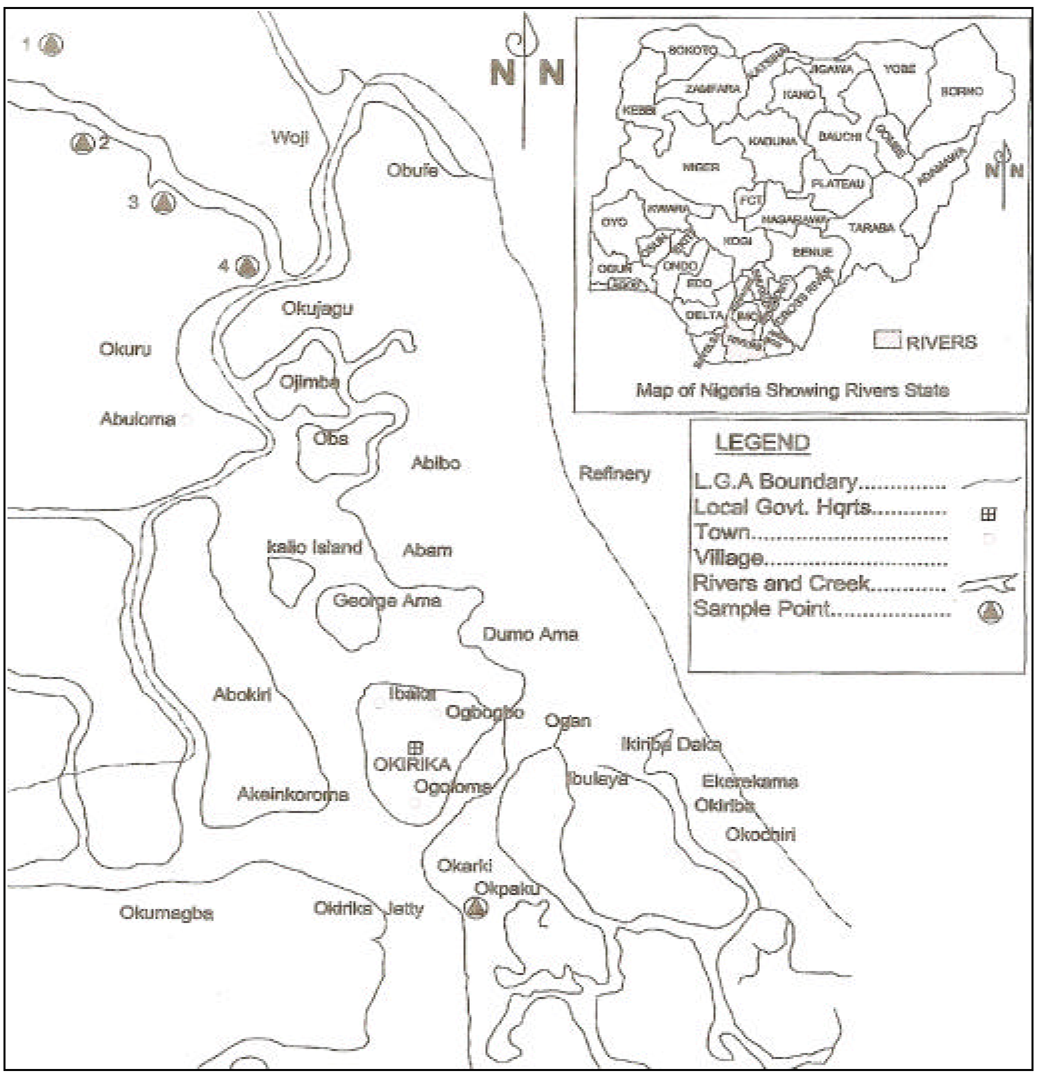

Fig. 1: Study area map

containers were kept in ice-chest box for laboratory analyses. Twenty physico-chemical parameters were measured *in-situ* and in laboratory according to standard methods (APHA, 1998). They were turbidity, transparency, temperature, salinity conductivity, pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Organic Matter (TOM), alkalinity, chloride, calcium, magnesium, hardness, ammonia, nitrate, phosphate and sulphate. At each sampling station, temperature, pH, transparency and dissolved oxygen were measured *in-situ* using mercury-in-glass thermometer (in Celsius), pH-EC-TDS meter model Hanna HI 9812, Secchi disc (20 cm diameter) and Winkler's method. Biological water samplers for oxygen demand were incubated for 5 days in the dark at room temperature. Then, the Winkler method (APHA, 1998) was used in determining the amount of dissolved oxygen present. Conductivity, salinity and turbidity were measured in the laboratory using conductivity meter Horiba-U 10 μ mm. Alkalinity, total organic carbon, total organic matter and total dissolved solids were determined titrimetrically following standard methods (APHA, 1998). Nutrient parameters, ammonium-nitrogen, nitrate-nitrogen, phosphate-phosphorus and sulphate were measured spectrophotometrically at various optimal wavelengths (APHA, 1998).

Statistical analyses: Data was analyzed by Statistical Analysis System (SAS, 2003) and Microsoft Excel 2003 packages for analysis of variance, Duncan multiple range and Pearson correlation coefficient.

RESULTS AND DISCUSSION

The minimum mean turbidity (1.74 NTU) was recorded in station 2 and the maximum (4.44 NTU) in Station 3 (Fig. 2). The wet season mean turbidity (4.68 NTU) was higher than the dry season (2.31 NTU). Seasonal variation of turbidity was significant ($p<0.05$) (Table 1). Wet season turbidity (4.68 NTU) was higher was higher than dry season (2.31 NTU). Seasonal transparency variation was insignificant ($p<0.05$). Station 3 had the lowest mean transparency value (0.59 m) and Station 4 the highest (0.67 m). These observations might be attributed to the raw slaughter effluents especially the animal blood, intestinal contents and manure (Punmia and Jain, 1998; Panigrahi *et al.*, 2003). However, the reported ranges of turbidity and transparency were within the acceptable limits for natural waters (McNeely *et al.*, 1979; Asonye *et al.*, 2007). The recorded high rainy season turbidity was probably due to the high natural erosion and runoffs from the surroundings as well as the increase

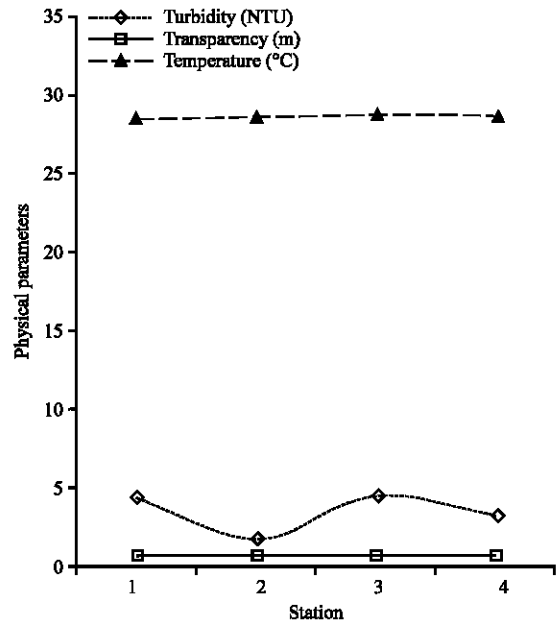

Fig. 2: Spatial variation of physical parameters of trans-amadi creek

Table 1: Seasonal variations of physical parameters of trans-amadi creek

Season	Turbidity (NTU)	Transparency (m)	Temperature (°C)
Wet	4.68±0.55	0.66±0.01[a]	28.38±0.09[b]
Dry	2.31±0.24[b]	0.66±0.01[a]	28.94±0.08[a]

Means with the same letter in the same column are not significantly different ($p>0.05$)

slaughtering activities in the abattoir. The insignificant spatial and seasonal variations of transparency might be linked to the shallow water depth and brackish nature of the creek.

The water temperatures were similar along the stations ($p<0.05$) ranging from 28.46°C (Station 1) to 28.71°C (Stations 3). This is typical for tropical estuarine waters (Obire *et al.*, 2003; Hart and Zabbey, 2005). The highest temperature (28.71°C) in Station 3 could be due to lack of marginal vegetation and pyric activities (burning of animal skin, decomposition of feacal wastes and left-over feed of slaughter animals). Higher temperature (28.94°C) in dry season than wet season (28.38°C) could be due to longer photoperiod and higher sunlight intensity.

The pH values ranged between 6.49 (Station 1) and 6.65 (Station 4) (Fig. 3). The spatial variation of pH was not significant ($p>0.05$). The present pH range was within the acceptable limit of international standard (IJC, 1977). The difference between the lowest and highest pH recorded was not up to 0.05 pH units. This is an indication that the various anthropogenic inputs did not alter the ambient pH (IJC, 1977). The seasonal variation of pH was

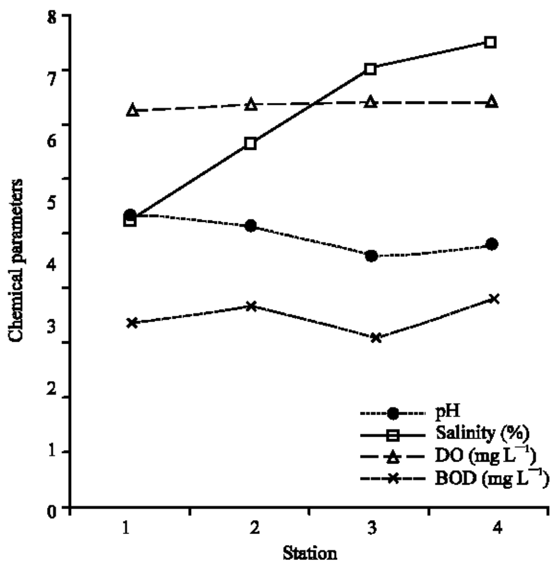

Fig. 3: Spatial variation of chemical parameters of trans-amadi creek

Table 2: Seasonal variations of chemical parameters of trans-amadi creek

	Season	
Parameters	Wet	Dry
pH	6.63±0.03[b]	6.78±0.04[a]
DO (mg L^{-1})	4.48±0.14[b]	5.14±0.16[a]
BOD (mg L^{-1})	3.11±0.12[a]	3.43±0.15[a]
Calcium (mg L^{-1})	856.77±32.81[a]	898.81±38.25[a]
Magnesium (mg L^{-1})	2587.44±148.29[a]	3924.809±360.40[a]
Hardness (mg L^{-1})	3457.09±161.78[b]	5439.84±243.81[a]
Chloride (mg L^{-1})	17698.17±867.49[a]	17723.14±652.99[a]
Salinity (%)	9.67±0.37[b]	20.00±10.17[a]
Conductivity (µs cm^{-1})	15450.0±730[a]	14610.0±760[a]
TDS (mg L^{-1})	10.500±440[a]	10190.0±530[a]
TOC (mg L^{-1})	114.15±439[a]	89.26±4.26[b]
TOM (mg L^{-1})	207.46±7.32[a]	153.27±7.35[b]
Alkalinity (mg L^{-1})	84.60±2.00[a]	83.41±1.98[a]

Means with the same letter in the same column are not significantly different ($p>0.05$)

significant ($p<0.05$) with higher pH value in the dry season (6.78) and lower one in wet season (6.63) (Table 2). This could be linked to increase photosynthetic rates of aquatic plants (Eyesink and Solomon, 1981). Station 3 had the minimum mean Dissolved Oxygen (DO) (4.12 mg L^{-1}) and Station 1 the maximum (4.74 mg L^{-1}). This observation might be attributed to the higher temperature and abattoir wastes in Station 3. The lowered dissolved oxygen (4.48 mg L^{-1}) in wet season than dry season (5.14 mg L^{-1}) might be explained by the reduced photoperiod and photosynthetic activities of aquatic plants. The range of dissolved oxygen was still within the acceptable limit for aquatic life (McNeely *et al.*, 1979). The biological oxygen demand (BOD) concentration ranged from 2.79 mg L^{-1} (Station 3) to 3.28 mg L^{-1} (Station2) might be due to the different organic wastes of varied quantities entering the creek. The BOD values were less than 4 mg L^{-1}, implying that the water body was, according to McNeely *et al.* (1979) ranking, fairly clean. The BOD level in Station 3 is expected to be the highest but a contrary observation was made. This might be attributed to the tidal effect on the creek; carrying the slaughter wastes further downstream or upstream depending on the tide (low high). The higher BOD level in dry season (3.43 mg L^{-1}) could be the effect of higher temperature, salinity and putrefaction of substances deposited in the river from the surroundings.

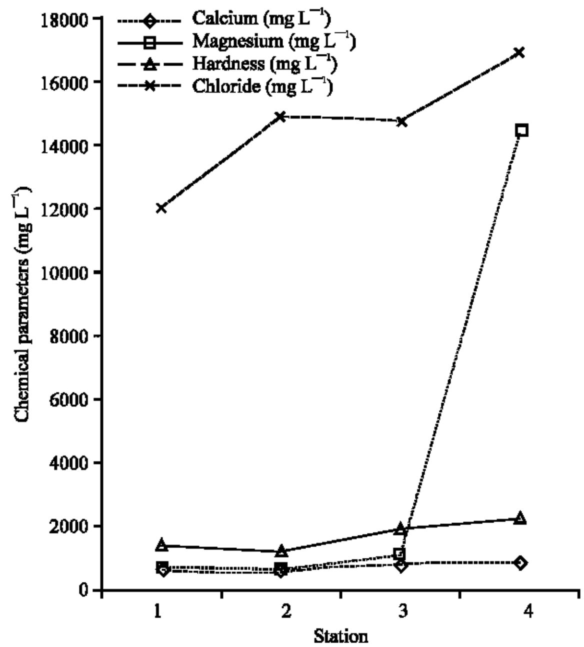

Fig. 4: Spatial variation of chemical parameters of trans-amadi creek

The calcium concentration ranged between 581.01 mg L^{-1} (Station 2) and 893.48 mg L^{-1} (Station 4) (Fig. 4). The recorded calcium level in this study is higher than the expected concentrations in brackish environment usually 400 mg L^{-1} (McNeely *et al.*, 1979). This present observation might be attributed to high amounts of human faeces, industrial wastes and animal wastes from the waterfront dwellers, industries and abattoir, respectively. The higher values in the dry season (898.81 mg L^{-1}) than wet season (856.77 mg L^{-1}) was expected due to the higher salinity concentrations in the dry season. The higher magnesium concentrations in the stations (679.94-1444 mg L^{-1}) and in dry season (3924.80 mg L^{-1}) might be attributed to high salinity. The range of hardness (1260.26-2308.67 mg L^{-1}) is characteristic of brackish environment (Edet, 1987). The chloride concentrations increased downstream from Station 1 (11,984.97 mg L^{-1}) to Station 2

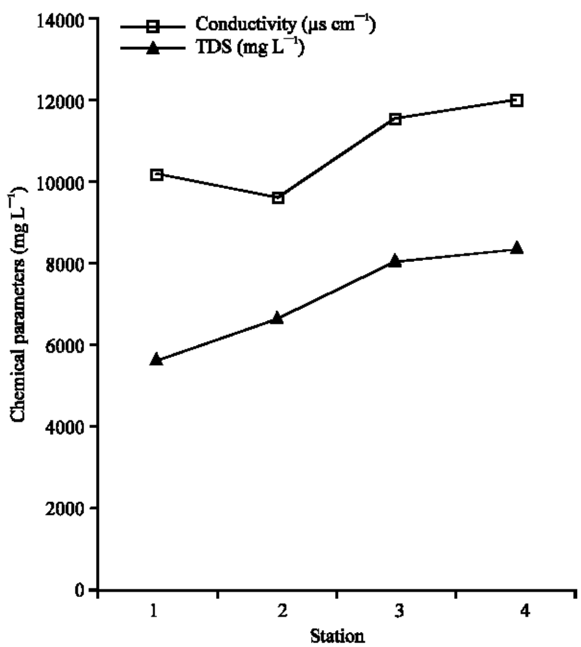

Fig. 5: Spatial variation of chemical parameters of trans-amadi creek

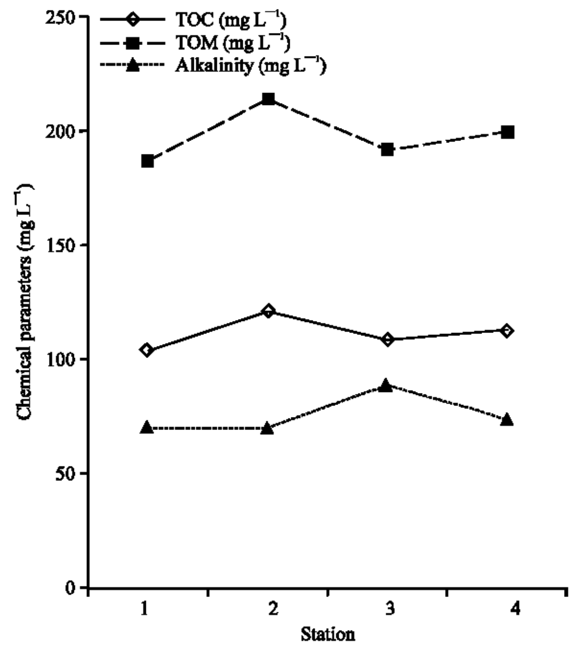

Fig. 6: Spatial variation of chemical parameters of trans-amadi creek

(16,853.93 mg L^{-1}). This suggests the influence of seawater on chloride level. The lower mean value recorded in the wet season (17723.14 mg L^{-1}) explains the dilution effect of increased municipal runoffs during the rains (Chindah and Braide, 2004).

Salinity varied from 4.71% (Station 1) to 7.57% (Station 3) and it is within the acceptable ranges coastal waters (Chindah and Nduaguibe, 2003) (Fig. 5). This might be attributed to proximity to the bonny estuary and sea. The recorded higher salinity (20.00%) in the dry season could be as a result of high sunlight intensity that increased the water evaporation rate. The observed high conductivity (9570-11,960 µs cm^{-1}) might be due to the creek brackish nature. The insignificant higher conductivity (15450 µs cm^{-1}) in wet season could be due to the large volume of water from the sea. Conductivity had positive correlation with salinity. The total dissolved solid (TDS) ranged from 5680 mg L^{-1} (Station 1) to 8370 mg L^{-1} (Station 4). This range is higher than the recommended values for brackish (McNeely *et al.*, 1979), an indication of organic pollution from anthropogenic sources (Saad *et al.*, 1994). The higher TDS concentration (10,500 mg L^{-1}) in wet season might be due to high surface runoff, overland flow and higher discharge of organic wastes into the river (Dejoux *et al.*, 1981).

The Total Organic Carbon (TOC) values ranged from 103.63 mg L^{-1} (Station 1) to 121.16 mg L^{-1} (Station 2) (Fig. 6). This range is above the 1-30 mg L^{-1} for natural water indicating pollution from anthropogenic inputs. Wet season TOC value (10500 mg L^{-1}) was higher than dry season value (10190 mg L^{-1}). This might be explained by the high runoffs from the surroundings as well as increased discharge of domestic and industrial wastes. The Total Organic Matter concentration (TOM) is directly proportional to TOC level in the creek. TOM ranged between 189.63 mg L^{-1} (Station 1) and 241.23 mg L^{-1} (Station 2). Higher TOM value (207.46 mg L^{-1}) was recorded in wet season than in dry season (153.27 mg L^{-1}). Alkalinity values recorded were between 69.92 mg L^{-1} (Station 1) and 88.90 mg L^{-1} (Station 3). This is characteristic of estuarine environment. The water of this creek is desirable for aquatic life and industrial uses as it is above 30 mg L^{-1} and less than 500 mg L^{-1} (Department of National Health and Welfare, 1969). Wet season alkalinity (84.60 mg L^{-1}) was higher than dry season (83.41 mg L^{-1}), an indication of increased runoffs from the surroundings.

The maximum ammonia level (0.21 mg L^{-1}) and minimum level (0.16 mg L^{-1}) were recorded in Station 3 and Station 1, respectively (Table 3). This study ammonia concentration exceeded the concentration of less than 0.1 mg L^{-1} found in natural water bodies (McNeely *et al.*, 1979). It also agrees with the report of Chindah and Nduaguibe (2003) of ammonia level range of 0.093-2.65 mg L^{-1} in the Niger Delta. The observed ammonia level in this study possibly indicates anthropogenic and domestic inputs especially

Table 3: Spatial variation of nutrient parameters of Trans-amadi creek

Station	Ammonia	Nitrate	Phosphate	Sulphate
1	0.14±0.01^{b}	1.11±0.09^{a}	0.50±0.10^{b}	325.76±42.11
2	0.17±0.02^{ab}	0.85±0.06^{b}	0.80±0.21^{a}	346.93±42.85
3	0.21±0.03^{a}	0.73±0.06^{bc}	0.89±0.14^{a}	347.19±43.86
4	0.18±0.02^{ab}	0.77±0.05^{b}	0.62±0.13^{b}	425.69±47.20

Means with the same letter in the same column are not significantly different ($p>0.05$)

Table 4: Seasonal variation of nutrient parameters of Trans-amadi creek

Season	Ammonia (mg L^{-1})	Nitrate (mg L^{-1})	Nitrate (mg L^{-1})	Phosphate (mg L^{-1})
Wet	0.16±0.01^{a}	0.71±0.03^{a}	0.76±0.07^{a}	661.68±51.57^{a}
Dry	0.18±0.01^{a}	0.56±0.03^{b}	0.73±0.06^{a}	441.49±20.81^{b}

Means with the same letter in the same column are not significantly different ($p>0.05$)

at Station 3. The decomposition of nitrogenous organic matter (vegetable, animal and human wastes) and the microbial reduction of nitrates or nitrites under anaerobic conditions might account for this observation. The discharge of ammonia is frequently associated with reduction of dissolved oxygen concentration in the receiving water. This is reflected in the lowest dissolved oxygen concentration in stations. Dry season ammonia value (0.18 mg L^{-1}) was higher than wet season value (0.16 mg L^{-1}) (Table 4), this might be attributed to increase rate of nitrogenous organic matter decomposition. Seasonal variation was insignificant ($p>0.05$) suggesting similar anthropogenic and natural inputs (atmospheric precipitation and dry fallout).

The observed nitrate ranging from 0.73 mg L^{-1} (Station 3) to 1.11 mg L^{-1} (Station 1) is below the more than 100 mg L^{-1} expected to be found in natural surface water (McNeely *et al.*, 1979). The highest nitrate recorded in Station 1 might be indicative of high human excrement and industrial discharges. The low nitrate concentration in this creek could possibly be due to high photosynthetic activities by aquatic plants. Nitrate concentration in the rains was higher (0.71 mg L^{-1} than in dry season (0.56 mg L^{-1}). Nwankwo (1996) also reported high nitrate levels in Lagos Lagoon during rainy season with lower levels in dry season. The decreased value in the dry season might be explained by the high uptake of nitrate by aquatic plants during phytosynthesis which is higher then.

The phosphate concentration ranged between 0.50 mg L^{-1} (Station 1) and 0.89 mg L^{-1} (Station 3). The highest phosphate level in Station 3 indicates high amount of slaughter wastes (animal dung, blood) and detergents discharges. The levels of phosphate in this creek are higher than the acceptable limit of 0.10 mg L^{-1} in flowing waters recommended by United State Environmental protection Agency (1976). However, natural inputs from decomposition of organic matter might be a contributor to the phosphate concentrations in this creek. The higher phosphate concentration (0.73 mg L^{-1}) in dry season than in wet season (0.67 mg L^{-1}) is in accordance with the findings of Chindah and Braide (2004) of the lower Bonny River, Niger Delta. Phosphorus stimulates algal growth thus higher biomass of phytoplankton and epiphyton in dry season might accounts for this observation.

The sulphate levels ranged from 325.76 mg L^{-1} (Station 1) 425.69 mg L^{-1} (Station 4). This range of sulphate is characteristic of brackish water. The sulphate concentration tended to increase downstream of the Upper Bonny Estuary indicating increasing ionic strength of the stations. The recorded levels were probably from oxidation of organic materials burning of fossil fuel and industrial effluents. Wet season sulphate concentration (661.68 mg L^{-1}) was higher than dry season (441.49 mg L^{-1}) seasonal variation of sulphate was significant ($p<0.05$). This might be attributed to higher wet precipitation from burning of fossil fuels.

The physico-chemistry characteristics of Trans-amadi creek shows that the creek is organic polluted and under stress due to high levels of ammonia, phosphate, total dissolved solids, total organic carbon and total organic matter. Concerted environmental surveillance is recommended to maintain good physico-chemical integrity of this creek.

REFERENCES

Adeniyi, I.F., 1986. The ecology of Bonny Estuary, the chemical composition of rivers in Greens. In: Akpata, TVI and Okali, D.U.U. (Eds). Proceedings of the workshop on Nigeria wetlands. Lagos, Nigeria.

Ajayi, S.O. and O. Osibanjo, 1981. Pollution studies on Nigeria Rivers. Water quality of some Nigerian Rivers. Environ. Pollut., 2 (2): 87-95.

APHA, 1998. Standard Methods for the Examination of Water and Waster Water. 20th Edn. APHA Washington, D.C., pp: 1213.

Asonye, C.C., N.P. Okolie, E.E. Okenwa and U.G. Iwuanyanwu, 2007. Some physico-chemical characteristics and heavy metal profiles of Nigerian rivers, streams and water ways. Afr. J. Biotech., 6 (5): 617-624.

Chindah, A. and U. Nduagwbe, 2003. Effect of tank farm waste water quality and periphyton of Lower Bonny River Delta. Nigeria J. Nig. Env. Soc., 1 (2): 206-222.

Chindah, A.C. and S.A. Braide, 2004. The physico-chemical quality and phytoplankton community of tropical waters. A case of 4 biotopes in the Lower Bonny River, Niger Delta, Nigeria. Caderno de' Pesquisa Ser Bio, Santa cruz da sul, 16 (2): 7-35.

Davies, O.A., U.U. Gabriel and T.B. Kingdom, 2007. Trace metals in periwinkle (Tympanotonus fuscatus) var. radula from Elechi Creek, Upper Bonny Estuary Nigeria. Asian J. Microbiol. Biotch. Envirorn. Sci., 9 (3): 445-450.

Dejoux, C., H. Deelstra and R. Wilkinson, 1981. Pollution. In: The ecology and utilization of African inland waters, Symoens, Y., M. Burgis and J. Graudet, (Eds.)UNEP Rep. Proc. Ser., 1: 149-161.

Department of National Health and Welfare, 1969. Canadian drinking water standard and objectives, 1968.

Edet, O.S.O., 1987. Effective treatment and disposal methods of refinery process waste waters. Proceedings of the seminar on the petroleum industry and the Nigeria environments. Owerri, Imo State.

Erondu, E. and A.C. Chindah, 1991a. Variation in the physico-chemical features and phytoplankton of the New Calabar River at Aluu, Rivers State, Nigeria. NIOMR Technical paper No. 75: 1-18.

Erondu, E.S. and A.C. Chindah, 1991b. Physico-chemical and phytoplankton changes in a tidal freshwater station of the New Calabar River. South Eastern, Nigeria. Environ. Ecol., 9 (3): 565-570.

Eye Sink, W.D. and W. Solomon, 1981. Pathways of mud and particulate trace metals from rivers to the Southern North Sea (Spec. Public). Int. Ass. Sediments, pp: 429-450.

Hart, A.I. and N. Zabbey, 2005. Physico-chemistry and benthic fauna of Woji creek in the Lower Nigeria Delta, Nigeria. Environ. Ecol., 23 (2): 361-368.

Herschy, R.W., 1999. Hydrometry Principles and Practices. 2nd Edn. John Wiley and Sons, Chichester.

International Joint Commission (IYC), 1977. New and revised specific water quality objectives. Vol. 11 Great Lake Water Quality Board Report.

IPS, 1990. Baseline studies of the Bonny South field location. Technical report of the institute of pollution studies, Rivers State University of Science and Technology, Port Harcourt, Rivers State RSUST/IPS/TR/91/04.

IPS, 1991. Ecological baseline data collection in the Soku field. Technical Report of the Institute of Pollution Studies, Rivers State University of Science and Technology, Nigeria. RSUST/IPS/TR/91/04.

McNeely, R.N., V.P. Neimanis and L. Dwyer, 1979. Water quality sourcebook. A guide to water quality parameters. Inland water directorate, water quality branch, Ottawa, Canada, pp: 88.

Nwankwo, D.I., 1996. Phytoplankton diversity and succession in Lagos Lagoon, Nigeria. Arch. Hydrobiol, 135 (4): 529-542.

Obire, O., D.C. Tamuno and S.A. Wemedo, 2003. Physico-chemical quality of Elechi creek in Port Harcourt, Nigeria. J. Applied Sci. Environ. Mgt., 7: 43-49.

Panigrahi, A.K., B. Goswami, S.S. Dana and B. Halder, 2003. Impact of diary and cattle effluents on exobiological conditions of shanty theel at Haringhata. Environ. Ecol., 21 (Supl. Pub.): 20-21.

Punmia, B.C. and A.K. Jain, 1998. Waste water Engineering. Laxmi Publication (P) Ltd., New Delhi, pp: 223.

Saad, M.A.H., A.T. Amuzu, C. Biney, D. Calamari et al., 1994. Domestic and industrial organic loads. Calamari, S and Naeve, H. (Eds.), In: Review of pollution in the African aquatic environment CIFA technical paper No. 23, Rome, FOA 1994, pp: 118.

SAS, 2003. Statistical Analysis System. User's Guide SAS/STA-t Version, 8th Edn., SAS, Institute, Inc. Cary, N. C., USA.

United State Environment Protection Agency, 1976. Quality criteria for water, EPA-440/9/76-023.

Vega, M., R. Pardo, E. Barrado and L. Deban, 1998. Assessment of Seasonal and polluting effects on the quality of River water by exploratory data analysis. Water Res. J. Int. Assoc. Water Quality, 32 (2): 3581-3592.