# Seasonal Dynamics in the Physiochemical Parameters of Hospital Effluent from a University Teaching Hospital based in Southern Nigeria.

**Author**

**Ibeh, I. N**

Department of Microbiology, Faculty of Life Sciences, University of Benin, Benin City, Edo State, Nigeria

**Omoruyi, M. I**

Department of Basic Sciences, Faculty of Basic and Applied Sciences, Benson Idahosa University, P.M.B. 1100, Benin City, Edo State, Nigeria

uyiwithintegrity@yahoo.com
+234(0)8062764607.

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**Abstract**

The treatment and disposal of hospital effluent is a major challenge in most developing nations, including Nigeria. This study was aimed at investigating the physiochemical properties of hospital wastewater from a University Teaching Hospital based in Southern Nigeria. Six sampling points were identified within and outside the premises of the university teaching hospital. The results showed that the values of biochemical oxygen demand (BOD) (43.77 – 235.64 mg/ml), chemical oxygen demand (COD) (572.46 -792.70 mg/ml), nitrate (1.00 – 1.77 µg/l), potassium (3.34 – 10.63 µg/l), zinc (0.02 – 0.08 µg/l), lead (0.2 – 0.5 µg/l) and sulphate (10.68 – 19.10 µg/l) were higher than the world health organization (WHO) acceptable limits. Statistical analysis revealed that there was a significant difference between some of the parameters studied during the wet and dry seasons. Two factors analysis of variance also showed that time and location played a significant role in the results of the physiochemical parameters studied. The results of our study however showed that indiscriminate discharge of hospital wastewaters could pose serious threat to the environment, soil and public health. Hence, proper treatment and disposal of such waste should be encouraged so as to reduce the rate of pollution.

## Introduction

Hospital effluent is referred to as wastewater from hospitals or health care centers, biological or non biological that is discarded and not intended for further use (Oyeleke *et al*., 2008; Omoruyi *et al*., 2011). Hospital effluent consists of both organic and inorganic substances including pathogenic microorganisms and heavy metals. Their presence in such effluent especially in high quantity could sometimes pose grave problem for populace (Omoruyi *et al*., 2011).

The amount of waste water discharged from hospital varies from hospital to hospital but it has been estimated at 400 to 120 liters/bed/day. Tsakona *et al*. (2006) reported an estimate on per capita production of waste water in hospital to be 1000 liters/person/day.

About 85% of hospital waste is said to be non hazardous, 10% infective/hazardous and 5% not infective in the United States of America (Oyeleke and Istifamus, 2009). Meanwhile about 15% of hospital waste is regarded infective in most developed countries. In India, it was reported that the value could increase from 15% to 35% depending on the total amount of hospital waste generated. In Pakistan, about 20% of hospital waste could be found potentially infective or hazardous (Agarwal, 1998; Ekhaise and Omavwoya, 2008). Hazardous medical waste consists primarily of chemicals and discarded cytotoxic drugs which find their way into the environment due to improper usage and indiscriminate disposal. Their presence in the environment have been reported to pose serious environmental health risk due to their toxic, genotoxic and/or carcinogenic effect (Akter *et al*., 1998; Shaner, 1997; Omoruyi *et al*., 2011) and could have potential negative effects on the biological balance of natural environment.

The direct exposure of hospital effluent to management workers and members of the public, soil and water body increases the hazard that it posses to

 

the environment. The major health risk posed by medical waste to the inhabitants of the terrestrial and aquatic ecosystem includes the following; contamination of dirty water, surface water, accumulation of toxic nonbiodegradable hospital waste products, accumulation of heavy metals and unprotected landfill as well as inefficient sorting of waste materials. The toxic substances discharged into water bodies are not only accumulated through the food chain (Odiete, 1999), but may also either limit the number of species or produce adverse effect on the receiving environment (Lateef, 2003).

Different countries are however putting down systems for the complete management of hospital effluent. All health care units in Greece for example are obliged to design and implement a comprehensive management strategy so as to safeguard the public and the environment (Tsakona *et al*., 2007). Some countries especially developing countries are however yet to put down legislature as to reducing the environmental impact of hospital effluent. In Nigeria, many health care centers/hospitals lack effluent treatment plants, the untreated waste are either disposed on the ground or discharged into nearby natural bodies which may pose serious health problems to communities (Chukwura and Okpokwasili, 1997; Odiete, 1999). Such hospital waste can have effects even at low concentrations. Aquatic organisms for instance respond negatively to low concentration of formaldehyde which is a frequently found contaminant in hospital effluent (Murphy *et al*., 1989). It was reported that formaldehyde in the range of 10 – 100 mg/l was toxic to the microbial in wastewater treatment system (Lu and Hegamann, 1998). In addition, the presence of organochlorine compounds in high concentrations in hospital effluent has also been reported as toxic to aquatic life (Gastiser *et al*., 1996). This work therefore is aimed at evaluating the physiochemical properties of hospital effluent as well as the possible effects of season and timing on the properties of such effluent.

## Materials And Methods

### Sample collection

Samples were collected six times during the wet season and six times during the dry season at 7:00 am, 12:00 noon and 6:00 pm for one year. The samples were collected from 6 different locations within and outside the hospital premises of the University teaching Hospital based in Benin City. They were designated station 1, 2, 3, 4, 5 and 6.

Station 1 = Effluent from laundry

Station 2 = Effluent from cafeteria

Station 3 = Effluent from children's ward

Station 4 = The point where all the effluent from University of Benin Teaching Hospital meet.

Station 5 = 100 meters away from station 4

Station 6 = 100 meters away from station 5

### Physiochemical analysis

### Temperature

The temperature of the samples was measured by dipping PT-2 digital thermometer with model number ST-3 into the samples immediately after collection at the different station. **Hydrogen ion concentration (pH)**

pH was measured using a pH meter (metro ohm model 610 ion meter). The pH meter was calibrated using buffer 4, 7 and 9.

### Dissolved Oxygen

A 250ml dissolved oxygen bottle was filled to the brim so as to minimize contact with air. 1ml of $MnSO_4$ solution was added to the down bottom of the bottle, and also in the same way, 1ml of Alkali-Iodide-Azide solution after which it was sealed with a stopper and shaked. When the precipitate had settled, 2ml of conc. $H_2SO_4$ was added to the mixture inside the dissolved oxygen bottle to dissolve the precipitate. 100 ml of the solution was measured out into a 250ml beaker after which 2 drops of starch was added as an indicator. The solution was then titrated against 0.0125M thiosulphate.

### Biological Oxygen Demand

This method measures the amount of oxygen required by microorganisms to decompose the organic matter in the wastewater samples at 20$^{o}$C for 5 days in continuous darkness. Samples were filled into light (clear white glass) and dark bottles (250ml each) stop corked, such that no bubble of air was trapped. Each duplicated samples was then placed in an incubator at 20$^{o}$C and kept closed for 5 days. The biochemical oxygen demand was then determined after 5 days of incubation in the dark.

### Chemical Oxygen Demand

Fifty milliliters of samples were placed in a 500ml refluxing flask, to which 1g of

tetraoxosulphate VI acid was added very slowly, with mixing to dissolve. 25ml of potassium chromate solution was added with cooling and mixing to avoid possible loss of volatile materials in the sample. The flask was attached to a condenser through which 70ml of the acid reagent was again added with continuous cooling and swirling.

**Metal Analysis**

All metals were analyzed using atomic absorption spectrophotometer. Concentrated nitric acid was added to raw samples so as to preserve the samples and to destroy organic matter and bring all metals into solution. Sodium and potassium was determined using flame photometer (APHA, 1985).

**Statistical analysis**

The data obtained were analyzed for significant difference using T-test: two sample assuming equal variances and two factors analysis of variance.

**Results**

The mean values of physiochemical parameters obtained during the wet season reveal that sampling point 5 (station 5) at 12:00 pm had the highest pH value during the wet season while sampling point 3 (station 3) at 12:00 pm had the least pH value. The highest temperature value was obtained in sampling point 6 (station 6) at 7:00 am; the highest values of dissolved oxygen and biochemical oxygen demand was obtained in sampling point 2 (station 2), both at 7:00 am while the highest value of chemical oxygen demand was recorded in sampling point 4 (station 4) at 7:00 am.

During the dry season, the highest pH value was obtained in sampling point 4 (station 4) at 7:00 am and sampling point 6 (station 6) at 6:00 pm. The highest BOD, zinc and sulphate values of 235.64 mg/ml, 0.08µg/l and 17.50µg/l respectively were recorded in sampling point 4 at 7:00 am. Sampling point 4 (station 4) at 12:00 pm also had the highest value of potassium.

Table 1: Mean values of physiochemical parameters obtained from sampling point 1 (station 1)

| | WET SEASON | | | DRY SEASON | | |
|---|---|---|---|---|---|---|
| **Parameters** | **7:00 am** | **12:00 noon** | **6:00 pm** | **7:00 am** | **12:00 noon** | **6:00 pm** |
| pH | 6.52 ± 0.25 | 6.48 ± 0.76 | 6.43 ± 0.00 | 6.65 ± 0.07 | 6.65 ± 0.33 | 6.65 ± 0.04 |
| Temperature ($^{O}$C) | 19.63 ± 0.98 | 20.33 ± 0.41 | 19.70 ± 0.52 | 21.53 ± 1.76 | 22.80 ± 2.87 | 21.40 ± 2.51 |
| Lead (µg/l) | 0.37 ± 0.05 | 0.27 ± 0.057 | 0.23 ± 0.05 | 0.47 ± 0.05 | 0.47 ± 0.05 | 0.40 ± 0.10 |
| Iron (µg/l) | 0.03 ± 0.01 | 0.02 ± 0.017 | 0.03 ± 0.00 | 0.04 ± 0.01 | 0.04 ± 0.01 | 0.03 ± 0.01 |
| DO (mg/ml) | 9.81 ± 3.32 | 15.78 ± 6.40 | 12.91± 5.03 | 12.62 ± 7.57 | 14.62 ± 8.60 | 13.25 ± 6.07 |
| BOD (mg/ml) | 76.92 ± 45.72 | 86.34 ± 23.02 | 68.70 ± 27.68 | 211.68 ± 83.24 | 187.45 ± 87.26 | 191.34 ± 72.01 |
| COD | 605.60 ± 149.65 | 687.35 ± 88.12 | 638.22 ± 60.84 | 584.90 ± 35.85 | 608.28 ± 66.80 | 608.91 ± 10.17 |
| Zinc (µg/l) | 0.04 ± 0.02 | 0.033 ± 0.01 | 0.027 ± 0.01 | 0.06 ± 0.02 | 0.04 ± 0.01 | 0.04 ± 0.01 |
| Potassium (µg/l) | 6.69 ± 1.75 | 7.12 ± 1.92 | 6.36 ± 1.84 | 8.62 ± 0.24 | 7.17 ± 1.99 | 8.61 ± 1.13 |
| Nitrate (µg/l) | 1.30 ± 0.17 | 1.50 ± 0.36 | 1.23 ± 0.20 | 1.30 ± 0.10 | 1.30 ± 0.10 | 1.30 ± 0.10 |
| Sulphate (µg/l) | 15.96 ± 4.34 | 17.3 ± 3.58 | 17.8 ± 1.25 | 17.30 ± 3.10 | 17.30 ± 3.10 | 17.10 ± 4.11 |

Result is given as Mean ± standard deviation.

Table 2: Mean values of physiochemical parameters obtained from sampling point 2 (station 2)

| | WET SEASON | | | DRY SEASON | | |
|---|---|---|---|---|---|---|
| **Parameters** | **7:00 am** | **12:00 noon** | **6:00 pm** | **7:00 am** | **12:00 noon** | **6:00 pm** |
| pH | 6.44 ± 0.24 | 6.64 ± 0.25 | 6.60 ± 0.25 | 6.66 ± 0.02 | 6.76 ± 0.26 | 6.84 ± 0.07 |
| Temperature ($^{O}$C) | 20.37 ± 0.66 | 19.50 ± 0.23 | 19.07 ± 0.57 | 20.63 ± 1.90 | 23.30 ± 4.94 | 21.33 ± 3.96 |
| Lead (µg/l) | 0.30 ± 0.00 | 0.17 ± 0.05 | 0.17 ± 0.05 | 0.47 ± 0.12 | 0.47 ± 0.15 | 0.47 ± 0.15 |
| Iron (µg/l) | 0.53 ± 0.01 | 0.05 ± 0.01 | 0.06 ± 0.02 | 0.04 ± 0.01 | 0.05 ± 0.01 | 0.04 ± 0.02 |
| DO (mg/ml) | 19.51 ± 2.02 | 9.74 ± 6.44 | 11.19 ± 1.08 | 15.06 ± 6.45 | 14.75 ± 6.47 | 15.50 ± 5.29 |
| BOD (mg/ml) | 166.41 ± 61.73 | 88.30 ± 48.82 | 53.34 ± 26.76 | 194.45 ± 17.96 | 183.11 ± 44.02 | 181.43 ± 63.62 |
| COD | 701.96 ± 109.66 | 783.80 ± 109.13 | 705.99 ± 96.77 | 572.68 ± 146.74 | 587.56 ± 95.92 | 572.46 ± 70.25 |
| Zinc (µg/l) | 0.06 ± 0.02 | 0.05 ± 0.00 | 0.07 ± 0.01 | 0.05 ± 0.01 | 0.05 ± 0.01 | 0.05 ± 0.10 |
| Potassium (µg/l) | 5.78 ± 0.33 | 5.75 ± 0.38 | 5.30 ± 0.29 | 6.67 ± 0.24 | 7.03 ± 0.55 | 7.41 ± 1.68 |
| Nitrate (µg/l) | 1.33 ± 0.11 | 1.2 ± 0.00 | 1.17 ± 0.05 | 1.37 ± 0.12 | 1.30 ± 0.10 | 1.27 ± 0.06 |
| Sulphate (µg/l) | 13.77 ± 1.55 | 13.43 ± 2.14 | 12.42 ± 1.04 | 15.88 ± 3.41 | 16.28 ± 4.32 | 16.08 ± 5.11 |

Result is given as Mean ± standard deviation.

Table 3: Mean values of physiochemical parameters obtained from sampling point 3 (station 3)

| | WET SEASON | | | DRY SEASON | | |
|---|---|---|---|---|---|---|
| **Parameters** | **7:00 am** | **12:00 noon** | **6:00 pm** | **7:00 am** | **12:00 noon** | **6:00 pm** |
| pH | 6.41 ± 0.05 | 6.20 ± 0.04 | 6.44 ± 0.18 | 6.83 ± 0.02 | 6.58 ± 0.13 | 6.71 ± 0.18 |
| Temperature ($^{O}$C) | 20.80 ± 1.65 | 20.50 ± 0.51 | 19.17 ± 0.68 | 20.30 ± 2.59 | 22.43 ± 3.01 | 20.83 ± 3.17 |
| Lead (µg/l) | 0.20 ± 0.00 | 0.23 ± 0.05 | 0.17 ± 0.05 | 0.47 ± 0.11 | 0.40 ± 0.10 | 0.37 ± 0.06 |
| Iron (µg/l) | | | | 0.02 ± 0.01 | 0.04 ± 0.02 | 0.02 ± 0.01 |
| DO (mg/ml) | 8.45 ± 5.19 | 6.21 ± 5.00 | 4.88 ± 3.49 | 14.69 ± 4.80 | 11.11 ± 1.98 | 13.74 ± 5.60 |
| BOD (mg/ml) | 55.28 ± 53.73 | 52.16 ± 45.15 | 43.77 ± 40.12 | 174.77 ± 43.59 | 174.77 ± 44.58 | 183.00 ± 68.25 |
| COD | 696.68 ± 37.80 | 625.28 ± 54.92 | 668.08 ± 34.54 | 618.54 ± 74.91 | 623.77 ± 61.74 | 622.76 ± 49.52 |
| Zinc (µg/l) | 0.02 ± 0.01 | 0.03 ± 0.02 | 0.03 ± 0.00 | 0.06 ± 0.01 | 0.05 ± 0.01 | 0.04 ± 0.01 |
| Potassium (µg/l) | 3.69 ± 1.20 | 4.24 ± 1.28 | 4.31 ± 0.66 | 7.08 ± 0.94 | 6.56 ± 1.12 | 6.05 ± 1.39 |
| Nitrate (µg/l) | 1.20 ± 0.17 | 1.10 ± 0.00 | 1.00 ± 0.00 | 1.37 ± 0.06 | 1.30 ± 0.10 | 1.20 ± 0.10 |
| Sulphate (µg/l) | 13.42 ± 0.85 | 16.90 ± 5.05 | 15.11 ± 3.62 | 15.71 ± 3.95 | 17.17 ± 5.92 | 16.43 ± 5.41 |

Result is given as Mean ± standard deviation.

Table 4: Mean values of physiochemical parameters obtained from sampling point 4 (station 4)

| | WET SEASON | | | DRY SEASON | | |
|---|---|---|---|---|---|---|
| **Parameters** | **7:00 am** | **12:00 noon** | **6:00 pm** | **7:00 am** | **12:00 noon** | **6:00 pm** |
| pH | 6.42 ± 0.07 | 6.37 ± 0.05 | 6.45 ± 0.28 | 6.88 ± 0.11 | 6.73 ± 0.19 | 6.75 ± 0.26 |
| Temperature ($^{O}$C) | 18.77 ± 1.05 | 20.50 ± 1.25 | 19.67 ± 0.40 | 19.77 ± 1.00 | 21.49 ± 1.82 | 19.25 ± 1.02 |
| Lead (µg/l) | 0.50 ± 0.17 | 0.43 ± 0.05 | 0.33 ± 0.01 | 0.53 ± 0.05 | 0.53 ± 0.06 | 0.50 ± 0.10 |
| Iron (µg/l) | 0.05 ± 0.02 | 0.06 ± 0.03 | 0.03 ± 0.01 | 0.06 ± 0.02 | 0.08 ± 0.02 | 0.05 ± 0.01 |
| DO (mg/ml) | 14.64 ± 0.50 | 13.59 ± 3.16 | 13.07 ± 4.45 | 14.11 ± 13.46 | 14.34 ± 4.19 | 9.10 ± 3.21 |
| BOD (mg/ml) | 89.09 ± 53.89 | 80.40 ± 61.98 | 65.10 ± 23.35 | 235.64 ± 52.67 | 179.78 ± 68.35 | 209.89 ± 54.97 |
| COD | 792.70 ± 126.08 | 694.60 ± 171.53 | 713.18 ± 101.21 | 739.64 ± 64.66 | 697.01 ± 95.36 | 673.54 ± 113.26 |
| Zinc (µg/l) | 0.08 ± 0.01 | 0.07 ± 0.01 | 0.03 ± 0.00 | 0.08 ± 0.00 | 0.08 ± 0.01 | 0.05 ± 0.01 |
| Potassium (µg/l) | 10.61 ± 2.03 | 9.70 ± 0.93 | 6.61 ± 2.24 | 10.56 ± 1.18 | 10.63 ± 0.72 | 8.09 ± 1.69 |
| Nitrate (µg/l) | 1.77 ± 0.15 | 1.70 ± 0.17 | 1.43 ± 0.31 | 1.47 ± 0.23 | 1.40 ± 0.20 | 1.23 ± 0.15 |
| Sulphate (µg/l) | 18.90 ± 5.59 | 19.10 ± 5.05 | 17.03 ± 3.93 | 17.5 ± 3.70 | 16.63 ± 4.25 | 15.83 ± 3.69 |

Result is given as Mean ± standard deviation.

Table 5: Mean values of physiochemical parameters obtained from sampling point 5 (station 5)

| | WET SEASON | | | DRY SEASON | | |
|---|---|---|---|---|---|---|
| **Parameters** | **7:00 am** | **12:00 noon** | **6:00 pm** | **7:00 am** | **12:00 noon** | **6:00 pm** |
| pH | 6.41 ± 0.21 | 6.66 ± 0.21 | 6.45 ± 0.29 | 6.78 ± 0.06 | 6.71 ± 0.19 | 6.68 ± 0.14 |
| Temperature ($^{O}$C) | 19.17 ± 2.13 | 19.27 ± 1.10 | 18.87 ± 0.92 | 19.58 ± 1.07 | 20.46 ± 1.16 | 18.42 ± 0.88 |
| Lead (µg/l) | 0.27 ± 0.05 | 0.30 ± 0.02 | 0.20 ± 0.10 | 0.47 ± 0.05 | 0.43 ± 0.15 | 0.33 ± 0.06 |
| Iron (µg/l) | 0.03 ± 0.02 | 0.04 ± 0.02 | 0.02 ± 0.01 | 0.05 ± 0.01 | 0.05 ± 0.01 | 0.04 ± 0.01 |
| DO (mg/ml) | 12.17 ± 6.94 | 8.69 ± 1.97 | 8.98 ± 1.56 | 9.48 ± 2.40 | 9.96 ± 1.16 | 9.82 ± 0.95 |
| BOD (mg/ml) | 115.66 ± 76.41 | 63.73 ± 44.50 | 70.61 ± 41.66 | 211.71 ± 49.45 | 201.13 ± 21.85 | 201.72 ± 25.55 |
| COD | 699.65 ± 41.92 | 596.79 ± 162.83 | 618.95 ± 141.45 | 744.08 ± 106.78 | 652.15 ± 111.11 | 687.86 ± 109.73 |
| Zinc (µg/l) | 0.06 ± 0.01 | 0.04 ± 0.01 | 0.04 ± 0.02 | 0.07 ± 0.01 | 0.06 ± 0.01 | 0.05 ± 0.06 |
| Potassium (µg/l) | 5.75 ± 0.57 | 5.70 ± 0.63 | 5.11 ± 0.59 | 7.42 ± 1.22 | 6.48 ± 1.64 | 7.84 ± 0.88 |
| Nitrate (µg/l) | 1.37 ± 0.05 | 1.30 ± 0.20 | 1.30 ± 0.10 | 1.4 ± 0.17 | 1.3 ± 0.06 | 1.23 ± 0.12 |
| Sulphate (µg/l) | 14.53 ± 2.62 | 11.0 ± 1.35 | 10.99 ± 1.20 | 17.33 ± 3.67 | 12.53 ± 5.00 | 9.75 ± 1.77 |

Result is given as Mean ± standard deviation.

Table 6: Mean values of physiochemical parameters obtained from sampling point 6 (station 6)

| | WET SEASON | | | DRY SEASON | | |
|---|---|---|---|---|---|---|
| **Parameters** | **7:00 am** | **12:00 noon** | **6:00 pm** | **7:00 am** | **12:00 noon** | **6:00 pm** |
| pH | 6.36 ± 0.02 | 6.32 ± 0.13 | 6.36 ± 0.06 | 6.85 ± 0.11 | 6.47 ± 0.15 | 6.88 ± 0.09 |
| Temperature ($^{O}$C) | 21.44 ± 0.85 | 20.87 ± 0.20 | 19.57 ± 1.04 | 18.9 ± 0.70 | 20.28 ± 0.82 | 19.07 ± 0.80 |
| Lead (µg/l) | 0.23 ± 0.05 | 0.20 ± 0.10 | 0.17 ± 0.05 | 0.40 ± 0.00 | 0.37 ± 0.21 | 0.37 ± 0.12 |
| Iron (µg/l) | 0.017 ± 0.01 | 0.01 ± 0.00 | 0.01 ± 0.00 | 0.04 ± 0.00 | 0.04 ± 0.01 | 0.04 ± 0.01 |
| DO (mg/ml) | 8.89 ± 2.18 | 3.85 ± 1.26 | 6.79 ± 2.14 | 12.04 ± 5.01 | 8.76 ± 2.11 | 8.23 ± 1.34 |
| BOD (mg/ml) | 57.97 ± 24.99 | 50.47 ± 39.47 | 59.13 ± 40.97 | 205.34 ± 19.04 | 230.48 ± 47.18 | 204.13 ± 81.65 |
| COD | 617.66 ± 76.85 | 579.67 ± 22.08 | 589.55 ± 72.78 | 669.14 ± 23.57 | 558.36 ± 26.26 | 606.34 ± 81.94 |
| Zinc (µg/l) | 0.03 ± 0.01 | 0.03 ± 0.01 | 0.03 ± 0.00 | 0.05 ± 0.01 | 0.04 ± 0.01 | 0.03 ± 0.01 |
| Potassium (µg/l) | 4.03 ± 0.52 | 3.34 ± 0.58 | 3.34 ± 0.53 | 5.82 ± 3.15 | 6.49 ± 1.51 | 6.91 ± 0.89 |
| Nitrate (µg/l) | 1.23 ± 0.05 | 1.10 ± 0.10 | 1.13 ± 0.15 | 1.33 ± 0.15 | 1.27 ± 0.12 | 1.30 ± 0.10 |
| Sulphate (µg/l) | 12.80 ± 1.44 | 14.93 ± 2.56 | 13.85 ± 3.54 | 11.55 ± 1.49 | 10.68 ± 1.59 | 9.28 ± 3.03 |

Result is given as Mean ± standard deviation.

**Discussion**

The results of the physiochemical parameters of the hospital effluent from the University Teaching Hospital showed that in all the studied samples from the different sampling points, pH was always in an acidic range (6.20 – 6.88) (Table 1-6). These values are similar to that obtained by Ekhaise and Omavwoya (2008). In Indonesia, the range of pH in hospital wastewater was 5.9 – 12.5 (Mesdaghinia *et al.,* 2009).

The results however varied from month to month and from season to season. The highest mean seasonal pH (6.88) was recorded during the dry season (Table 4 and 6) while the lowest mean monthly pH (6.20) was recorded during the wet season (Table 3). The pH values of sampling point 2 (station 2) during the wet season was generally high compared to the values obtained from other sampling points. This could be as a result of the washing agents and disinfectants used in the laundry. The mean pH values obtained during the wet season showed that sampling point 5 (station 5) at 12:00 noon had the highest pH value during the wet season, meanwhile the highest pH value obtained during the dry season was obtained in sampling point 4 (station 4) at 7:00 am and sampling point 6 at 6:00 pm. However, all the pH values obtained during the wet and dry seasons were within the World Health Organization acceptable limit and is suitable from the viewpoint of wastewater and comparable to pH value of domestic wastewater (Mesdaghinia *et al*., 2009). Although there was an observable difference in the pH values obtained during the wet and dry season, statistical analysis using paired t-Test revealed that there was also a significant difference between the pH values obtained during the wet and dry seasons at 95% confidence level ($P < 0.05$). Two factors analysis of variance also showed that both time and location had no effect on the pH values of hospital effluent from the University Teaching Hospital.

In sampling point 1 (station 1), temperature values ranged from $19.63^{O}C$ to $20.33^{O}C$ during the wet season and $21.53^{O}C$ to $22.80^{O}C$ during the dry season. The mean seasonal temperature values as presented in Table 1-6 showed that there is a significant difference ($P < 0.05$) between the temperatures obtained during the wet and dry seasons. Two factors analysis of variance showed that during the wet season, both time and location had no effect on the temperature. Meanwhile, during the dry season, time and location affected/influenced the values of temperatures obtained.

The concentration of dissolved oxygen was higher in sampling point 1 and 2 (station 1 and 2) for both wet and dry season compared to other sampling points, which could be due to increased waste disposal and other human activities that may enhance their growth and proliferation leading to the consumption of available oxygen (Ekhaise and Omavwoya, 2008). The DO is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as the self purification capacity of the wastewater. The mean values of DO obtained both during the wet and dry seasons exceeded the WHO standard 0f 5 mg/ml. hence, the wastewater from the teaching hospital can affect aquatic life and its receiving environment. At 95% confidence level, it was observed that there was no significant difference between the values of dissolved oxygen obtained during the wet and dry season. Meanwhile, location affected the values obtained for dissolved oxygen for both wet and dry season.

An indication of organic oxygen demand content of wastewater can be obtained by measuring the amount of oxygen required for its stabilization either as BOD or COD. Biological Oxygen Demand is the measure of the oxygen required by microorganisms whilst breaking down organic matter while Chemical Oxygen Demand is the measure of amount of oxygen required by both potassium dichromate and concentrated sulphuric acid to breakdown both organic and inorganic matters (Chukwura and Okpokwasili, 1997). According to Tables 1 to 6, the BOD and COD values obtained during the wet season ranged from 43.77 to 166.41 mg/ml and 579.67 to 792 mg/ml respectively. During the dry season, BOD and COD values ranged from 174.77 to 235.64 mg/ml and 558.36 to 744.08 mg/ml respectively. The concentrations of BOD and COD in all the sampling points for both wet and dry seasons were higher than the WHO values of 50 mg/ml and 1000 mg/l respectively. Only the BOD value obtained in sampling point 3 (station 3) during the wet season at 6:00 pm fell within the WHO standard (Table 3). High BOD and COD concentrations observed in the wastewater might be due to the use of chemicals, which are organic or inorganic that are oxygen demanding in nature. There was however a significant difference between the BODs obtained during the wet and dry season.

The concentration of nitrate, sulphate, potassium and other metals were relatively high with some degree of variation among the sampling points. The concentrations of these metals in all the sampling points for both wet and dry seasons were higher compared to WHO values of 2.50µg/l for sulphate

and 0.45µg/l for nitrate. The high level of nitrate in the hospital wastewater may give rise to methaemoglobinemia and may pose serious problem to other use. Lead, Zinc and Potassium showed significant difference at 95% confidence level between wet and dry seasons when compared with nitrate and sulphate. Most of the parameters investigated were higher at 12:00 noon when compared to samples collected at both 7:00 am and 6:00 pm. This is an indication of increased human activities around the hospital at this time.

Hence, indiscriminate disposal of these effluents without proper treatment should be avoided so as to prevent possible impact on the environment, soil, aquatic environment as well as human health.

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