

Effects of Solid Wastes on Ukwaka Stream, Nnewi, Nigeria

Okeke Ignatius Emeka¹, Ekenta E. O.² Mbanefo Dozie³

¹⁻²Department of Civil Engineering,

Nnamdi Azikiwe University,

Awka,

³Department of Chemical Engineering, University of Benin

Nigeria

ABSTRACT

Deteriorating of water qualities is grave consequences of open wastes dumping which have resulted in growing public concern. In this study, the effects of solid wastes were identified. Industrial and domestic solid wastes have been linked to numerous environmental pollution problems ranging from long-term environmental degradation to increased incidence of waterborne disease. This study was conducted to investigate the effects of solid waste on the water quality of Ukwaka stream in Nnewi, Nigeria. Both the upstream and downstream sampled water from the selected points were analyzed according to the standard method of American Public Health Association (APHA). The parameters analysed were: pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), and Heavy Metals like copper (Cu), cadmium (Cd), iron (Fe), lead (Pb) and zinc (Zn) concentrations. AAS was used to analyze the heavy metals. Results of the study showed that the water was slightly acidic; the color was dark brown and emitted the noxious smell. The water collected from the point just after the solid waste is contaminated most when compared with other points. There was moderate contamination of the environment by the metals studied. Results of the heavy metals were high, with iron and zinc being exceptionally high and above the specified international standards. This study indicated that solid waste from households and the community is a serious health hazard. Also industrialization has contributed to the large-scale pollution and this polluted water is not good for human consumption. It is therefore recommended that the disposal of untreated wastes should be stopped to save the stream water from further deterioration.

Key words: Contamination, Deteriorating, Environmental degradation, Effect, Solid Waste, Ukwaka stream, Water borne diseases.

1. INTRODUCTION

Life cannot exist without water because it is the major component of all living things. According to [1] water is a vital commodity and its sources include rivers, streams, lakes, wells, boreholes, spring etc. It is important both physiologically and ecologically as it plays an essential role in temperature control and also is the media in which many organisms live [2]. It is the most essential requisite that nature provides to sustain life for plants and animals, and also has tremendous role in every mode of human life [3, 4], Water pollution is unarguably one of the most fundamental environmental issues globally and locally, as untreated or inadequately treated waste and solid wastes are being discharged into streams, estuaries and seas [5] Water bodies especially freshwater reservoirs are the most affected. Careless disposal of industrial effluents and other wastes have contributed greatly to the contamination of the water [6]. As a result, water bodies which are major receptacles of treated and untreated or partially treated industrial wastes have become highly polluted [7]. To buttress the above point, [8] affirmed that the water from these sources is contaminated with domestic, agricultural, and industrial wastes and likely to cause water related diseases.

1.2 Domestic solid waste and its impacts on stream

Domestic solid waste refers to wastes produced from residential areas from day to day activities called "household" solid wastes [9]. Municipal solid waste (MSW) is an inevitable byproduct of human activity. They pose a threat for health and also they may have long term effect on environment [10]. Urbanization and population growth are solely responsible for high increasing rate of solid wastes and its proper management is a major problem of Municipal Corporation. Due to inadequate domestic waste collection and disposal, considerable amounts of waste in developing countries ends up in open dumps or drainage system, threatening both surface and ground water quality and provide a breeding ground for pests [11]. The adverse effect of inadequate

waste management service on productivity and economic development of the city is very significant. [12] Improper Municipal Solid Wastes (MSW) disposal and management causes all types of pollution: air, soil, and water.

In developing countries open dumpsites are common, due to the low budget for waste disposal and non-availability of trained manpower. Open dumping of MSW is a common practice in Nigeria. It poses serious threat to surface water resources. The contamination of water and soil by heavy metal could be attributed to solid waste dump and could cause adverse effects on human health, animals and soil productivity [13, 14]. In Nigeria, pollution of water bodies is further worsening with lack of adequate environmental monitoring schemes; weak enforcement of environmental regulations. Making his contribution, [15] pointed out that river pollution is becoming a central issue in water management in Nigeria. Contributing to this, [16, 17, 18] pointed that many streams and rivers in Nigeria get polluted as a result of the discharge of untreated wastewater and other organic wastes directly into the streams. [19] affirmed that the water quality situation is becoming very critical in developing countries and is of great environmental and public health concerns. The case is not different from the situation in Nnewi town. Nnewi has most industries discharging their untreated effluents either directly into stream or indirectly through ditches. Researchers like [20, 21] have worked on the influence of industrial effluents on the streams around Nnewi. However none of them went in details as far as solid wastes disposal into the streams is concerned.

2.0 MATERIALS AND METHODS

2.1 Study area Description

The study area is located close to Uru Industrial Estate in Nnewi about 22 km south east of Onitsha, Nigeria. It lies on the latitude of 6° 1'N and longitude of 6°55'E, [22]. It has altitude that ranges from 105m to 300m above sea level. It is a commercial city in Anambra, [23] state, in the south east of Nigeria. Its commercial nature influences its rapid urbanization, [24]. Generally, the soil is composed mainly of iron rich tropical soils which may be in the form of loamy clay, and sandstones. The climate is hot and humid; Nnewi has two major seasons namely: raining season (April to October) and dry season (November to March). The annual rainfall ranges from 165 mm in April to 1025 mm in September. The mean annual temperature ranges from 13°C in February to 22°C in October [24]. The study area (Ukwaka stream) shown in Fig. 2.1 is a unique place where industrial effluents from Chicason Group of Industries and solid wastes are dumped regularly into the bank of the streams at site C in an unscientific manner as shown in plates 2.1 and 2.2.

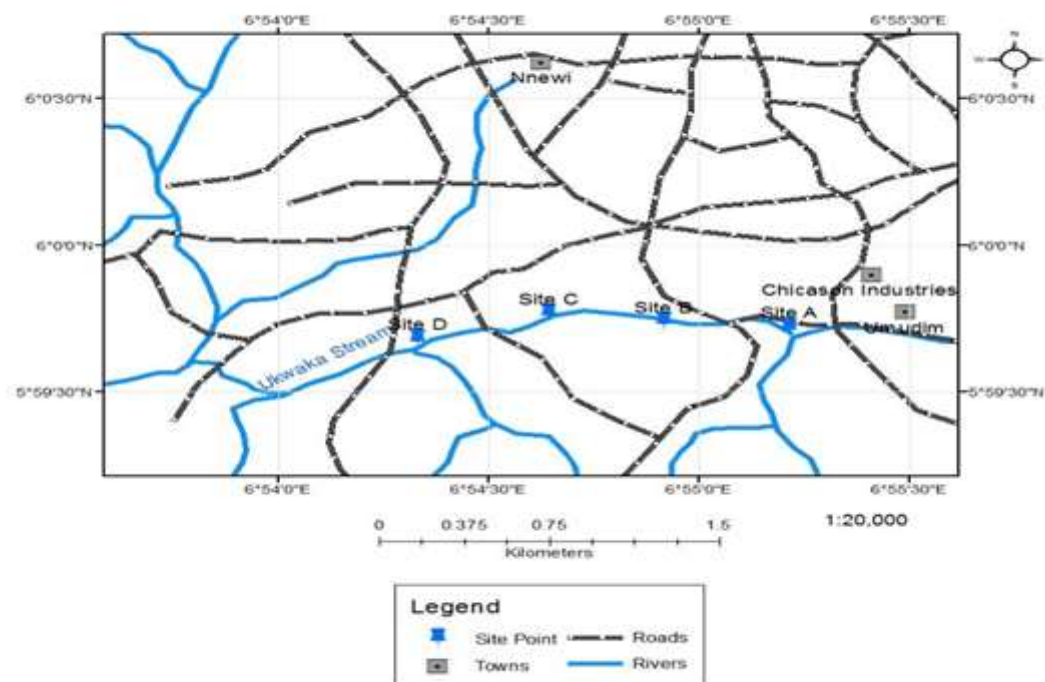


Figure 2.1 Map of some part of Nnewi showing Ukwaka stream



Plate 2.1 Solid wastes being dumped into the stream.



Plate 2.2 Solid wastes in the stream at site C

2.2 Outline of Methodology

2.2.1 Water Sampling and Preservation procedure

The Ukwaka water samples were collected from four different points of the stream for a period of six months (July to December 2017). The GPS co-ordinates in UTM were recorded for each sampling site as follows: point 0m (site A) 6.820°E , 5.885°N , point 300m (site B) 6.915°E , 5.996°N , point 600m, (site C) 6.911°E , 5.996°N and point 900m (site D) 6.906°E , 5.995°N . The effluent samples were collected from the effluent channel leading into the stream. The Samples were collected in 1 litre plastic bottles at a distance of about 300 meters from each other point. They were taken from the mid-stream at approximately 0.20 meters below the surface. These effluent samples were collected monthly in the first week of the month, from July to December, 2017; while the water samples from four different points of Ukwaka stream were collected every week from July to December, 2017. The GPS co-ordinates were recorded for each site as indicated in Fig 2.2. The collections were done on the first day of every week between 8.00 am and 12 noon and put in an iced block stocked cooler for preservation.

To provide necessary information for each sample taken, it was collected into appropriately well labelled plastic bottle with a unique identification number. While collecting, the bottles containing samples were sealed immediately under the stream water to avoid exposure to air. The dates of collection, location were recorded in the note book and each sample collected was labelled separately. Prior to this, all the bottles were washed and rinsed three times with the water to be sampled. They were transported within 48 hours to the laboratory, preserved according to the standard method of American Public Health Association (APHA, 2012), ready for the Physical, Chemical and Heavy Metals parameters analyses.

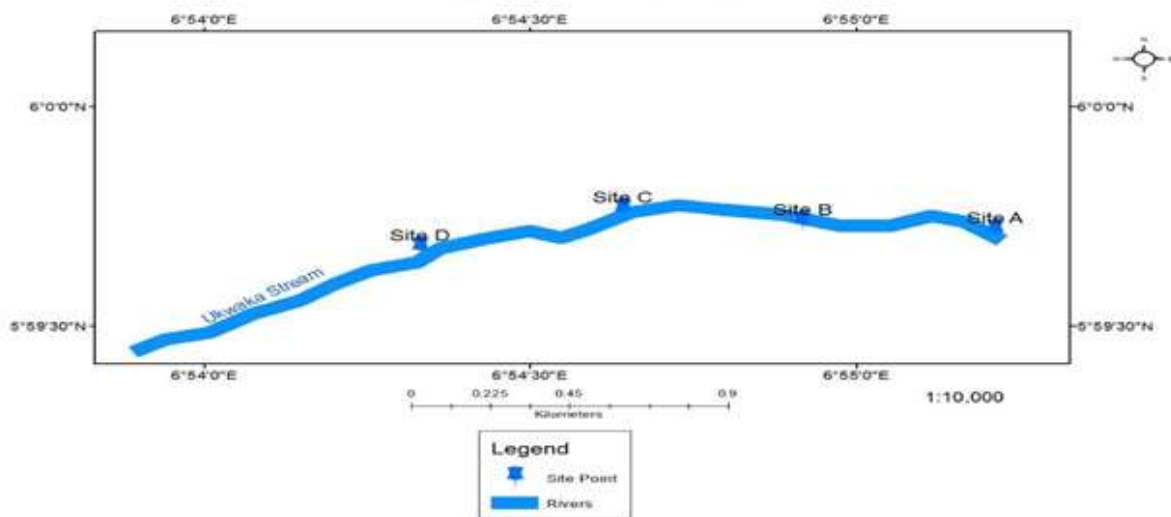


Figure 2.1 Sampling points with GPS positions: A (6.820°E , 5.885°N); B (6.915°E , 5.996°N); C (6.911°E , 5.99°N); D (6.906°E , 5.995°N).



Plate 2.3 labelled samples

2.2.2 Determination of physicochemical characteristics

Physicochemical characteristics determinations were carried out according to the Standard Methods for the Examination of Water and Waste water [22]. Various standard methods were followed and a number of sophisticated instruments were used. Water colour was observed by naked eyes and odor was felt with nose. The water temperatures, electrical conductivity (EC), were taken immediately in the field by using pocket instruments for that.

2.3 Physical Parameters taken

2.3.1 pH

Values of pH were measured by portable digital pH water analyses kit with pH electrodes. The instrument was calibrated with buffer solutions having pH values of 4 to 9. A pH of 7.0 indicates a neutral solution, pH values smaller than 7.0 indicate acidity, pH values larger than 7.0 indicate alkalinity.

- the sample was measured into a conical flask.
- the pH electrode was inserted into the sample
- the value of the pH was then read on the calibration on it.

2.3.2 Specific conductance

The value of Electrical Conductivity (EC) is a measure of the ability of ions in a solution to carry electric current. A measure of the ability of water to conduct an electrical current varies with temperature. Magnitude depends on concentration, kind, and degree of ionization of dissolved constituents. The EC values were measured by portable kit with electrodes. The meter was switched on and its probe dipped into the sample contained in a beaker. The electrical conductivity was read directly and recorded in micro-Siemens per centimeter.

2.3.3 Temperature

Thermometer was used to measure this. The thermometric bulb containing the mercury was vertically immersed in the effluent and allowed to stand for some minutes till the temperature reading was steady before taking reading.

2.3.4 Turbidity

The turbidity levels were measured in Nephelometric units. The turbid meter was first of all calibrated in order to make sure the instrument is capable of giving accurate results for analyzing the water samples. The water sample was shaken to mix thoroughly. After the disappearance of air bubbles, turbidity was determined by filling the water sample into a curvature and inserted into the Digital turbidometer compartment to allow light pass through it. The reading displayed was the turbidity value.

2.3.5 Total Suspended Solids (TSS)

- Filter paper of diameter 5.5cm was dried to a constant weight (w_1) at $103-105^{\circ}\text{C}$ in an oven.
- cooled to room temperature in a desiccator and the weight was noted.
- Gooch funnel and rubber adapter were fixed to a filtering flask,
- the glass fiber was placed into the Gooch funnel carefully with the aid of a pair of tongs.
- The water sample was thoroughly mixed on a magnetic stirrer, after which 50ml was quickly measured into the filtering apparatus.
- After filtration elapsed, the filter paper containing the suspended particles was put into the oven for 1 hour at $103\pm 2^{\circ}\text{C}$ to dry. .
- .This was allowed to cool in a desiccator and reweighed w_2 . The weight (w_2) was taken.

-The difference in the two weights $w_2 - w_1$ was noted.
Where w_1 = Initial weight of filter, w_2 = Final weight of filter

$$\text{TSS} = \frac{\text{Weight loss}(w_2 - w_1) \times 1000}{\text{Volume of sample}} \dots\dots\dots(2.1)$$

The Equipment and materials used were:

Electronic hot plate (Gallenkamp, 125567AMP, England), Crucible, Whatman filter paper (No.4), Measuring cylinder (Pirex), Weighing balance (Ohaus – CP413).

2.3.6 Total Dissolved Solids

-The sample was stirred with a magnetic stirrer and a measured volume was taken onto a glass fiber.
The glass beaker was earlier washed successively three times with distilled water, allowing complete drainage between washings.
-The beaker was dried to a constant weight.
-A known volume of the sample was measured in a volumetric cylinder and filtered into the weighed dried beaker (using previously dried filter).
-Total filtrate was weighed w_1 . The beaker containing the suspended particles was put into the oven for 1 hour at $103 \pm 2^\circ\text{C}$ to dry.
-This is allowed to cool in a desiccator and weighed again to get w_2 .

Where w_1 = Initial weight of beaker
 w_2 = Final weight of beaker

$$\text{TDS} = \frac{\text{Weight loss}(w_2 - w_1) \times 1000}{\text{Volume of sample}} \dots\dots\dots(2.2)$$

The Equipment and materials used were:

Electronic hot plate (Gallenkamp, 125567AMP, England), Crucible, Whatman filter paper (No.4), Measuring cylinder (Pirex), Weighing balance (Ohaus – CP413).

2.3.7 Alkalinity by Titration

-50ml burette was severally rinsed with 0.02 N HCL.
-The burette was filled with the HCL solution, making sure there were no air bubbles in the tip, and that the meniscus was readable at close to 0.00ml on the burette scale.
-100 ml of the water sample to be analysed was measured into a 250 ml Erlenmeyer flask.
-This was titrated to a bromo cresol green (pH = 4.5) end point.

CALCULATIONS

$$\text{Alkalinity} = \frac{\text{titre} \times \text{normality of HCL} \times 50,000}{\text{Volume of sample used}} \dots\dots\dots (2.3)$$

This is expressed in terms of milligrams of calcium carbonate per liter.

.Equipment used-

Retort stand, Burette, Funnel, Beaker, pH meter (labtech 1167).

Reagents

Hydrochloric acid (0.02 N)
Bromo cresol green indicator

2.3.8 Phosphate determination

-Exactly 100ml of the homogenized and filtered sample was pipetted into a conical flask.
-The same volume of distilled water (serving as control) was also pipetted into another conical flask.
-1ml of 18M H_2SO_4 and 0.89g of ammonium persulphate were added to both conical flasks and gently boiled for $1\frac{1}{2}$ hrs, keeping the volume to $25\text{-}50\text{cm}^3$ with distilled water. It was then cooled.
-A drop of phenolphthalein indicator was added. This was neutralized to a faint pink colour with the 2M NaOH solution.
-The pink colour was discharged by drop-wise addition of 2M HCl.
-Distilled water was added to the solution to make up to 100ml.
-For the colorimetric analysis, 20ml of the sample was pipette into test tubes.

-10ml of the combined reagent was added, shaken and left to stand for 10mins before reading the absorbance at 690nm on a spectrophotometer, using 20ml of distilled water plus 1ml of the reagent as reference.

Methods for Calibration

-Standard phosphate solution: 219.5 mg of dried AR potassium hydrogen phosphate was dissolved in distilled water and made up to 100ml, where 1ml = 50.mg. of phosphate.

-10ml of the stock solution was made up to 1000ml to give 1 ml = 0.05 mg.

-Standards of strength ranging from 0 (blank) to 0.05mg/L at intervals of 0.01mg were prepared by diluting the stock with distilled water.

$$\text{Concentration of sample} = \frac{\text{Absorbance of sample} \times \text{Concentration of standard}}{\text{Absorbance of standard}} \dots\dots\dots(2.4)$$

The Equipment and materials used were

UV Spectrophotometer (Apel PD-3000 UV), Beaker (pyrex), Measuring cylinder (pyrex), Pipette, Pipette pump (pyrex), Cuvette.

Reagents used-

SO₄ (18M), Ammonium persulphate (0.8g), Phenolphthalein indicator, HCl (2M), Distilled water

2.3.9 Chloride Determination

Chloride was analysed according to APHA standard method (APHA; 1998)

Procedure:

-A 100ml of the clear sample was measured through pipette into an Erlenmeyer flask

-the pH was adjusted to 7 – 10 with either H₂SO₄ solution.

-Then 1ml of K₂CrO₄ indicator solution was added

-it was titrated using standard solution of AgNO₃ which made it to turn to a permanent reddish brown colouration. End point is pinkish yellow.

-The titer volume was noted.

-The AgNO₃ titrant was standardized and a reagent blank established. A blank of 0.2-0.3ml is usual for the method.

Calculation: Chloride concentration = Titre value (x) 10 = mg/l

The Equipment and materials used were

Pipette (pyrex), Burette(pyrex), Retort stand, Beaker (pyrex), Funnel

Reagents:

Standard Silver nitrate AgNO₃ (1 ml = 0.5 mg chloride)

Potassium chromate K₂CrO₄ (5%) (Indicator)

2.3.10 Determination of Salinity

To determine the salinity, the result gotten from the determination of the chloride was multiplied by 0.0018066.

Salinity = chloride content x 0.0018066 (ppt)

2.3.11 Sulphate Determination

Method: Sulphate was analysed according to APHA standard method (APHA; 1998)

Procedure:

-250m⁻³ of the sample was measured out and dried in a crucible.

-Three (3) drops of concentrated Hydrochloric acid was added into the dry crucible to moisten it.

-30cm³ of distilled water was added to this, and all the content were mixed together by stirring.

-The mixture was boiled and filtered into a beaker.

-The crucible was washed three times with 30cm³ of distilled water.

Digestion

-The filtrate was heated to boiling

-10cm³ of 10% BaCl₂ solution was added to it, drop by drop with constant stirring for the development of turbid suspensions of barium sulphate.

-The mixture was digested for about 30 minutes, filtered and the filter paper was washed with warm distilled water.

- This was allowed to cool before filtering through a pre-weighed filter paper.
- The filter paper containing the precipitate was dried in an oven and was allowed to cool in desiccators.
- Thereafter, it was weighed. The difference in weight was noted.
- The sulphate concentration was calculated with the formula below;

Calculation

$Mg/dm^3SO_4 = Mg BaSO_4 \times 411.5cm^3$ of water sample.
MgBaSO₄²⁻ concentration = MgBaSO₄²⁻ x 411.5 of calibrate the volume.

The Equipment and materials used were

Crucible, Electric hot plate, Measuring cylinder, Filter paper, Oven (Mammert 12880KL, Germany), Desiccator, Weighing balance

Reagents: Concentrated HCl, 10% BaCl

2.3.12 Dissolved Oxygen Determination

- The water sample was put in a 250ml bottle,
- 1ml of MnSO₄ solution and 1ml alkali-iodide-azide reagent were added well below the surface of the liquid.
- It was stoppered with care to exclude air bubbles and mixed by inverting and rotating until clear supernatant water was formed. It was then allowed to settle for 2 minutes,
- After the settlement, 1ml of concentrated H₂SO₄ was added by allowing the acid to run down the neck of the bottle,
- the stopper was replaced, and mixed by gentle inversion until dissolution of the precipitate was completed. At this stage, the iodine must have been uniformly distributed through the solution.
- 2ml of the solution was titrated with 0.0125M Na₂S₂O₃. 5H₂O (sodium thiosulphate) solution to a pale straw color
- 2ml of starch solution was added as indicator, which turns the color blue;
- the titration was preceded by adding the thiosulphate solution drop wise until the blue color disappears. The reappearance of blue color was disregarded.

$$D.O = \frac{\text{mole of titrant} \times \text{normality of titrant} \times 8000}{\text{ml of sample}} \dots\dots\dots (2.5)$$

The Equipment and materials used were

Refrigerator (L.G, Model GL 2250M), Sample bottle, Measuring cylinder, Conical flask, Pipette pump, Stopper

Reagents: MnSO₄, sodium thiosulphate, MnSO₄, alkali-iodide-azide, H₂SO₄, starch solution

2.3.13 Determination of Biochemical Oxygen Demand

- The water sample was put in a 250ml bottle,
- 1ml of MnSO₄ solution and 1ml alkali-iodide-azide reagent were added well below the surface of the liquid.
- It was stoppered with care to exclude air bubbles and mixed by inverting and rotating until clear supernatant water was formed. It was then allowed to settle for 2 minutes,
- After the settlement, 1ml of concentrated H₂SO₄ was added by allowing the acid to run down the neck of the bottle,
- the stopper was replaced, and mixed by gentle inversion until dissolution of the precipitate was completed. At this stage, the iodine must have been uniformly distributed through the solution.
- 2ml of the solution was titrated with 0.0125M Na₂S₂O₃. 5H₂O (sodium thiosulphate) solution to a pale straw color
- 2ml of starch solution was added as indicator, which turns the color blue;
- the titration was preceded by adding the thiosulphate solution drop wise until the blue color disappears. The reappearance of blue color was disregarded.
- Carry out the titration in duplicate

$$D.O = \frac{\text{mole of titrant} \times \text{normality of titrant} \times 8000}{\text{ml of sample}} \dots\dots\dots (2.6)$$

The general equation for the determination of a BOD value is

$$BOD (mg/l) = D_1 - D_5 \dots\dots\dots(2.7)$$

Where D₁ is the initial DO of the sample, D₅ is the final DO of the sample after 5 days.

The BOD was not diluted because the concentrations were not high.

The Equipment and materials used were

Refrigerator (L.G, Model GL 2250M), Sample bottle, Measuring cylinder, Conical flask, Pipette pump, Stopper

Reagents: MnSO₄, sodium thiosulphate, MnSO₄, alkali-iodide-azide, H₂SO₄, starch solution

2.3.14 Determination of Chemical Oxygen Demand

- 1 ml of the sample was measured into a 250 beaker.
- 2.5ml of 5% K₂CrO₄ digestion reagent was slowly added and mixed.
- 3.5 ml of concentrated sulphuric acid reagent was added into the tube, making sure it reached the bottom.
- This was capped and the content mixed together.
- Then it was transferred into a water bath and heated at 50 degree.
- A blank test was also conducted.
- Distilled water was added to make up the volume to 50 ml.
- 2 drops of phenolphthronlein indicator was added.
- It was then titrated with 0.05M of Ferrous ammonium sulphate solution (Morh salt).

Calculation= COD as mg/l= $\frac{A - B \times 8000}{\text{ml of sample}}$ (2.8)

Where A= Titre of blank
 B= Titre of sample
 M= Molarity of FAS (0.05m)

The Equipment and materials used were

Electric hot plate (Gallenkamp 125567 Amp, England), Water bath, Beaker, Burette, Measuring cylinder, Conical flask (pirex), Pipette, Pipette pump (pirex),

Reagents:

K₂CrO₄ (5%), Ferrous ammonium sulphate (0.05M), Sulphuric acid (concentrated), Phenolphthronlein (indicator),

2.3.15 Determination of heavy metals

Heavy metal analysis was conducted using Atomic Absorption Spectrometer according to the method of APHA 1995 (American Public Health Association).

Working principle:

Atomic Absorption Spectrometer’s working principle is based on the sample being aspirated into the flame and atomized when the AAS light beam is directed through the flame into the monochromator and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristics absorption wavelength, a source lamp composed of that element is used making the method relatively free from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample. Earlier before now, the metals were digested using concentrated nitric acid.

The Equipment and materials used were

Electric hot plate (Gallenkamp 125567 Amp, England), Whatman filter paper, Reagent bottle, Volumetric flask (pirex), Pipette, Pipette pump (pirex), Atomic Absorption Spectrometer, AAS (240 FS AA Agilant, USA)

Reagents:

Nitric acid (concentrated)

3. RESULTS AND DISCUSSION

3.1 Results

Table 3.1 Mean concentration of Ukwaka stream on different points for the period (July to December)

| Parameters | Units | Stream Sampling Points | | | | WHO 1993 | Comment |
|------------------|----------------|------------------------|--------------|-------------|-------------|------------|--------------|
| | | 0m, site A | 300m, site B | 600m site C | 900m site D | | |
| pH | - | 6.77 | 6.77 | 6.83 | 6.97 | 6.5- 85. | Within limit |
| Temp | ⁰ C | 31.80 | 32.00 | 32.00 | 31.70 | 40 | ok |
| EC | µS/cm | 163.80 | 169.67 | 197.0 | 140.30 | 250 | ok |
| TDS | mg/l | 15.07 | 16.41 | 16.82 | 12.28 | 5 | Not ok |
| TS | mg/l | 21.70 | 20.34 | 18.82 | 16.81 | 500 | ok |
| Turbidity | ntu | 338.54 | 251.54 | 243.88 | 180.00 | 5 | Not ok |
| COD | mg/l | 311.27 | 293.13 | 342.45 | 264.89 | NG | No guideline |
| BOD | mg/l | 20.55 | 17.94 | 15.80 | 12.67 | NG | No guideline |

| | | | | | | | |
|-------------------|------|--------|--------|--------|--------|--------------|--------------|
| DO | mg/l | 43.04 | 50.61 | 56.96 | 63.93 | NG | No guideline |
| Alkalinity | mg/l | 25.19 | 24.97 | 26.40 | 33.87 | 100 | ok |
| Phosphate | mg/l | 6.19 | 6.13 | 6.85 | 7.25 | NG | No guideline |
| Chloride | mg/l | 122.93 | 123.71 | 164.82 | 137.38 | 250 | ok |
| Sulphate | mg/l | 204.06 | 219.13 | 239.17 | 211.66 | 500 | ok |
| Cadmium | ppm | 0.103 | 0.050 | 0.038 | 0.040 | 0.003 | Not accepted |
| Zinc | ppm | 0.456 | 0.402 | 1.422 | 0.484 | 3.0 | ok |
| Copper | ppm | 0.084 | 0.048 | 0.043 | 0.045 | 2.0 | ok |
| Iron | ppm | 6.420 | 4.832 | 2.074 | 1.466 | 0.3 | Not accepted |
| Lead | ppm | 0.299 | 0.231 | 0.260 | 0.310 | 0.01 | Not accepted |

Footnote: NG : No Guideline

3.2 Discussion

Ukwaka stream takes in large amount of solid wastes apart from effluents from adjacent industries. The solid wastes in turn caused unfavorable changes in physicochemical parameters. Results of the study showed that the color of water was brownish to dark black and emitted noxious smell due to the industrial effluents and the waste dump. However, point C has a high concentration of most of the parameters when compared with upstream point D. This is due to solid waste the stream received just before point C. (Although not elaborated here, the samples were slightly acidic in wet seasons of July to September on almost all the sites but a bit alkaline from October to December. The levels of biological oxygen demand, electrical conductivity, and suspended solids were relatively high in dry season of October to December. The results also implicated site C (600m), to be the most polluted site. Generally, the pollution level was found to be significantly high in dry season, October to December but relatively low in rainy season of July to August). The solid wastes, apart from making the stream unsightly, nauseating, it also rendered the water useless for any domestic usage, and instilled undesirable effects on biotic community.

The high total solids recorded in observed in site C might have led to an increase in electrical conductivities and turbidity. Lesser values in July to September could be attributed to the dilution of ionic substance as a result of large volume of water in the streams due to the runoff. These observations agreed with the submission of [26] that the high turbidity of water could be linked to the presence of dissolved solids in the effluents released into the water.

There are monthly variations in the results. As indicated in figures 3.1 the maximum total dissolved solids were observed in the months of August and September than in any other months. Higher level of TDS during the wet season is more likely due to the influence of runoff into the surface water

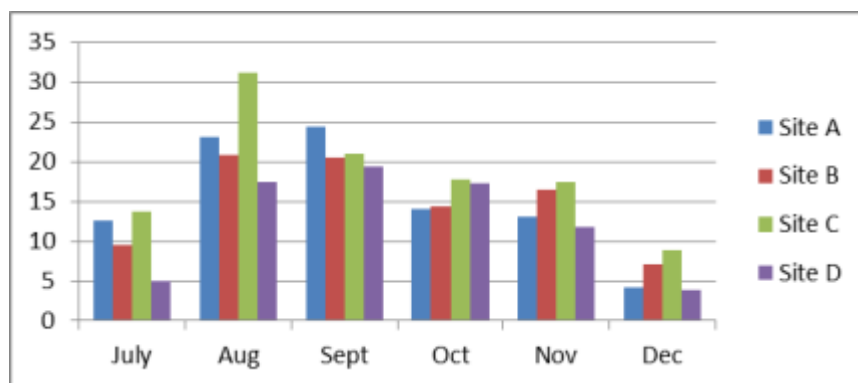


Fig. 3.1 Variation of Total Dissolved Solid in the months

pH

The World Health Organisation (WHO 2010) recommends a pH value of 6.5 or higher for drinking water to prevent corrosion. The study revealed that the pH values of the stream appeared to be slightly acidic as it had values that ranged from 6.77- 6.97 though within the permissible limit of WHO standard of 6.5-8.5 for drinking water..

The temperature

The results of the physical water quality characteristics of water samples from Ukwaka stream are shown in Tables 3.1. The result shows variations in the physical properties of the water from the point of effluent discharge into the stream (0m), to downstream waters (900m). The mean temperature for July to December ranged from 31.7 to 32.0°C. From this, it was observed that all the water samples conformed well to the permitted temperature range for surface water [27]. This suggests that the temperature is good for consumption for consumers who prefer cool to warm water, since high temperature negatively impact water quality by

enhancing the growth of microorganisms which may increase taste and corrosion problems [28]. High Temperature affects biological, chemical and physical activities in the water [29]. This was supported by [30] who opined that temperature of stream water is reported to be an important index as it governs the biological species in the water and their activities to a large extent.

Total Solids

The mean total solids in the stream water at point of the discharge of the industrial effluent site A (0m) and other sites B (300m), C (600m), and D (900m) were 21.70, 20.34, 18.82, 16.81, respectively, It was observed that the total solids in the stream water was below the 500 mg/L permitted by regulatory bodies. The reduction in the solids downstream could be attributed to self-purification of the stream. [31] observed similar reduction and attributed it to physiochemical reactions such as sedimentation, coagulation, fixation as well as possible oxidation and precipitation. Similarly, both the total dissolved solids (TDS) and suspended solids (SS) varied in line with the total solids as described above

Turbidity

Turbidity in water is caused by the presence of suspended matters such as clay, silts, finely divided organic and inorganic matters, plankton and other microscopic organisms. The turbidity of water samples showed variation between the sampling points. The water samples at the effluent receiving point (site A) and the downstream water beyond the point have turbidity values well beyond the recommended level for surface water (5 NTU) as set by the World Health Organization. From Tables 3.1 the turbidity value was increasing as the TDS value increased. These observations agreed with the submission of [32]. that the high turbidity of water could be linked to the presence of dissolved solids in the effluents released into the water. Surface water is open to receiving soil washout from slopes into the water sometimes including animal and human faeces, carcass of dead wild animals etc., and high turbidity is not desirable in surface water as it leads to restriction in light penetration processes such as flocculation and filtration which increases cost of purification. [33] reported that high turbidity is associated with microbial contamination as high turbidity makes it difficult to disinfect water properly.. [34] observed that highly turbid water is disqualified as source of water for domestic use in the community..

Alkalinity

The alkalinity level of the upstream was in the range of 24.97 to 33.87 mg/l. The effluent polluted water at the entry point (0m) recorded 025.19, the other points of 300m, 600m and 900m recorded 24.97, 26.40, and 33.87 mg/l respectively. The alkalinity value rose with the distance except at point 300m that dropped a little. This might be caused by the influx of flood from the upland into the stream just immediately after point 0m

Phosphates

Phosphates in the water samples varied significantly. The phosphate levels varied along the sampling points and time. In the upstream, (site A, point 0m), the value obtained for phosphate was 6.19 mg/l while on the other hand, values recorded at points 300m, 600m and 900m were, 6.13 mg/l, 6.85mg/l and 7.25mg/l respectively. This result showed that the value of the phosphates increased much at point 600m in the water following pollution by the solid waste dump. The range of the values obtained in this study agrees with the high to moderate levels of phosphates in southern Nigeria Rivers [35]. Although phosphates are not toxic and do not represent a direct threat to animals and other organisms, they do represent a serious indirect threat to water quality [36].

Chloride and Sulphate

Table 3.1 shows the recorded values of the Chloride and Sulphate in the stream for the given period. The chloride values ranged from 122.93mg/l to 164.83mg/l. while the sulphate value ranged from 204.06 mg/l to 239.17 mg/l. in both of them, site C recorded the highest value of 164.82mg/l and 239.17mg/l respectively. This was contributed by the solid wastes dumped into the stream just before site C. Though chloride was high but it is within the stipulated WHO limit of 250 mg/l. Presence of chloride ion in Ukwaka stream agrees with the report of [37]. that chloride is commonly found in streams and freshwater. Figs.3.2 and 3.3 respectively show the trends of Chloride and Sulphate along the stream

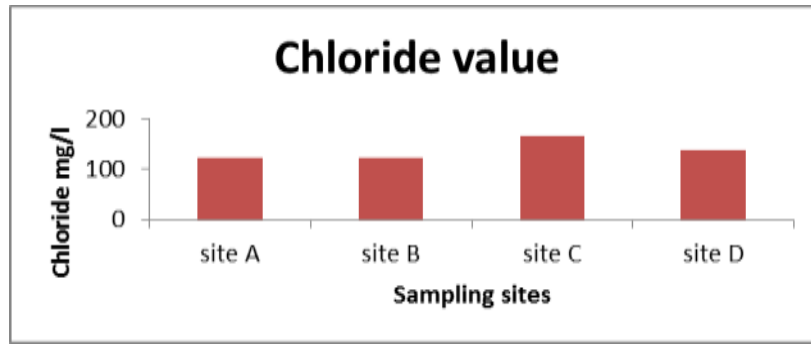


Fig. 3.2 Trend of chloride value along the Ukwaka stream

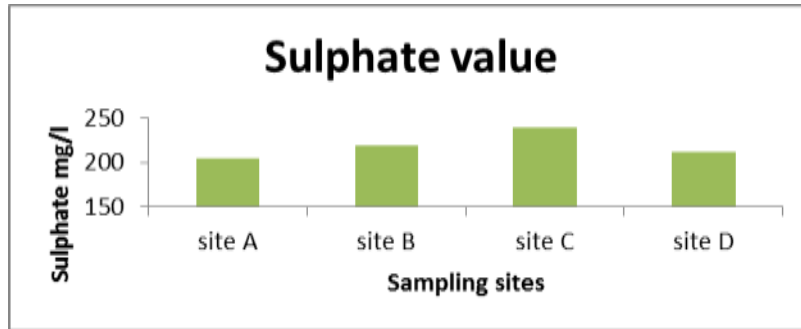


Fig. 3.3 Trend of Sulphate value along the Ukwaka stream

Dissolved Oxygen

Dissolved Oxygen (DO) of the stream had values of 43.04, 50.61, 56.96 and 63.93 mg/l respectively for sites A, B, C and D. There was no guideline from the WHO, 1993. However, the DO levels of the stream water samples were higher than the acceptable limits for aquatic life (6.8 mg/l) and for recreational water quality (7.5 mg/l) in accordance with the Nigerian government regulatory body (FEMA,) [38]. In general, DO levels less than 5 mg/l are stressful to most aquatic organisms. Dissolved oxygen is an important indicator of water quality and its productivity. The low Dissolved oxygen (DO) recorded in all the sites in October to December could be traced to the low level of water during the dry season with little self- purification of the pollutants. The continuous introduction of effluents into the water might likely support the growth of aquatic weeds and formation of flocs on the surface of the water, hence a reduction in the dissolution of oxygen into water. [39], however opined that the depletion of dissolved oxygen in a water body could be attributed to increase in plant and algal growth on the surface of water as a result of common practice of dumping of wastes

Biochemical Oxygen Demand

BOD is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given sample at certain temperature over a specific time period. Biological Oxygen Demand (BOD) test is useful in determining the relative waste loading and higher degree therefore indicates the presence of large amount of organic pollutant and relatively higher level of microbial activities with consequent depletion of oxygen content. Generally speaking, there were significantly different variations in the biochemical and biological quantity of the ukwaka stream water. It was observed that the industrial effluent impacted negatively on the biochemical and biological quality of the stream water. This negative impact was attributed to the poor quality of the effluent discharged into the river. The BOD values of the different sampling points were recorded from -2.44-0.86 ppm. The study revealed (Table 4.7) that the water upstream, site A had a higher value of BOD (20.55 mg/l). The least value was recorded at site D (12.67 mg/l). This may be due to the nearness of site A, upstream to the industrial disposal point. It was reported that natural water with the BOD values of 4 mg/l is considered to be slightly polluted with organic matter, but safe for drinking. Stream keeper's field guide [38] reported that unpolluted natural waters should have a BOD of 5 mg/L or less. From the result of the table the BOD values were more than 5 mg/l. The BOD values ranged from 12.67 to 20.55 mg/l .

Chemical Oxygen Demand (COD)

COD is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemical such as ammonia and nitrite. The COD varied significantly along sampling sites, and ranged from 264.89mg/l to 311.27 mg/l. Figure 3.4 shows the trend of the COD along the stream. COD values conveyed the amount of dissolve oxidizable

organic matter including non-biodegradable matter present in it. The high COD values, of 264.89 to 342.45 mg/l in the sample recorded shows that the effluent had high organic load [40].

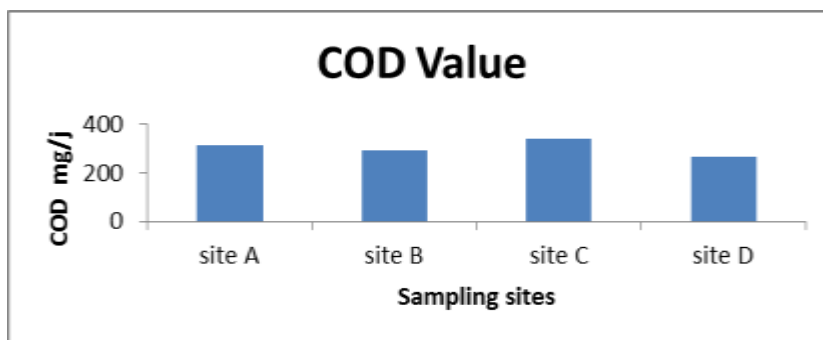


Fig. 3.4 Trend of COD value along the Ukwaka stream

Generally it is observed that the following parameters: EC, TDS, Chloride, and sulphate, determined, were higher at point 600m (site C) than other points. This is due to the fact that site C got more effect of the solid waste dump. The EC and TDS of the downstream water were much higher than the upstream. The higher EC and TDS were found at the point C, which indicates the greater amount of salts in the water due to dumping of solid waste [41]. The degree of relationship between EC and TDS of the water samples depicted that the value of TDS is increasing with the increasing of EC value.

Heavy Metals (cadmium, zinc, copper, iron and lead)

Table 3.2 Heavy Metals of Ukwaka for the period July to December 2017

| Parameters | Units | Sampling Points | | | | Range |
|------------|-------|-----------------|---------------|---------------|---------------|-------------|
| | | 0m (site A) | 300m (site B) | 600m (site C) | 900m (site D) | |
| Cadmium | ppm | 0.103 | 0.050 | 0.038 | 0.040 | 0.038-0.103 |
| Zinc | ppm | 0.456 | 0.402 | 1.422 | 0.484 | 0.402-1.422 |
| Copper | ppm | 0.084 | 0.048 | 0.043 | 0.045 | 0.043-0.084 |
| Iron | ppm | 6.420 | 4.832 | 2.074 | 1.466 | 1.466-6.420 |
| Lead | ppm | 0.299 | 0.231 | 0.260 | 0.310 | 0.231-0.310 |

Figure 3.5 below shows the trend of the Heavy Metals along the stream

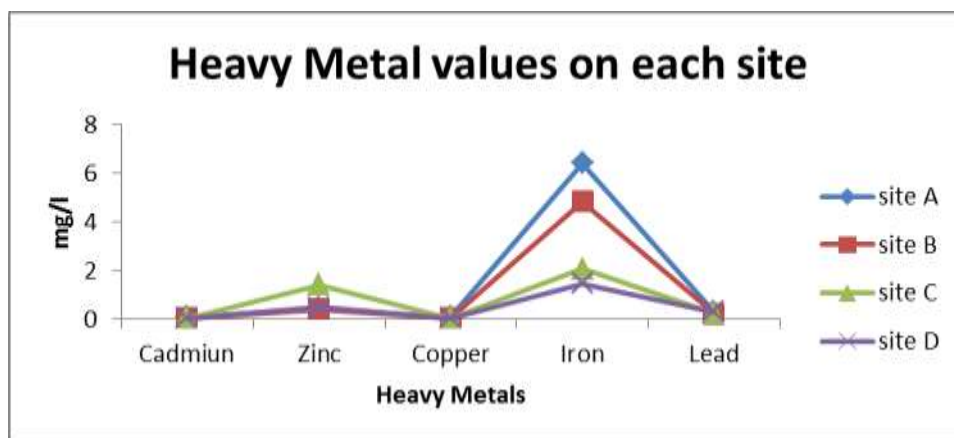


Fig. 3.5 Trend of Heavy Metals values along the Ukwaka stream

Heavy metals (lead, copper, cadmium etc) are among the major toxic pollutants in surface water. These have been found to be a problem in stream abutted by catchment with industries dealing with tanning, renovation petroleum and oil. Heavy metals are very toxic; when consumed causes many effect to health. Some of the metals are cacogenic which affect the cell. Table 3.2 shows the concentration of the heavy metals in the samples

Cadmium

Cadmium has highly toxic effect in all chemical form [55]. It detected at all the sites. The minimal detected value was 0.038ppm at site C. the highest was at site A (0.103ppm). The WHO set a maximum contaminant level goal for cadmium at 0.003 parts per million. At all the sites the value exceeds the set standard.

Zinc

Zinc concentration greater than 15ppm is undesirable. Zinc is not considered detrimental to health, but it will impact undesirable taste to drinking water. In the analysis, the values of zinc ranged from 0.402ppm to 1.422ppm with site C having the highest value of 1.422ppm. This high value was caused by the scrapped metal dumped before site C. The WHO set a maximum contaminant level goal for zinc at 5.00 parts per million. However, none of the values gotten at the sites exceeded the WHO standards,

Copper

Copper is not present in significant quantity in natural water. The presence of copper is therefore an indication of pollution. The value of copper in the result ranged from 0.043 to 0.084ppm which shows that it was below the maximum permissible limit of 2.00 stipulated by the WHO.

Figure 3.5 below shows the trend of the Heavy Metals along the stream

Iron has the highest record of 6.420ppm at site A. this might be perhaps due to some rust in the pipe that conveyed the effluent from the industry. The least value was recorded at site D (1.466ppm). The recorded values exceeded the limit of 0.3 set by the WHO. The high level of iron in the samples could be attributed to rust in the pipe.

Lead

The presence of lead in water causes lead poisoning because of its tendency to accumulate in the body. Lead is a toxic element that accumulates in the skeletal structures. The recorded values of lead (0.231 -0.310), were generally above the limit of 0.01 set by the WHO. The highest value of 0.310ppm recorded at site D could be ascribed to lead originating from the use of leaded fuel released by the smoke into the stream since site D is by the heavy traffic road.

From the results obtained, it can be observed that the level of zinc and iron in the samples were high when compared to the level of other metals in the samples

5. CONCLUSION

It would be stated that the results of the analyses indicated that the discharge of solid waste dump into the Ukwaka stream has contributed to the large scale pollution.. The organic contaminants leading to high BOD and COD values are possibly due to soluble and stable emulsified organic matter in the dumped wastes. The study revealed that both the upstream and downstream water were polluted and unsuitable for human consumption and aquaculture purposes. Site C which is immediately after the dump is the most polluted.

The dumped solid wastes have a significant negative impact on the water quality, because it affected the physical, chemical and biological characteristics of the stream ecosystem. The continued dumping of solid wastes may result in severe accumulation of the contaminants. This can constitute dense growth of microbial population due to the changes in physical status and presence of anions and cations in the receiving water bodies which hampers the quality of water and also affects the aquatic life form; affect the lives of human as well as animals around this stream. This study deduced that volume of solid wastes discharged into the Ukwaka stream was already overtaxing their capacity for self-purification hence; there is an urgent need to stop discharging of the wastes to save the stream water from further deterioration. The prevailing practice of unregulated and uncontrolled discharge of waste dump into water bodies constitutes serious abuse and portends serious danger to their species diversity and beneficial use to the municipality.

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