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THE IMPACTS OF MAJOR DRAINS CONTENTS ON RIVER BENUE, MAKURDI TOWN: NITRATE AND PHOSPHATE AS CASE STUDY

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Abstract

The effects of drainage contents on River Benue was verified by determining the concentration of nitrate and phosphate in the open drainages and at the confluence point with the river. The impute of phosphate and nitrate concentration from the major open drains into River Benue at the confluence points was determined: sodium salicylate Colorimetric Method was employed for nitrate analysis while vanado-molybdo phosphoric acid colorimetric method was used for phosphate analysis. Triplicate samples were taken to make a composite sample from each sample site at interval of one week from the body of the drainage and at the confluence for the three major drainages located in Kwararafa, Wadata, and Wurukum region of Makurdi, Benue State. Phosphate concentration in the drainage was found to be between 5.129 mg/L and 0.083 mg/L. While phosphate concentration in the confluence was between 8.343mg/L and 0.052 mg/L. Nitrate concentration in the drainage was between 10.788 mg/L mg/L and 0.193 mg/L. While nitrate concentration in the confluence was between 7.822 mg/L1mg/L and 1.128 mg/L. The percentage concentration of nitrate and phosphate in the drainage results higher than confluence results is about 60%. Which confirmed that drainage abuse with wastes

Keywords:
Drainage, Confluence, Phosphate, Nitrate, Pollution, Concentration

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affect the quality of river Benue by increasing the concentration of nitrate and phosphate pollutant in the river. 47.222% of phosphate and nitrate concentrations were found above the EPA Maximum Contaminant Level Goal (MCLG) of phosphate, 0.1 mg/L and nitrate, 10mg/L). This indicates the extent of pollution of river Benue with nitrate and phosphate from drainages and that there should be a concern for drainages abuse in Makurdi. Therefore, a good attention should be given to the drainages to protect the river from pollution.

Introduction

Drainage is the natural or artificial removal of surface and sub-surface water from an area. A storm water system with open channels or drains for the discharge of rainwater exists in most urban areas. The channels usually drain off rainwater into rivers or sometimes into agricultural irrigation canals. Unauthorized discharge of domestic wastewater and solid waste into the system leads to surface water pollution and contamination (Baker *et al.*, 2010). This is particularly a problem in many middle- to low-income countries.

An open channel or drain system generally consists of a secondary drainage system, with a network of small drains attached (micro-drainage). Each serves a small catchment area that ranges from a single property to several blocks of houses. These small drains bring the water to a primary drainage system, composed of main drains (also called interceptor drains), which serve large areas of the city. Thereafter these drains are generally connected with natural drainage channels such as rivers or streams (WHO, 1991).

The abuse and poor management of the open drainages affects the nutrients, contaminants and chemical constituents of rivers and seas. This is because the wastes indiscriminately disposed into the drainage systems contain different substances (elements, compounds and ions) from vegetables and fruits, animals excretal and urine, decayed plants and animals, washing soap and detergent, oil spillage, agricultural run-off etc. All these are taken to the rivers (Kaltenborn *et al.*, 2010). At the point of confluence where the drainage discharges into the river, is certain to have characteristics which are different from those of the drains and the main river. This is because the two water bodies will certainly not have the same concentrations of elements, compounds and ions. (Baker, 2010). The chemical constituents of interest in this work are nitrate and phosphate. They both act as contaminants and nutrients depending on one's point of view. This research will consider them more as contaminants.

All living organisms require the nutrients, nitrogen and phosphorus for their growth, metabolism and reproduction. Nitrogen is a component of amino acids, nucleic acids

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and other cell components, while phosphorus is found primarily in nucleic acids, phospholipids and adenosine triphosphate (ATP). Nitrogen and phosphorus are made available to plant and animals in the form of nitrates and phosphates respectively. They are also mainly used in this form by living things (Kaltenborn *et al.*, 2010).

The commonly expected compounds or nutrients/contaminants in open drains are inorganic nitrogen compounds (NO_3^-, NO_2^-, NH_4^+), phosphate (PO_4^{3-}) and silicate (SiO_4^{3-}). Other ions like Na^+, Mg^+, $Ca^{+,}$ Cl^- are also present. Nutrients/contaminants in open drains are considered trace compounds and their presence is due to various sources of contamination. Open drainage water for nutrient/contaminants analysis is of great importance because the nutrients/contaminants contents of the drainage determine a lot of the water body the drainage discharged into (Smith *et al.*, 2009). This in turn determines the state of the aquatic life of the water body, health effect of the water on the community dwellers etc.

Nitrate and phosphate can get into open drains directly through the following means: runoff of fertilizers containing nitrates and phosphates, sewage disposal, decay of plant and animal parts, industrial and domestic waste disposal, oxidation of nitrogen and phosphorus or their compounds to nitrate and phosphate respectively can also increase these compounds in the drains (Melillo and Cowling, 2002).

Nitrate toxicosis can occur through enterohepatic metabolism of nitrate due to nitrite being an intermediate moiety (Bastide *et al.,* 2015). Nitrites oxidize the iron atoms in hemoglobin from ferrous iron (II) to ferric iron (III), rendering it unable to carry oxygen. This process can lead to generalized lack of oxygen in the tissues and leads to a dangerous condition called methemoglobinemia. This affects both aquatic animals and non-aquatic animals consuming the water. Children are more vulnerable. Although nitrite converts to ammonia, if there is more nitrite than can be converted, the animal slowly suffers from a lack of oxygen (Stoltenow and Lardy, 2008). Infants who drink water high in nitrates may turn "bluish" and appear to have difficulty in breathing since their bodies are not receiving enough oxygen. Methemoglobinemia in infants is known as blue baby syndrome (Parthasarathi and Olsson, 2004).

The presence of normal level of nitrates usually does not have a direct effect on aquatic organisms. However, excess levels of nitrates in water can create conditions that make it difficult for aquatic organisms to survive. Algae and other plants use nitrates as a source of food. If algae have an unlimited source of nitrates, their growth is unchecked. (Ryle *et al.,* 1981). **Eutrophication** – "The process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates which enables algae and other aquatic plants growth. (Gladwin *et al.*, 2005). Occurs. As the algae and plants die and decompose, high levels of organic matter and the

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decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish (Stoltenow and Lardy., 2008).

Like nitrogen, Phosphate determine the rate of growth of aquatic animals. This is generally true of freshwater environments, whereas nitrogen is more often the limiting nutrient in marine (seawater) environments (Hochanadel, 2010). Addition of high levels of phosphate to environments and to micro-environments in which it is typically rare can have significant ecological consequences (Gnandi, 2006). Hence, phosphate can increase the growth of algae and other aquatic plants, and like nitrate cause **Eutrophication.**

Phosphate itself does not have notable adverse health effects. However, high phosphate levels may interfere with coagulation in water treatment plants. As a result, organic particles that harbor microorganisms may not be completely removed before distribution (Kasten *et al.*, 2008).

This study is designed to determine the concentrations of nitrate and phosphate in open drains and at the confluence points of major drains with River Benue in Makurdi Town, considering the drainage environment and its influence on the drainage contents and the concentration of nitrate and phosphate in question. This will give an insight to the impute of phosphate and nitrate from the major open drains into River Benue at the confluence points, and to determine any relationship between the concentration of phosphate and nitrate in the drains and in River Benue. The method employed in this research for nitrate determination is sodium salicylate colorimetric method. While for phosphorus, it is Vanado-molybdo phosphoric acid colorimetric method.

Materials and Methods

To ensure accuracy and reliability of results, analytical standard reagents were procured from Fumman Chemicals Industry, Nigeria, with seal and label on each of the reagents**.** Glass wears were thoroughly washed, rinsed and sterilized in autoclave before use. Apparatus were ensured to be in good condition and operated at standard specification. Solutions required were strictly prepared according to the procedural recommendations of the method in use.

Reagents and apparatus for nitrate determination

The following reagents were required alongside the usual laboratory reagents: Sodium salicylate solution, Mecury (II) chloride solution, Concentrated H_2SO_4 solution, Sodium hydroxide, NaOH solution, Sodium hydroxide-potasium-sodium tartrate solution, Potassium nitrate (KNO_3) solution

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Apart from the usual glass wears, the following apparatus were required: Spectrophotometer, Direct Reading Spectrophotometer (DR/2000 model), pH meter, Hanna company pH (model H198127), Shaker, Water bath, Evaporating dishes and Oven.

Reagents and apparatus for phosphate determination

Together with the usual laboratory reagents, the following reagents were required. Phenolphthalein solution, Conc. Hydrochloric acid solution, Vanadate-molybdate reagent, anhydrous potassium dihydrogen phosphate (KH_2PO_4), Activated carbon. The following apparatus were required together with the usual laboratory glass wears: Spectrophotometer Direct Reading Spectrophotometer (DR/2000 model), pH meter, Hanna company pH (model H198127), Chemical beam balance, thermometer.

Study Area

Makurdi is the capital of Benue state in Nigeria. The city is located along the Benue River bank on latitude 7.44^{O}N and longitude 8.32^{o}E, situated in a valley 100m above sea level. As at 2007 Makurdi has an estimated population of 500,791 people with a total land area of about 200km^{2}. (Ajaero 2007). The population in the city is evenly distributed such that commercial, industrial and agricultural activities, recreational and administrative, auto-mechanic site and residential areas are scattered all over the city.

Along the River Benue bank in Makurdi is the Wadata market from which various kinds of wastes are generated especially domestic and agricultural produces from Wadata market and channeled to the river via the open drains. By Kwararafa is a very big block making industry located on the river bank, which use the open drain just beside it for chemical and human waste disposal. The other major establishments along the river bank are Wurukum market (not directly on the river bank), Benue links, Benue State University, and the teaching hospital; all these have major open drains which they abuse with their respective wastes, especially Wurukum market and Benue links.

Sample Collection and Pre-treatment

Samples were collected with a thoroughly washed transparent, plastic bucket and carefully filtered to remove particles and immediately transferred into polypropylene bottles of 100mls that have been previously washed and rinsed with the sample water three times. Triplicate samples were taken to make a composite sample at interval of one week from each sample sport. First from the body of the drainage, secondly at the confluence of the drainage with the river for the two ions (nitrate and phosphate) under study. This was done for the three major drainages described in the study area

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from 25th November – 14th December, 2019. The samples were preserved in ice packed box and transferred to laboratory for analysis.

Determination of Nitrate

The method employed in this research is sodium Salicylate Colorimetric method. The principle of this method is based on the reaction of sodium salicylate with nitrate ion in tetraoxosulphate (VI) acid medium to produce nitrosalicylate, which has a yellow colour under alkaline condition. The intensity of the yellow colour is proportional to the intensity of the nitrate in the sample and bears a linear relationship, (Ademoroti 1996). Maximum absorbance was obtained at wavelength of 420nm.

Determination of Phosphate

The method employed in this research is Vanado-molybdo phosphoric acid colorimetric method. The principle is based on the reaction of ammonium molybdate in dilute autho-phosphate solution under acidic condition to form a heteropoly acid: molybdate phosphoric acid. In the presence of vanadium, used as soluble ammonium trioxovanadate (V) NH_4VO_3; yellow colour vanado-molybdo-phosphoric acid is formed. The intensity of the yellow colour is proportional to the phosphate concentration in the solution (Ademoroti 1996). The equation is as shown below:

Results

Temperature and pH of samples

The temperature and pH values of the samples at the time of sampling are given in Table 1.

Table 1**:** Temperature and pH of samples.

Sample Site		Temperature			pH		
Kwararafa		Week I	Week II	Week III	Week I III	Week II	Week
	Drainage	32^{O}C	35 ^{O}C	37 ^{O}C	5.9	6.2	6.4
	Confluence	22^{O}C	21 ^{O}C	26 ^{O}C	6.0	7.1	8.0
Wurukum	Drainage	34 ^{O}C	33 ^{O}C	37 ^{O}C	5.8	9.8	10.4
	Confluence	25 ^{O}C	20 ^{O}C	25 ^{O}C	8.3	9.2	5.8
Wadata	Drainage	31 ^{O}C	34 ^{O}C	39 ^{O}C	6.8	8.8	4.7
	Confluence	23 ^{O}C	21 ^{O}C	28 ^{O}C	9.1	6.5	7.3

Phosphate (PO_4^{3-}) concentration (mg/L) in drainage and confluence

Figures 1 - 3 represent the concentration of phosphate (PO_4^{3-}) in drainages and confluences. MCLP stands for maximum contaminate level for phosphorus as reference by environmental control agency (EPA)

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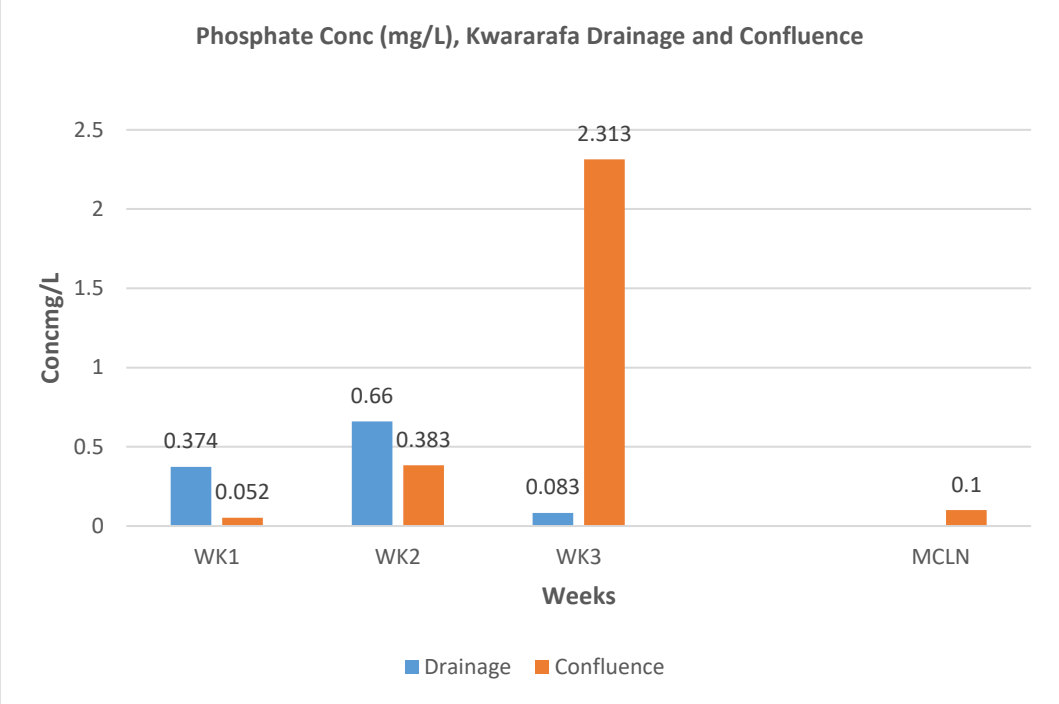


Figure 1: Phosphate Concentration (mg/L), Kwararafa Drainage and Confluence.

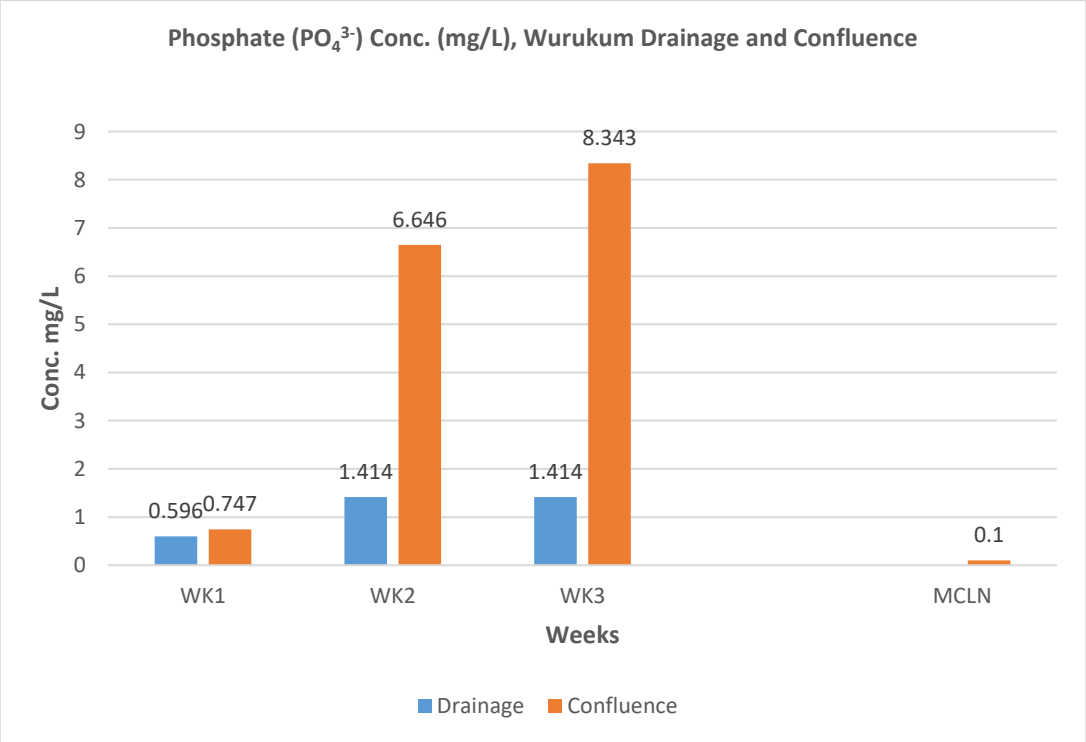


Figure 2: Phosphate (PO_4^{3-}) Concentration (mg/L), Wurukum Drainage and Confluence.

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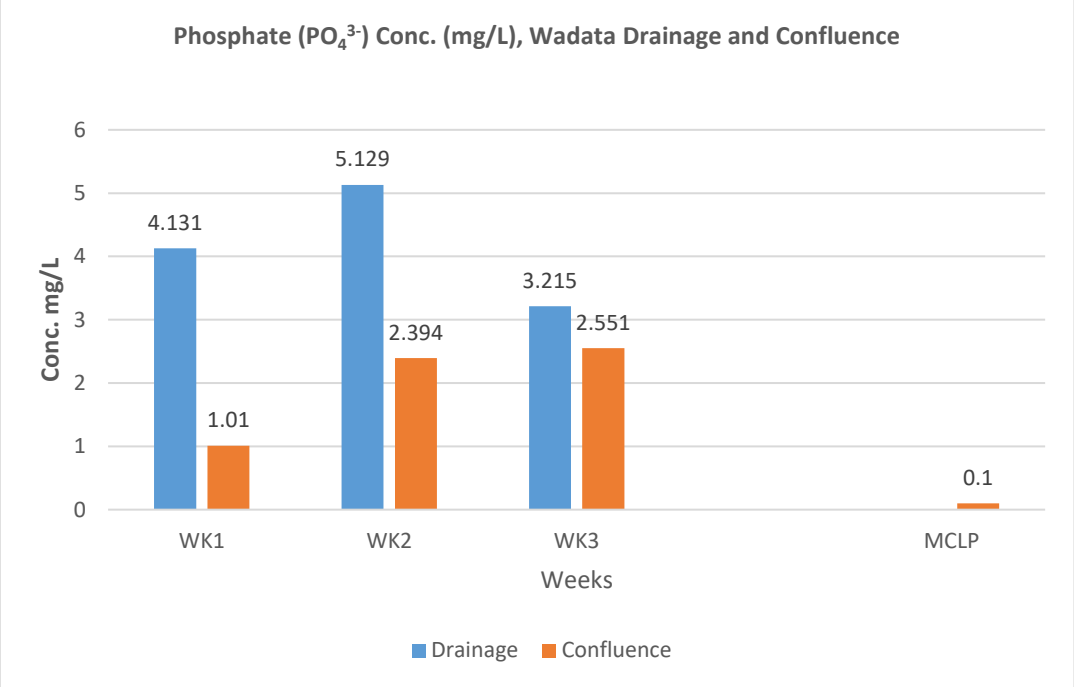


Figure 3: Phosphate (PO_4^{3-}) Concentration (mg/L), Wadata Drainage and Confluence.

Nitrate (NO_3^-) concentration (mg/L) in drainage and confluence.

Figure 4 - 6 represents the concentration of nitrate in drainages and confluences. MCLN stands for maximum contaminate level for nitrate as reference by environmental control agency (EPA)

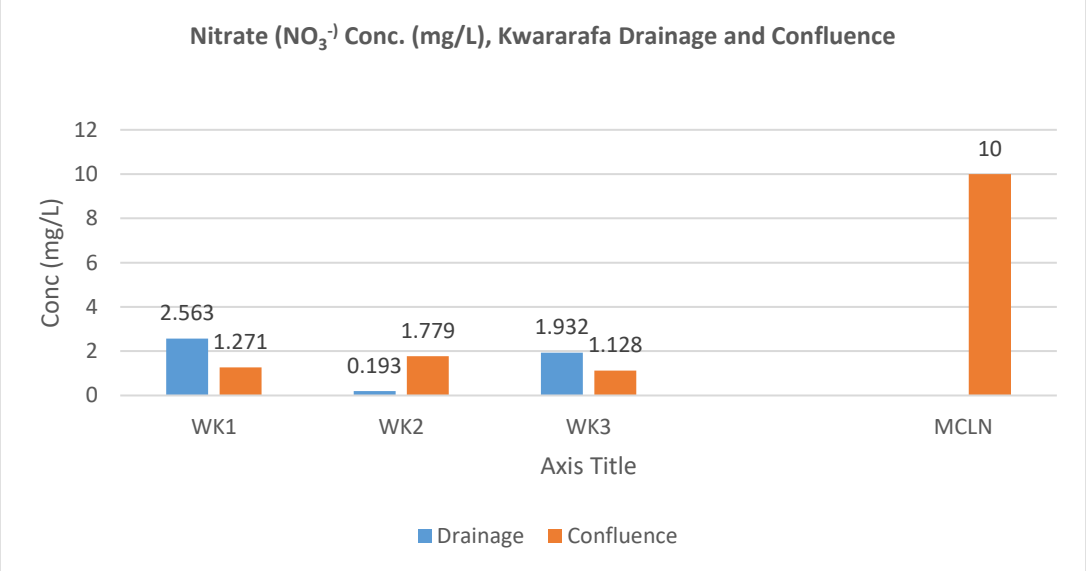


Figure 4: Nitrate (NO_3^{-}) Concentration (mg/L), Kwararafa Drainage and Confluence

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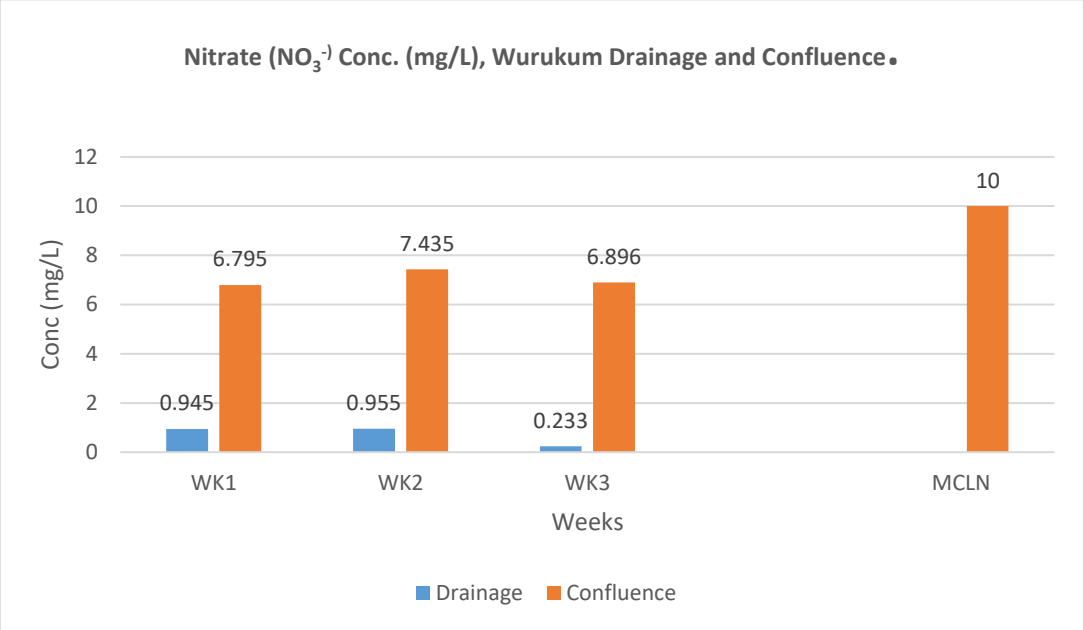


Figure 5: Nitrate (NO_3^{-}) Concentration (mg/L), Wurukum Drainage and Confluence.

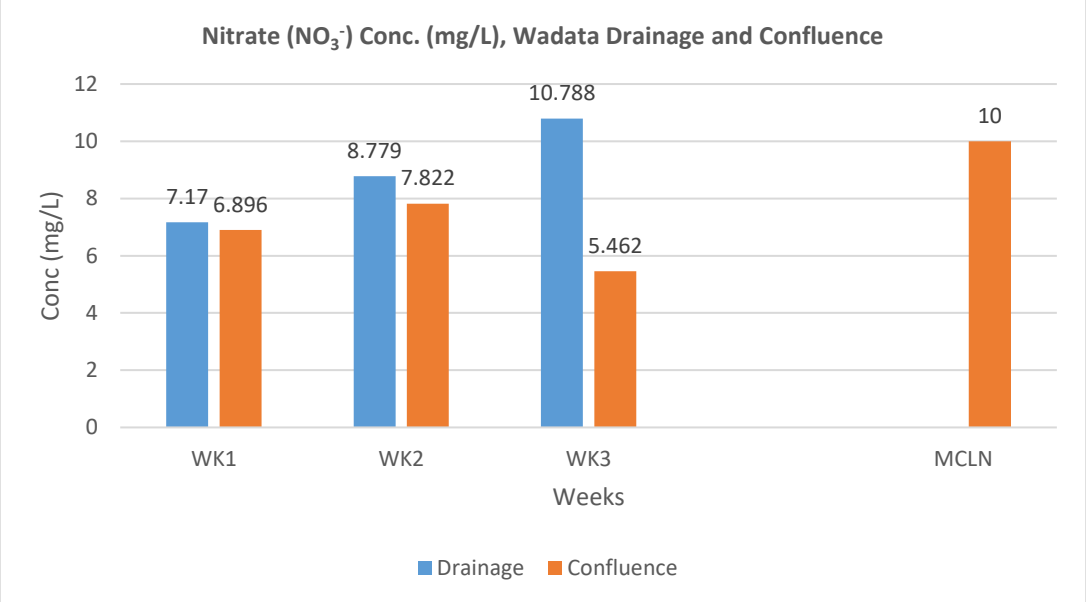


Figure 6: Nitrate (NO_3^{-}) Concentration (mg/L), Wadata Drainage and Confluence.

Statistical Analysis

Data will be presented in triplicate as mean +/- standard deviation (SD) of statistical analysis by variance (ANOVA test) using SPSS 26 software package. Standard plots will be done on Microsoft excel. Difference will be considered significant at P>0.05.

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Discussion

A detail examination of the results presented in the tables above shows that the drainages and their confluences have different concentrations from time to time and from one another. This confirms the drainage survey that was done alongside the sampling. This survey revealed that the different drainages have different surrounding, dwellers exposure and education. The activities around the drainages also differ. These include: market and cattle farming in Wadata area. Cement block industries in Kwararafa area. (Singh *et al.*, 2012) also stated in his conclusion that the high level of the parameters in his research must be as a result of the nature of wastewater from Pharma City and Sara industry in the sampling area. Generally, all the drainages are seriously abused with domestic wastes, humans and animal's excretal and urine. This is in accord with (Khan 2007), who explained that the most important contributions to the pollution were raw crops, agricultural and animal waste. These factors affect the concentration of nitrate and phosphate as follows:

i. Like the Wadata area where there are uneducated dwellers without proper toilet and waste disposal system, domestic waste, human and animal fecal and urine disposal into the drainage has a great tendency to increase nitrate and phosphate concentration. Though this affects all the drainages, it is worst in Wadata area.
ii. Market activities increases the availability of waste like vegetable, fruits etc. these waste on decay, releases nitrate and phosphate into the drainage.
iii. Farming activities and agricultural runoff also have big tendency to increase nitrate and phosphate concentration because most fertilizers contain nitrate and phosphate.
iv. The cement block industry and the auto mechanic site may not have serious effect on the concentration of nitrate and phosphate because they do not contain these ions. But with crude reactions following decomposition of compounds and organic matter after a period of time may have an indirect effect on the concentrations of the two ions in question.

The concentration of the ions in the river may changes continually due to various activities taking place in the river as observed at the survey. These include: fishing with chemicals, washing with soap and detergent, decaying of organic matter, disposal of waste into the river etc. at confluence.

Temperature and pH are factors that often affect the of dissolution of solutes. Dissolution of solute increases with increase in temperature, while most solutes have a specific pH of optimal dissolution. The rate at which drainage contents dissolves, determine the concentration expected in the drainage. But the concentration of

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nitrate and phosphate did not follow any particular pattern with temperature or pH. This could be because other factors like volume and nature of waste had more effects on the determination of the drainage concentration than temperature and pH.

A good observation of nitrate results for Wadata drainage revealed that the nitrate concentration of the drainage is higher than that of the confluence for the three weeks, fig. 6. Phosphate results for Wadata, fig. 3 also show that drainage concentration is higher all through. Week 1 and 3, nitrate results for kwararafa drainage shows that drainage concentration is higher than confluence concentration too, fig. 4. Massive domestic waste, human and animal excretal, and market waste disposed into the drainage, may be responsible for this in Wadata result.

Wurukum result for both phosphate and nitrate concentration for the three weeks took a different form. The concentration of the drainage is lower all through than that of the confluence, fig. 2 and 5. This could be as a result of the farming activities involving the use of fertilizers and other chemicals about the confluence. Most fertilizers contain nitrate and phosphate. The farms are so close to the confluence such that whatever fertilizer or chemical applied can quickly lynch into the confluence. This could only become diluted when the water has flown into the main body of the river. The drainage sampling was done before the farms. (Khan 2007) also encountered some results that were dependent on particular factors. More of the results were higher in drainage than confluence with about 60%.

Increase or decrease in concentration of phosphate and nitrate at the confluence indicates the effect of the drainage contents on the river. If the concentration of phosphate and nitrate in the drainage is higher than that of the confluence, it shows that the concentration of the drainage is higher than that of the River Benue. This is because only a contact with a less concentrated water body (River Benue) will cause a dilution of the incoming one, drainage water in this case. Hence, those results higher in concentration of phosphate and nitrate in the drainages increases the concentration of river Benue. The reverse is through for concentration of nitrate and phosphate lower in the drainage than confluence.

Phosphate concentration: drainage is between 5.129±1.010 mg/L - 0.083±0.201 mg/L, confluence is between 8.343±0.011 mg/L - 0.052±0.010 mg/L. Nitrate concentration: drainage is between 10.788±1.011 mg/L, - 0.193±0.032 mg/L, confluence is between 7.822±1.128 mg/l - 1.128 mg/L. (Adesuyi *et al.,* 2015) showed that phosphate ranged between 0.89 – 14.91 mg/L, nitrate ranged between 0.56 – 9.96 mg/L. These results are closely in agreement with that of this research. Pointing to drainage abuse. (Singh *et al.*, 2012) found out that the concentrations of nitrate and phosphate in all the sampling points varied between 211.43±0.340 to 284.33±1.74 mg/L for nitrate; and 103.23±0.11 to 164.22±0.56 mg/L for phosphate respectively. Though the results are

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higher than the ones of this thesis, the same conclusion is reached, that the ion in question should be a concern as pollutants, with their major sources as domestic, agricultural, industrial discharge.

According to the Environmental Protection Agency (EPA), the Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health, for phosphate, is 0.1mg/L (in streams/river that does not empty into reservoirs) and for nitrate, is 10mg/L. (EPA 2019). By these standards, it could be seen that only phosphate concentration in kwararafa drainage and confluence, 0.083±0.201 and 0.052±0.010 respectively were lower than the maximum contaminant level goal, (MCLG), fig, 1. Nitrate concentrations is only higher than the maximum contaminant level goal (MCLG) in Wadata drainage, 10.788±0.001mg/L, fig. 6. In summary, the percentage of results above the maximum contaminant level goal (MCLG) for the two pollutants is 47.222%. Though the results, particularly for phosphate are considerably higher than the maximum contaminant level goal (MCLG), it should be noted that the analysis is for drainage and confluence, not for the river. This points to the necessity to ensure that a good attention is given to the drainages to protect the river from pollution.

Conclusion

Considering the Environmental Protection Agency (EPA) Maximum Contaminant Level Goal (MCLG), 0.1 mg/L for phosphate and 10mg/L for nitrate, 47.222% were found above the Maximum Contaminant Level. This indicates the extent of pollution of river Benue with nitrate and phosphate from drainages, and also revealed that there should be a concern for drainages abuse in Makurdi which should be checked. From the results, it is observed that the drainage contents have concentration of about 60% higher than that of the confluence. Which indicates that on the average, drainage increase the concentration of nitrate and phosphate in river Benue. The above conclusion is based on the statistical confirmation that there is a significance difference between the comparison of drainage concentration and confluence concentration of phosphate and nitrate.

From the survey and results, it is shown that the concentration of the drainages depends on the following factors; the level of enlightenment or education of the surrounding dwellers, rate of abuse or maintenance of the drainages, the nature of the activities around the drainages, the activities going on in the river, such as fishing with chemicals, washing with detergent, decaying of organic matter etc. The inconsistency of these factors is responsible for the change in concentration from time to time and from one drainage to another. Therefore, it is necessary to enlighten the community on the need to maintain drainages and stop indiscriminate waste

disposal into the river. Washing in the river and fishing with chemicals should be prohibited. Agricultural runoff should be channeled to appropriate place or recycled.

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