Seasonal Nitrate Content of Stream Water, Soil and Some Foodstuffs Samples in Abuja Municipal Area of Federal Capital Territory, Nigeria

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The vegetation of Abuja, Nigeria's new Federal Capital Territory is predominantly guinea savannah. The need for a new Federal Capital Territory for Nigeria was necessitated by the congestion and environmental problems in the old capital. Nitrates are widespread in soil, and are present in small amounts in plant and animal tissues. Water and food containing high nitrate concentrations are potentially harmful to infants and young children. Nitrate content of Stream water, soil and some food samples was assessed, in Wuse, Garki and Maitama with a view to determine regular monitoring of the environment in the Municipal of Nigeria's Federal Capital Territory, Abuja. River water, soil and food samples from Wuse, Garki and Maitama were collected during the rainy (July) season and dry (February) season. Nitrates and ammonia levels were determined using spectrophotometer. Results showed a low contamination pattern of nitrates in river water, soil and foodstuff samples. Regular monitoring of Nitrate levels need to be put in place to check for contamination levels.

Key words —— nitrates, ammonium, pollution, contamination, toxicity

INTRODUCTION

Abuja, Nigeria's new Federal Capital became a necessity when Lagos the old capital territory was faced with over-population, poor topography, environmental pollution, traffic congestion and many more. Abuja is basically affected by the dry and rainy season. The dry season is between December and March while the rainy season is from April to November. Since the movement of Government seat to Abuja, the city has witnessed an unprecedented influx of people from all walks of life with attendant environmental problems. The levels of Nitrates were therefore assessed in soil and stream water for the following reasons:

- To assess existing nitrates concentrations in the streams, soil and foodstuff samples of Abuja Municipal.
- To assess/identify the health risks to humans and other creatures that lives or come in contact with the water.
- To provide technical assessment information to the department of environment for their use in environmental protection policies.

Although nitrate occurs naturally in drinking water, elevated levels in groundwater usually result from human activities such as overuse of chemical fertilizers and improper disposal of human and animal wastes are sources of nitrogen, containing compounds, which are converted to nitrates in the soil. Nitrogen represents the total amount of dissolved and organic forms of nitrogen in a water sample. Nitrogen is an essential element for both plants and animals to survive. It enters waterways either from the breakdown of dead organic matter or via atmospheric nitrogen gas fixation by specially adapted plants. Excess nitrogen in rivers enhances nutrient

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enrichment leading to algal blooms, fish kills and weed infestation. High levels of dissolved forms of nitrogen (nitrate, nitrite and ammonium) can also be toxic to many aquatic organisms and can prevent the water from being used as potable supply.[1)]

Bacteria in the gut can reduce nitrate to nitrite which when absorbed into the blood stream oxidizes haemoglobin to methaemoglobin,[2)] which cannot carry oxygen for respiration and therefore cyanosis and anoxia set in. Although methaemoglobinaemia occurs occasionally in babies causing illness and deaths of infants, it constitutes a frequent major health problem in cattle.[3)] In cattle, chronic consumption of more than 100 ppm of nitrate can cause decreased weight gain, feed efficiency and milk production; abortion, hay poisoning in grass tetany.[4)]

Despite the fact that most nitrate health hazards come from polluted water,[5)] water planners and managers in developing countries lay emphasis only on water quantity and neglect water quality. Thus water supplies in most rural and urban areas in Nigeria are supplied to the people without proper treatment. Borehole water is never treated and is supplied to homes directly from the aquifers. It is not strange in iron-rich ground water areas to find coloured (brownish) water running out from taps, and colouring wash-basins and toilet bowls; Endemic proportions occur periodically in parts of the country especially during the early rains.[1)] Above all, water quality guidelines for various physical, chemical and biological parameters are yet to be established in Nigeria. In this situation, nitrate-nitrite problem becomes an unfortunate non-priority event but because of its hazardous nature it cannot be ignored.

Calabrese,[6)] reported that infants are at considerable risk for nitrate related toxicity, as compared to adults. He revealed that levels of nitrate beyond 20 mg/l resulted in a marked up—shift in the frequency of methemoglobinemia in infants but not in adult. Nitrates can be reduced endogenously by microbial systems to nitrates, which then oxidise the haemoglobin to methaemoglobin (heme iron from ferrous to ferric state). Methaemoglobin, being unable to combine with oxygen, following accumulation in sufficient quantities, can lead to anoxia. The use of water with high (> 30 mg/l) nitrate content (from soils, ponds, fertilisers, *etc.*) in making baby formula and foods, spinach with high nitrate content, and occasionally meats with high levels of added nitrates and nitrites have resulted in life-threatening methomoglobinemia in human, especially children.[7, 8)] Consequently, a standard of 10 mg/l is principally designed to prevent the occurrence of elevated levels of methemoglobin in infants. Concentrations twice as great would still protect adults.

Of the total daily dietary intake of nitrates, of 10–150 mg/day, leafy vegetables contribute 99%. In developed countries, nitrates are used to treat meats (to give characteristic flavour and pink colour, to prevent rancidity, and to prevent growth of spores of *Clostridium botulium*) contributes < 0.1 mg/day.[7)] If there are excessive quantities of nitrates, they percolate into the ground water supplies, flow into streams and rivers and eventually reach the sea or lakes where they become concentrated. Nitrates may also be concentrated in groundwater, which tends to be a very long-lived effect because of the slow turnover of ground water reservoirs. This may have detrimental effects on aquatic and marine ecosystem, and may lead to public health problems when drinking water is contaminated. Natural fertilizers or manure also produce large quantities of nitrates. In addition, animal husbandry generates huge amounts of excrement, which contains some quantity of nitrates that are added to the environment.

Human exposure to nitrates occurs primarily through the diet because nitrate is a natural substance found in both water and plants, hence the rational behind studying foodstuff samples. In the United States, the average dietary intake of nitrates is about 75 to 100 mg per day. About 80 to 90 percent of this amount comes from vegetables.

There is the need therefore to determine the nitrate levels in stream water at different locations in the Federal Capital Territory of Nigeria with a view to establishing the degree and possible extent of nitrate exposure to animals and the contamination pattern in the new capital.

MATERIALS AND METHODS

Study Area/Collection of Samples —— Two samples each of stream water; soil and foodstuff (Cassava, Spinach and Sugar Cane) were collected during the dry season (February) and the rainy season (July). Stream water samples were collected from Garki Stream (near Garki General Hospital), Maitama Stream (In-between the Federal Secretariat and Hilton Hotel), Wuse Stream (In-between Berger Yard and Federal Ministry of Finance Hous-

ing Estate). Water samples were collected on polythene bottles after acid washed, rinsed with deionized water, and oven dried. For water samples, surface water and deep water was collected, and for soil, surface soils and another soil from about 30 cm depth referred to as deep soil was collected. Foodstuff samples were collected from gardens at Garki, Maitama and Wuse areas at a distance of about 75–200 m from each other. Samples collected were immediately transported to the laboratory for processing. Water samples that were not immediately analyzed were refrigerated at 4°C till processed.

Extraction of Nitrates from Soil —— 50 g soil sample, free from coarse stone was mixed with 100 ml of 0.025 mol/l calcium chloride solution in a glass bottle. A spatula-tip full of charcoal activated for soil test was added and the closed bottle placed on a shaking machine for 1 hr. The suspension was allowed to settle then filtered with Whatman No. 42 filter paper. The filtrate was used for nitrate analysis.[9)]

Extraction of Juice from Food Stuff —— 100 g each of samples of cassava, sugarcane and spinach were blended separately using Hach® 120 blender (Hach Company, Loveland, CO, U.S.A.). 100 ml of distilled water was then added to the mixture, which was then sieved, using a plastic siever (0.01 diameter of mesh), the extract was then filtered through acid washed filter paper (Whatman 541). The filtrate was used for nitrate analysis (Adopted for this work).

Nitrate Analysis —— The UV-spectrophotometric method outlined in Pye Unican Spectrophotometric Manual (Pye Unican Ltd., Cambridge, U.K.) was used for the determination of nitrate content of samples. The procedure basically involves the preparation of calibration curve using a range of standards of potassium nitrate. All stream water samples were filtered through acid washed Whatman 18.5 cm filter paper and the absorbance of all samples was read at 210 nm. Correction for organic constituents was made by reading the filtered samples at 275 nm. Nitrate concentrations were extrapolated from the calibration curve by using the absorbance values calculated as follows: $A = A_{210} - 4A_{275}$. Concentrations of Ammonium were also determined using the Spectrophotometric method. Internal standards were run to check for the accuracy of the method.[1)]

Statistical Analysis —— Results are expressed as mean ± S.D. Analysis of variance, student "*t*" test was determined using Statustucak Pacjage fir Social Sciences software version 6 on a V570 Compaq computer. The statistical level of significance was set at 95% ($p < 0.05$).

RESULTS AND DISCUSSIONS

With the exception of Wuse River, all the nitrate levels seen in all samples were below the World Health Organisation (WHO) recommended maximum safe level (45 ppm) for human consumption.[10)] Significant ($p < 0.05$) increases in rainy season nitrate levels were seen in all river samples when compared with dry season samples. Wuse rainy season river samples had the highest nitrate level (49.7 ± 3.37), which is above the maximum safe limit of 45 ppm. The highest level of nitrates was seen in Garki and Wuse rainy season soil samples. The levels were above the WHO safe limit of 45 ppm (Table 1). Wuse rainy season stream samples had the highest (44.21 ± 1.07) levels of ammonia (Table 1), increase in rainy season ammonia was seen in rainy season when compared to dry saeason ammonia.

Nitrate levels in foodstuff are shown in Table 2. Highest levels of nitrates were recorded in Wuse cassava sample (230.6 ± 1.07) with the range of nitrates level at 150.9 ± 1.82 – 230.6 ± 1.07. The level of nitrates in Wuse rainy season cassava sample was significantly ($p < 0.05$) higher than that of Maitama sample. The highest (200.10 ppm) levels of nitrates were seen in rainy season sugarcane samples. This level is significantly ($p < 0.05$) higher than all nitrate levels detected from other districts. A significant ($p < 0.05$) increase in rainy season spinach nitrates (2800.7 ± 1.35) was obtained when compared with other nitrate levels. Maitama had the lowest nitrate level when compared to Garki and Wuse, though these levels were not statistically significant ($p > 0.05$). Nitrates levels in all food samples were not up to the WHO acceptable safe limit of 45 ppm.

Higher concentration of nitrates has a detrimental effect on humans as well as animal health. With the exception of Wuse Stream, all the nitrate levels obtained in all the samples analysed fall below the WHO recommended maximum safe level for human consumption (45 mg/l)[10)] (Table 1). The increase of nitrate contents of water and soil during the rainy season can be considered an indication of increased pollution of water and soil from organic sources and increased in agricultural activities during this period. Significant sources of these organic matter and nitrates are, chemical fer-

Table 1. Nitrates and Ammonia Content in Dry and Rainy Season Water and Soil Samples of Abuja Municipal

Sample	Nitrate (ppm) In Stream Water		Ammonium (ppm) in Stream Water		Nitrate (ppm) in Soil	
	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
Garki	42.7 ± 2.36*	44.8 ± 3.39*	33.2 ± 2.44*	37.9 ± 1.21*	43.2 ± 1.30	46.7 ± 1.07*
Maitama	33.9 ± 3.53	37.3 ± 2.01	30.7 ± 1.05	34.5 ± 2.22	36.7 ± 1.62	40.2 ± 1.35
Wuse	46.4 ± 3.63*	49.7 ± 3.57*	38.3 ± 2.52*	44.21 ± 1.07*	45.4 ± 1.60*	48.1 ± 1.81*

Values are expressed as mean ± S.D. of two samples. Values marked with asterisk differ significantly $p < 0.05$ (Student's t-test) when compared with other values.

Table 2. Nitrates Content in Foodstuff Samples

Sample	Nitrates (ppm) In Cassava		Nitrates (ppm) in Sugar Cane		Nitrates (ppm) in Spinach	
	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
Garki	170.8 ± 2.01	180.2 ± 1.13	140.7 ± 1.03	150.9 ± 0.72	2100.3 ± 0.16	2300.5 ± 0.07
Maitama	150.9 ± 1.82	160.6 ± 1.01	140.2 ± 1.73	140.7 ± 1.03	1900.2 ± 0.01	1800.1 ± 0.05
Wuse	200.0 ± 0*	230.6 ± 1.07*	150.7 ± 1.02	200.1 ± 1.79*	2200.3 ± 0.19	2800.7 ± 1.35*

Values are expressed as mean ± S.D. of two samples. Values marked with asterisk differ significantly $p < 0.05$ (Student's t-test) when compared with other values.

tilizers from cultivated land, drainage from sewage, livestock feeds, domestic and industrial waste water. The level of industrialization in Abuja is low at present, as such; pollution of water and soil from industrial wastewater is not expected for now. In most urban and rural areas in Nigeria, human wastes are poorly handled and in many cases not safely disposed of. In rural areas, and some part of Abuja, some people construct pit latrines while majority of the people use open bush for toilet purposes. The pit latrines are usually in close proximity with artesian wells or the faeces can be conveniently passed near the stream. In urban areas, wastes are either disposed off in open fields or when treated, the resulting effluents are pumped directly into nearby water drainages, streams or lagoons that become continuously polluted. It is also common practice in many parts of Nigeria to rear livestock at home. The dung and feed waste are used as manure and are therefore kept at a site within the household before use. These activities act as available sources of nitrate inputs around the house.[1] During the rains, increased percolation and seepage of fluid from close pit latrines and water run off from livestock and sewage disposed site into aquifers might account for elevation of nitrate content of the stream samples analysed during the rainy season. The result obtained in this study is in agreement with that of a similar study conducted in Bosso, Niger State, Nigeria.[1]

Another primary source of contamination of rivers or land by nitrate is agricultural fertilizers and these are applied in a reckless and widespread manner as the rural dwellers and amateur farmers are encouraged by government to use fertilizers extensively in order to produce more food for the teeming Nigerian population. Many households maintain gardens and small farms around the compound and on these residential farms nitrogenous fertilizer and manure are applied. It is believed that most of the applied fertilizers used by ignorant farmers are washed away to pollute shallow and deep waters during the rains when agricultural activities are at their peak.[1,5] Although most of the farmlands in Abuja are rapidly giving way for construction of offices and residential accommodation, reasonable farmlands are still cultivated with the use of artificial fertilisers within and outside the city, which can contribute to the nitrate burden on the soil and the streams.

The pollution peaks are sustained in the rainy season because sludge deposits with high ammonia content become suspended in water and are washed into various water bodies including wells and waterworks reservoirs.[1,11] This may explain the high levels of ammonia seen in rainy season when compared to dry season (Table 1). Death and decay of plants, animals and other organisms contribute to soil organic matter, which, in turn, is washed into water bodies particularly during the rains.[1,12] These may also explain the high nitrates and ammonia levels in rainy season when compared to that of the dry season in this study.

Although the original master plan of the city of Abuja was made in such a way as to accommodate

civil servants and other business entrepreneurs and to handle waste generated by human activities, the present situation on the ground is that many low income people are in the city, the houses are not enough to accommodate all the people; and as such, many have resorted to building make-shift tents for accommodation with the attendant generation of domestic waste and attendant pollution problems.

All foodstuff samples contained various levels of nitrates (Table 2); the highest levels of nitrates seen in Wuse food samples were below the WHO recommended intake of 45 ppm and the results obtained in this study agree with other studies.[8] Green leafy vegetables have been shown to contain high nitrates levels and to contribute about 99 percent of total daily dietary intake.[7,8] A lot of farming activity goes on around the streams of Abuja Municipal both during the dry and rainy season. Artificial fertilizers are always applied on the vegetables cultivated. The vegetables produced from these farms are sold to the public, which are consumed cooked, parboiled, and sometimes even raw depending on the vegetables. Many of these peasant farmers and a lot of low-income earners who do not have access to tap borne water consume the unprocessed stream water without any regard to their health.

A high nitrate intake has been associated with stomach cancer.[13] A nitrate concentration above the safe level causes cyanotic effect particularly in infants when contaminated water is used in preparation of their food formula.[1,3,7] The most significant health effect associated with nitrate ingestion is methemoglobinemia in infants under six months of age. This condition results from the presence of high nitrite levels in the blood. Untreated, severe methemoglobinemia can result in brain damage and even death. Infants in the first six months of life are particularly susceptible to nitrite-induced methemoglobinemia. Infants have a higher intake of water for their weight than adults; so consequently, they ingest a relatively higher amount of nitrate. In addition to small infants, some adults may be susceptible to the development of nitrite, induced methemoglobinemia. These include pregnant women with a particular enzyme deficiency, adults with reduced stomach acidity, and those with a deficiency in the enzyme needed to change methemoglobinemia back to normal haemoglobin, a condition that can be hereditary. Fortunately, methemoglobinemia is easily recognised by the medical and public health communities and can be readily diagnosed and treated. Although data on the category of people that use the municipal stream was not the focus of this study, virtually all categories of human life from infants to the aged use the city streams both for drinking and cooking. Drinking water generally accounts for 5 to 10 percent of nitrates consumed. However, where drinking water is contaminated to a level of 50 mg/l, it may supply as much as half of the total daily intake. Ingested nitrate is the major source of nitrate in the body; high levels of nitrate in drinking water are generally responsible for high levels of nitrite in the body. Nitrate intake however, depends on a variety of factors, including diet, and amount and quality water consumed. Studies on blood nitrate levels in people using the streams need to be conducted to determine the level of human exposure.

In freshwater systems close to land, nitrate can reach high levels that can potentially cause the death of fish. While nitrate is much less toxic than ammonia or nitrite, levels over 30 ppm of nitrate can inhibit growth; impair the immune system and cause stress in some aquatic species. In most cases of excess nitrate concentrations, the principal pathway of entering aquatic systems is through surface runoff from agricultural or landscaped areas, which have received excess nitrate fertilizer. Even though the levels of nitrates seen in the streams of Abuja in this study did not exceed the WHO safe limit for drinking water quality for humans, these levels can be harmful to aquatic life. Increase in construction and landscaping activity that has been going on in the city for the past twenty (20) years may have contributed to the levels of nitrates seen in this study in addition to agricultural activity and other organic matter. These levels of nitrates can also lead to algae blooms, and when nutrients become limited (such as potassium, phosphates or nitrate) then eutrophication can occur as well as leading to water anoxia, these blooms my cause other changes to the ecosystem function, favouring some groups of organisms over others.

In conclusion, even though the presence of Nitrates substances were observed in the city of Abuja Municipal in this study, the contamination pattern at the present level is low and may not constitute an immediate problem to public health if controlled and if people are enlightened about the dangers involved in consuming such water. Safe drinking water should also be made available to the public to promote public health. Even though the levels of nitrates seen in the streams of Abuja in this study did not exceed the WHO safe limit for drinking water

for humans, these levels can be harmful to aquatic life.

The environment and the ecosystem in general needs to be monitored and checked regularly to forestall danger due to increase in Nitrates substances and accumulation of such substances in the environment.

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