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IMPACT OF BOREHOLE WATER QUALITY AND WATER POLLUTION INDEX (WPI) ON POULTRY PRODUCTION IN MAIDUGURI METROPOLIS, BORNO STATE, NIGERIA

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ABSTRACT

Water quality and pollution index were determined for poultry production in Maiduguri Metropolis. Ten poultry farms were sampled in Maiduguri metropolis for water quality analysis. Water samples from 10 boreholes and 10 tanks were collected during wet and dry seasons and analysed in the laboratory for physicochemical and biological parameters. Water Quality Pollution Index (WQPI) was computed using the standard formula and classified as excellent, good quality water, moderately polluted, and highly polluted water based on the scores obtained through interview on poultry production which were recorded and subsequently transcribed. The findings from the study revealed that out of 40 water samples tested, only 12.5% of samples were found in the excellent category, 45% were categorized as good quality water, 27.5% were moderately polluted and 15% sample were categorized as highly polluted. All respondents reported chemical contaminants like pesticides, herbicides, and heavy metals can adversely affect poultry performance. Respondents acknowledged the adverse effects of TDS and the corrosion of pipelines and metal tanks. Bacterial contamination can cause digestive disorders, reduced egg production, poor egg quality, including shell abnormalities and discolouration, reduced feed intake, and increased mortality, leading to financial losses for poultry farms. The study established that water sources from DF, AM, UF, and FGF farms are detrimental and unfit for poultry production. The study recommended that appropriate remediation measures should be implemented through installation of water treatment systems or the identification of alternative sources of water for the affected poultry farms.

KEY WORDS: Borehole water; Pollution Index; Poultry production; Water contaminants

INTRODUCTION

Globally total water abundance is not the problem, the problem is water availability in the right place, at the right time, in the right form with the right quality. Water in Africa is an important issue encompassing the sources, distribution, and economic uses of the water resources on the continent. Ground water is a major source of water supply throughout Nigeria. Hence, throughout Nigeria, individuals, communities, Locals, States, Federal government, and agricultural sectors (farms) have been sinking wells and boreholes to tap the rich ground water resources for livestock, human use, and irrigation purposes.

Good quality water is essential for the production of livestock and poultry, it is an essential ingredient for life, and nutrients and is also involved in many essential physiological functions such as digestion, absorption, enzymatic function, nutrient transportation (glucose, amino acids,

vitamins, and minerals), conduction of gases, (in particular oxygen and carbon dioxide), thermoregulation, lubrication of joints, organ and elimination of waste. It is also an essential component of blood and tissues. A chicken's body weight is 70% water, a loss of only 10% of that water will result in the bird's death (McCreery, 2015).

Chicken can survive for longer periods without any other nutrient than they can survive without water. It is the major component of the cell as well as the extracellular environment and contributes to the regulation of cellular physiological balance (McCreery, 2015). Despite significant improvement in technology and hygienic practices in developed countries at all stages of poultry production accompanied with advanced improvement in public sanitation, foodborne diseases remain a persistent threat to human and animal health. Increase in contacts of poultry with microbes leads to increased contact rates with humans and opens new avenues for the introduction, proliferation, and transmission of pathogens and ultimately more threats to public health (Hafez and El-Adawy, 2019). Poor water quality can retard growth, curtail egg production, or produce lower egg quality. Feed conversion, for example, has been positively correlated to the presence of sulfate and copper concentrates in the water, and livability with potassium, chloride, and calcium. Body weight is positively influenced by water hardness and dissolved oxygen and negatively influenced by total bacteria and a pH less than 6.0 (Animal and Food Sciences University of Kentucky: Retrieved 2022). Between 2006 and 2008, a total of 939,620 poultry mortality has been recorded in Nigeria due to the outbreak of pathogenic Avian Influenza (HPA1) H5N1. HPA1 causes up to 100% mortality in domestic chickens (Akanbi and Taiwo, 2014). In 2017, Avian Metapneumovirus (aMPV) caused over 11,000 deaths mostly to chickens in Maiduguri metropolis (MVH, 2017). The outbreak of Bird Flu ravaged several farms within the metropolis in August 2021, and over 13,000 mortalities have been recorded (Business Day, 2021), the casualties have raised a serious concern in the study area and the possibility of borehole water contamination has been the leading edge of this research, therefore, this study determines borehole water quality using water quality pollution index, and effects of contaminated water on poultry production/performance.

3.3 MATERIALS USED IN THE STUDY

3.3.1 Apparatus

Digital pH meter (Model Hanna), Environmental thermometer, Turbidimeter, Spectrophotometer, Flame photometer, Water checker, Coliform counter, Lamotte test kits, Lamotte smart spectrophotor, Incubator, Microscope, Colorimeter, Autoclave, Forceps, Direct reading titrator, Universal sample holder, Vacuum pump, Funnel, Filter, Phone, Test tubes, Test tube racks, Petri dishes, Glass slides, Beakers, Coverslips, Sterile plastic bottles, Syringes, pipettes, Dilution bottles, Graduated cylinders, Erlenmeyer flasks with metal caps, Metal foil, Covers, or screw caps, 1-L filtering flask with side tube and Filtering flask.

3.3.2 Culture media

A broth agar (membrane lauryl sulphate) was used as a nutrient and the bacteria were incubated in a petri dish at 37°C for 24h and 44.5ºC respectively. A microscope was used to enumerate all yellow colonies and the counts were expressed in colony-forming units (cfu/ml) (APHA, 2017).

3.3.3 Reagents

Buttered ammonium reagent, Stabilizing reagent, Hard butter reagent, Manganese indicator reagent, Chloride reagent A, Chloride reagent B, Chloride reagent #1, Chloride reagent #2, Nitrate powder cap, Sulphate reagent, Ammonium molybdate, Methyl orange indicator, TDS reagent (A), TDS reagent (B), Demineralized water, Methyl orange indicator, Ammonium chloride buffer, Sodium cyanide, PAR indicator, Sodium absorbed powder, Zinc buffer powder, Formaldehydes solution, Zinc indicator solution, Sulfuric acid, Sodium hydroxide, Hardness reagent 5, Hardness reagent tablet 6, Hardness reagent 7, Hardness titration reagent, Sulfuric acid, Distilled water, Phenolphthalein indicator, Sodium arsenite solution and Acid-Zirconyl SPADNS reagent.

STUDY AREA

Maiduguri metropolis is the capital of Borno state located between latitude 10º00′00′′ and 14º 00′00′′ North of the equator and longitude 11 º 00′ 30′′ and 14 º 45′ 00′′ east of the Greenwich Meridian (Figure 1). The area lies some 320m above sea level and it occupies a total area of 3000 sqkm (Ministry of Land and Survey Maiduguri, 2008). It lies on a vast open plain which is flat or gently undulating. The landscape is developed on the young sedimentary rocks of the Chad Formation. The River Ngadda and some short-course rivers drain the northern part of the plateau and flow northeast towards Lake Chad. River Yedsaram and its tributaries take their source from the Mandara Mountains and flow northeasttoward Lake Chad (Daura, 2002: Nyanganji, 1994). Köppen-Geiger's climate classification system classifies Maiduguri's climate as hot semi-arid (BSh). It is characterized by a semi-arid and hot season, with a mean annual temperature of 250°C (Bello et al, 2023). The vegetation found in the Maiduguri metropolis is tropical Sahel Savannah consisting of mainly grasses with few droughts' resistant trees (Bukar *et al.,* 2021). The soil of the area is clay in nature which varies in colour, texture, structure, physico-chemical, and other essential characteristics from the hilly south to the northern dune landscape. Maiduguri Metropolis has an estimated population of 904,696 people out of which 473,125 were male while 431,571 were female (NPC, 2021).

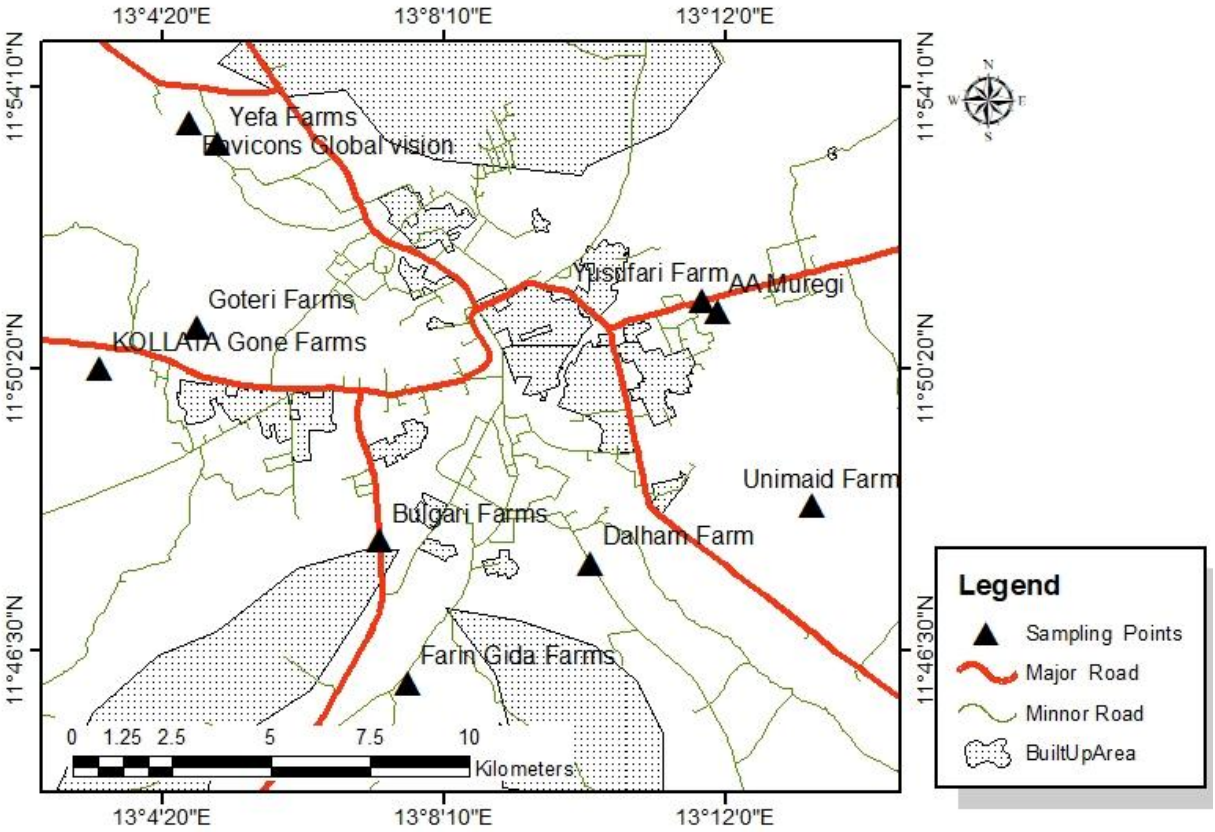

Fig. 1 Map of the study area showing the study locations
Source; Geospatial services 2021

METHODS

The target population for this study is the poultry farms within Maiduguri metropolis. All farms that house more than two thousand birds constituted the sample size for this study.

Water samples were collected in clean and sterile plastic bottles with screw caps for the analysis. All the samples were labeled with appropriate codes (YSB and YST) for proper identification. Y indicatesthe first letter of the farm's name, B indicates borehole water,and T indicates tank water respectively. The water samples were collected in both wet and dry seasons.

WQPI was obtained using the formula:

The water quality pollution index (WQPI) is in the following form:

In the first step, the pollution load (PLi) of the i^{th} parameter was calculated using the following formula

(Eq. (1); $PLi = 1 + (\frac{Ci-Si}{Si})$ ……..…….(i)

Ultimately, the pollution status of a sample or water quality pollution index (WQPI) with *n* number of variables (parameters) can be evaluated by aggregating all the pollution load and finally dividing with *n*.

$WPI = \frac{1}{n}\sum_{i=1}^{n} PLi$ ..... (ii)

The WQPI values may be classified based on *n* number of parameters into four categories.

Table 1 Water classification method with respect to WQPI score.

WQPI level	Category
1. <0.5	Excellent water
2. 0.5-0.75	Good water
3. 0.75-1	Moderately polluted water
4. >1	Highly polluted water

Source; Water pollution index – "A new integrated approach to rank water quality" Mobarok& Patra (2020).

Interviewed participants were recruited purposively. A total of 10 farm managers who have first-hand knowledge of poultry productivity/performance on their farms were interviewed.Interviews were conducted during sample collection and all information obtained from the participants was recorded and subsequently transcribed.

RESULTS AND DISCUSSION

Water quality pollution index

WPI is based on the standard permissible limits of groundwater parameters recommended by FAO. In this study, WPI for each sample was calculated to evaluate the degree of pollution in groundwater for drinking purposes using 21 physical, and chemical water quality parameters and 3 microbiological parameters (n = 24). The WPI classified groundwater into four categories such as excellent type when WPI < 0.5; good water quality if WPI ranged from 0.5 to 0.75; moderately polluted water, when it varies between 0.75 and 1; and highly polluted groundwater, when WPI is > 1.

The results presented in Table 2 showed that WPI for borehole water ranged from 1.43 to 0.62 and 0.83 to 0.43 during the wet and dry seasons respectively, with a mean value of 0.86 and 0.57, indicating that during the wet season, the overall groundwater quality of the study area was moderately polluted and good for consumption during the dry season. For tank/reservoir, WPI ranged from 1.67 to 0.77 and 0.78 to 0.48 during the wet season and dry season respectively, with a mean value of 1.04 and 0.60 respectively, indicating that during the wet season, the overall tank/reservoir water quality of the study area is highly polluted and good for consumption during the dry season.

Out of 40 water samples tested, only 12.5% of samples were found in the excellent category, 45% were categorized as good quality water, 27.5% were moderately polluted and 15% samples were categorized as highly polluted.

Table 2 Water classification with respect to WPI score

S/N	FARMS	SEASON	SOURCE	WPI	CATEGORY
1.	YSF	WET	BOREHOLE	0.69	Good water
			TANK	0.89	Moderately polluted water
		DRY	BOREHOLE	0.53	Good water
			TANK	0.54	Good water
2.	AMF	WET	BOREHOLE	1.15	Highly polluted water
			TANK	1.59	Highly polluted water
		DRY	BOREHOLE	0.74	Good water
			TANK	0.70	Good water
3.	YEF	WET	BOREHOLE	0.71	Good water
			TANK	0.79	Moderately polluted water
		DRY	BOREHOLE	0.47	Excellent water
			TANK	0.49	Excellent water
4.	EGF	WET	BOREHOLE	0.62	Good water
			TANK	0.77	Moderately polluted water
		DRY	BOREHOLE	0.43	Excellent water
			TANK	0.55	Good water
5.	GRF	WET	BOREHOLE	0.86	Moderately polluted water
			TANK	0.90	Moderately polluted water
		DRY	BOREHOLE	0.56	Good water
			TANK	0.59	Good water
6.	KLF	WET	BOREHOLE	0.68	Good water
			TANK	0.81	Moderately polluted water
		DRY	BOREHOLE	0.54	Good water
			TANK	0.70	Good water
7.	BGF	WET	BOREHOLE	0.69	Good water
			TANK	0.81	Moderately polluted water
		DRY	BOREHOLE	0.53	Good water
			TANK	0.58	Good water
8.	FGF	WET	BOREHOLE	0.79	Moderately polluted water
			TANK	1.06	Highly polluted water
		DRY	BOREHOLE	0.47	Excellent water
			TANK	0.48	Excellent water
9.	DF	WET	BOREHOLE	1.43	Highly polluted water
			TANK	1.67	Highly polluted water
		DRY	BOREHOLE	0.83	Moderately polluted water
			TANK	0.78	Moderately polluted water
10.	UF	WET	BOREHOLE	0.98	Moderately polluted water
			TANK	1.11	Highly polluted water
		DRY	BOREHOLE	0.60	Good water
			TANK	0.62	Good water

Field /laboratory work: 2022/23

The contamination of the water sources could be attributed to percolation or infiltration of contaminated water to the ground through septic system failures, agricultural runoff, poor waste disposal, or nearby sources of fecal contamination. Poultry may reduce their feed intake when provided with polluted water. Polluted water may contain harmful substances and these substances can interfere with nutrient absorption and utilization, leading to slower growth and reduced weight gain. This study is supported by the work of Mobarok and Pulak, (2020) inWest Bengal India, and Nathan *et al.,* (2022) at River Molo water basin.

Effects of contaminated water on poultry performance

Contaminated water can have a significant impact on poultry performance and overall health. Poultry consuming contaminated water may experience reduced growth rates. Waterborne pathogens, such as bacteria, viruses, and parasites, can cause digestive disorders, leading to poor nutrient absorption and slower growth. Contaminated water can negatively affect the bird's ability to convert feed into body mass. Poultry may consume less feed or have reduced nutrient utilization, resulting in a lower feed conversion ratio (FCR). Waterborne pathogens can compromise the immune system of poultry, making them more susceptible to various diseases. Bacterial and viral infections can spread rapidly through contaminated water sources, leading to outbreaks and increased mortality rates. Poultry consuming contaminated water may produce eggs with weaker shells, lower hatchability rates, and reduced egg size.

These findings were similar to the findings of Boumedous, *et al.,* (2017) at Oum El Bouaghi province, Algeria. According to Klasing (2013), an excess of sodium (Na) in broiler drinking water causes dehydration, heart failure with edema, ascites, and a high death rate.

Waterborne contaminants can negatively affect the quality of eggs (making them more susceptible to breakage during handling and transportation), leading to reduced hatchability. Contaminants may impair the development of embryos, resulting in a lower hatch rate and an increased number of non-viable or deformed chicks. It is captured that:

> "Poultry consuming contaminated water may experience a decline in egg production. This reduction can be caused by various factors, including reduced feed intake, impaired reproductive health, stress, or the direct effects of contaminants on egg-laying physiology"

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This finding is in agreement with the work of Boumedous, *et al.,* (2017) at Oum El Bouaghi province, Algeria.

It is captured from the response of the respondent:

> "Contaminated water can contribute to increased mortality rates among poultry, leading to financial losses for poultry farms. Contaminated water

can reduce productivity, including decreased weight gain, lower egg production, and compromised meat quality"

The finding of this study is in line with the work of Sarkingobir (2020) at Sokoto that poultry farms using contaminated water for their poultry may record high loss in productivity and more mortality that may results in low income and profit.

CONCLUSION AND RECOMMENDATIONS

The water quality pollution index analysis reveals that water samples analysed from DF and AMFfarms during the wet season for both boreholes and tank/reservoir water were highly polluted, while samples from FGF and UF farms during the wet season for tank/reservoir water were also highly polluted. The study established that these water sources are detrimental and unfit for poultry production. The study concluded that it is therefore evident, that contaminated water has claimed lots of lives, aggravated the food, financial outfit, and nutrition insecurity, further damaged to economy and agricultural sector, and has caused general fear and anxiety among poultry farmers, an urgent solution is needed. The study recommended that poultry farmers should protect water sources by installing non-corrosive pipes, tanks, proper covers, or barriers to prevent the entry of animals, debris, or pollutants that could compromise water quality.

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