IRESPUB Journal of Environmental & Material Sciences
ISSN: 2770-4084
Volume: 2 | Issue: 5 | MAY - JUN 2023 | Available Online: www.irespub.com

Assessment of Drinking Water Quality Using Water Quality Index (WQI) for Lake Gwakra, Gerie Local government, Adamawa State, Nigeria

Yohanna Peter
Department of Geography Adamawa State University, Mubi. Adamawa State, Nigeria

ABSTRACT
The Lake Gwakra water quality for human consumption was assessed using the Weighted Arithmetic Water Quality Index Method in the dry season. Water samples from the lake were taken and the physicochemical parameters were tested according to standards. The pH, electrical conductivity, total hardness, total alkalinity, total dissolved solids, , sodium, magnesium, calcium, chlorides, sulfates, nitrates, dissolved oxygen, and biochemical oxygen demand are among the parameters used to determine the water's level of quality. The drinking water quality standard by World Health Organization (WHO) was used for this research. The findings showed that all of the parameter values were within the ranges permitted by the standard agencies used. However, the total Water Quality Index (210.25) showed that the water quality status of the lake is absolutely unfit for drinking.

KEYWORDS
water quality index;
physicochemical parameter;
lake, water.

CORRESPONDING AUTHOR*
Yohanna Peter

INTRODUCTION

The foundation of the ecosystem is made up primarily of water, which is a valuable natural resource and is regarded as the second most crucial natural resource for all life after air (Bariweni, 2017).Despite its widespread availability, access to and the quality of drinkable water remain major global problems, particularly in developing countries' rural and semi-rural regions (Ohwo & Abotutu, 2014;). Since the only freshwater available for drinking, farming, and residential purposes is subjected to a variety of contaminants, one of the main causes being unchecked human activity, the supply of fresh water through surface and groundwater resources has become crucial (Bariweni, 2013; Oribhabor, 2015). Particularly unimproved sources are contaminated due to both anthropogenic and natural processes, including flooding, climate, parent material deterioration, terrain, and others (Vadde et al., 2018). Some of the illnesses connected to poor drinking water quality include polio, cholera, dysentery, typhoid, and diarrhea. According to estimates, polluted drinking water causes 485,000 cases of diarrhea deaths annually (WHO, 2019). Concerns about water quality are typically the most crucial aspect of drinking water as measured by physical, chemical, and bacteriological variables (WHO, 2004). Physicochemical and biological metrics can be used to assess the water quality of various sources. To assess the analytical outcomes of the parameters, the standard limits were applied. Understanding whether a water source is suitable for human consumption is a difficult issue. As a result, water consumers, planners, and policy makers can assess the water quality of sources and take action to safeguard them for the benefit of human health, social welfare, and economic development. To track the quality of surface and subsurface water sources, a number of WQI have been developed. Worldwide, water quality indexes have been created, altered, and adopted, including the Nation Sanitation Foundation Water Quality Index (NSFWQI) (Noori et al., 2019) among others, the Oregon Water Quality Index (OWQI) (Chandra et al., 2017), the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) (Hurley et al., 2012; Lumb et al., 2011; Noori et al., 2019; Tyagi et al., 2013), and the Weighted Arithmetic Water Quality Index (WAWQI). The Water Quality Index (WQI) is a useful and distinctive assessment that summarizes the state of the water supply in a single number, making it easier to choose the best treatment method to address the challenges at hand. (Yonnana et al., 2015; Tyagi et al., 2013; Khwakaram et al., 2012) The index tries to translate complicated data on water quality into a digestible and useful form for use by interested parties. In this study, the WAWQI method was used, which categorized water quality based on its degree of purity and this has been widely used by various scientists.

STUDY AREA

Location and extent

The Gwakra Lake is the main destination of the Jibiro drainage system. The lake is situated on the right bank of the River Benue (Upper Benue Trough) at Gwakra, Girei Local Government Area of Adamawa State. It is located between latitudes 09°24'09"N and 09°25'07"N of the Equator and between longitudes 12°23'04"E and 12°24'11"E of the prime Meridian (Figure 1). It covers a total surface area of 1.41Km2, with its surrounding flood plains making up the irrigation area.

The area has a humid tropical climate with distinct wet and dry seasons controlled by the yearly fluctuations of the Inter-Tropical Convergence Zone (ITCZ). The dry season which makes up the irrigation farming period runs from December to May. The lake area and its entire irrigable land is characterized by the Gleyic cambisols (FAO) or Typic topoqualfs (USDA)-213 soil type. This is a mineral hydromorphic and juvenile soil of recent riverine and lacusterine alluvium (Areola 1983). Its colour ranges from dark brown (10yr3/2) to very dark grey (10yr3/1) with loamy, sandy-loam and silty loam textural characteristics. The soil type is also of low to high cation exchange capacity with pH values ranging from 5.9 to 4.9 indicating slightly acidic to very strongly acidic conditions (Usman, 2005). Being characterized by high water-holding capacity and nutrients content (Usman, 2005) the soil type is naturally fertile enough to support substantial agricultural productivity. The major sources of water for the lake are the Jibiro Drainage System and episodic inundations from the River Benue during flood periods. With a surface area of about 1.41Km2 and a mean depth of 1.46m (Yonnana et al., 2015), the lake basin is capable of storing over 2.0mcm of water annually. which could support substantial irrigation agriculture and other socioeconomic activities as fishing and recreation.

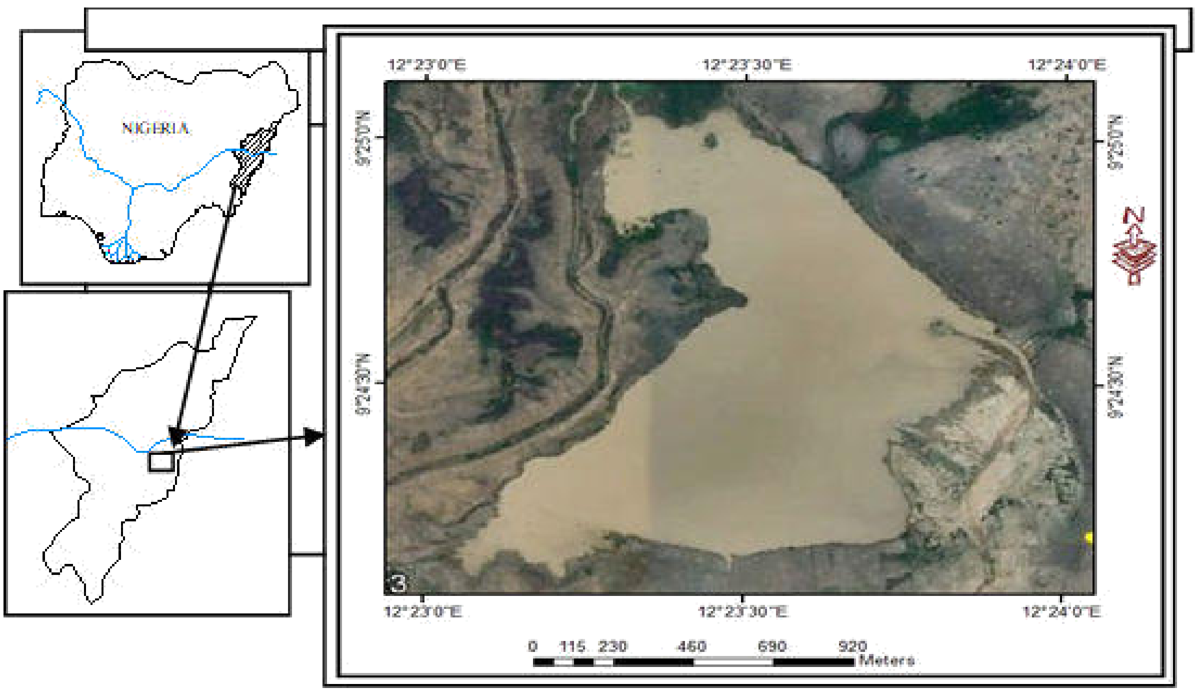

FIGURE 1: The Study Area.

METHODOLOGY

Since Lake Gwakra may be more useful as a supply source of drinking water during dry seasons when alternative supplies (rain and ground water) are scarce, the study was conducted on water samples collected in the dry (January, February, and March) season of 2021. The water samples were taken at three different locations throughout the lake in clean one-liter bottles at a depth of 0.3m in Accordance with Sisodia and Moundiotiya (2006) and Maitera et al. (2011) The three samples from the lake were then put into a container, and a composite sample of one liter was taken, treated with 10ml of HNO3, and transported to the lab for physicochemical tests in order to keep the cations in solution and slow down biological changes. According to the advice given by Maitera et al., (2011) 10ml of concentrated HNO3 was added. Water samples were evaluated using the gravimetric, colorimetric, and titrmetric procedures for Total Dissolved Solids (TDS), Turbidity, and Hardness, respectively. By using the Atomic Absorption Spectrophotometric (AAS) method, chemical concentrations (Na, K, Mg, Ca, Cl, SO42, CO32, PO43, NO3) were assessed. By using an oxygen meter, Winker's method, and Eijkman tests, the following parameters were examined: dissolved oxygen (DO), biochemical oxygen demand (BOD), and fecal coli form count.

The Color Match Method was used to measure the pH of the water on the spot (CMM). The lakes' water quality for human consumption was evaluated using a Quality Index Analysis. The Weighted Arithmetic Index Method of Water Quality Index (WQI) evaluation as defined by Brown et al., (1972), and Chauhanand Singh was used to determine the general Water Quality Statuses (WQS) of the lake for human consumption in the dry season (2010). The index is a single number that, based on a number of water quality measures, defines the overall quality of a water body with the aim of simplifying complex data into information that the general public can utilize (Thakor et al.,2012). In this study, the WAWQI method was used, which categorized water quality based on its degree of purity and this has been widely used by various scientists. The Water Quality Index (WQI) for the lake was calculated using fourteen (14) significant physico-chemical water quality parameters and their related standard values for drinking water quality as advised by the World Health Organization (WHO) and the Standard Organization of Nigeria (SON) (WHO).

The following formula was used to determine the water quality rating (Qn) for each parameter during the computation process:

$$Q_n = \frac{V_n - V_{io}}{V_s - V_{io}} * 100 \quad \text{............Equation 1}$$

Where;

Q_n= Water quality rating of each parameter

V_n= the measured value of the water quality parameter as determined by laboratory testing.

V_{io}= Ideal value of water quality parameter as obtained from standard tables (i.e., zero (0) for all other parameters with the exception of pH and Dissolved Oxygen (DO) having 7.0 and 14.6mg/l respectively).

V_s= Standard permissible value of water quality parameter as recommended by SON/WHO.

Then, a value inversely proportionates to the parameter's recommended standard value (Vs) was used to compute the relative weight for each water quality parameter, i.e:

$$Wn = \frac{K}{Vs} \quad \text{.................Equation 2}$$

Where;

Wn= Unit weight for water quality parameter

K= Constant of proportionality and can also be calculated by using the following equation:

$$K = \frac{1}{\frac{1}{Vs1} + \frac{1}{Vs2} + \frac{1}{Vs3} + \cdots + \frac{1}{Vsn}} \quad \text{................Equation 3}$$

The weighted arithmetic index equation was then used to aggregate the water quality rating with unit weight in order to determine the total WQI:

$$WQI = \frac{\sum Q_n W_n}{\sum W_n} \quad \text{...............Equation 4}$$

Finally, the WQS of each lake was determined using Water Quality Index and Status rating provided by Mishra and Patel (2001) on Table 1.

TABLE 1: Water quality index and status of water quality.

Water quality index levels	Water quality status description
0-25	Excellent Water
26-50	Good Water
51-75	Poor (Bad) Water
76-100	Very Poor (Bad) Water
>100	Unsuitable (unfit) for drinking

Adopted from Mishra and Petal, 2001and Chaterjee and Razuddin, 2002.

RESULTS AND DISCUSSION

On Table 2, the observed values of all the parameters that were analyzed (Vn) are shown along with the corresponding recommended standard values (Vs). In determining the quality of water, pH is a crucial factor (Mbaka et al., 2017). As a result, even though it does not directly affect human health, proper water quality analysis must be performed. The pH is a measure of the water's acidity or basicity and is a crucial aspect of water quality since it establishes the solubility and biological availability of substances in water that are chemical. The pH value of the Lake Gwakra if 7.75. in this research the pH values have not exceeded the standard limit, the value falls within the basic ranged which is similar to the results obtained by Adefemi and Awokunmi (2010).

Another one of the main indicators of water quality is the amount of dissolved oxygen (DO), which is a measurement of the degree of contamination by organic matter, the destruction of organic substances, as well as the potential for self-purification. To human palates, DO levels taste fresh (Davie, 2008). When compared to the permitted level (5.00 mg/L) specified by (WHO, 2004), the research lake's DO level (5.30 mg/L) was found to be appropriate. Biological Oxygen Demand (BOD) level is another important indicator of the quality of the water. The amount of oxygen needed by bacteria and other microbes to decompose organic matter in a body of water is measured by the BOD (Davie, 2008). A typical unpolluted or less polluted water body is anticipated to have a BOD value of less than 5.00 mg/L, even while this is not a specific sign of water pollution (Davie, 2008; WHO, 2004). Because the oxygen that is present in the water is being used by the microbes already present, high BOD levels imply a fall in DO. The studied lake's BOD value (3.8 mg/L) was less than 6.00 mg/L standard as suggested by, showing that microbiological contamination has little to no impact on the lake.

Solids in a water body is a key indicator of the pollution load. Without regard to the sources, the more particulates there are in the water, the more likely it is that it is contaminated. There was no evidence of anthropogenic input in the lake's calcium (24.62mg/L), magnesium (19.10mg/L), total alkalinity, or overall hardness. The total hardness of the water (45.67mg/L) was found to be within the allowed limit (150 mg/L) as suggested by WHO, 2004. The study lake's Total Dissolved Solids (TDS) concentration was 271 mg/L.

Transparency in any water sample caused by the presence of particle matter, such as lay or slit, finely divided organic materials, plankton, and other microscopic organisms, is known as turbidity (Srivastava et al., 2011). lake's water has turbidity levels that are more than allowed by a factor of 5 NTU WHO (2006). (2006). According to Sinha et al. (2013), there may be suspended particulate matter, a drop-in water level, and human activity contributing to high turbidity. The results are congruent with investigations by Adimasu (2015). No health risks are posed by turbidity. Turbidity serves as a breeding environment for bacteria and can hinder disinfection, though than the allowed maximum of 5NTU (Table 2).

Despite the fact that the values of all the physicochemical parameters evaluated in the lake water, including SO42 (8.02 mg/L), PO43 (0.23 mg/L), and NO3 (5.59 mg/L), were determined to be within the WHO, 2002 recommended allowed ranges (Table 2).

The results of water quality index assessment for human consumption (Table 2) revealed that water Quality indices (WQI) for the Lake Gwakra was found to be 210.25 which exceeds the standard permissible limit (Table 1) indicating unfit water quality status. This results suggests that the lake is polluted and not totally safe for human consumption without proper treatment.

Table 2: Weighted arithmetic water quality index computations.

Parameter	Standard Value (sn)	Observed value (V_n)	Unit Weight (W_n)	Quality Rating (Q_n)	WnQn
Na	200	20.42	0.001533	10.21	0.01565
Mg	50	19.1	0.006131	38.2	0.23421355
Ca	100	24.62	0.003066	24.62	0.07547562
Cl^-	250	9.12	0.001226	3.648	0.00447336
$SO4^{2-}$	100	8.02	0.003066	8.02	0.02458629
$PO4^{3-}$	0.4	0.23	0.766406	57.5	44.0683213
$NO3^-$	50	5.59	0.006131	11.18	0.06854732

Parameter	Standard Value (sn)	Observed value (V_n)	Unit Weight (W_n)	Quality Rating (Q_n)	WnQn
DO	5	5.3	0.061312	900	55.1812023
BOD	6	3.8	0.051094	63.33333	3.2359347
TDS	500	86	0.000613	17.2	0.01054574
pH	8.5	7.75	0.036066	50	1.80330727
TH	150	45.67	0.002044	30.44667	0.06222532
Turbidity	5	86	0.061312	1720	105.457409
EC	1000	130	0.000307	13	0.00398531
			∑Wn=1		**WQI=210.25**
					WQS=Not Suitable

CONCLUSION

water quality index, (WQI) is to provide a single value for the water quality assessment of a specific source by condensing a variety of diverse factors into a straightforward phrase. The findings of this investigation showed that the lake used for the study had water of poor purity and unfitness for human consumption. As a result, the chosen indices will be an effective instrument for disseminating information about the water quality to the general public as well as the relevant authorities and policy makers in the State.

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