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Surface and Drinking Water Quality Monitoring of Thomas Reservoir, Kano State, Nigeria

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***Abstract*—**Drinking water is supplied to Danbatta, Makoda and some parts of Minjibir local government areas of Kano State from the surface water of Thomas Reservoir. The present land use in the catchment area of the reservoir indicates high agricultural activities, fishing, as well as domestic and small scale industrial activities. To study and monitor the quality of surface and drinking water of the area, water samples were collected from the reservoir, treated water at the treatment plant and potable water at the consumer end in three seasons November - February (cold season), March - June (dry season) and July - September (rainy season). The samples were analyzed for physical and chemical parameters, pH, temperature, total dissolved solids (TDS), conductivity, turbidity, total hardness, suspended solids, total solids, colour, dissolved oxygen (DO), biological oxygen demand (BOD), chloride ion (Cl^-) nitrite (NO_2^-), nitrate (NO_3^-), chemical oxygen demand (COD) and phosphate (PO_4^{3-}). The higher values obtained in some parameters with respect to the acceptable standard set by World Health Organization (WHO) and Nigerian Industrial Standards (NIS) indicate the pollution of both the surface and drinking water. These pollutants were observed to have a negative impact on water quality in terms of eutrophication, largely due to anthropogenic activities in the watershed.

***Keywords*—**Surface water, drinking water, water quality, pollution, Thomas reservoir, Kano.

I. Introduction

WATER is needed for many purposes, drinking, industrial, recreation, fishing etc. Thus, water for different purposes has its own requirements for the composition and purity and each water body has to be analyzed on a regular basis to confirm its suitability for specific purposes. The physical and chemical parameters of water have always been used as quality parameters in monitoring the chemical and pollution level of water [1], [2].

The physical and chemical parameters which include pH, conductivity, turbidity, colour, total suspended solids, nitrate, NO_2^- etc. are indicators of water pollution. The pH represents effective concentration or activity of H^+ ions in water. Low pH values adversely affect aquatic life and impair recreational uses of water [3]. High pH values could also alter the toxicity of water pollutants in the water body. A decrease in pH values could also reduce the solubility of certain essential elements. Low pH also increases the solubility of many other elements such as Al, B Cu, Hg, Mn and Fe [2]. Conductivity is used as a measure the total concentration of ionic species or salt content. The temperature of a waterway is significant because it affects the amount of DO in the water. The amount of oxygen that will dissolve in water increases as temperature decreases. Water at 0 ºC will hold up to 14.6 mg of oxygen per litre, while at 30 ºC it will hold only 7.6 mg/L [4].

The sources of water pollution vary and involve almost all significant human activities, such as, dumping of industrial effluents, sewage, agricultural wastes, and domestic wastes into water bodies. Waste dumped on land, such as animal dung, litter, and wind deposited pollutants etc., form part of sources of water pollution [5].

Air pollutants like oxides of nitrogen and sulphur become acidic contaminants during rainfall. The increase in industrialization as a result of modern and sophisticated technology, has introduced many synthetic materials example, agrochemicals such as herbicides, pesticides etc., into our environment [5], [6]. Another source of pollution is the urban solid dump side. Reference [7] analyzed municipal solid waste dumpsites in Kano and Kaduna states and concluded that the concentration of heavy metals is higher than the threshold limits and therefore poses a danger on the sub-soil and underground water underneath them.

Another source of concern is dam construction, irrigation channels, factory farming, as well as forest and wetland destruction [8]. Disturbances of the soil mantle by ploughing, road construction, stream irrigation/channelization and mining break the protective vegetation cover and encourage soil washout by storm water during rainfall [5]. This result in organic, inorganic salts, nutrients, heavy metals, pesticides, pathogens and heat pollutants being washed into reservoirs and dams.

Rapid population growth and industrialization in sub-Saharan Africa has brought about an increase in urbanization with an attendant increase in the volume of domestic and industrial waste-water [9]. An increase in pollution is generally expected, because of poor management of individual and municipal pollution. The aim of this work is to monitor the quality of surface and treated water of Thomas Reservoir, Kano State using selected physical and chemical parameters. Physical and chemical parameters were determined seasonally from 2012-2013 from Thomas Reservoir, Kano State to ascertain the quality of the reservoir in respect to its intended purposes.

II. Materials and Methods

A. Materials

All reagents were of AnalaR grade and purchased from TOTEIL Nig. Limited, Kano State. Some of the major instruments used include Jenway pH meter model 3505,

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Jenway DO_2 meter model 9200, HI ECi model 961, turbidity meter Wag WT model 3020, HACH BODTrak meter model 205, and HACH colorimeter model No. 890.

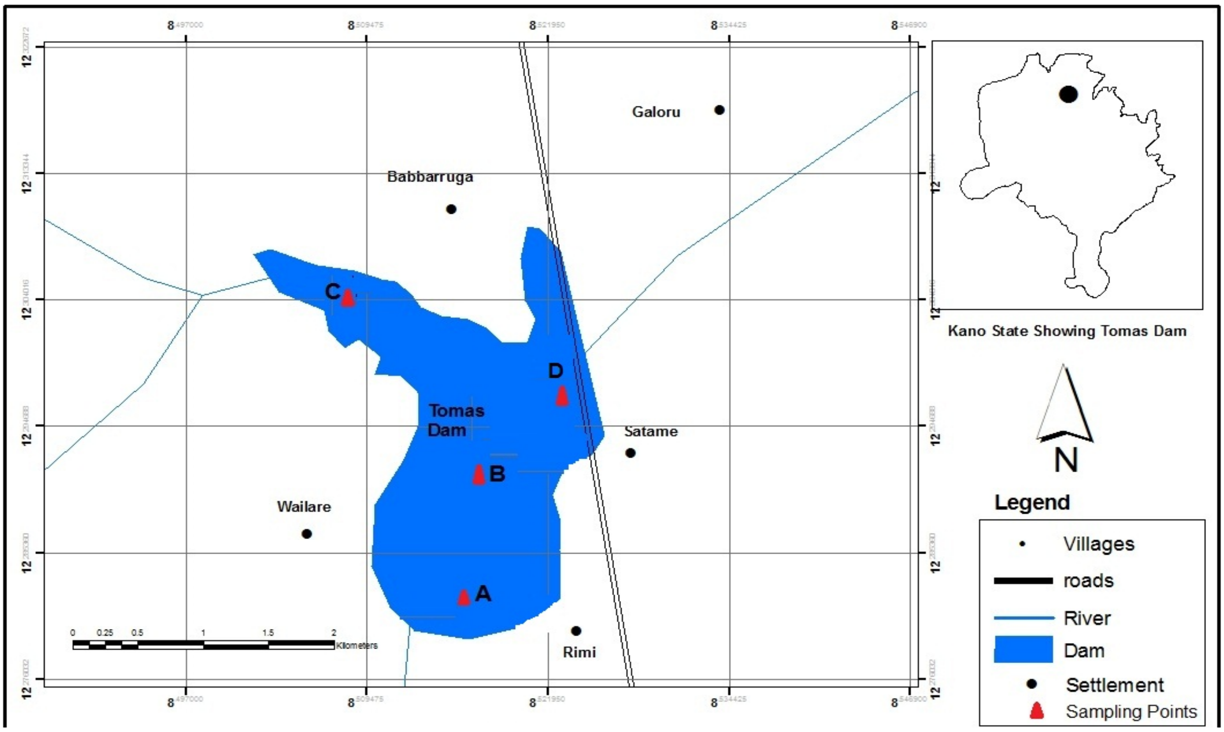

Fig. 1 Map of Thomas Reservoir

B. Study Area

The dam is about 585 square meters, with a depth of about 30 m. The dam is now sited near Danmarke village under Dambatta Local Government Area of Kano State, some 30 km away from the ancient Kano city. It is located on 12°25'59" 8°30'55"E [11].

C. Collection of Samples

Surface water was collected from the reservoir at a depth of 20cm into two separate pre-cleaned plastic containers [10]. Approximately 1,000 cm^3 of water was collected into each container. The samples were labelled, sealed and preserved. AnalaR grade reagents were used throughout. Water samples were also collected from the treatment plant and consumer end at varying distances in towns that receive supply from the treatment plant.

D. Determination of Physicochemical Parameters

Physical parameters temperature, TDS, conductivity, turbidity and suspended solids; chemical parameters. The pH, total hardness, DO, BOD, Cl^-, NO_2^-, NO^-_3, COD, and PO_4^{3-} were analyzed using standard methods and procedures [4], [12]. Some of the parameters were determined *in situ* using pre-calibrated hand held equipment. The pH was measured using a Jenway pH meter model 3505. DO was determined using water proof Jenway DO_2 meter model: 9200; conductivity, TDS and temperature were measured using HI ECi model No. 961. Turbidity was determined using a Wagtech turbidity meter Wag WT 3020 model. The other parameters like, Chloride, COD, PO_4^{3-} etc., were brought to the laboratory for immediate analysis following the procedures in [4]. Chloride was measured in the laboratory by silver nitrate titration method. Suspended solid was measured gravimetrically after filtration. BOD was measured using HACH BODTrak meter model No. 205 by measuring initial and final DO after incubation in the dark for five days. NO_2^- was determined using sulphanilamide spectrophotometric method and Nitrate was determined by cadmium reduction method using HACH colorimeter model No. 890. COD was determined by dichromate oxidation method. PO_4^{3-} was measured using ascorbic acid molybdate spectrophotometric method.

E. Results and Discussion

The results of physicochemical parameters of Thomas reservoir, treated and portable water are as depicted in Figs. 1-7. Fig. 2 shows the result of physical and chemical parameters of Thomas Reservoir treated and potable water in cold season. DO values 2.10, 2.56 and 2.72 mg/L were obtained for the reservoir, treated and potable water, respectively. All the values were found to be lower than the WHO permissible limit of 5 mg/L. Similar values were reported by [13] 1.04 to 6.68 mg/L when assessing qualities of surface water from selected major rivers in south western Nigeria. The mean DO showed no significant difference $p<0.05$ between the three sampling seasons. BOD values have a mean range values of 5.62 mg/L obtained in treated water to 9.40 mg/L obtained in the reservoir. BOD values varies significantly between the three sampling sites (p=<0.05) and is generally higher than the WHO permissible limit of 2 mg/L.

Chloride recorded mean values of 10.10 to 20.76 mg/L. The chloride values were fairly consistent in most of the locations. All the results obtained were within the WHO recommended values for chloride in water (250 mg/L). Sight increase observed in treated and potable water may be due to chlorination during the treatment process. The major sources of nitrates in drinking water are run-off from fertilizer use, leakages from septic tanks, sewage and erosion of natural deposits [14]. The result showed no relationship with season but there is drastic reduction in NO_2^- and nitrate values in the treated and potable water which is likely due to effectiveness of the treatment process. Similar values of NO_2^- were obtained 0.001 to 0.007 mg/L by [15] in the determination of physical and chemical parameters of River Shkumbi (Pena). Reference [16] obtained similar values when studying nitrate and PO_4^{3-} levels in river Jakara, Kano State, Nigeria.

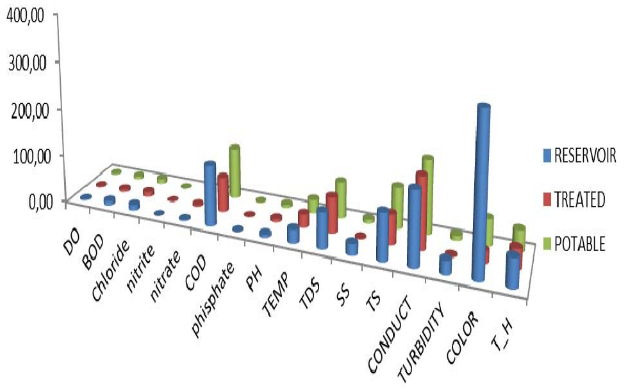

Fig. 2 Result of physical and chemical parameters of Thomas Reservoir, treated and potable water for cold season

DO values in dry season ranged from 1.96, 2.19, 2.63 mg/L. The low DO values may be as a result of high temperature, decomposition of algae and organic matter [17]. The only significant decrease in DO values was noticed in the reservoir and in dry season, which may be as a result of high temperature observed in the dry season. BOD values in the range of 9.31, 1.82, 188 mg/L were obtained in the reservoir, treated and potable water, respectively (Fig. 3).

The mean pH values obtained in all the sampling locations ranged from 6.64 to 8.90 (Fig. 6). All the values were however within the WHO permissible limit of 6.5-8.5. Higher pH values were obtained in the rainy season. This might be due to the deposition of some organic matters into the water from run-off in rainy season. Reference [1] recorded mean pH values in the range of 6.35 to 8.90 in assessing water quality of Osun River. The temperature ranged between the lowest values of 27.92 ºC obtained in cold season and the highest of 33.46 ºC obtained in dry season. Dry season temperature was significantly higher than cold season and rainy season at $p<0.05$. No significant variations were seen among the reservoir, treated and potable water. Temperature has a negative effect on DO. Increase in water temperature more than necessary leads to a decrease in DO level in water [18].

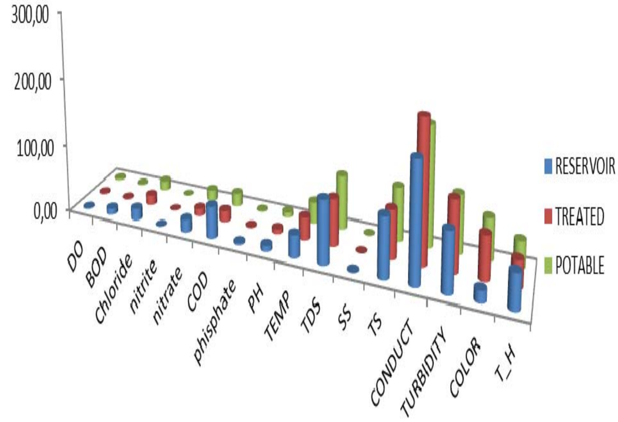

Fig. 3 Result of physical and chemical parameters of Thomas Reservoir, treated and potable water for dry season

The COD is an important parameter in water quality analysis. COD and BOD are both a function of DO. Decrease in DO will lead to increase in BOD and COD values. Industrial effluents rich in starch, waxes, carboxymethyl cellulose (CMC), polyvinyl alcohol etc. from textile industries are bound to have high BOD and COD levels [19]. The COD levels exceeded the limit [20] of 10 to 20 mg/L set by [20] in most of the locations which is an indication of organic pollution. The mean PO_4^{3-} concentrations in all the sampling locations ranged from 0.04 mg/L to 5.35 mg/L (Fig. 4). All the samples assessed in this study were observed to have PO_4^{3-} concentration lower than the WHO permissible limit of 10 mg/L [20]. The nutrient enrichment of Thomas Reservoir was reported by [21]. Agricultural activities and cultural eutrophication around the reservoir were noticed during the sampling operations.

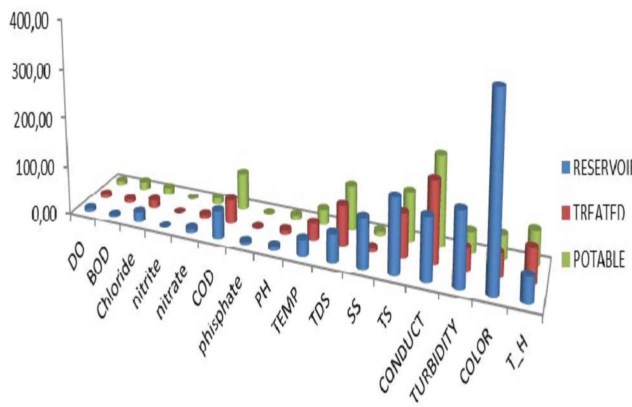

Fig. 4 Result of physical and chemical parameters of Thomas Reservoir, treated and potable water for the rainy season

TDS comprise of inorganic salts principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates and small amounts of organic carbon that are dissolved in water [13]. TDS values obtained was found to be within the maximum permissible limit of 500 mg/L [22]. The values obtained ranged from 55.84 to 92.40 mg/L, which is much lower than the permissible limit.

The mean conductivity values recorded in this study ranged between the lowest values of 123.20 μScm^{-1} obtained in the rainy season and the highest values of 207.40 μScm^{-1}obtained in the dry season The noticeable increase in conductivity values in the dry season may be as a result of decrease in the total volume of the water and high temperature due to excessive sunlight [23], [24] Conductivity values in all the locations followed a consistent pattern with slight increase across the sampling sites in order of reservoir > treated > potable water. This may be as a result of the addition of chemicals such as chlorine, during the treatment process. All the values obtained are within the maximum permissible limit of 1000 μScm^{-1} set by WHO. Suspended solids and total solids obtained in this study have total mean values of 0.14 mg/L to 98.40 mg/L and 61.80 mg/L to 147.48 mg/L. The marginal difference was achieved by the efficiency of the treatment process with lower values obtained in the treated and potable water (Figs. 1-3).

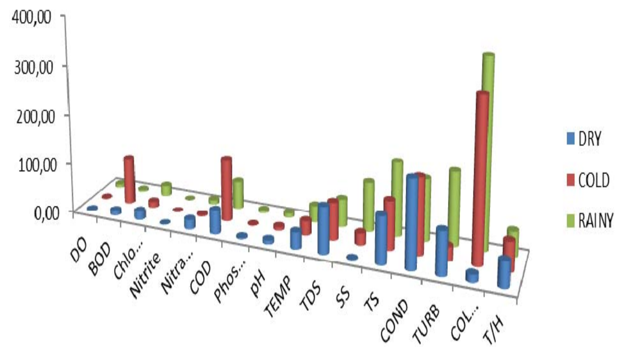

Fig. 5 Seasonal variations of physical and chemical parameters of Thomas Reservoir water

The mean values obtained for turbidity ranged from 1.80 FAU to 146.04 FAU. The large variations existing between the sampling locations were as a result of the treatment process which effectively eliminates turbidity in treated and potable water. The consistently high turbidity observed in the reservoir (Fig. 1) water may be as a result of earth disturbing activities occurring in the tributary rivers around the reservoir. This was confirmed by [25] on the study of the effects of extensive sand mining on surface water quality and concluded that sand mining impairs water quality of the Kano River. Reference [21] working on Thomas and Challawa dams, Kano state, Nigeria, observed that turbidity was high during rainy season (Fig. 5) due to the increase in surface run-off water flood from the catchment. The values obtained for colour in this work have a mean range values as low as 24.60 Hazen to as high as 371.60 Hazen, which is higher than WHO limit of 15 Hazen. Higher values were obtained in the reservoir water. When colour is caused by metals it is usually due to iron, copper or manganese ions in the water. Leaves and peat may add tannins, glucosides and their derivatives to the water, resulting in a yellow or brown hue. Industries can also add a variety of chemicals with various colours [26]. The levels of colour above 15 Hazen can be detected in a glass of water.

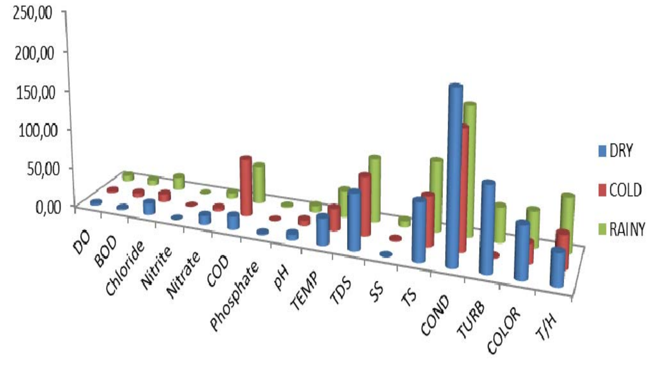

Fig. 6 Seasonal variations of physical and chemical parameters of Thomas Reservoir treated water

The mean values obtained for total hardness ranged from 41.60 mg/L to 68.00 mg/L. Reservoirs with less than 100 mg/L $CaCO_3$/L can be categorized as 'soft' [27]. This indicates that Thomas Reservoir can be categorized as soft. Reference [28] recorded T/H values in the range of 10 mg/L to 97 mg/L in the assessment of groundwater quality of the Jada area, North-Eastern Nigeria.

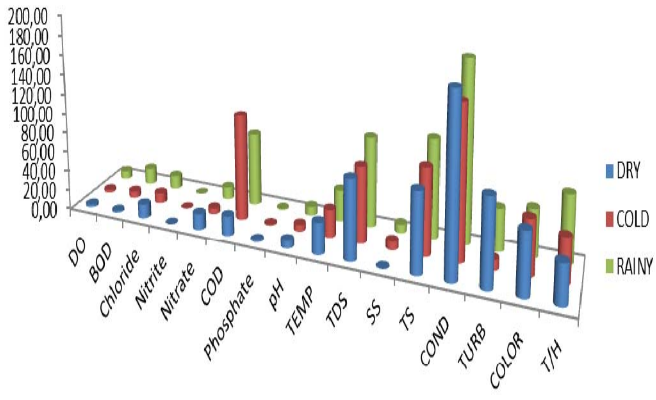

Fig. 7 Seasonal variations of physical and chemical parameters of Thomas Reservoir potable water

III. Conclusion

The results obtained from the assessment of the quality parameters of Thomas Reservoir, treated and potable water indicate that the reservoir water is fit for recreation, agriculture and limnology, while the treated water is fit for industrial and domestic purposes. Water quality monitoring is a continuous process and should be maintained to avoid building up of pollutants which may pose serious threat to human, aquatic and animal health.

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