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SEASONAL VARIATIONS OF SOME PHYSICO-CHEMICAL PARAMETERS OF WATARI RESERVOIR, TREATED AND POTABLE WATER, IN KANO STATE NIGERIA

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Abstract- Seasonal variations of selected physico - chemical parameters were investigated for three seasons of the year to determine the drinking water quality of Watari reservoir, Kano state, Nigeria, between the months of November - February (cold season); March - June (dry season) and July - September (rainy season). Five stations were chosen on the reservoir at intersect of the adjourning rivers. Treated water was collected from the treatment plant and potable water from the consumer end. pH, temperature, TDS, conductivity, turbidity, total hardness, suspended solids, DO, BOD, Cl^-, NO_2^-, NO_3^-, COD and PO_4^{3-} were analyzed using standard procedures. The mean values of these parameters indicate the effectiveness of the treatment process on turbidity, color, suspended solids and NO_3^-.The high values for nitrates observed may be as a result of the use of nitrous based fertilizer in the localities. There is significant variation ($P < 0.05$) between the values of temperature, suspended solids, conductivity, color, nitrate and phosphates observed for the three seasons. The overall quality of Watari reservoir was found to be within the WHO recommended value for drinking water. However, denitrification and nutrient control need to be ensured to halt the impending threat on the reservoir.
Key words: ***seasonal variation, physico - chemical, reservoir, treated water, potable water.***

1. Introduction

The impact of human activities in and around reservoirs is felt on the unique physical and chemical properties of the water. A large proportion of Nigerian population depends heavily on the resources of aquatic environment for livelihood [1]. Due to increased population, industrialization, use of fertilizers in agriculture and man-made activities, the natural aquatic environment is increasingly polluted leading to depletion of aquatic biota and water quality [2]. Adequate determinations of physical and chemical parameters of reservoirs are important for controlling their pollution [3].

One of the major purposes of reservoirs is production of drinking water to surrounding communities. The water has to undergo various treatment processes of sedimentation, filtration, coagulation/flocculation and the essential pretreatment. The treated water is supplied to the consumers via pipelines linking the various towns served by the treatment plant. In Kano metropolitan, the pipe lines for the supply of treated water from the old treatment plant at Challawa were buried over 60 years ago by the then colonial administration. Most of the pipes have either broken, fouled or have serious leakages [4]. It was through these leakages that contaminants find their way through the water supply lines and the tap water (potable water) in most of the cities is found to contain deposits of sand and organic matter, where it has to further be boiled, filtered or ozonized for safe consumption. Potable water is water that is intended to be ingested by humans [5]. Estimates suggest that nearly 1.5 billion people lack safe drinking water and that at least 5 million deaths per year can be attributed to water borne diseases [6].

Impairment of water quality in reservoirs arises largely from anthropogenic contamination and natural mineralization [7]. The effect of these ‘imports’ into the reservoir do not only affect the socio economic functions of the reservoir negatively, but also bring loss of structural biodiversity of the reservoir [1]. The physical and chemical parameters serve as pollution indicators in water quality monitoring which is a fundamental tool in the management of fresh water resources. Monitoring can be conducted for the purpose of identifying trends in water quality over time, identifying emerging water quality problems, design specific pollution remediation programs and respond to emergencies such as spills or flood [8].

Many researchers [9], [10], [11] postulate the threat of pollution on the quality of water resources in Kano state and the need to monitor and evaluate the quality of water meant for human consumption. Reference [12] in their work on water quality monitoring in Nigerian's industrial states, state that there are no incentives for implementing pollution reduction measures. Wastes are disposed indiscriminately especially for small and medium scale industries and therefore proposes constant river water monitoring as a step towards pollution abatement.

Reference [13] studied the physical and chemical characteristics of Danube River near Kovin, Serbia and confirms the poor water quality of the river and advice on the need for local waste water treatment plant. Reference [14] assess the physical and chemical quality of river Shkumbini (Pena) and conclude that the river is overloaded with contaminants. Reference [15] in assessing the organic pollution indicators of River Benue, Adamawa state conclude that the river is moderately clean and warn on the risk of future pollution. The negative impact of water ways pollution due to discharge of untreated solid and liquid wastes are always felt by the reservoirs.

This study was conducted for the purpose of monitoring the quality of Watari reservoir, Kano state Nigeria for drinking water purpose, using selected physico - chemical parameters. The result will help in predicting the pollution status of the reservoir and form a baseline data in identifying emerging water quality problems.

2. Study Area

Kano state covering a perimeter extending between latitudes of 120 40' and 100 30' and longitudes of 70 40' and 90 30' [16]. Bagwai (Watari) dam is located in Bagwai local government area, Kano state, Nigeria on 12°9'24"N 8°8'12"E [17]. The main spillway of the Watari regional water supply dam (with reservoir capacity of 104.55 million cubic meters) serving a total population of about 117,000 people of Bichi, Bagwai and Northern Districts of Kano.

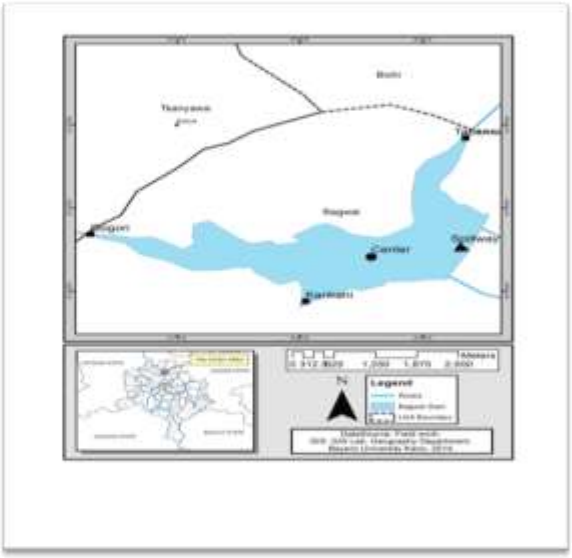

Fig. I: Map of Watari Reservoir Showing the Sampling Sites

3. Materials and Method

Sampling: water samples were collected using clean plastic containers [18], and preserved following [19] procedure, from three sampling sites reservoir, treated water at the treatment plant and potable water from the consumer end in three seasons between the months of November - February (cold season); March - June (dry season) and July - September (rainy season).

Reservoir: 1litre of water was collected from five points at each of the five sampling stations where rivers meet the reservoir (Figure I). Kankani (Bagwai river), Gogori (Watari river), Tabanni (Wuyan kanyi), spill way and center of the reservoir.

Treated Water: five samples were collected from the new water treatment plant at Bagwai town.

Potable Water: 1 liter of water was collected directly from the tap at five stations (towns) Bagwai (Ramin Abashe), Kasuwar Laraba, Madawaki, Gurdo and Jan ruwa.

The sampling was repeated for three seasons during the study period.

4. Methodology

Physical parameters temperature, total dissolved solids, conductivity, turbidity and suspended solids; chemical parameters. pH, total hardness, DO, BOD, Cl^-, NO_2^-, NO_3^-, COD, and PO_4^{3-} were analyzed using standard methods and procedures [20],[21]. Some of the parameters were determined in the field using pre-calibrated hand held equipment. pH was measured using 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 Wagtech turbidity meter Wag WT 3020 model. The other parameters were brought to the laboratory for immediate analysis [20]. 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 BOD after incubation in the dark for five days. Nitrite 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. Phosphate was measured using ascorbic acid molybdate spectrophotometric method [20].

5. Results and Discussion

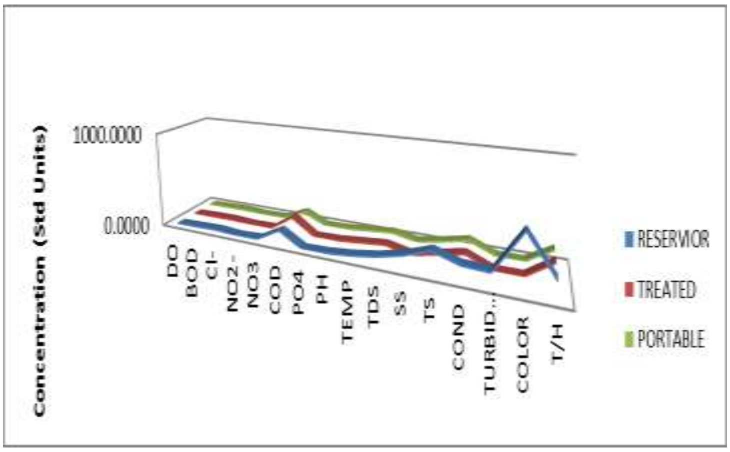

Fig. II: Mean values of Physical and Chemical Parameters for Cold Season (Std. Units)

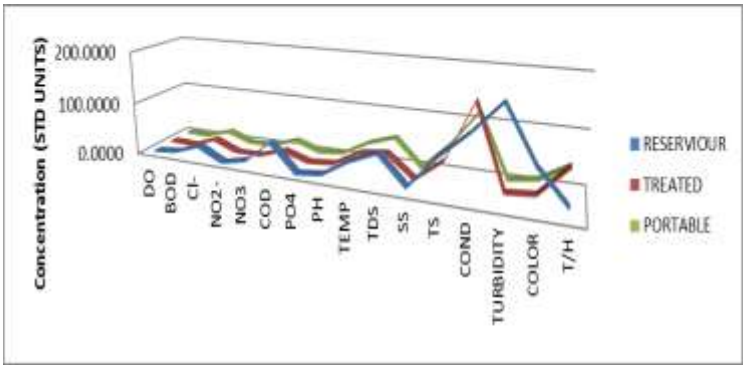

Fig. III: Mean Values of Physical and Chemical Parameters for Dry Season (Standard Units)

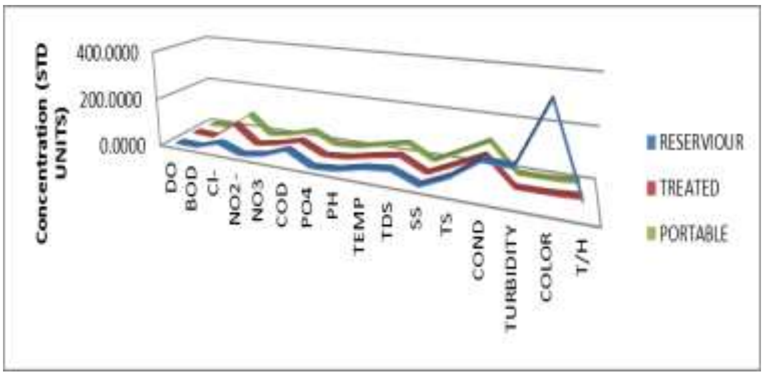

Fig. IV: Mean Values of Physical and Chemical Parameters for Rainy Season (Standard Units)

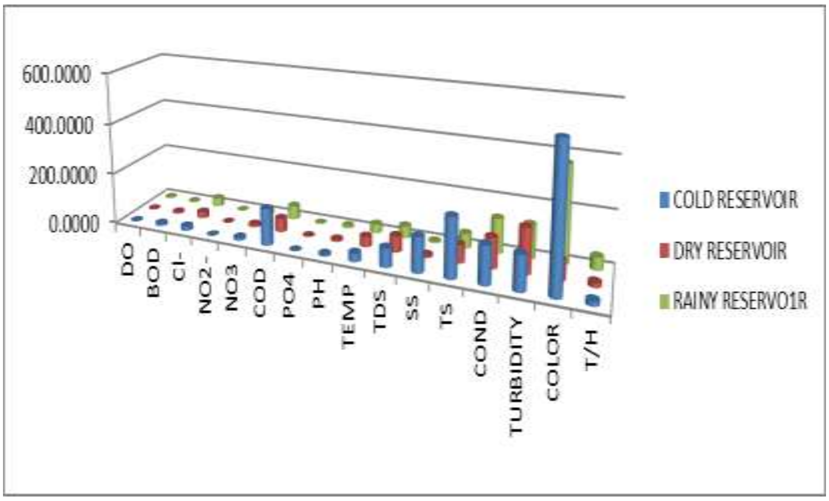

Fig. V: Mean Values of Seasonal variation of Physical and Chemical Parameters for Watari Reservoir (Std. Units)

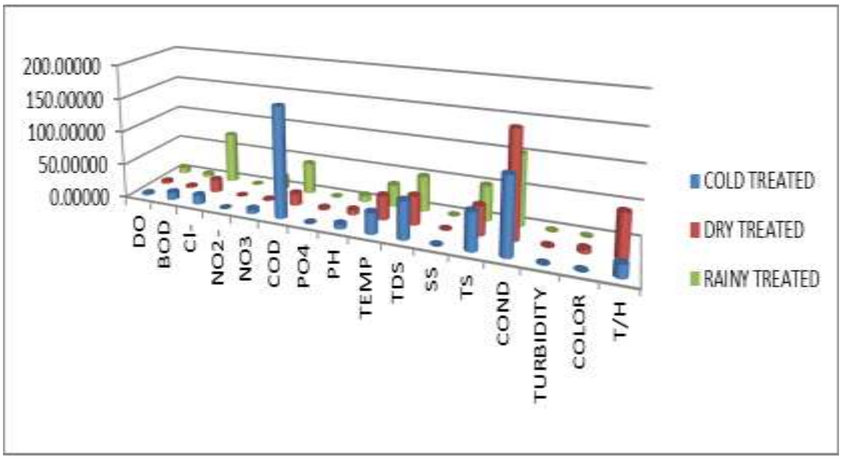

Fig. VI: Mean Values of Seasonal variations of Physical and Chemical Parameters for Watari Treated Water (Std. Units)

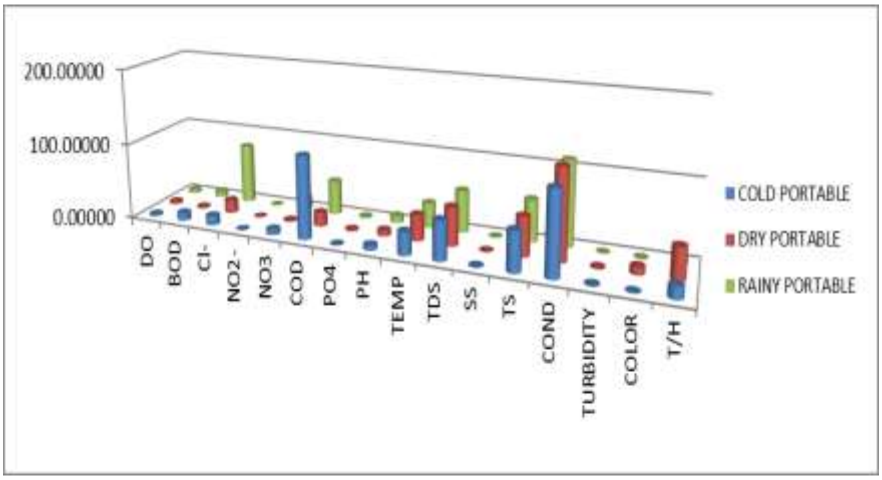

Fig. VII: Mean Values Seasonal variations of Physical and Chemical Parameters for Watari Potable Water (Std. Units)

6. Discussion

Physical and chemical parameters of Watari reservoir, treated and potable water were studied for three seasons of the year; cold season (Hamattan period), dry season and rainy season. The mean values of the results obtained for the three sampling sites, reservoir, treated water at the treatment plant and potable water at the consumer end indicate that there is significant variation ($P<0.05$) for most of the parameters. (Figures II to IV).

The mean pH values for cold season (Figure II) ranges from slightly acidic at treated and potable water to slightly alkaline at the reservoir. For dry season (Figure III), the pH values fall within the WHO ranges for drinking water quality (6.5 – 8.5). The pH values for rainy season have a mean value of 9.51 (Table II) which is above the WHO standard value for drinking water. This may be due to high water volume and leaching of soil by water run-off along the adjourning rivers. High pH values affect aquatic organisms by increasing solubility of toxic substances. Temperature have a mean range value between 32.0-38.9ºC which is lowest during the hamattan period and highest during dry season (Table II). There is however no significant variation at $P<0.05$ between the three seasons. Similar values were also reported by [22], on assessing pollutant levels in Mario Jose tannery effluents from Kano metropolis, Nigeria.

Total dissolved solids and conductivity have mean range values of 41.4 to 71.6 (mg/L) and 103.0 to 153.0 (μScm^{-1}) respectively for the three seasons (Table II). The values obtained for both TDS and conductivity were found to be higher in dry and cold seasons due to low volume of the reservoir water (Figure V). The values recorded are much lower than WHO and EPA values for surface water 500mg/L and 1000μScm^{-1} respectively. Conductivity indicates presence of dissolved ions in water. Water treatment process involves the use of flocculants to remove suspended and dissolved solids. Higher value for TDS is unpalatable and potentially unhealthy. The lower values for TDS and conductivity may be responsible for the soft nature of the water and excellent quality for drinking purpose. Similar values were reported by reference [1] when assessing water quality of Oyun reservoir Offa, Nigeria. TDS concentration at the range of 25-80mg/L represent moderate quality above which serve as potential impairment of water bodies [23].

The main physical problem that may be caused by suspended solids and turbidity in natural water bodies is that they cut down light transmission through the water and so lower the rate of photosynthesis in plants [21]. Values obtained for suspended solids (SS) were significantly reduced at the treated and potable water (Figures II - IV) this reflects the excellent treatment process at the newly constructed Watari treatment plant. It is also evident in the values recorded for turbidity and suspended solids (Table II) which is much lower at the treated and potable water. The WHO recommended values for turbidity in drinking water is 5NTU. Turbidity is the measure for cloudiness of water. It provides a medium for bacterial growth [24], hence a good treatment process must effectively reduce turbidity to the minimum [21]. ANOVA at $P<0.05$ shows the values of turbidity and SS to be significantly higher at the reservoir water.

Water containing hardness concentrations of up to 60mg/L (ppm) are referred to as "soft", those containing 120-180 mg/L (ppm) as "hard". Mean values obtained for total hardness ranges from 7.78 - 62.44mg/L. All the values are within the standard level. The dry season have higher values which may be as a result of high concentration of ions during the period (Table I). There is significant variation between the sampling sites at $P<0.05$ (Figures V to VII). The values obtained are similar to reports by [2] when analyzing water quality of Tolmande tank of Kolhapur district, Maharashtra.

Chloride does not cause health problems, but high chloride levels in drinking water may be a sign of other problems. For example, road salt can contaminate water supplies causing chloride levels to be high. High levels of chlorides in drinking water may also give water an unpleasant taste. The maximum level for chlorides in water is 250 mg/L [21]. The values obtained for chloride are within the range set by WHO [23] and NIS [25]. There is however no significant variation at $P<0.05$ between the reservoir, treated and potable water (Figure V to VII). The values obtained in rainy season were found to be much higher (Table I).

DO is vital to aquatic life, oxygen enters the water by diffusion from the atmosphere or through plant photosynthesis [21]. The dissolved oxygen level in water is constantly changing and represents a balance between respiration and decomposition that deplete oxygen and photosynthetic activity that increases it. The amount of DO ranges from 2.28 to 8.60 mg/L with the dry season having the lowest value and the higher value found in the rainy season (Table I) due to increased water volume and relatively lower temperature. DO level >2 supports aquatic life. The results obtained correspond to reports by other researchers [1]. There is no significant variation between dry and cold season at $P<0.05$ confidence level.

Biochemical Oxygen Demand (BOD) refers to the amount of oxygen that would be consumed if all the organics in one liter of water were oxidized by bacteria and protozoa. The range of possible readings can vary considerably: water from an exceptionally clear reservoir might show a BOD of less than 2 mg/L of water. Raw sewage may give readings in the hundreds and food processing wastes may be in the thousands. The mean values of BOD obtained ranges between 1.82 – 10.96 mg/L (Table I). The result is in agreement with other report by [3] when investigating some physical and chemical parameters in Lake Isykli, in Denizli Turkey.

Variation of Nitrate, Nitrite and phosphate in the reservoir reflect the effect of watershed and anthropogenic contamination around the reservoir. Mean values in the range of 1.09 to 18.60 for nitrate and 0.06 to 2.3 (mg/L) for phosphates, were obtained (Table I). ANOVA ($P<0.05$) shows the values for Nitrate to be significantly higher in rainy season for all the three sampling sites. (Figure V-VII). Significant reduction in nitrate concentration is noticed at treated and potable water when compared with reservoir water (Figure II-IV). Nitrate in elevated levels is linked with two known health problems: Methemoglobinemia or "blue baby syndrome" is caused by an oxygen deficiency in the blood. This causes bluish skin tone in infants [26]. In adults, nitrates can form chemicals called nitrosamines that have been linked to cancer. These may pose long-term health risks. Agricultural run-off of pesticides, plant and animal's wastes, phosphate fertilizers from nearby farms in addition to cow dungs washing from the watershed into the Reservoir is also a major contributing source of organic pollution to water bodies in Nigeria [8]. The maximum level for nitrate in water is 10.0 mg/L. However, when levels exceed 5 mg/L, the source of nitrate should be investigated [27]. The values obtained (Table I) is in agreement with the work by [10].

Color has a mean value that ranges from of 0.02 to 540.80 HAZEN. The large difference is as a result of values obtained at the treated and potable water which is very low compared to that obtained at the reservoir (Table II). The value at the reservoir exceeds the NIS maximum permissible limit of 15 HAZEN for drinking water [25]. Color in water is associated with absorption of certain wavelengths of normal white light by dissolved or colloidally dispersed substances. Similar results were obtained by [28]. There is significant variation at $P<0.05$ between the three seasons (Figure V-VII). In (Figure II-IV), the lower values obtained for color in the treated and potable water indicates treatment efficiency.

7. Conclusion

The overall quality assessment of Watari reservoir shows that most of the parameters are within the WHO and NIS recommended values for drinking water quality with few exceptions. The results obtained correspond to that recorded for tropical reservoirs by other researchers. The treated water was found to have excellent quality indicating efficiency of the treatment process. However, slight increase in the values of some parameters at the consumer end (potable water) may point to possible leakages along the supply lines and deserve attention of the authorities concerned.

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