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Assessment of some Physico-Chemical Parameters of Tagwai Reservoir in Minna, Niger State, Nigeria

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Abstract

This study on the assessment of physico-chemical parameters of Tagwai Dam in Minna, Niger State, Nigeria, was carried out from February 2016 to July 2016. Five sampling stations were randomly selected, namely; Tasabo (Station 1), Maigan-ga (Station 2), Lokoto (Station 3), Dutsen-kura (Station 4), and the dam site named Gmukpa (Station 5). The physico-chemical parameters were determined using standard methods, procedures, and instruments. The result revealed that; Water temperature (26.36±0.70-32.40±4.17°C), pH (6.53±0.20-7.91±0.11), Transparency (99.60±2.70-135.40±25.25), Conductivity (74.60±1.14-91.60±1.67µS/cm), Total Dissolved Solids (0.09±0.03-0.26±0.38mg/L), Nitrate-nitrogen (0.16±0.03-0.43±0.17mg/L), Total hardness (31.46±1.64-43.38±0.85mg/L$CaCO_3$), Dissolved Oxygen (5.76±2.10-13.60±3.85mg/L), Phosphate-phosphorus (6.53±0.20-0.30±0.15mg/L), and water depth (6.38±2.75-11.18±4.80m) varied with months and seasons. Analysis of variance showed significant difference between seasons ($P < 0.05$). Water quality of the dam is influenced by anthropogenic activities such as runoffs of inorganic fertilizers and pesticides. Dam water is suitable for irrigational and domestic purposes as indicated by most of the physico-chemical parameters analysed in this research. Hence, there is the need for effective anthropogenic inputs control programme in the dam.

Keywords:
Physico-chemical parameters,
Tagwai Reservoir,
Anthropogenic activities.

Introduction

Nigeria is blessed with about 853,600 hectares of freshwater capable of producing over 1.5 million metric tonnes of fish annually (FAO, 2009). There is the need to exploit means of using these precious resources even though there are some hindrances, which include effects of domestic and agricultural wastes on the water quality and aquatic life, physical and chemical factors like temperature, turbidity, pH, dissolved gases and carbondioxide, salts and nutrients. It is no doubt that dams have contributed to the economic growth of many nations with Nigeria inclusive.

Dams built in several parts of the world have played important role in helping communities to harness water resources for several uses. An estimated 30-40% of irrigated land worldwide now relies on reservoir water (Mustapha, 2011). In Nigeria, many researchers have conducted works on different water bodies, some of them include, Balogun *et al.* (2005) on some aspects of the limnology of Makwaye Lake in Ahmadu Bello University Farm, Samaru, Zaria; Balarabe (2001), on effect of limnological characteristic on zooplankton composition and distribution in Dumbi and Kwangila ponds, Zaria; Ibrahim *et al.* (2009) on an assessment of the physico-chemical parameters of Kontagora reservoir, Niger State; Hassan *et al.* (2010) on the algal diversity in relation to physico-chemical parameters of three ponds in Kano metropolis and Abubakar (2009) on the limnological studies for the assessment of Sabke Lake, Katsina State. This study however established physical, chemical, and biological parameters of Tagwai dam, and provided better understanding of the dam's ecosystem.

Materials and Methods

Study Area

Tagwai dam is located in Chanchaga Local Government Area in southwest zone of Minna. The dam is at the east of Tungan Goro about 10km southeast of mobile market and northeast of Paiko. It is an earthen dam constructed in 1978 by the Kano State Water Resources Engineering Construction Agency (NSWB, 1991). The dam lies on latitude 9° 34' N and longitude 6° 39' E. Fishing activities are carried out on the water body and also serves as a primary reservoir for the city of Minna under the supervision of Niger State Water Board (NSWB).

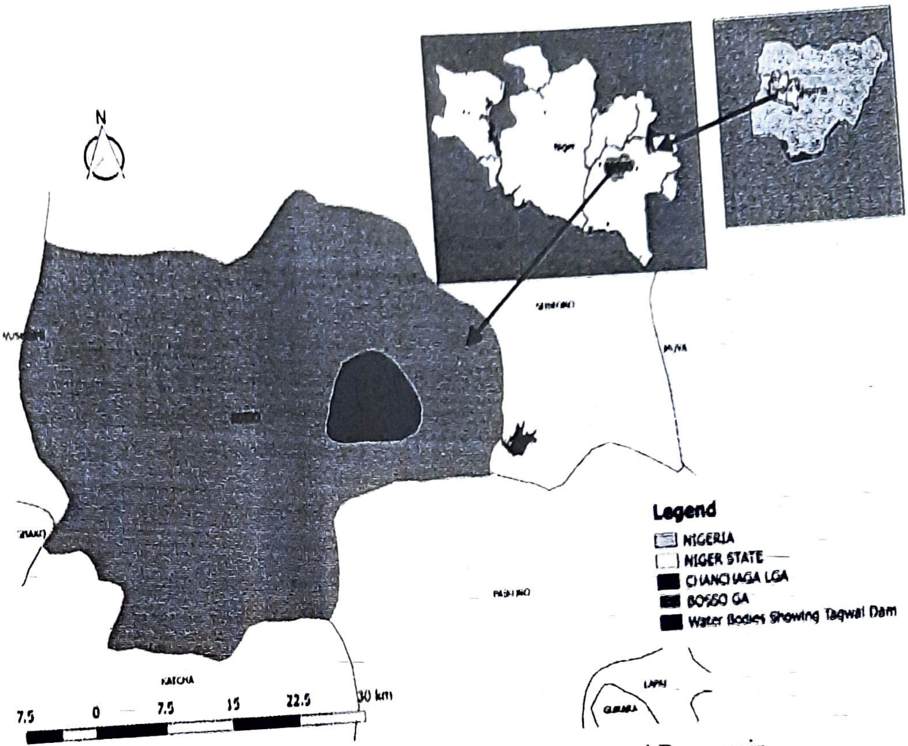

Figure 1: The geographical location of the study area showing Tagwai Reservoir

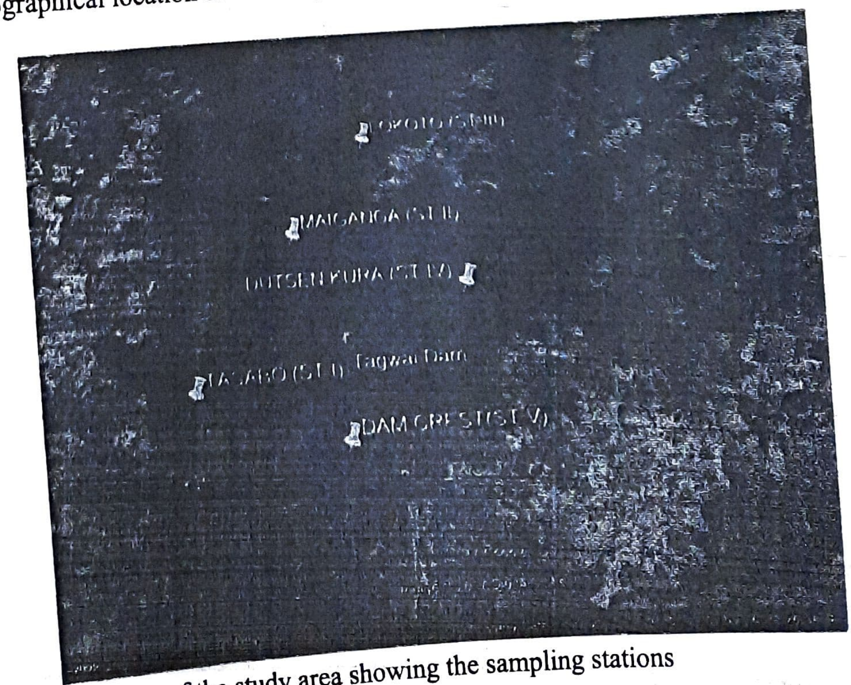

Figure 2: The google image of the study area showing the sampling stations

Water Sampling and Analysis

Water samples were collected from each station once every month for six months. 100ml dissolved oxygen bottle was used for dissolved oxygen and one litre plastic bottle was also used for the analysis of other water quality parameters which include; conductivity, alkalinity, pH, water temperature. The parameters were analysed at the Water Resources, Aquaculture and Fisheries Technology Laboratory of the Federal University of Technology, Minna. Dissolved oxygen was determined using the Winklers method. The pH of the water samples was determined using a B. Bran Scientific pH- meter (pHS-25). Conductivity was determined using the Jenway 4010 Conductivity Meter. Other methods used in water sampling, preservation and analysis were those prescribed by APHA (2005).

Water temperature (°C) was measured by dipping the echo sounder (Garmin Fish Finder 400C) into the water for about 1-2minutes so as to know the temperature alongside the depth at each station.

The turbidity of water was measured with turbidity tube. The tube was calibrated at the bottom with "X" mark in black colour. The water sample was measured in 200ml beaker and poured gradually into the turbidity tube, while at the same time observing the calibration mark at the bottom of the tube from the upper side of the tube until the calibrated line disappeared. The depth at which it disappeared was recorded in Nephelometric Turbidity Unit (NTU) from the graduated readings of the turbidity tube (Nathanson, 2003).

Statistical Analysis

The statistical analysis of the samples was carried out using the one way analysis of variance (ANOVA) to determine the variation of parameters within the months and stations. The Duncan multiple range test for the separation of mean was used to compare parameters between the months and stations.

Results

The physico-chemical parameters of the dam water (Table 1) revealed stations mean variation of Tagwai Dam, with respect to water temperature, dissolved oxygen, pH, alkalinity and conductivity. Table 2 shows the mean monthly variation of the parameters. The water temperature monthly variation ranged from $26.36{\pm}0.70^a$ to $30.32{\pm}0.81^{bc}$ °C; the pH values ranged between $6.53{\pm}0.20^a$ and $7.91{\pm}0.11^c$; transparency of the reservoir fluctuated with mean value of 99.60 ± 2.70^a to 135.40 ± 25.25^b. The dissolved oxygen values in the reservoir ranged from 5.76 ± 2.10^a to 13.60 ± 3.85^c. The electrical conductivity ranged from $74.60{\pm}1.14^a$ to $91.60{\pm}1.67^c$. The hardness of the dam water ranged from $36.92{\pm}1.21^b$ to $43.38{\pm}0.85^d$; Nitrate-nitrogen indicated the mean value ranged from $0.16{\pm}0.03^a$ – $0.43{\pm}0.17^d$ during the period of study. Total dissolved solids in the dam had the peak value of $0.26{\pm}0.38^a$ which was recorded in the month of July while the least value of $0.09{\pm}0.03^a$ was also recorded in the month of June; and the mean value of Phosphate-phosphorus ranged from $0.10{\pm}0.01^a$ – $0.19{\pm}0.05^a$. The mean value of depth ranged from $6.38{\pm}2.75^a$–$11.18{\pm}4.80^b$.

Table 1: Physico-chemical parameters of Tagwai Reservoir

Parameters	ST1	ST2	ST3	ST4	ST5
DO (mg/l-1)	$9.00{\pm}3.03^{bc}$	$10.40{\pm}4.57^c$	$5.33{\pm}1.54^a$	$9.33{\pm}3.72^{bc}$	$7.83{\pm}2.56^b$
Conductivity (µS/cm)	$86.67{\pm}6.25^a$	$87.17{\pm}7.08^a$	$88.67{\pm}6.95^b$	$87.67{\pm}6.38^{ab}$	$86.67{\pm}5.35^a$
TDS (mg/l)	$0.14{\pm}0.03^a$	$0.23{\pm}0.35^a$	$0.12{\pm}0.02^a$	$0.08{\pm}0.03^a$	$0.13{\pm}0.02^a$
Transparency (cm)	$117.33{\pm}28.75^a$	$110.50{\pm}12.19^a$	$109.00{\pm}13.18^a$	$106.00{\pm}2.00^a$	$109.83{\pm}9.17^a$
PH	$7.19{\pm}0.61^a$	$7.02{\pm}0.65^a$	$7.06{\pm}0.60^a$	$7.18{\pm}0.66^a$	$7.20{\pm}0.64^a$
Nitrate	$0.29{\pm}0.12^{ab}$	$0.21{\pm}0.05^a$	$0.30{\pm}0.09^b$	$0.34{\pm}0.16^b$	$0.32{\pm}0.13^b$
Phosphate	$0.19{\pm}0.16^a$	$0.15{\pm}0.07^a$	$0.18{\pm}0.11^a$	$0.13{\pm}0.03^a$	$0.17{\pm}0.06^a$
Total Alkalinity(mg/l)	$23.35{\pm}9.20^a$	$22.63{\pm}6.62^a$	$23.00{\pm}7.46^a$	$23.92{\pm}9.90^a$	$23.00{\pm}5.45^a$
Total hardness(mg/l)	$38.63{\pm}3.30^a$	$38.63{\pm}4.70^a$	$37.63{\pm}4.90^a$	$36.88{\pm}4.47^a$	$38.03{\pm}4.29^a$
Temperature (°C)	$29.90{\pm}3.52^a$	$28.90{\pm}5.54^a$	$29.07{\pm}2.18^a$	$27.05{\pm}2.07^a$	$28.02{\pm}2.05^a$
Depth (m)	$5.33{\pm}1.20^a$	$4.35{\pm}0.91^a$	$13.11{\pm}3.39^d$	$7.52{\pm}2.55^b$	$10.33{\pm}2.98^c$

Table 2: Monthly variation of water physico-chemical parameters of Tagwai Reservoir

Parameters	February	March	April	May	June	July
DO(mg/l-1)	8.60±1.95[b]	7.60±1.82[ab]	5.76±2.10[a]	8.80±3.03[b]	13.60±3.85[c]	5.92±1.34[a]
Conductivity(µS/cm)	91.60±1.67[c]	90.80±1.48[de]	89.20±0.84[bc]	89.80±1.30[cd]	88.20±0.84[b]	74.60±1.14[a]
TDS (mg/l)	0.15±0.04[a]	0.13±0.03[a]	0.11±0.03[a]	0.10±0.03[a]	0.09±0.03[a]	0.26±0.38[a]
Transparency(cm)	135.40±25.25[b]	108.40±2.30a	108.00±1.41[a]	107.40±0.55[a]	104.40±1.82[a]	99.60±2.70[a]
PH	7.04±0.30[b]	7.76±0.47[c]	7.91±0.11[c]	6.53±0.20[a]	6.99±0.47[b]	6.55±0.06[a]
Nitrate	0.21±0.02[ab]	0.43±0.17[d]	0.35±0.09[cd]	0.32±0.03[c]	0.29±0.03[bc]	0.16±0.03[a]
Phosphate	0.10±0.03[a]	0.10±0.01[a]	0.19±0.05[a]	0.14±0.03[a]	0.15±0.03[a]	0.30±0.15[b]
T. Alkalinity(mg/l)	21.62±0.42[b]	18.86±0.94[a]	19.26±0.48[ab]	20.64±0.21[ab]	19.90±0.60[ab]	38.80±4.15[c]
T. Hardness(mg/l)	41.00±1.95[c]	31.46±1.64[a]	43.38±0.85[d]	36.92±1.21[b]	37.82±1.21[b]	37.20±2.70[b]
Temperature(°C)	27.40±1.53[ab]	26.36±0.70[a]	28.60±4.55[ab]	30.32±0.81[bc]	32.40±4.17[c]	26.44±0.55[a]
Depth(m)	6.38±2.75[a]	6.46±2.82[a]	6.38±2.75[a]	7.92±3.52[a]	10.44±5.16[b]	11.18±4.80[b]

Discussion

The water temperature of the reservoir fluctuated within months, which was between 26.36°C and 32.40°C. The low water temperature recorded in the reservoir was in the dry season, which could be as a result of seasonal changes in air temperatures associated with the cool dry North-East winds. This is in line with the findings of Indabawa (2009) which reported variations in water temperature in the dry season and can be attributed to intensified heat radiation and effect of harmattan. In the water temperature, no significant difference ($p>0.05$) was observed between the months, which was similar with the observation of Tisser *et al.* (2008), who reported the lack of significant difference ($p>0.05$) in monthly variations of water temperature as characteristic of the tropical climate. Temperature influences the oxygen content of water, quantity and quality of autotrophs, while affecting the rate of photosynthesis as well as the quality and quantity of heterotrophs. The water pH in the dam was within 6.53 to 7.76, which makes the water of the dam to be cecum-neutral during the study. This was similar to the results of Ibrahim *et al.* (2009) that hydrogen ion concentration (pH) was nearly neutral throughout both seasons, and it was within the range for inland water (pH 6.5 - 8.5) in Kontagora Reservoir, Niger State, Nigeria; which makes it suitable for optimal biological activity. The little increase in pH during the dry season was due to decaying and decomposition of living organisms in the water coupled with the reduction in the water level during the dry season.

The little decrease in pH during the rainy season might be due to the effect of incoming rainwater. According to Janjua *et al.*, (2009) the drop in pH can also be due to the stirring effect of the incoming flood from the rivers and streams that converged towards the lake. It results in the mixing of the poorly alkaline or acidic bottom water with alkaline surface water to reduce pH as evidenced in Shahpur Dam, Pakistan. The transparency of the reservoir was high during the dry season; the higher values of transparency in the dry season may be due to the settling effect of surface run-offs and suspended materials that followed the cessation of rainfall. Ayoade *et al.* (2006), observed the onset of rain decreased the Secchi-disc visibility in two mine lakes around Jos. This supports the observation of Mustapha (2008) that the transparency of water is affected by the amount of the suspended solids in it, and it reduces the light penetrating depth, and hence, reduces the growth of the plants. Dissolved oxygen in the dam indicates two peaks, high in the wet season and low in the dry season. Dissolved oxygen supply in water mainly comes from atmospheric diffusion and photosynthetic activity of plants (Akomeah, *et al.* 2010). The drop of oxygen values from February to April may be due to low temperature in the reservoir. Oxygen plays the most important role in determining the potential biological quality of water.

The highest value was recorded in the dry season while the lowest was recorded in the wet season. The values may be due to chemical fertilizers from irrigated farmlands around the dam coupled with higher rate of evaporation that reduced the level of the water during the dry season. Thus conductivity of water depends upon the concentration of ions and its nutrients status.

Table 2: Monthly variation of water physico-chemical parameters of Tagwai Reservoir

Parameters	February	March	April	May	June	July
DO(mg l-1)	8.60 ± 1.95^{b}	7.60 ± 1.82^{ab}	5.76 ± 2.10^{a}	8.80 ± 3.03^{b}	13.60 ± 3.85^{c}	5.92 ± 1.34^{a}
Conductivity(µS/cm)	91.60 ± 1.67^{e}	90.80 ± 1.48^{de}	89.20 ± 0.84^{bc}	89.80 ± 1.30^{cd}	88.20 ± 0.84^{b}	74.60 ± 1.14^{a}
TDS (mg/l)	0.15 ± 0.04^{a}	0.13 ± 0.03^{a}	0.11 ± 0.03^{a}	0.10 ± 0.03^{a}	0.09 ± 0.03^{a}	0.26 ± 0.38^{a}
Transparency(cm)	135.40 ± 25.25^{b}	108.40±2.30a	108.00 ± 1.41^{a}	107.40 ± 0.55^{a}	104.40 ± 1.82^{a}	99.60 ± 2.70^{a}
PH	7.04 ± 0.30^{b}	7.76 ± 0.47^{c}	7.91 ± 0.11^{c}	6.53 ± 0.20^{a}	6.99 ± 0.47^{b}	6.55 ± 0.06^{a}
Nitrate	0.21 ± 0.02^{ab}	0.43 ± 0.17^{d}	0.35 ± 0.09^{cd}	0.32 ± 0.03^{c}	0.29 ± 0.03^{bc}	0.16 ± 0.03^{a}
Phosphate	0.10 ± 0.03^{a}	0.10 ± 0.01^{a}	0.19 ± 0.05^{a}	0.14 ± 0.03^{a}	0.15 ± 0.03^{a}	0.30 ± 0.15^{b}
T. Alkalinity(mg/l)	21.62 ± 0.42^{b}	18.86 ± 0.94^{a}	19.26 ± 0.48^{ab}	20.64 ± 0.21^{ab}	19.90 ± 0.60^{ab}	38.80 ± 4.15^{c}
T. Hardness(mg/l)	41.00 ± 1.95^{c}	31.46 ± 1.64^{a}	43.38 ± 0.85^{d}	36.92 ± 1.21^{b}	37.82 ± 1.21^{b}	37.20 ± 2.70^{b}
Temperature(°C)	27.40 ± 1.53^{ab}	26.36 ± 0.70^{a}	28.60 ± 4.55^{ab}	30.32 ± 0.81^{bc}	32.40 ± 4.17^{c}	26.44 ± 0.55^{a}
Depth(m)	6.38 ± 2.75^{a}	6.46 ± 2.82^{a}	6.38 ± 2.75^{a}	7.92 ± 3.52^{a}	10.44 ± 5.16^{b}	11.18 ± 4.80^{b}

Discussion

The water temperature of the reservoir fluctuated within months, which was between 26.36°C and 32.40°C. The low water temperature recorded in the reservoir was in the dry season, which could be as a result of seasonal changes in air temperatures associated with the cool dry North-East winds. This is in line with the findings of Indabawa (2009) which reported variations in water temperature in the dry season and can be attributed to intensified heat radiation and effect of harmattan. In the water temperature, no significant difference ($p>0.05$) was observed between the months, which was similar with the observation of Tisser *et al.* (2008), who reported the lack of significant difference ($p>0.05$) in monthly variations of water temperature as characteristic of the tropical climate. Temperature influences the oxygen content of water, quantity and quality of autotrophs, while affecting the rate of photosynthesis as well as the quality and quantity of heterotrophs. The water pH in the dam was within 6.53 to 7.76, which makes the water of the dam to be cecum-neutral during the study. This was similar to the results of Ibrahim *et al.* (2009) that hydrogen ion concentration (pH) was nearly neutral throughout both seasons, and it was within the range for inland water (pH 6.5 - 8.5) in Kontagora Reservoir, Niger State, Nigeria, which makes it suitable for optimal biological activity. The little increase in pH during the dry season was due to decaying and decomposition of living organisms in the water coupled with the reduction in the water level during the dry season.

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The highest value was recorded in the dry season while the lowest was recorded in the wet season. The values may be due to chemical fertilizers from irrigated farmlands around the dam coupled with higher rate of evaporation that reduced the level of the water during the dry season. Thus conductivity of water depends upon the concentration of ions and its nutrients status.

Water hardness was higher in the month of April and lower in the month of March and could be as a result of water levels and the concentration of nutrients. The lack of significant difference($p>0.05$) between stations and seasons could be because of water low levels and concentration of carbonates. This result is in contrast with the findings of Balogun *et al.* (2005) who observed that water hardness was highly significant($p<0.05$) between stations and within the months in Makwaye Lake, Zaria. Nitrate-nitrogen was found to exhibit monthly variation range of 0.43mgL-1 to 0.16mgL-1. The mean value recorded was higher in May than in June. The reason for this high concentration in rainy season may be due to excessive influx of nutrients from farmlands where fertilizer is used to boost crop production particularly around the reservoir, as well as input through runoff into the reservoir.

The findings of this study tally with that of Balogun *et al.* (2005) who observed mean monthly variation and significant difference ($p<0.05$) between seasons in Makwaye. The reservoir has higher value of TDS during the dry season; this could be due to decaying of vegetation, higher rate of evaporation caused by increase in air temperature and wind during the dry season. Similar observation was made by Atobatele and Ugwumba (2008) who reported increase in the values of total dissolved solids during the dry season which may be due to most of the vegetation decaying, so giving rise to amount of dissolved solids. However, during the rainy season, the amount of total solids was low, and this may be due to the dilution of water. The values of phosphate-phosphorus in the dam during the dry season may be due to reduced water volume, intensive agricultural activities around the Reservoir as well as the use of fertilizers and pesticides to produce dry season crops like vegetables and maize. Farmers were also using the water from the dam for domestic activities including washing of clothes with detergents, which increased the phosphate-phosphorus level of the water. The result of phosphate-phosphorus variation within seasons also conform with the result of Balogun *et al.* (2005), who observed high significant phosphate-phosphorous variation within months and no significant variation between the sampling stations in Makwaye Lake Zaria.The water depth of the dam fluctuated within seasons; the water depth increased during the rainy season, while it decreased in the dry season. The decrease in water depth especially during the dry season was caused by high evapo-transpiration during the dry season. Ibrahim *et al.* (2009), made similar observation of water depth fluctuation within seasons in Kwantagora Reservoir. As the depth of the reservoir increased, the dissolved oxygen decreased. Araoye (2008) reported that the depth of the reservoir decreased light intensity, the light penetration depends on the available intensity of the incident light, which varies with geographical location of the reservoir.

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