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Limnological Studies of Water Column Properties of Kuntbhoyag Lake, Mandi District Himachal Pradesh India

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ABSTRACT

Lakes play important role in the biochemical and hydrological cycle. The water in lakes is the valuable source for hydropower, domestic, industrial purpose, drinking water and irrigation etc. The water column quality properties are monitored during December 2020. To find out the suitable water column properties in different locations is an intricate task. The potential of water column properties from different locations to achieve maximum desirability for different properties of water with the help of the desirability function has been reported in this article. However, the level of water quality parameters was found to be more than criteria level in all the intake points. This is due to contaminated surface rain runoff enter into the lake.

Key words : *Lake Kuntbhayog, Mandi District. Rewalsar, Water Column, Anova, Depth.*

Introduction

Reservoir and lake ecosystems are vital for aquatic biodiversity, human needs, and wildlife. Increased emissions in the atmosphere, the nature of the environment, the functioning and stability of the environment have all begun to affect reservoirs and lake ecosystems around the world, with even more impacts anticipated in the future. These changes may be caused by climate fluctuations (precipitation, evapotranspiration, and other meteorological components) or changes in the catchment area's runoff characteristics. According to McIntyre (1995), Human cultures produce enormous amounts of waste, up to 40 kilogrammes per person per day in developed nations. The sewage fluid is rich in nutrients, but the sludge has a high BOD content. This wastewater pollutes lakes, wetlands, rivers, streams, and other bodies of water. Several other researchers have proposed methods for retrieving the water column's properties. Lakes are categorised as freshwater, brackish, or salinebased on the salinity level of the water. These lakes are also classified as Oligotrophic (low nutrients), Mesotrophic (medium nutrients), and Eutrophic (high nutrients) based on their nutrient content. Since they receive nutrients from their catchments, the vast majority of Indian lakes are either Eutrophic or Mesotrophic. According to the literature, a number of studies on water quality assessment of water bodies such as Halai, Koloroi, Kalyani, Salim Ali, Dahi-Khura, Ramgarh, Kalakho, and Dalvoy Lake have been conducted in India (Jain *et al.*, 1996; Moundiotiya, Sisodia *et al.* 2004; Sisodia and Moundiotiya, 2006).

Depth modelling improves depth and water quality estimations, particularly in shallow water, according to the findings. Since depth differences are minimal in comparison to the depth mean value,

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it is fair to assume that the bottom is locally flat in deep water. The measured bathymetry was correct for depths up to 14 m when the water quality was taken into account. For the entire depth range, the calculated concentration maps were consistent. Estimated bathymetry had a spatial resolution of 50 cm in shallow water (for depths up to 10 m) and 2.5 m to 5 m in deep water (for depths between 10 m and 14 m). Bio-optical modellings effect is also illustrated. Many researchers have focused on the topwater surface and used laboratories to calculate various parameters. More precise instruments were used in this analysis to determine the onsite column property of Kuntbhyog lake water at various depths, i.e., top surface zero metre, 2 metres, 4 metres, and 6 metres at a different location.

Materials and Methods

Kuntbhayog Lake is a holy lake in Himachal Pradesh's Mandi District, near Rewalsar, in the village panchayats Sarkidhar. The Kuntbhayog lake is surrounded on one side by hills, with forest and farmland on one side and residential areas on the other. From Rewalsar to Naina Devi Temple, the road passes through agricultural and residential areas. The lake is 1,750 metres above sea level, with hills on three sides (76°49′6″ E, 31°37′ N). The lake is 12 to 15 metres deep at its deepest point.

Analytical Methods

A Horiba multiparameter water quality instrument with an 8-meter flexible cable was used to investigate water column samples onsite.

Temperature, pH, Salinity, Conductivity, Turbidity, Total Dissolved Solids (TDS), Oxidation-Reduction Potential (ORP), and Dissolved Oxygen are the variables to remember (DO). The properties of the onsite water column were investigated at various depths and locations. The Hanuman temple side of the lake is where Site H1, H2 and H3 are situated, and this side has agricultural and residential areas. From this side, the majority of the contaminated water enters the lake. Side F4, F5 and F6 are situated towards the forest catchment side as shown in Fig. 1. Side C7 to C10 is located in the middle of the Lake or the centre of the lake and thus have the greatest depth. The lake has 12 to 15 m depth at monsoon season. The lake water seeps and comes out at the downstream side. This water is collected by the irrigation and public health department (IPH) Rewalsar for public water supply. The water column property of lake water analysed in the month of December 2020. In the month of December, the lake water is stable.

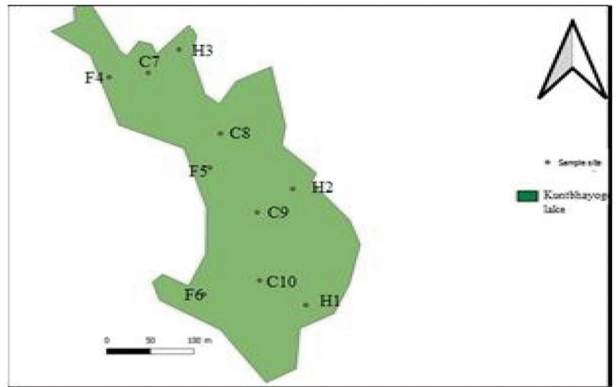

Fig. 1. Kuntbhayog Lake map showing the location of water column sites

Results and Discussion

pH

The pH level of water shows how acidic or alkaline it is. Figure 2 illustrates the effect of various sites and water column depths on pH. It has been discovered that as we travel deeper into the lake, the pH value decreases, indicating that the water becomes less alkaline. According to Stumm and Morgan (2007), the rise in pH at depth may be attributable to organic matter reparation at the bottom, which consumes DO. In Table 1, ANOVA was used to determine the effect of various locations and water column depths, as well as their interactions, on water pH. The results of the ANOVA table show that the different locations and water column depth has a major impact. The result shown in the ANOVA Table 1 indicates that there is a significant effect of different location and water column depth (0, 2 and 4m) on pH (Figure 2).

Electrical Conductivity

The potential of water to carry electrical current is measured by its electrical conductivity. The concentrations of ions in water decide the capability. The conductivity of the water is increased by adding different electrolytes to the lake, such as carbonates, calcium, sodium, and magnesium. Figure 3 describes the effect of location and depth on the electrical conductivity of water. From Figure 3 it is observed that at higher depth there is less value of

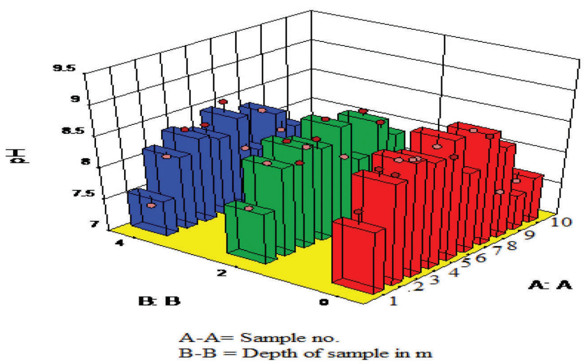

Fig. 2. Effect of location and water column depth on pH

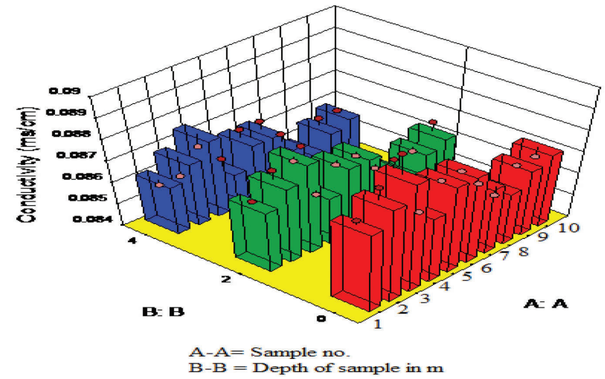

Fig. 3. Effect of location and water column depth on Electrical Conductivity

electrical conductivity of water in comparison to value at the surface. There is a significant effect of different location and water column depth (0, 2 and 4m) on electrical conductivity as shown in Table 2.

Dissolved oxygen (DO)

Dissolved oxygen (DO) is essential to the health of aquatic organisms; without it, these organisms cannot survive in the water. Fish require at least 3-5 mg/l of DO to survive. DO enters the water through atmospheric diffusion and as a byproduct of photosynthesis by plants and algae. The concentration of DO in the water body regulates the distribution of flora and fauna. There is a lesser value of DO at the bottom in comparison to the top surface of the water. It may be due to organic matter reparation at the bottom which ultimately consumes DO. The result described in ANOVA Table 3 indicates that there is a significant effect of different location and water

Table 1. ANOVA for pH

Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	6.79	11	0.62	32.74	< 0.0001	Significant
A-A	5.92	9	0.66	34.89	< 0.0001	
B-B	0.87	2	0.44	23.08	< 0.0001	
Residual	0.34	18	0.019			
Std. Dev.	0.14	R-Squared	0.9524			

Table 2. ANOVA for Electrical Conductivity

Source	Sum of Squares	df	Mean Square	F p-value Value		
Model	2.810E-005	11	2.555E-006	10.00	<0.0001	significant
A-A	1.670E-005	9	1.856E-006	7.26	0.0002	
B-B	1.140E-005	2	5.700E-006	22.30	<0.0001	
Std. Dev.	5.055E-004	RSquared	0.8593			

Table 3. ANOVA for DO

Analysis of variance table [Classical sum of squares - Type II]						
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	29.51	11	2.68	8.90	< 0.0001	significant
A-A	26.16	9	2.91	9.64	< 0.0001	
B-B	3.35	2	1.68	5.56	0.0132	
Std. Dev.	0.55	R-Squared	0.8447			

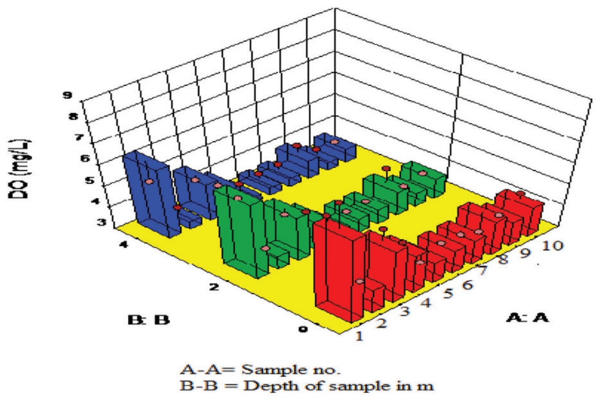

Fig. 4. Effect of location and water column depth on DO

column depth (0, 2 and 4m) on DO.

Oxidation-Reduction Potential (ORP)

The oxidation-reduction potential (ORP) of a lake measures its ability to clean its own water or decompose waste products in it, such as contaminants, dead plants and animals. A higher ORP value indicates that the water contains a lot of oxygen, which aids bacteria in decomposing dead tissue and contaminants. In general, a lake is considered healthier if its ORP value is higher. ORP also provides scientists with additional information about water quality and pollution levels. A lake with a lower ORP value increases the toxicity of certain metals and contaminants, resulting in an increase in dead and decaying material in the water that cannot be easily

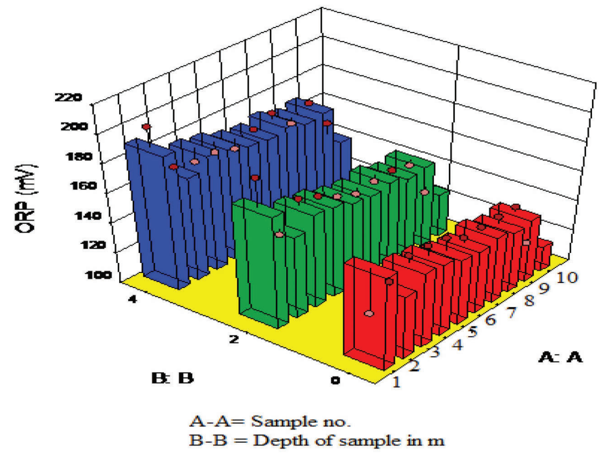

Fig. 5. Effect of location and water column depth on ORP

cleared or decomposed. The result shown in the ANOVA Table 4 indicates that there is a significant effect of different location and water column depth (0, 2 and 4m) on pH as shown in Fig. 5.

Total dissolved solids (TDS)

Total dissolved solids represent the amount of dissolved substance in water, such as organic salts like calcium, sodium, potassium magnesium, cation and carbonates, hydrogen carbonate, chloride, sulphate and nitrate anion. TDS level for drinking water probably is less than 300 mg/l, it is excellent, between 300 -600 mg/l is good, between 600-900 mg/l is fair, between 900-1200 mg/l poor and greater

Table 4. ANOVA for ORP

Analysis of variance table [Classical sum of squares - Type II]						
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	7504.33	11	682.21	5.72	0.0006	Significant
A-A	3660.53	9	406.73	3.41	0.0128	
B-B	3843.80	2	1921.90	16.11	< 0.0001	
Std. Dev.	10.92	RSquared	0.7776			

Table 5. ANOVA for TDS

Analysis of variance table [Classical sum of squares - Type II]						
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob > F	
Model	51.00	11	4.64	17.15	< 0.0001	Significant
A-A	24.53	9	2.73	10.08	< 0.0001	
B-B	26.47	2	13.23	48.95	< 0.0001	
Std. Dev.	0.52	R-Squared	0.9129			

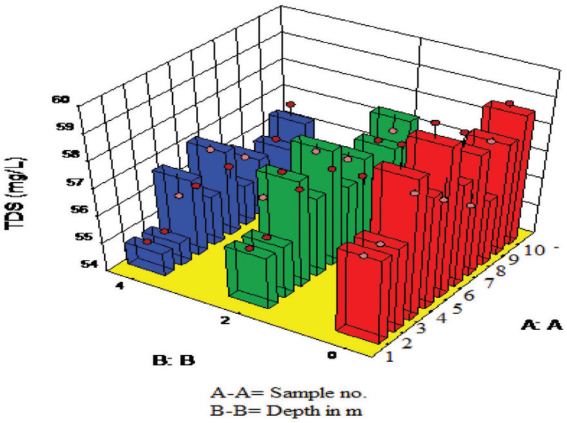

Fig. 6. Effect of location and water column depth on TDS

than 1200 mg/L is unacceptable. The result is shown in ANOVA Table 5 at the depth of (0, 2 and 4m) are within the permissible limit, which is excellent. The result shown in the ANOVA Table 5 indicates that there is a significant effect of different location and water column depth (0, 2 and 4m) on TDS as shown in Figure 6.

Turbidity

Water clarity is indicated by turbidity. The main reason for turbidity is suspended particles, such as algae and dirt. This particle block sunlight and reduce the clarity of the water. These particles make it difficult to breathe the gills of the organism. When the particle settles down, the bottom of the lake is covered with a layer of silt, which can also affect the fish egg and macroinvertebrates. It is a water optical property that is measured by the amount of light dispersed by the material in the water. Turbidity is proportional to the intensity of dispersed light, so the higher the intensity of dispersed light, the higher the turbidity value. The result shown in the ANOVA Table 6 indicates that there is a significant effect of different location and water column depth (0, 2 and 4 m) on turbidity as shown in Figure 7.

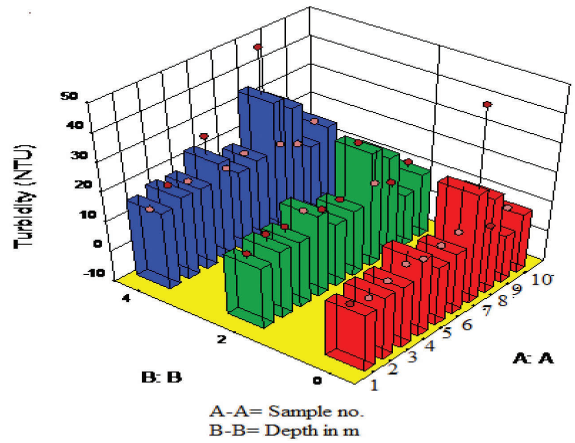

Fig. 7. Effect of location and water column depth on Turbidity

Multi-response optimization was used to solve the problem of contradicting responses of single response optimization. In multiresponse optimization, all responses are assigned with desired weight (in this study equal weightage to all desired attributes), and desirability is calculated for different input parameter values based on the collective influence of all responses. The criteria for maximizing water quality are adjusted according to costumer preferences. Table 7 shows, a variety of input parameter and responses, as well as the target and weight assigned to each parameter of water Figures 8 show

Table 7. Response Optimization of lake water

Name	Goal	Lower limit	Upper limit	Importance
Sample no.	In range	1	10	3
Depth	In range	0	4	3
pH	Minimize	7.2	8.76	3
TDS	Minimize	54	60	3
Turbidity	Minimize	7	50	3
Conductivity	Minimize	0.085	0.09	3
DO	Maximise	3.51	8.35	3
ORP	Maximise	114	205	3

Table 6. ANOVA for turbidity

Analysis of variance table [Classical sum of squares - Type II]						
Source	Sum of Squares	df	Mean Square	F Value	p-value Prob >F	
Model	1452.10	11	132.01	1.41	0.2497	not significant
A-A	1174.70	9	130.52	1.39	0.2613	
B-B	277.40	2	138.70	1.48	0.2536	
Std. Dev.	9.67	RSquared	0.4629			

the impact of different quality parameters of water (equal weightage are assigned for all six responses). The appropriate criteria to maximize the overall desirability involve the following water quality specifications, as indicated in Figure 8. Optimization results indicates that best quality of water is obtained toward the Hanuman Temple side and at 4m depth.

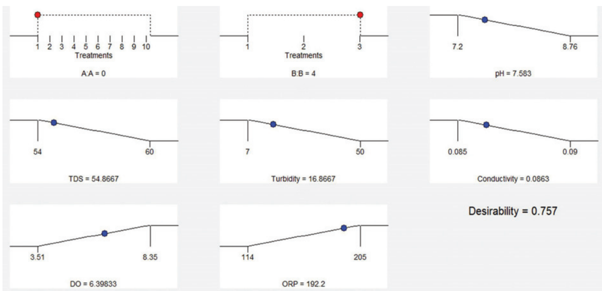

Fig. 8. Impact of different quality parameters of water (equal weightage are assigned for all six responses).

Over all desirability for quality of water is illustrated in Figure 8. Harrington's rating system was used to interpreting the desirability values. The quality of water parameters as a composite desirability of 0.757. This borderline specifies that the quality is acceptable to the specification according to Harrington standards. According to Harrington slandered, individual desirability of TDS and ORP are acceptable and provides excellent quality (equal to 0.855 and 0.859, respectively). The individual desirability of DO is acceptable but needs improvement (respectively equal to 0.596).

Conclusion

The effect of various water quality parameters on water column depth (0, 2, 4 m) is investigated in this paper. In general, water quality deteriorates in areas where there is less depth of water and water from the outer side flows into the lake. The optimum desirability for using water is found at H1 at a depth of 4 m, according to optimization techniques. Using multi-response optimization, it was also optimising the percentage of different water quality parameters

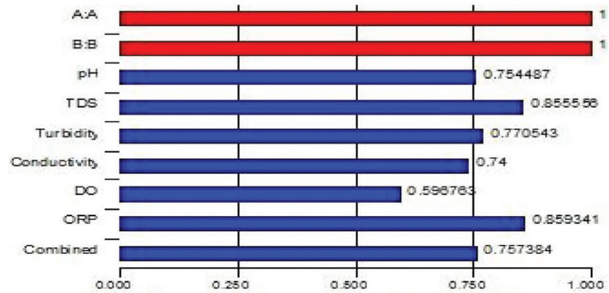

Fig. 9. Over all desirability for different test parameter

for various places and heights in order to achieve maximum desirability for water uses. Using a multi-response optimization technique, the problem of conflicting responses in single-response optimization can be resolved. In multi-response optimization, all responses are having been given equal weightage, and overall desirability is assessed for a variety of parameters at different locations.

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