

Physico-Chemical Characteristics Study in the Bhimtal Lake of Bhimtal (Uttarakhand)

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Abstract: Bhimtal Lake is one of the important lake of Nainital regions in Uttarakhand state. Physico-Chemical Characteristics Study in the Bhimtal Lake has been studied.. Chemical examination of the water samples collected from the sampling stations of Bhimtal lake were done for the tests like Total Solids (TS), pH of water, acidity of water, alkalinity of water, hardness of water, sulfate in water, Chlorides in water, Fluorides in water, Dissolved Oxygen in water, biochemical Oxygen Demand in water, chemical oxygen demand in water, total organic carbon / organic matter in water, nitrogen in water, nitrogen, ammonia, Nitrogen, nitrate, nitrogen, nitrite, nitrogen, organic and Metals in water. The study indicates that Bhimtal Lake is becoming a eutrophic lake. The data have been reported in the study or present paper

Key Words: Bhimtal Lake, Pollutant, Sites, Sampling, Water analysis.

I. Introduction

Water is perhaps the most important natural resource required by all the living organisms. No life can be imagined without water. Be it the moon or mars, space scientists search for the existence/availability of water on the satellites or the planets to explore the possibility of any life as the first and foremost requirement. It is believed that everything originated in and everything is sustained by water (Gupta, P.K.; 2002). Water has been presumed to be one of the five major constituents of human body viz. **earth, water, fire, sky and air.**

A human being may have lost as much as 40% of his body weight including half of the protein or nearly all glycogen during starvation and yet without any serious danger. But if 10% of water of the human body is lost, serious disorder result. At 20% loss of water from the human body, death is almost sure.

Sources of water:

Following are the main sources of water:-

- (i) Atmospheric water
 - (ii) Surface water
 - (iii) Stored water
 - (iv) Ground water
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- (i) **Atmospheric water:** Rain water and water formed by the melting of snow are called the sources of water from atmosphere. During the rains and/or snow falls the dust, soot and other suspended particles are brought to the earth. The air-borne bacterias also reach the earth during rains and/or snow falls.
 - (ii) **Surface water:** Water made available to the earth as a result of rain or snow-fall is absorbed by the soil. Such water which is absorbed by the soil may become contaminated and may be taken away from the hills or from the river banks.
 - (iii) **Stored water:** Water stored in oceans, lakes ponds or reservoirs is called stored water. This stored water is one of the most important sources of water.
 - (iv) **Ground water:** When rain water falls on the dry soil it wets the soil. If the rain fall continues even after the soil surface is saturated with water, gravity pulls down excess of water, from the soil surface through the spaces in rock, sand or gravel below. The larger the underground space, the faster the water flows down. The down-ward flow of water stops when the water flowing downwards meets rocks which have no porosity. Since the water cannot move in further, it blocks up, filling all the pores in the rock above the barrier. This causes saturation of water in the soil and zone is called the saturation zone. The upper boundary of the saturation zone is called the **water table** of the Ground water.

Lakes: Main sources of water in Kumaon Region.

Besides forming as aesthetic beauty of the region lakes contribute about one percent of the total water reserve of the world. This one percent of the water reserve is an important source of drinking, irrigation, recreation or other development activities for a major population of the world. In a developing country like India the inhabitants residing around the lakes entirely depend on the lake water for their daily needs.

In the Chhakata region of Kumaon, central Himalaya, there were about sixty lakes in the past (**Jalal, D.S.; 1988**), but most of these lakes have now vanished due to various reasons. **Nainital, Bhimtal, Naukuchiatal, Sattal, Khurpatal and Nal Damyantital** are some of the lakes, which still have enough water in them. Except Nal Damyantital near which the dead bodies are cremated, almost all these lakes are the only sources of water for about one lakh floating and one lakh permanent population residing around these lakes.

Potable water:

Drinkable water rich in minerals good for human health is known as Portable water. World Health Organization (WHO) has laid down international standards for drinking water. In India, agencies like the Indian Council of Medical Research (ICMR), Bureau of India Standards and the Ministry of Health & Family Welfare provide the drinking water standards to be followed by the authorities of **Jal Sansthan** or **Jal Nigam**, directly responsible/accountable for maintaining water quality in our country. But still we are far behind the WHO standards in maintaining the water quality.

Water Pollution:

Water containing impurities due to one or the other reason which does not remain usable, is said to be **polluted water** and the process by which the impurities enter/dissolve in water is known as the **water pollution**. Water may get polluted either by the processes occurring in the nature or by the human activities.

Water Pollutants:

A water pollutant can be defined as a physical, chemical or biological factor causing aesthetic or detrimental effects on aquatic life and on those who consume water (**Gupta, P.K.; 2002**). Most of the water pollutants are chemicals which remain suspended or resolved in water. Some physical factors like heat and radiation may also cause pollution of water. Some microorganism known as bio-pollutants may also cause water pollution.

Reasons of Water Pollution:

Water may get polluted due to the processes occurring in nature or due to the various human activities mentioned below:-

- (i) Processes occurring in nature
- (ii) Domestic use of water
- (iii) The sewage
- (iv) Recreational activities
- (v) Agricultural wastes
- (vi) Industrial wastes
- (vii) Educational Institutions and Hospitals
- (viii) Developmental activities
- (ix) Biological factors

PRESENT WORK

It is well known that a periodical study is a must to record the quality of water. There are various factors which cause water pollution. Besides these factors a number of other factors like cutting of trees, increase in population, nuclear-explosions, global warming etc. are some other reasons which cause water pollution. As a result of all these factors and many more the water quality changes regularly. It is therefore mandatory that the quality of water should be checked on a regular basis either by the Government Organization, or by the researchers to update the knowledge about the quality of water. Such studies are essential for the survival of all living organisms and future generations.

The present work is a small attempt in this field. **Bhimtal Lake** of Kumaon, Uttarakhand (India) has been selected for studying the extent of pollution and the probable reasons of pollution. Depending upon the extent of pollution the lake shall be categorized as eutrophic or the oligotrophic. Remedial measures shall also be suggested to minimize the extent of water pollution in this lake.

The present work has therefore been undertaken with the following objectives:

- (i) To review the studies done on the lake water, river water and ground water.
- (ii) To study the physico-chemical characteristics of the lake.
- (iii) To study the pollutant dynamics in the lake.
- (iv) To establish the reasons of pollution in the lake.
- (v) To suggest remedial measures to minimize the extent of pollution in the lake.

The Bhimtal Lake

The Bhimtal Lake (Fig. 1.0) is situated at a distance of about 22 km (by road) from Nainital. A beautiful island containing some trees, almost at the center of the lake adds to the aesthetic beauty of lake. As per an ancient Hindu scripture “The Holy Geeta” the name Bhimtal is derived from the great warrior “Bhima”, one of the five Pandawas.

The Bhimtal lake is also the major source of drinking water and other house hold activities for about ten thousand permanent and about twenty thousand floating population of the Bhimtal City. (Table 1.0)

Table 1.0 The Bhimtal Lake.

Sl. No.	Parameter	Data
1.	Height above sea level (i.e. altitude)	1331 m
2.	Longitude	79° 36' E
3.	Latitude	29° 20' N
4.	Length	1974 m
5.	Breadth	457 m
6.	Maximum Depth	25.8 m
7.	Mean Depth	11.5 m
8.	Surface area	850 m ²
9.	Catchment area	11.4 Km ²
10.	Volume of water	40,77,01,200 m ³
11.	Ratio of the Lake surface area to the Catchment area	1:13.1

Source: (a) Gupta, P.K.; 1981.

(b) Irrigation department, Uttaranchal.

II. Experimental

Digital pH meter (micro processor based) (Systronics μ pH-362), Conductivity meter (digital micro-processor based) (Systronics 306), Centrifuge with centrifuge tube (Remi 4C). Flame photometer (Na, K & Ca Filters) (Systronics Mediflame-127), Magnetic stirrer (with hot plate), Electrical balance (Single pan) (Verbal 200 super), Water bath (Sonar), Hot air oven (small) (RTSE), Atomic absorption spectrophotometer (Cameto 201), Distillation assembly (NPL), Water Analysis kit (ELICO, Model PE 138 Water Quality Analyser), UV-VIS spectrophotometer (Hitachi) (Japan), Grinding mortar (Toshiba), Pestle mortar (Toshiba Fish Type) and Micro Kjeldahl apparatus (Borosil) equipments/apparatus were used in the present work.

Standard solutions of NaOH, HCl, KCl, $[\text{NH}_2]_2\text{H}_2\text{SO}_4$, $[(\text{CH}_2)_6\text{N}_4]$, Sodium Carbonate (0.1) solution, Methyl Orange indicator, Phenolphthalein indicator, Starch indicator, Sodium thio-sulphate (Hypo) solution. Alkaline Potassium Iodide solution, Manganous Sulphate solution and some other specific solutions were used for the present work.

Water Sampling

The first and perhaps the most important task for the analysis of water is the selection of the true representative sample of the water body. Almost accurate water analysis of the water body is possible only if the following conditions are fulfilled:

- The water sample truly represents the water body from which it was taken.
- The water sample does not change prior to its analysis.
- The water analysis determines the true values of the characteristics of the water body under investigation.
- The analysis is possible strictly according to the objectives of the study.

In view of the above the representative water samples from the water bodies (i.e. lakes) were collected vide the following two phases:

- Selection of the sampling sites i.e. sampling stations.
- Collection of the water samples.

Selection of the sampling sites (Sampling stations)

The sampling sites i.e. the sampling stations were selected such that they fulfill the requirements of the objectives of the study being undertaken.

Sampling stations in Bhimtal Lake were selected in view of the following:

- The sites where there were the major input/inlet contributors.
- The sites from where the average quality of the lake can be assessed.
- The sites from where the water is being used or taken for drinking and/or other domestic uses.

- The sites where is maximum accumulation of pollutants and is not of temporary nature and may affect the entire water body i.e. the lake.
- The sites where there are the outlets of lake water.

Five sampling stations S₁ to S₅ were selected in Bhimtal Lake as shown in Fig 1.1.

The Bhimtal Lake

- a) Near Mallital (S₁)
- b) Near L.P. Intermediate college (S₂)
- c) Near the Boat Stand (S₃)
- d) Near the island (S₄)
- e) Near Tallital (S₅)

Collection of the water samples

Water samples from all the identified sampling stations from all the five lakes were collected at a depth of about 50 cm every time. Water samples were collected using a pyrex Glass bottle whose neck was tied to a strong nylon rope. The water samples were immediately transferred to clean already marked plastic containers, (like S₁, S₂, S₃ etc. marked with marker pen). Some of the parameters were measured at the site immediately. Separate fresh samples were again collected from each of the sample stations and brought to the laboratory in closed plastic containers of one litre capacity.

Every care was taken so that minimum time elapsed between the collection of the water samples and their analysis in the laboratory. Sample preservatives as and when required were added in accord with the NH manual (**Jain, C.K. et a.;1987-88**). Water samples from all the sampling stations were collected at monthly intervals in the forenoon between 09:00 a.m. to 05:00 p.m. It was ensured that the time of sample collection from a particular sampling station in a lake was almost the same on each day selected / identified for sampling.

WATER ANALYSIS

Analysis of water quality was done under the following two major categories:

(a) Physical Examination

Physical examination of the water of Bhimtal Lake was done for the following:

- (i) Colour
- (ii) Odour
- (iii) Taste
- (iv) Turbidity
- (v) Temperature
- (vi) Conductance
- (vii) Optical Density (O.D.)

(b) Chemical Examination

Chemical examination of the water samples collected from the sampling stations of Bhimtal lake were done for the following test:

- 1) Total Solids (TS)
- 2) pH of water
- 3) Acidity of water
- 4) Alkalinity of water
- 5) Hardness of water
- 6) Sulphat in water
- 7) Chlorides in water
- 8) Fluorides in water
- 9) Dissolved Oxygen in water
- 10) Biochemical Oxygen Demand in Water
- 11) Chemical Oxygen Demand in Water
- 12) Total Organic Carbon / Organic matter in water
- 13) Nitrogen in water
- 14) Nitrogen, ammonia
- 15) Nitrogen, nitrate
- 16) Nitrogen, nitrite
- 17) Nitrogen, organic
- 18) Metals in water.

III. Results And Discussion

The analysis of water for the Physical examination as well as the Chemical examination was done for Bhimtal lake. The details of the observations and results are as follows:

COLOUR OF WATER

The colour of water of Bhimtal lake has been given in Table 1.1

Table 1.1 COLOUR OF WATER OF THE BHIMTAL LAKE

LAKE	Sampling Station		Colour of Water (Average Colour observed during the year)
	No.		
BHIMTAL LAKE	S ₁		Light Yellow
	S ₂		Light Yellow
	S ₃		Almost Colourless
	S ₄		Light Yellow
	S ₅		Light Yellow

ODOUR OF WATER

The odour of water of Bhimtal lake has been given in Table 1.2

Table 1.2 ODOUR OF WATER OF THE BHIMTAL LAKE

LAKE	Sampling Station		Odour of Water (Average Odour observed during the year)
	No.		
BHIMTAL LAKE	S ₁		Unpleasant smell
	S ₂		Almost no smell
	S ₃		Almost no smell
	S ₄		Unpleasant smell
	S ₅		Almost no smell

TASTE OF WATER

The Taste of water of Bhimtal lake has been given in Table 1.3

Table 1.3 TASTE OF WATER OF THE BHIMTAL LAKE

LAKE	Sampling Station		Taste of Water (Average Taste observed during the year)
	No.		
BHIMTAL LAKE	S ₁		Almost Disagreeable
	S ₂		Almost Disagreeable
	S ₃		Almost Agreeable
	S ₄		Almost Disagreeable
	S ₅		Disagreeable

TURBIDITY OF WATER

The turbidity of water of Bhimtal lake has been given in Table 1.4

Table 1.4 TURBIDITY OF WATER OF THE BHIMTAL LAKE

LAKE	Sampling Station		Turbidity of Water (Average value observed during the year)
	No.		
BHIMTAL LAKE	S ₁	3.3	3.2
	S ₂	3.2	
	S ₃	2.9	
	S ₄	2.5	
	S ₅	3.2	

TEMPERATURE OF WATER

The temperature of water was recorded for each of the sampling stations for Bhimtal for all the month of the calendar year 2003, i.e. from January 2003 to December 2003. The results have been given in Table 1.5.

Table 1.5 TEMPERATURE OF THE WATER OF BHIMTAL LAKE

Sl. No.	MONTHS	TEMPERATURE (°C)				
		LAKES AND SAMPLING STATIONS				
		BHIMTAL LAKES				
		S ₁	S ₂	S ₃	S ₄	S ₅
1.	Jan.	12.8	11.1	11.4	11.2	10.9
2.	Feb.	7.3	7.3	7.6	7.7	7.7
3.	Mar.	8.1	8.2	8.5	8.1	8.8
4.	Apr.	19.9	20.1	20.5	20.4	20.3

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5.	May.	20.6	21.0	21.6	21.5	21.6
6.	June	21.1	21.6	22.0	22.1	22.5
7.	July	21.6	21.5	22.1	22.0	21.8
8.	Aug.	21.5	21.6	21.3	20.9	21.0
9.	Sep.	20.6	20.5	20.1	20.4	21.0
10.	Oct.	20.0	19.8	19.6	19.9	20.1
11.	Nov.	20.3	20.4	20.0	20.5	20.6
12.	Dec.	18.6	18.9	19.0	18.3	18.0
Average		17.7	17.6	17.8	17.7	17.8
Average		17.73				

CONDUCTANCE OF WATER

Table 1.6 CONDUCTANCE OF WATER OF BHIMTAL LAKE

Sl. No.	MONTHS	CONDUCTANCE				
		LAKES AND SAMPLING STATIONS				
		BHIMTAL LAKE				
		S ₁	S ₂	S ₃	S ₄	S ₅
1.	Jan.	198	193	197	190	187
2.	Feb.	178	191	168	188	184
3.	Mar.	200	209	213	200	198
4.	Apr.	211	214	218	220	209
5.	May.	215	218	219	224	211
6.	June	221	225	220	221	210
7.	July	229	226	228	226	218
8.	Aug.	230	228	221	225	219
9.	Sep.	212	216	219	210	196
10.	Oct.	211	215	218	211	199
11.	Nov.	198	196	191	189	186
12.	Dec.	190	191	189	187	188
Average		207.7	210.83	208.4	207.5	200.4
Average		206.83				

OPTICAL DENSITY (O.D.) OF WATER

Table 1.7 OPTICAL DENSITY OF WATER OF BHIMTAL LAKE

Sl. No.	MONTHS	OPTICAL DENSITY (O.D.)				
		LAKES AND SAMPLING STATIONS				
		BHIMTAL LAKE				
		S ₁	S ₂	S ₃	S ₄	S ₅
1.	Jan.	0.151	0.152	0.019	0.161	0.181
2.	Feb.	0.161	0.151	0.018	0.165	0.175
3.	Mar.	0.158	0.152	0.019	0.166	0.180
4.	Apr.	0.160	0.151	0.018	0.170	0.177
5.	May.	0.161	0.153	0.019	0.178	0.181
6.	June	0.162	0.154	0.020	0.171	0.182
7.	July	0.158	0.156	0.021	0.181	0.179
8.	Aug.	0.150	0.158	0.022	0.180	0.181
9.	Sep.	0.158	0.157	0.021	0.181	0.182
10.	Oct.	0.161	0.156	0.022	0.179	0.178
11.	Nov.	0.158	0.155	0.025	0.180	0.176
12.	Dec.	0.156	0.157	0.055	0.181	0.175
Average		0.158	0.154	0.042	0.184	0.178
Average		0.1128				

TOTAL SOLIDS (TS), TOTAL DISSOLVED SOLIDS (TDS) AND TOTAL SUSPENDED SOLIDS (TSS) IN WATER

The TS, TDS and TSS in the Bhimtal have been given in Table 1.8.

Table 1.8 TS, TDS AND TSS IN THE WATER OF BHIMTAL LAKE

LAKE	Sampling Station No.	Total Solids (mg/l)	Total Dissolved Solid (mg/l)	Total Suspended Solids (mg/l)
BHIMTAL LAKE	S ₁	113.2	112.0	1.21
	S ₂	123.8	114.0	1.24
	S ₃	115.6	113.5	1.22
	S ₄	112.6	111.8	1.21
	S ₅	111.8	112.5	1.25
Average		115.4	112.76	1.226

pH OF WATER

The pH of water was determined by the **ELICO Water Quality Analyser Model 138** and the results have been given in Table 1.9.

Table 1.9 pH OF THE WATER OF BHIMTAL LAKE

Sl. No.	MONTHS	pH				
		LAKES AND SAMPLING STATIONS				
		BHIMTAL LAKE				
		S ₁	S ₂	S ₃	S ₄	S ₅
1.	Jan.	7.08	7.12	7.09	7.03	7.03
2.	Feb.	7.14	6.65	7.03	7.01	7.01
3.	Mar.	7.15	7.11	7.14	7.13	7.16
4.	Apr.	7.11	7.12	7.14	7.15	7.11
5.	May.	7.12	7.10	7.11	7.18	7.09
6.	June	7.16	7.15	7.15	7.16	7.11
7.	July	7.20	7.22	7.24	7.20	7.31
8.	Aug.	7.18	7.19	7.11	7.15	7.16
9.	Sep.	7.19	7.20	7.22	7.03	7.24
10.	Oct.	7.24	7.22	7.24	7.25	7.26
11.	Nov.	7.21	7.21	7.20	7.24	7.21
12.	Dec.	7.19	7.20	7.18	7.11	7.10
Average		7.153	7.124	7.154	6.567	7.149
Average		7.029				

ALKALINITY OF WATER

The total Alkalinity of the water of Bhimtal Lake has been given in Table 1.10.

Table 1.10 TOTAL ALKALINITY OF WATER OF BHIMTAL LAKE

LAKE	Sampling Station No.	Total Alkalinity (mg/l)
BHIMTAL LAKE	S ₁	89.0
	S ₂	90.2
	S ₃	90.3
	S ₄	89.2
	S ₅	88.9
Average		89.52

TOTAL HARDNESS OF WATER

Table 1.11 TOTAL HARDNESS OF WATER OF BHIMTAL LAKE

LAKE	Sampling Station No.	Total Hardness (Ca ⁺⁺ + Mg ⁺⁺) (p.p.m.)
BHIMTAL LAKE	S ₁	88.0
	S ₂	90.4
	S ₃	90.1
	S ₄	89.5
	S ₅	90.5
Average		89.7

ORGANIC MATTER IN WATER

No significant data/figures were observed in Bhimtal Lake. The organic matter present in water of Bhimtal Lake was therefore considered to be almost nil.

DISSOLVED OXYGEN IN WATER

Table 1.12 DISSOLVED OXYGEN IN WATER OF THE BHIMTAL LAKE

Sl. No.	MONTHS	DO (p.p.m.)				
		LAKES AND SAMPLING STATIONS				
		BHIMTAL LAKE				
		S ₁	S ₂	S ₃	S ₄	S ₅
1.	Jan.	9.5	9.9	9.9	10.0	9.9
2.	Feb.	11.0	10.9	10.9	10.9	10.8
3.	Mar.	12.0	12.2	11.6	10.9	11.6
4.	Apr.	11.5	11.6	11.5	11.4	11.5
5.	May.	11.6	11.7	11.5	11.8	11.4
6.	June	11.9	11.8	12.0	11.5	11.3

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7.	July	11.8	12.0	11.9	11.8	11.6
8.	Aug.	12.1	12.1	11.9	11.9	11.7
9.	Sep.	12.3	12.0	11.8	12.0	11.8
10.	Oct.	11.9	11.8	11.8	11.6	11.5
11.	Nov.	12.1	12.1	11.9	11.6	11.6
12.	Dec.	11.8	11.6	11.5	11.4	11.5
Average		11.62	11.64	11.51	11.48	11.35
Average		11.52				

THE BIOCHEMICAL OXYGEN DEMAND AND THE CHEMICAL OXYGEN DEMAND

In comparison to the DO in water as reported in Table 1.12, the BOD and COD values were not found to be significant in the present analysis.

ANIONIC COMPOSITION OF WATER

The anionic composition of Bhimtal Lake has been reported in Table 1.13.

Table 1.13 ANIONIC COMPOSITION OF WATER OF BHIMTAL LAKE

LAKE	Sampling Station No.	Sulphate (SO ₄) ⁻² (p.p.m.)	Chloride (Cl ⁻¹) (p.p.m.)	Fluoride (F ⁻¹) (p.p.m.)	Nitrate (NO ₃ ⁻¹) (p.p.m.)
BHIMTAL LAKE	S ₁	4.51	42.21	0.04	1.61
	S ₂	5.62	42.61	0.03	1.01
	S ₃	4.68	43.09	0.02	1.35
	S ₄	5.81	45.01	0.04	0.98
	S ₅	6.32	41.35	0.03	1.36
Average		5.388	42.854	0.032	1.262

CATIONIC COMPOSITION OF WATER

The Cationic composition of Bhimtal Lake has been reported in Table 1.14.

Table 1.14 CATIONIC COMPOSITION OF WATER OF BHIMTAL LAKE

LAKE	Sampling Station No.	Na ⁺ (p.p.m.)	K ⁺ (p.p.m.)	Fe ⁺⁺⁺ (p.p.m.)
BHIMTAL LAKE	S ₁	24.00	1.01	0.04
	S ₂	24.08	1.02	0.03
	S ₃	25.01	1.00	0.02
	S ₄	24.05	1.02	0.04
	S ₅	24.82	1.01	0.04
Average		24.392	1.012	0.034

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A perusal of the result of this study clearly indicates that Bhimtal Lake is almost an oligotrophic lake. Hence remedial measures should be taken to preserve the lake for its proper use.

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