



STATUS OF POLLUTION IN AND AROUND NAINITAL LAKE, NAINITAL DISTRICT, UTTARAKHAND

**Sudhir K
Srivastava**

Central Ground Water Board, Bhujal Bhawan, NH-4, Faridabad

ABSTRACT The Nainital Lake receives wastes from the surrounding areas, run off from catchments and residues of construction activities through small and large drains. The Nainital Lake is a large water body with two basins Mallital and Tallital. The physico-chemical profile of Nainital lake has been studied. A total of 49 water samples were collected from Nainital lake and its surroundings. 15 samples were collected out of above 49 samples for total non-purgeable organic carbon (NPOC) and total carbon and 13 samples (acidified) were collected for trace elemental analysis. The Non-Purgeable Organic Carbon (NPOC) are found to be less than 3 mg/l except in few samples near Mallital. Total Organic carbon up to 70.3 mg/l has been detected.

KEYWORDS :

INTRODUCTION

Nainital Lake is situated at about 1937 meter above mean sea level in the central Himalaya, is the unrivalled queen of Kumaun lakes. This water body is multipurpose in character, for a side from its use as boating, fishing, this lake is the most important sources of drinking water supply to about one lac permanent and several thousands tourists population. Tourism industry in the back-bone of the local economy.

In the past few decades this beautiful mountainous lake has become endangered, as drastic changes have accrued in its physical, chemical and biological features as a result of man's accelerated and unthoughtful activities in the catchment areas. This contamination has made a great impact on the economy as well as on medical fronts. The lake has undergone eutrophication due to human activities in the last fifty (50) years or so. Recently it has been identified as a National lake and to revert the eutrophication processes, National lakes conservation programme is under implementation.

Every year large amounts of extraneous materials were carried into the lake. In addition the water was found to be contaminated by pathogenic and non-pathogenic organism of faecal origin. Bacteria of the coli form group particularly *E. coli*, which may survive for longer periods in aquatic environments, have been observed by the earlier workers (Pant et. al. 1981). Infected fishes and certain pollution-tolerant organisms along with certain physical-chemical characteristics of the lake water have also been studied by several other workers.

Central Ground Water Board has also taken a study during its Annual Action Plan 2007-2008 to know the status of pollution, in Nainital lake by physical-chemical and organic parameters presents in the lake water and its surrounding ground water/spring water.

DESCRIPTION OF THE LAKE

Nainital lake is a cup shaped water body (Fig. 1). It is surrounded on the north west side by the high "Naina Peak" (earlier it was known as China Peak), on the south west by Tiffen Top etc mountain and on the north by Snow-View Peak etc.

However, the south-east side is more flat and is popularly known as "Danth" (meaning a dam). Locally, the upper part of the lake is called "Mallital" and lower part towards the 'dam' is "Tallital". The lake is fed by 21 seasonal and two perennial open drains (nallahs). Beside these, some internal under water, springs are believed to feed into the lake. The excessive water is discharged from the dam towards the lower end of the lake during the months of heavy monsoons, through a single outlet.

At Mallital, Jal Sansthan, Government of Uttarakhand has constructed around 8-9 deep Tube wells almost adjacent to the Nainital lake for supply of water to the entire population of the area.

The lake Nainital can be closed as a warm monomictic lake. It stratifies thermally during summers, mixes freely in winters and at no time its water cools to 4°C, thus Lake Falls under subtropical lakes. The surface water of the lake attained a maximum temperature of 22.5°C in June (1999), while the minimum temperature reached 9.4°C in January

(2000), (IIT Roorkee, 2002).

SOURCES OF POLLUTION

The Nainital Lake is a receptacle of water and wastewater from adjoining areas and the catchments. The sources of pollution are both point sources and non-point sources including 21 drains, which join the lake (Fig.1). Recently, the city has now a developed sewerage system through which around 12.0 mld of waste-water is collected and transported to Russi village for irrigation. However, some amount of sewage and sullage fluid access to the surface drains. Most of these drains are seasonal and bring in large quantities of surface run off, when it rains. However, there is no discharge in the non-monsoon months.

Four drains viz. Metro pole drain, drains at Tallital Rikshaw stand, drain at St. Francis Catholic Church and drain near Elphinston Hotel have the flows all through the year. The approximate average flows of these drains are mentioned in the following Table. 1.

Table.1. The approximate average flows of the drains into Nainital Lake, Nainital district

S.No	Drain	Discharged (mld)
1	1. Metro pole drain	1.28
2	2. Drain near Tallital Rikshaw stand	0.04
3	3. St. Francis Catholic Church drain	0.06
4	4. Drain near Elphinston Hotel	0.061

The Metro pole drain is a major polluter. The quality of these drains was also determined (IIT, Roorkee 2002). The characteristics of the water flowing through the metro pole drains are as mentioned in the following Table.2.

Table.2. Characteristics of the water flowing through the metro pole drains, Nainital Lake

S. No	Parameters	Range
1	PH	7.5 – 8.2
2	Alkalinity (mg/l)	185 – 390
3	Hardness mg/l	> 300
4	T.D.S. mg/l	300 – 610
5	D.O. mg/l	2.5 – 8.0
6	B.O.D. mg/l	22 – 58
7	Phosphate mg/l	0.23 – 0.396
8	NO ₃ - N mg/l	0.6 – 2.15
9	NH ₃ - N mg/l	0.06 – 1.2
10	NO ₂ - N mg/l	0.02 – 1.2

(Sources: AHEC/2002, DPR for Conservation & Management plan for Nainital lake; IIT, Roorkee)

On the basis of these results it can be seen that Metro pole drain alone contributes 63.18 kg of Phosphates, 711.2 kg of Nitrogen (all forms) and 18688 kg of B.O.D. per annum. If we consider the pollution from all other drains and non-point sources is assumed to be equal to the contribution by nutrients per annum would be Phosphorous – 126.36 kg
Nitrogen - 1422.4 kg

B.O.D. - 37376 kg

The addition of these nutrients through run off and sewage increases the concentration of Nitrogen and Phosphorous, which ultimately results in the production of aquatic vegetation that leads to eutrophication. The status of quality of water in Nainital lake tends to indicate that the Lake is significantly eutrophic and that this lever increased with increase in accumulation of nutrients in waters specially NO₃-N and Phosphate.

The Dissolved Oxygen (D.O.) and Biochemical Oxygen demand (BOD) are the indicative parameters showing the health of the water body. Due to pollution with organic materials the D.O. may deplete as it would be utilized by the microbes in degrading it. The depletion of D.O. is therefore indicative of lever of pollution. Similarly the B.O.D. (Biochemical Oxygen Demand) is a measure of pollution load of water, which indicates the amount of biologically oxidisable organic matter present that can be used to determine the rates at which degradation occurs. Varied beneficial used water requires different levels of minimum purity. Water is suitable for certain designated use if it complies certain criteria.

In the studies reported by Gupta (1990-2001), the average BOD in the Nainital lake water is around 23 3.0 mg/l. The maximum value was recorded as 40.0 mg/l and minimum 13.0 mg/l. These higher values of BOD indicative of organic pollutants including the algal mass.

The concentration of Dissolved Oxygen ranged from 2 mg/l to 16.7 mg/l during a study (IIT Roorkee 2002) in 1999-2000. The annual mean concentration at surface water was 10.1 mg/l and 8.8 mg/l during 1999-2000 and 2000-01 respectively. At 9m depth, the concentration of Oxygen was very low, usually nil. Thus, the entire hypolimnion remained devoid of Oxygen with high Oxygen demand.

METHODOLOGY

A total of 49 water samples were collected from Nainital lake and its surroundings. 15 samples were collected out of above 49 samples for total non-purgeable organic carbon (NPOC) and total carbon and 13 samples (acidified) were collected for trace elemental analysis. Hydrogen ion concentration (pH) were recorded on the spot in the field by portable PH-meter Henna make. The various other physico-chemical parameters such as PH, EC (Electrical Conductivity), Carbonate, Bicarbonate, Chloride, Sulphate, Magnesium, Sodium, Potassium, total hardness, Calcium, Phosphate etc. were analyzed by Standard Methods (APHA).

The metallic ions/ trace elements were analyzed by Atomic Absorption Spectro-Photometer (SHIMADZU-Make). The totals Non-Purgeable Organic Carbon (NPOC) were determined by T.O.C. analyzer SHIMADZU-Make at IIRS, Dehradun.

RESULTS AND DISCUSSIONS

The Water quality of the Lake water depends largely on catchment characteristics, geology of the area and the inputs of human activities. A catchment of poorly weathered rocks and intact natural ecosystem will produce a water with low fertility. A catchment with reactive rocks and soil will produce more fertile waters. The inputs in the form of sewage, sillage and remains of construction materials along with forest run off adds to a multitude of organic and inorganic molecules which undergo change in the body of receiving waters. The Nainital Lake is a large water body with two basins Mallital and Tallital. The physico-chemical profile of Nainital lake has been studied and the chemical quality data are given in Table 4. The water samples collected during May 2007 from various sampling location are shown in Figure.2. It has been observed that in general the lake water has been found to be Calcium-Magnesium-Bicarbonate (Ca-Mg-HCO₃) type. The details of other chemical characteristics are as follows-

pH

pH of water is usually denote the concentration of hydrogen ion & shows the acidic or alkaline nature of the water.

It has been observed that lake water and its surrounding ground water/spring water bodies remained alkaline. The horizontal profile of the PH in the lake varied from 7.4 to 8.1. The highest value was found near Nainadevi Temple drain.

Electrical Conductivity

The electrical Conductivity of the lake water ranged from 472 to 500

s/cm in surface water (below 30cm). The electrical conductivity increased from Tallital to Mallital. This may be due to the drain near Nainadevi Temple at Mallital. The EC near this drain water has been found to be 868s/cm at 25°C. The EC of the various Tube wells (Jal Sansthan water supply pump house) ranges between 566 to 754 s/cm. The EC of the spring water at snow view road ranges between 717 to 830 s/cm. Hence the water of the lake and its surrounding area is fresh with low content of salts (TDS).

Alkalinity

During the study, alkalinity (CO₃+HCO₃) of the lake water was found in the range of 171 to 342 mg/l. The springs & T.W. content higher alkalinity than lake water. The highest value of 354 mg/l was observed in spring water at snow view Road.

Hardness

The hardness (as CaCO₃) of the lake was found to be almost constant at 200 mg/l except near drain of Nainadevi Temple. The higher of hardness was observed in Tube well and spring water at snow view Road.

Chloride

Chloride content was found in the range of 14 to 21 mg/l in lake water. In Tube wells and springs it ranges from 18 to 60 mg/l.

Sulphate

Sulphate has been observed in the range of 7.0 to 100 mg/l with highest value of 100 observed in the T.W. No-5 Mallital.

Nutrients

The microbial flora is largely depends upon the availability of nutrients as Nitrogen and Phosphorous. The Nitrogen has been measured as Nitrate and Phosphorous as Phosphate. The Nitrate and Phosphate have been observed in the range of 0 to 23 mg/l and 0 to 1.73 mg/l respectively. Phosphate has been found to be almost nil in the surface water of the lake except near drain at Nainadevi Temple, Mallital.

Sodium & Potassium

Sodium and Potassium content have been observed in low concentration. The highest values of sodium and Potassium have been found to be 8.3 and 3.05 mg/l respectively.

Metal Ions

Metal Ions leach out from deposits during erosion and reach the water body through surface run off. Most of the metal elements are due to natural erosion. Some reach through anthropogenic sources as well. However, in case of Nainital lake, anthropogenic sources are minimal. The values of metal ions concentration is summarized in Table 5. The values are well with in safe limits as prescribed by Bureau of Indian standards (BIS). The maximum-minimum values are given as follows

S. No	Trace Element	Range of concentration in mg/l
1	Copper	03 - 32
2	Iron	08 - 113
3	Zinc	46 - 320
4	Manganese	08 - 117
5	Nickel	0 - 2
6	Lead	0 - 1
7	Chromium	Nil
8	Cadmium	0 - 1

Total Organic Carbon

To study the organic carbon pollution, 15 samples were collected and analyzed for non-purgeable organic carbon and total carbon content. The results are given in Table 6. It has been found that Non-Purgeable Organic Carbon (NPOC) are less than 3 mg/l except in few samples near Mallital such as near boat club and near Nainadevi Temple drain, which indicates the pollution due to domestic wastes/sewage water or due to degradation of algal. Total organic carbon has been detected up to 70.3 mg/l indicating organic pollution.

CONCLUSION & RECOMMENDATIONS

Based on the information and data it can be concluded that the problems associated with lake are due to anthropogenic interventions. The data collected shows conclusive evidence that lake system is under stress. The Nainital Lake receives wastes from the surrounding areas, run off from catchments and residues of construction activities through small and large drains. The lake water have many uses such as (i)

Provision of drinking water (ii) Recreation and aesthetics (iii) Assimilation of wastes & (iv) Fisheries and aquaculture. Therefore to improve the quality of the lake water the measures are being taken by the Govt. of Uttarakhand, which include the control of external inputs/ loads to the lake. When external supply of nutrients will be successfully cut off, the lake eutrophication may be reduced. Sediments may be removed from the areas where pollutants have accumulated, debris from the catchments has settled and inflow streams are depositing their silt load. The monitoring of the quality of water should be periodic.

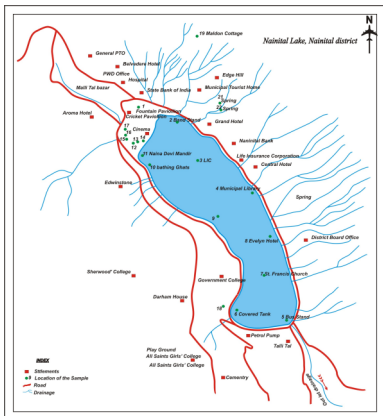


Fig.1 Cup shaped Water body of Nainital Lake, showing drains around the lake.

Table – 5: Concentration of Metal Ions, in the Surface and Ground Water Sources, Nainital Lake

S No.	Location	Cu	Fe	Zn	Mn	Ni	Pb	Cr	Cd
1	Mallital	25	65	112	14	1	0	0	0
2	Busstand	15	68	46	15	0	0	0	0
3	St. Josef College	3	95	115	21	2	0	0	0
4	Nainadevi temple	17	103	320	16	0	1	0	0

Table – 4: Chemical Quality Data of Surface & Ground Water Sources, Nainital Lake

Sl. No.	Location	Type of sample	pH	E.C. (µ/cm at 25°C)	All values in mg/L											
					CO ₃	HCO ₃	Cl	SO ₄	NO ₃	F	PO ₄	Ca	Mg	Na	K	TH as CaCO ₃
1	Mallital near Boat Club	S.W.	7.6	481	Nil	207	21	7	2.9	0.21	Nil	20	36	5.1	1.55	200
2	Mallital opp N. Restaurant	S.W.	7.5	490	Nil	207	14	15	1.3	0.21	Nil	20	36	5.1	1.6	200
3	Tal close to Tourist Office	S.W.	7.7	472	Nil	183	18	30	2.6	0.31	Nil	20	36	5	1.6	200
4	Tal close to Library	S.W.	7.6	472	Nil	171	18	40	2.3	0.21	Nil	20	36	4.7	1.65	200
5	Tal close to Bus Stand	S.W.	7.7	481	Nil	195	14	24	3.4	0.1	Nil	20	36	4.7	1.55	200
6	Tal near St. Joseph College Boat Culb	S.W.	7.5	481	Nil	183	14	32	3.3	0.14	Nil	20	36	4.8	1.65	200
7	Centre of lake near Bouy	S.W.	7.6	481	Nil	171	14	42	3.4	0.15	Nil	20	36	4.7	1.65	200
8	Tal near St. Francis Church	S.W.	7.4	481	Nil	195	14	25	2.9	0.13	Nil	20	36	4.7	1.65	200
9	Centre of lake near Bouy/Library	S.W.	7.5	490	Nil	183	21	25	3.3	0.18	Nil	20	36	4.6	1.65	200
10	Mallital near Naina Devi Temple	S.W.	7.6	500	Nil	195	14	22	3.8	0.16	Nil	26	33	4.4	1.53	200
11	Drain near Naina Devi Temple	S.W.	8.1	868	Nil	342	35	65	20.9	0.17	1.73	80	49	8.3	2.8	400
12	Jal Sansthan Pump House Dug Well	D.W.	7.6	575	Nil	281	18	10	4.2	0.13	Nil	40	39	4.6	1.65	260
13	Jal Sansthan Pump House Tubewell No -2	T.W.	7.7	566	Nil	232	25	26	6	0.12	Nil	28	44	4.6	1.75	250
14	Jal Sansthan Pump House Tubewell No -1	T.W.	7.4	594	Nil	244	18	25	8.8	0.12	Nil	32	41	5	1.75	250
15	Jal Sansthan Pump House Tubewell No -6	T.W.	7.5	754	Nil	293	25	78	12.7	0.1	Nil	48	58	4.5	1.8	360
16	Jal Sansthan Pump House Tubewell No -5	T.W.	7.6	726	Nil	268	18	100	9.6	0.18	Nil	48	56	3	1.8	350
17	Jal Sansthan Pump House Tubewell No -4	T.W.	7.4	594	Nil	256	21	45	3.7	0.12	Nil	40	44	5	1.9	280
18	Handpump near Raj Bhawan Pump House	H.P.	7.3	566	Nil	207	21	61	0	0.13	Nil	32	44	3.3	1.03	260
19	Snow View, No-7 Staff Colony	Spring	7.6	717	Nil	220	28	85	23	0.18	Nil	52	46	4.2	2.4	320
20	Snow View Rd. Rt. of Mr. SK Shah House	Spring	7.7	811	Nil	354	25	80	7.7	0.1	Nil	52	68	2.9	1.9	410
21	Snow View Rd. Rt. of Mr. SK Shah House	Spring	7.8	830	Nil	305	60	20	12	0.12	Nil	48	58	3.3	3.05	360

REFERENCES

- M.C. Pant, P.K. Gupta, J. Pande, P.C. Sharma & A. P. Sharma (1981) Aspects of water pollution in lake Nainital, UP, India, Environmental conservation vol. 8 No. 2, P 113-118.
- Alternate Hydro Energy Centre, IIT, Roorkee (2002) DPR for conservation and Management plan of Nainital lake for Govt. of Uttarakhand.
- A.P.H.A. (1989) Standard Methods for examination of water and waste water, American Public Health Association, New York.
- S.S. Nagdali & P.K. Gupta (2003), water quality of an urban drain and nutrients input through it to Lake Nainital, a subtropical heterotrophic system, Environmental Biology and Conservation, vol. 8, p 1-7.
- P.K. Gupta (1999-2001) report on the project, Limnological Investigations on lake Nainital with Particular Reference to its Conservation and Management, and Follow up Monitoring regarding the Quality Control of the lake water Department of Zoology

5	Drain N D temple	21	34	184	129	1	0	0	0
6	Jal Sansthan	5	54	167	171	1	0	0	0
7	Jal Sansthan	32	67	68	95	1	0	0	0
8	Jal Sansthan	6	113	98	18	0	0	0	0
9	Jal Sansthan	12	37	164	11	0	0	0	0
10	Jal Sansthan	14	61	152	8	1	0	0	0
11	Rajbhawan	8	8	134	140	1	0	0	0
12	Snow view	14	13	87	9	0	0	0	1
13	Jal Sansthan	13	17	66	9	0	0	0	1

Concentrations are in microgram/liter

Table – 6: Total Organic Carbon In Surface And Ground Water Sources, Nainital Lake

S No.	Location	Date of Collection	Type	NPOC, mg/L	T.C., mg/L
1	MalliTal near Boat Club	22/5/2007	S.W.	3.22	43
2	MalliTal opp N. Restaurant	22/5/2007	S.W.	2.85	43.2
3	Tal close to Tourist office	22/5/2007	S.W.	2.74	41.6
5	Tal close to Bus Stand	22/5/2007	S.W.	2.81	42
9	Centre of lake near Bouy/Library	22/5/2007	S.W.	2.74	36.2
10	MalliTal near Naina Devi Temple	22/5/2007	S.W.	2.48	31.1
11	Drain Near Naina Devi Temple	22/5/2007	S.W.	6.21	70.3
12	Jal Sansthan P. House dug well	23/5/2007	D.W.	0.95	46
13	Jal Sansthan P. House Tubewell No-2	23/5/2007	T.W.	0.5	45.4
14	Jal Sansthan P. House Tubewell No-1	23/5/2007	T.W.	0.27	48.6
15	Jal Sansthan P. House Tubewell No-6	23/5/2007	T.W.	0.07	52
16	Jal Sansthan P. House Tubewell No-5	23/5/2007	T.W.	0.02	47.1
17	Jal Sansthan P. House Tubewell No-4	23/5/2007	T.W.	0.31	48.5
18	Hand pump near Raj Bhawan Pumphouse	24/5/2007	H.P.	0.01	31.1
19	Snow View, NO- 7, Staff Colony	24/5/2007	Spring	0.02	42.2

Kumaon University, Nainital.