



Assessment of Surface Water Quality of Chimdi Lake of Sunsari District, Nepal

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Abstract: Chimdi Lake has ecological significance as it has been a home for several associated biodiversities. A study was carried out to investigate the pollution status by analyzing some important physicochemical parameters of Chimdi Lake. The parameters analyzed were ambient temperature water temperature, Turbidity, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Conductivity, Hydrogen- ion-concentration (pH), Dissolved Oxygen (DO), Total hardness (TH), Chloride, Nitrate – Nitrogen ($\text{NO}_3\text{-N}$), Phosphate- phosphorus ($\text{PO}_4\text{-P}$), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and fecal coliform. On the basis of pollution status found, the water of the lake was unfit for drinking purposes.

Keywords: Chimdi Lake, Water Quality, Microbiological, Pollution Status, Nepal

1. Introduction

Water is the most vital natural resource of our environment. Functioning of biosphere is totally dependent upon water and its quality. Water as environmental factor which maintains the integrity of the aquatic ecosystem [1]. Changes in water quality are reflected in its physical, biological, and chemical conditions; and these in turn are influenced by physical and anthropogenic activities [2]. Lakes are the important habitats for the study of ecosystem dynamics: interactions among biological, chemical and physical processes are frequently either quantitatively or qualitatively distinct from those on land or in air. Most of the surface waters are heavily loaded with phosphate and nitrate [3].

A Lake ecosystem consists of the physical, chemical and biological properties contained within these water bodies. There are several medium and small lakes in the country which cover, 5000 hectares. These have different geological origins and can be classified into glacial, ox-bow, and tectonic categories [4]. Mostly ox-bow lakes and ponds occur in the Terai plain of Nepal and they are eutrophic. In many places lakes/ponds have converted into marshes (Ghols) or swamps due to siltation and plant succession [4]. The movement of chemicals, sediments, detritus, and of many organisms, is typically unidirectional from the watershed to

the lake, but fish may migrate upstream, and aquatic insects may emerge and disperse on to land. A lake and its watershed are often considered to be a single ecosystem [5]. Water quality in aquatic system is important because it maintains the ecological processes that support biodiversity. However, declining water quality due to environmental perturbations threatens the stability of biotic integrity and therefore, hinders the ecosystem services and functions of aquatic ecosystems [6].

Lake water is a source of drinking and domestic use water for rural and urban population [7]. The main goal of the present study was to assess drinking water quality of Chimdi Lake. For this, lake water samples were collected from three different sites and sample prepared were analyzed for ambient temperature water temperature, Turbidity, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Conductivity, Hydrogen- ion-concentration (pH), Dissolved Oxygen (DO), Total hardness (TH), Chloride, Nitrate – Nitrogen ($\text{NO}_3\text{-N}$), Phosphate- phosphorus ($\text{PO}_4\text{-P}$), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and fecal coliform.

2. Materials and Methods

2.1. Site Description

The small and landlocked Kingdom of Nepal extends from

the highest peak in the world to the plains of the Terai. It lies along the slopes of the Himalaya between China and India with a land area of 147 181 sq. km being 800 km from east to west, and from 144 to 240 km north to south, between 80° 0' – 88° 0' E and 26° 0' – 31° 0' N. The country borders India to the East, South and West and China to the North. The elevation ranges from 66 to 8 848 m above sea level. Nepal has many types of wetlands scattered in the Mountain and Terai regions. Its wetlands (approx. 743,500 ha) are particularly important for threatened species [8]. Wetlands provide homes for a huge diversity of wildlife: birds, mammals, fish, frogs, insects and plants [9].

Chimdi Lake (Birju Tal) is located in Chimdi Village Development Committee of Sunsari district of Nepal; 15 km west from Biratnagar submetropolitan city of Morang district. It has an area of about 101.6 hectare. Its geographical coordinates are 87°10'51.3" E longitude and 26°29'23.5" N latitude. It is situated at an elevation of 70m above mean sea level [10].

2.2. Methodology

The physico-chemical and microbiological analysis of water was done on December 15; 2016 (post-monsoon). Water samples were collected between 9 AM to 11am from the three different representative sites and were brought to the laboratory in 2.5 L plastic container. Water samples were collected in polyethylene plastic bottles rinsed three times with distilled water for laboratory analysis.

Temperature, pH, EC and TDS were detected using a multi-parameter water quality monitoring instrument (HANNA). Dissolved Oxygen (DO) was determined by Modified Winkler Method and free carbon dioxide (FCO_2) was calculated by Phenolphthalein indicator method on the spot. Likewise, Total hardness (TH) was measured by EDTA (Ethylenediamine tetra acetic acid) method, Turbidity was measured by Digital Nephelometer-132 (Systronic), Chloride by using Volhard argentometric method, Nitrate – Nitrogen ($\text{NO}_3\text{-N}$) by Phenol Disulfonic Acid Method, Phosphate- phosphorus ($\text{PO}_4\text{-P}$) by Stannous Chloride Method, Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Chemical Oxygen Demand (COD) Biological Oxygen Demand (BOD) along with fecal coliform (by Membrane filter Technique) were measured in the laboratory by standards prescribed by APHA.

All the sample collection techniques, quality control technique and analytical methods were followed by using Standard Methods for the Examination of Water and Wastewater [11]. The result was tabulated and compared to the guide line for drinking water given by WHO [12].

3. Result and Discussion

All the results for physicochemical and microbiological parameters are enumerated in the Table-1 whereas their graphic representations are given in the Fig.-2 and Fig.-3 respectively.

3.1. Temperature (Air and Water) and Turbidity

Air temperature recorded was 24°C, 25°C and 25°C from Site I, Site II and Site III respectively and the average temperature was 24.66°C. Water temperature was 22°C from all the sites.

Clear water contains low turbidity level while muddy water contains high turbidity level. The Turbidity of the lake water was 32.4, 31.5 NTU, and 31.8 NTU from the site I to III respectively and average value was 31.9 NTU which crossed the permissible limit. The turbidity value is influenced by amount of total solids, plankton density, suspended materials and various human activities.

3.2. Total Dissolved Solid (TDS) and Total Suspended Solid (TSS)

The value of Total Dissolved Solid was 189.2 mg/L, 227.3 mg/L and 220.0 mg/L from the site I to III respectively and average value was 212.166 mg/L which was under the permissible limit. Similarly, the value of Total Suspended Solids was 187.1 mg/L, 226.21 mg/L and 219.23 mg/L from the site I to III respectively and average value was 210.846 mg/L which was crossed the tolerance limit.

3.3. Electrical Conductivity and Hydrogen-Ion-Concentration (pH)

It is a measure of the ability of an aqueous solution to carry an electric current. It depends on the presence of ions, on their total concentration, mobility and temperature of measurement. Higher value of conductivity shows higher concentration of dissolved ions. E. Conductivity of the lake water was recorded 312.2 μS , 377.8 μS and 365.6 μS from the site I to III respectively and the average value was 351.866 μS which is under the WHO guideline.

The chemical condition of normal water is reflected by its pH. pH plays an important role on the biotic life of a lentic and lotic system. The fluctuation in pH is mostly due to diurnal interplay of photosynthesis and respiratory processes of animal and plant communities. pH was recorded 7.5, 7.0 and 7.2 from Site I, II and III respectively and average pH was 7.23 which is under the permissible limit. The pH of waters varies with the geological nature of the source and the presence of dissolved solids.

3.4. Dissolved Oxygen and Total Hardness (TH)

Dissolved oxygen has the most significant role in natural waters among all the chemical substances. The amount of dissolved oxygen in Chimdi lake was found to be ranged 5.6 mg/L, 9.6 mg/L and 6.8 mg/L from the sites I to III respectively. The minimum range is 5 mg/L for drinking water.

The hardness of water is not pollution parameter but indicates water quality mainly in terms of Ca^{2+} and Mg^{2+} expressed as CaCO_3 [13]. Hardness is the indication of suitability of its use in washing and domestic purpose. The hardness in water is due to presence of divalent metallic ions,

the principal ones are calcium and magnesium. Total hardness was from 204 mg/L, 178 mg/L and 179 mg/L from site I to site III respectively and the average TH was 187 mg/L which is more than permissible limit.

3.5. Chloride

Chloride content in water may be due to the minerals like mica, apatite and from the liquid inclusions through the igneous rocks [14]. The main concentration of chloride in lakes and pond were due to fecal deposition and household sewage. It is considered as the pollution indicator when present in high concentration. Chloride values recorded 12.99, 7.99 and 5.98 mg/L, from the site I to III respectively and average value was 8.986 mg/L which was below the permissible limit.

3.6. Nitrate – Nitrogen ($\text{NO}_3\text{-N}$)

Nitrate is important nutritional factor in any water body that indicates the rate of eutrophication in the system. $\text{NO}_3\text{-N}$ is incorporated in water bodies from natural sources like sewage, household runoff, and runoff from agricultural fields. Nitrogen content of the lake water was 0.065 mg/L, 0.050 mg/L and 0.053 mg/L from the site I to III respectively and the average value was 0.053 mg/L which is under the permissible limit.

3.7. Phosphate- Phosphorus ($\text{PO}_4\text{-P}$)

Phosphorus acts as growth limiting factor and is one of the basic nutrients for plants and microorganisms. The concentration of $\text{PO}_4\text{-P}$ in the lake water was 0.129 mg/L, 0.038 and 0.131 mg/L from the site I to III respectively and

the average value was 0.099 mg/L which was under the permissible limit. It is a pollution indicator, as its higher amount causes eutrophication in freshwater and it acts as growth limiting factor and is an important nutrient for microorganisms.

3.8. Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)

Chemical Oxygen Demand is the amount of oxygen required for the oxidation of chemical wastes. COD values recorded was 87.8, 80.1 mg/L and 82.4 mg/L from the site I to III respectively and the average value was 83.433 mg/L which was above the tolerance limit.

Biological Oxygen Demand is the measure of degradable organic material present in a water sample, and is the amount of oxygen required by the micro-organisms in stabilizing the biologically degradable organic matter under aerobic conditions. BOD values recorded from the Sites I to III were 1.8 mg/L, 2.32 mg/L and 1.6 mg/L respectively and the average value was 1.906 mg/L which was under the tolerance limit.

3.9. Microbiological Examination

Fecal coliform was found in all three stations, which show that water is contaminated with human excreta and not suitable for drinking purpose. The presence of fecal coliform recorded in the water samples were 170 MPN/100 ml, 220 MPN/100 ml and 380 MPN/100 ml from the site I to III respectively and the average value was 256.66 MPN/100 ml which was essentially polluted.

Table 1. Physico-chemical and microbiological characteristics of water of Chimdi Lake of Sunsari District, Nepal (Post-monsoon, 2016).

Sl.No.	Parameters	Units	Post-monsoon (2016)				WHO Guideline
			Site I	Site II	Site III	Mean	
1	Water depth	(ft.)	3.5	6	4	4.5	-
2	Ambient Temp.	(°C)	24	25	25	24.66	-
3	Water Temp.	(°C)	23	23	23	23.0	22.25°C
4	Turbidity	(NTU)	32.4	31.5	31.8	31.9	1.5
5	TDS	(mg/L)	189.2	227.3	220.0	212.166	1200
6	TSS	(mg/L)	187.1	226.21	219.23	210.846	25
7	Conductivity	(µs)	312.2	377.8	365.6	351.866	1000
8	pH		7.5	7	7.2	7.233	6-5-8.5
9	DO	(mg/L)	5.6	9.6	6.8	7.333	5
10	TH	(mg/L)	204	178	179	187	<180
11	Cl ⁻ (mg/L)		12.99	7.99	5.98	8.986	200
12	$\text{NO}_3\text{-N}$	(mg/L)	0.065	0.050	0.045	0.053	50
13	$\text{PO}_4\text{-P}$	(mg/L)	0.129	0.038	0.131	0.099	14
14	COD	(mg/L)	87.8	80.1	82.4	83.433	40
15	BOD	(mg/L)	1.8	2.32	1.6	1.906	5
16	F. Coliform	(MPN/100 ml)	170	220	380	256.66	Nil

TDS= Total Dissolve Solid, TSS= Total Suspended Solid, DO= Dissolved Oxygen, TH = Total Hardness, Cl⁻ = Chloride, $\text{PO}_4\text{-P}$ = Phosphate – phosphorus, $\text{NO}_3\text{-N}$ = Nitrate – nitrogen, BOD= Biological Oxygen Demand, COD = Chemical Oxygen Demand. (Bold numbers indicate the crossed limit of WHO guideline)

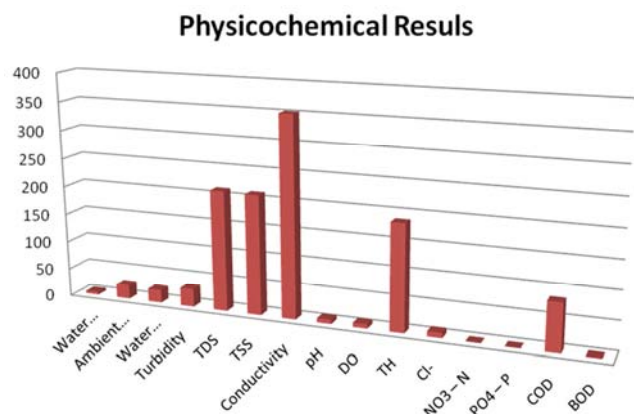


Figure 1. Physico-chemical characteristics of water of Chimdi Wetland of Sunsari District, Nepal (Post-monsoon, 2016).

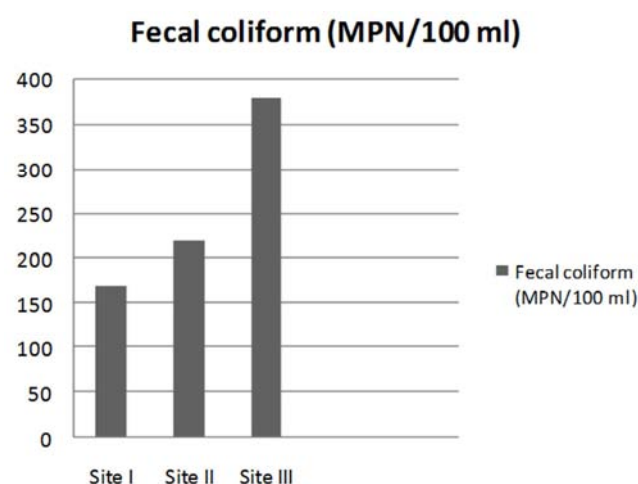


Figure 2. Fecal coliform from water of Chimdi Wetland of Sunsari District, Nepal (Post-monsoon, 2016).

4. Conclusion

The present study disclosed the physicochemical and bacteriological contamination of Chimdi lake of Sunsari district, Nepal in post-monsoon season. From the overall assessments of the present work, a unique finding was the presence of some pollutants, such as turbidity (31.9 NTU). TSS (210.846 mg/L), TH (187 mg/L) and COD (83.433 mg/L) were found to be crossed the permissible limit. The findings indicate that the sites of the studied area are in the threshold of mild pollution. High concentration of nutrients may reflect the corresponding increase in algal activity. Another significant finding of this research which supports the nature of pollution is the presence of biological species *E. coliform* in the water body of the Chimdi Lake. It was observed the bacteria, *E. coli* is isolated from all water samples. The water from the studied area should not be used

for drinking and domestic purposes from the microbial viewpoint, so that this water can only be used for multi-purpose by boiling to kill bacteria.

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