

## **1. Introduction**

Geographically, The Kingdom of Nepal is divided into three regions; Mountain, Hill and Terai accommodating 7.3, 44.3 and 48.4 percent of the population respectively. The elevation ranges from 90 to 8848 meters. There are number of peaks, rivers and Lakes in the country including Mt Everest (8848m.), the highest peak in the world. About 100 lakes and more than 1000 of ponds are distributed over the country and are found in tropical low land to high altitude i.e. in Himalayan regions. Lakes are classified into glacial, tectonic and ox- bow according to their origin (Shrestha 1919).

The middle ranges (Hill) consist of valleys and Lakes, surrounded by many beautiful snow covered mountains. Pokhara valley is one among those valleys which is surrounded by high peaks of Mt. Annapurna (8091m.) and Mt. Macchapuchhre (6996 m.). Pokhara valley comprises a subtropical type of climate and a highest rainfall area of Nepal as well and is famous for having three sizable Lakes, Phewa, Begnas and Rupa.

Phewa Lake is situated at the southern edge of the Pokhara city. This is the second largest lake of the country and the largest among the three lakes of Pokhara valley. A famous Barahi temple representing the Barahi goddess is located at a small island in the Lake. View of Annapurna and fishtail Himal are the tourist attraction centre here. So Pokhara is one of the most beautiful city of the country for its scène and beauty. The local people utilize the Lake water for various purposes like washing clothes, cleaning utensils, bathing, swimming and other recreational activities. Several pipelines are connected to the Lake for extracting water. But in the other hand the lake is found polluted by liquid waste directly discharge from the shops located at the periphery of lake side and even municipal waste as well.

Environment and Public Health Organization (ENPHO) under the Phewa Lake Environment Awareness and Capacity Building Project (PLEACBP) carried out water quality monitoring program in the Phewa Lake of Pokhara valley. The project is being implemented under the Pokhara Sub Metropolitan City to improve Phewa Lake by conservation management through initiatives of local communities to reduce urban pollution loads to the Lake. The major goal of the project is to conserve Lake through water quality management by enabling the local community through activities like supporting environmental awareness, capacity building and conservation programs.

Water quality monitoring is one of the major projects among the other activities of the project (PLEACBP). Altogether there are six different sampling sites in the Phewa Lake, and all are located in ward no. 6 Pokhara Sub Metropolitan City. These sites are Dammed site, Gaighat, Barahighat, Camping chowk, Seti Canal (Siltration Basin) and Gaira Ko Cautara.

## **2. Objectives:**

The main objective of this monitoring program is to know the water quality of Phewa Lake, pollution status and the potential cause for the pollution.

## **3. Methodology**

The description of the sampling sites, sample collection and analytical methods are described below.

### 3. 1 Description of the sites

Table 1: Name of the sites and their location

Name of the Sites	Sample Code	Municipality & VDC	Detailed information of the sampling location	Appearance of the Lake
Dam-side	P1	Ward No. 6	Final discharge point of Phirke Khola	clear
Gaighat	P2	Ward No. 6	Ending point of Phirke khola	clear
Barahi Ghat	P3	Ward No. 6	In front of famous Barahi Temple	clear
Camping Chowk	P4	Ward No. 6	Outlet of Strom water drainage	quite turbid
Seti Canal	P5	Ward No. 6	Siltration Basin	quite turbid
Gaira Ko Chautara	P6	Ward No. 6	Rain water discharged point	highly turbid

### 3.2 Sample Collection

Sample collection and analysis of water quality parameter was performed by following the Standard Methods APHA, AWWA, WPCF 19<sup>th</sup> Edition 1995.

Samples were collected from six different sites of Phewa Lake as proposed by (PLEACBP) and brought to the laboratory at Kathmandu on the same day of collection by ENPHO staff. Samples for physico – chemical parameters were collected in the pre washed polyethylene bottles which were also rinsed several times with lake water before collecting the water sample. Dissolved Oxygen (DO) was fixed immediately in the sampling spot and kept in a cool box until they reached the laboratory.

Samples from the same spots were taken for bacteriological analysis. Samples were collected in the 100ml pre – sterilized glass bottles. Bacteriological samples were collected before the collection of chemical samples in all the sites. The bottle caps up to neck were covered by thin paper with aluminum foil to protect from contamination.

Macro invertebrates were also collected from all the sampling sites. A qualitative sampling method has been adopted for determination of the macro invertebrate in all the sites. Sampling for macro invertebrates were carried out at least three times in each sampling spot. The collected macro invertebrates were sorted and preserved with 70% ethanol into a separate plastic container and labeled as well. The same processes were repeated in each sampling sites.

### 3.3 Sample Analysis

All the recommended parameters were analyzed in the ENPHO Research laboratory as per the method based on “Standard methods for the Examination of Water & Wastewater (APHA, AWWA & WEF) 19<sup>th</sup> Edition (1995)”. The list of analyzed parameters and their specific test method followed in the laboratory are given in table 2.

The identification of organisms was carried out in the laboratory using a zoom stereoscopic microscope.

The biotic index is used to classify and quantify the degree of pollution in an aquatic system by determining the tolerance or sensitivity of taxa. This method was introduced by Trent River board in 1950 and later it was developed as biotic index (Woodiwiss 1978).

**Table: 2 List of analyzed parameters and their test method**

S. N.	Parameters	Unit	Test Methods
	<b>Physico - chemical Analysis:</b>		
1	pH	-	Potentiometric
2	Electrical Conductivity	µs/cm	Potentiometric
3	Turbidity	NTU	* Spectrophotometric
4	Total Hardness as CaCO <sub>3</sub>	mg/L	EDTA titration
5	Total Suspended solids (TSS)	mg/L	Gravimetric (filtration and weighing of residue)
6	Chloride	mg/L	Argentometric titration
7	Nitrate - Ammonia (NH <sub>3</sub> <sup>-</sup> - N)	mg/L	Spectrophotometric (Phenate method)
8	Nitrate - Nitrogen (NO <sub>3</sub> <sup>-</sup> - N)	mg/L	Ultraviolet Spectrophotometric screening method
9	Orthophosphate (PO <sub>4</sub> <sup>-3</sup> - P)	mg/L	Ammonium molybdate ascorbic acid reduction method
10	Dissolved Oxygen (DO)	mg/L	Alkali - Iodide Azide Modification
11	Biochemical Oxygen Demand (BOD)	mg/L	5 days incubation at 20 <sup>o</sup> C and titration of initial and final DO.
12	Chemical Oxygen Demand (COD)	mg/L	Dichromate Oxidation & Titration with ferrous ammonium sulphate
	<b>Bacteriological Parameters:</b>		
13	Fecal Coliform	CFU/ 1ml	Membrane Filter
	<b>Biological Parameter:</b>		
14	Macro invertebrates		Identification

### 3.4 General description of the parameters

#### *pH*

This indicates the acidity or alkalinity of the water. Natural water usually has pH values between 5.0 and 8.5. These values are typical with slight seasonal variations; a sudden change would indicate industrial pollution. Many chemical reactions are controlled by pH and biological activity is usually restricted to a fairly narrow pH range of 6.0 to 8.0. Highly acidic or highly alkaline waters are undesirable because of corrosion hazards and possible difficulties in treatment.

#### *Electrical Conductivity*

Conductivity of solution depends upon the quantity of dissolved salts present. It is related to TDS content. Its value becomes greater with the increase of the degree of pollution.

#### *Turbidity*

The presence of colloidal solid gives liquid a cloudy appearance, which is aesthetically unattractive and may be harmful. Turbidity in water may occur due to clay and silt particles, discharge of sewage or industrial waste or to the presence of large number of microorganisms.

#### *Total Suspended Solids (TSS)*

TSS is due to particles, which can be measured by filtering a sample through a fine paper surface. Run off generally increases the TSS in streams. The global most common natural concentration of TSS in the fresh water is ranging from 3.0 to 15.0 mg/L (Mayback & Helmen, 1989)

#### *Total Hardness as CaCO<sub>3</sub>*

This is the property of water, which prevents lather formation with soap and produces scale in hot water systems. It is mainly due to the dissolved calcium and magnesium salts. There is no health hazard but economic disadvantages of hard water include increased soap consumption and higher fuel costs.

#### *Chloride*

It enters into the surface water due to the weathering of some sedimentary rocks, from sewerage, industrial or agricultural run off. It is responsible for the brackish taste in water and is an indicator of sewage pollution because of the chloride content in urine.

#### *Nitrogen –Ammonia (NH<sub>3</sub> - N)*

Ammonia occurs naturally in water bodies arising from break down of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of the nitrogen gas in water by microorganisms and from gas exchange with the atmosphere. It is also discharged into water bodies by some industrial processes (i.e. ammonia based pulp and paper production) and also as a component of municipal or community waste. So it is an useful indication of recent organic pollution. Higher concentration could be an indication of organic pollution such as from domestic sewage, industrial waste and fertilizer run off. Unpolluted waters contain small amounts of ammonia and ammonia compounds, usually less than 0.10mg/L as nitrogen (Chapmann, 1992)

#### *Nitrogen - Nitrate (NO<sub>3</sub> - N)*

Nitrogen - Nitrate is the final oxidation product of nitrogen. Natural sources of nitrate to surface waters include igneous rocks, land drainage and plant and animal debris. Natural levels, which seldom exceed 0.1mg/L NO<sub>3</sub> - N, may be enhanced by municipal and industrial wastewater, including leachates from waste disposal sites and sanitary landfills. In rural and suburban areas the use of inorganic nitrate fertilizers can be a significant source.

#### *Orthophosphate*

Phosphate is essential for the growth of organisms and can be nutrient that limits the primary productivity of a body of water. In instances where phosphate is a growth - limiting nutrient, the discharge of raw or treated wastewater, agricultural drainage, or certain industrial wastes to that water may stimulate the growth of photosynthetic aquatic micro- and macro- organisms in nuisance quantities.

#### *Biochemical Oxygen Demand (BOD)*

BOD is a measurement of the Oxygen required for microorganisms whilst breaking down organic matter to stable inorganic forms such as CO<sub>2</sub>, NO<sub>3</sub>, H<sub>2</sub>O. So the water with high BOD indicates the organic pollution.

#### *Chemical Oxygen Demand (COD)*

COD is used as a measurement of the Oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. Usually the concentrations of COD in surface water ranges from 20mg/L or less in unpolluted water to greater than 20 mg/L in water receiving effluents.

#### *Fecal Coliform*

Microbiological examination for fecal indicator is the most sensitive and specific method for detecting recent contamination and therefore, potentially dangerous fecal pollution. Fecal coliforms are the common indicator bacteria and is commonly known as thermo tolerant bacteria. Mostly they comprise the genus *Escherichia* and to a lesser extent some species of *Klebsiella* are also found. Presence of fecal coliform is the evidence of fecal contamination, always found the intestine of human and other warm blooded animals. Most of the fecal coliforms are *E. coli*.

If the water is contaminated with fecal matter, there is a chances of spreading of epidemic i.e. water borne diseases like dihoorea, dysentery, cholera etc. So it also one of the root cause of environmental hazardous.

#### *Macro invertebrates*

Macro invertebrates are one of the major biological water quality indicator of fresh water bodies and is a common practice of assessing water quality, especially in the European countries. Benthic macro invertebrates of lotic & lentic aquatic system can serve as an indicator of water pollution in water quality monitoring. We can assess the water quality from its presence and absence which indicates their suitability for habitation and their requirements. Because there are no single organisms or species on a habitat composition of the aquatic composition gives complex information about the properties of the surrounding waters.

## **4. Result and Discussion**

The table of physico – chemical, bacteriological and biological parameters analysis results are given in annexes.

### **4.1 Water Quality of Sampling Sites**

#### **4.1.1 Dam-side**

Dammed site is the last discharge point of Phirke Khola and is represented by (P1). The site is about 5 km far from Pokhara Sub Metropolitan city office. The concentration of most of the physico- chemical parameters are found to be not so hagdardous as compared to EC standard for surface water quality. However the value of BOD and COD are found to be slightly high as than the EC standard of surface water quality. The other parameters are normal as found in natural water bodies at the time of sampling.

Bacteriologically, the site shows domestic pollution i.e. the water is contaminated with Faecal coliform which is mainly due to fecal matter contamination.

Among the macro invertebrates, Hirudinea, Chironomidea, Lubriculidae and Hydrobiidae are found in this site.

#### 4.1.2 Gaighat

The Gaighat is the last point of Phirke khola and is represented by code (P2). The site is located just behind the training center of Shasastra Police Force. The site looks like a dumping site, polluted by dispersion of solid wastes like paper, plastics, bottles, many metallic containers and so on. However analyzed physico – chemical parameters are found normal as found in natural water bodies. Samples were collected near the dam, flow rate of water is quite high. The high value of COD found is comparison to BOD value is due to the minute organic suspended particulates which could not be degradable bacteriologically but only oxidized by chemical oxidation.

Bacteriologically, the site is found to be more polluted due to fecal matter contamination. It might be due to domestic sewage pollution.

Hirudinea and Lubriculidae are the major macro invertebrate groups are found in the site Gaighat. In this site flow rate of water is quite high than the other sites.

#### 4.1.3 Barahighat

The site is famous for the popular temple of Barahi. The sampling site is located just front side of a small island and is represented by the code (P3). The site is crowded by local people as well as tourists because of being the entrance point to the island and is way to the temple. Many small shops are also concentrated around the sites. The water from the lake is directly used by the shops for various purposes and wastewater is directly discharged in to the lake by open drain. Yet the concentration of most of the physico – chemical parameters are found to be normal as found in the natural water.

Bacteriologically, the site is found to be contaminated with fecal coliform which is mainly due to fecal matter contamination.

Among the macro invertebrates, Hirudinea, Chironomidea, Anisoptera, Zygoptera and Oligochaete are found in this site.

#### 4.1.4 Camping Chowk

The site is an entrance for boating in the lake and also a sight seeing place for the tourist. It is represented by the code (P3). So the area is crowded as well. Municipal waste is discharge directly in to the lake. The concentration of some of the analyzed physico – chemical parameters shows normal. However COD & BOD are found quite high and water is turbid as well.

Bacteriologically the site is found to be highly polluted with fecal matter contamination as compared to other sampling sites.

In this site, Hirudinea, Zygoptera and Lymnacidiae are only found.

#### 4.1.5 Seti Cannal (Siltation Basin)

The site is located near the core residential area and is represented by the code (P5). A Seti Cannal is directly discharge to the lake where municipal waste water drainage is connected. Many restaurants, hotel tourist shopping centre are located around the site as well.

Bacteriologically, the lake water sample is also found to be contaminated with fecal matter.

Among the macro invertebrates, Anisoptera, Oligochaeta and Lymnecidae are found in this Seti Cannal.

#### 4.1.6 Gaida Ko Chautara

It is about 15 km far from the PSMC office. The Lake water also is polluted and here the surface of water is covered by weeds like Trapa. Water is almost stagnant in conditioned. It is about 15 km far from the PSMC office. Water is quite turbid. Even though the site is polluted. DO is found very high. It can be due to the dissolved oxygen produced by photosynthesis process of the floating aquatic plants. Bacteriologically, site is found polluted with fecal matter contamination.

In the macro invertebrate groups, chironomidea, Dygopteraand Culicidae etc are found.

## 5. Conclusion

On the basis of analyzed physico – chemical parameters, the water quality in all the sampling sites of Lake Water have no health risk. Most of the tested parameters are normal as found in natural surface water bodies. Among the six sampling sites the water is found quite turbid in the site P6. High concentration of BOD and COD are recorded at P4, P5, and P2 respectively and water is turbid as well in all the sites, which is mainly due to domestic as well as organic pollution.

However, bacteriologically, the water quality of lake in all the sampling sites were found heavily polluted with fecal coliform. Hence lake water has high health risk factor because they are all highly polluted with fecal matter contamination. Fecally polluted water may contain a variety of intestinal pathogens (disease causing organisms). If the water source is contaminated with fecal matter of human and other warm blooded animals, it can caused water borne diseases such as typhoid, dysentery, cholera, jaundice, gastroenteritis etc. More than fifty diseases are transmitted through contaminated water. So water can be extremely dangerous when it becomes the vehicle of transmission of diseases. There are also chances of skin diseases as well.

Thus all the sampling sites of lake is found to be polluted with domestic as well as municipal liquid waste i.e. sewerage, which might have interred from settlement area which direct impact is fall into the Lake.

Hence the water from the lake can not be used, not only for drinking for other domestic purpose like cleaning, washing, swimming, even bathing etc. without disinfecting it before removing the turbidity.

Biologically, the water quality of Phewa Lake shows polluted as well due to the polluted group of macro invertebrates are recorded. Abundance of Macro invertebrates was very less in all the sampling sites. On the basis of macro invertebrates water quality class is II – III and the degree of pollution is mesosaprobic.

From the over all point of view, WHO has no guideline value for surface water quality. Although, it can be compared with the standard of the European Community for raw water sources for potable water abstraction. The comparison shows that the water quality can be used and is categorized under the class A2 on the basis of average concentration of analyzed parameters. But the kind of water can be supplied only by normal full physical and chemical along with

disinfection treatment. (Annexes).

## **7. Recommendation and Suggestion**

- Only discharged points are selected for sampling points. Hence the water quality of sampling sites does not represent the Phewa Lake water quality as a whole.
- Recommended parameters for analysis are not sufficient to study the water quality of Phewa Lake and complete health risk factor.
- Steps should be taken to reduce the pollution load discharge directly to the lake Phewa, especially sewerage drainage.
- If the sewage drainage, wastewater, water quality is deteriorated and its direct impact is fall on human health as well as aquatic environment of lake.
- As one of the famous lake, as well as tourist point of view Phewa Lake water should be preserved for the protection of natural environment.
- It is recommended that first to control the discharge of pollution load i.e. chemical load (wastewater discharge) to help to maintain the water quality of Phewa.
- Wastewater should be suitably treated before discharging into the Lake.
- Solid wastes should not be dumped around the Lake, because it creates nuisance and also deteriorate water quality as in P2 site.

## **8. References**

ENPHO, 1996 A reports on “The Water Source Monitoring Program for the Shivapuri Watershed by Assessing Water Quality”.

Shakya, S. K. (2000), water Pollution into the Urban Rivers of Kathmandu. Ph. D. Thesis, University of Agricultural Sciences, Vienna.

Shrestha, R. R. (1994) A Review of Limnological Studies and Research in Nepal, Kathmandu, Nepal

Standard Method for the Examination of Water and Wastewater (APHA, AWWA, WEF) 19<sup>th</sup> Edition (1995)

T. H. Tebbutt, (1992) Principles of Water Quality Controlle fourth edition, pergamon press.

Woodiwiss, F. S. (1978), Comparative study of biological water quality assessment methods. Summary report. Commission of European Committes. Seven Trent River water Authority, UK, 45pp.