

## Physico-Chemical and Bacteriological Characteristics of Umiam Lake, Meghalaya, India

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### Abstract

The objective of this study was to determine the bacterial contaminations of Umiam Lake in Meghalaya, Northeast India. Thirty six water samples from three different locations were collected for seven months. Ecological parameters like dissolved oxygen, pH, nitrate, phosphate and bacterial population were analyzed and compared with standard permissible limits of BIS and WHO. Total coliform, faecal coliform and faecal Enterococci were detected using the most probable number method. Results revealed that the three indicator bacteria were abundant in all water samples. Percentages of the three indicator bacteria count were above the permissible limits for drinking water in all samples. They were 72.20% total coliform, 91.60% faecal coliform and 32.40% faecal Enterococci. Enteric bacteria isolated were *Escherichia coli* (35.85%), *Enterococcus faecalis* (27.72%), *Klebsiella* (15.78%), *Staphylococcus* (4.55%) and *Pseudomonas* (3.60%). All these bacteria were isolated throughout the study period. Data suggested the importance of public health education aimed at improving personal, household and community hygiene.

**Keywords:** Bacterial contamination; coliform bacteria; public health; Umiam Lake.

### Introduction

The increasing vulnerability of natural resources and the environment to pollution is one of the grand challenges to humanity in recent times. Water, which is essential to all forms of life and makes about 50–97% of the weight of all plants and animals, is the most poorly managed resource in the world (Buchholz, 1998 and Fakayode, 2005). About 20% of the world's population lack access to safe drinking water (UNEP 2000). The quality of surface water is constantly changing in response to daily, seasonal, and climatic rhythms. The quality of surface water also depends on the equilibrium between the physical, chemical, and

biological characteristics of the surrounding environment (Langmuir, 1997 and Lester and Birkett, 1999). The proportion of available but polluted water is continuously increasing as a result of changes in the modes of industrial activities, agricultural production, and increasing urbanization (Pestle, 1997).

Although statistics vary, the World Health Organisation (2006) reports that approximately 36% of urban and 65% of rural Indian's were without access to safe drinking water. Normally, water is often used for domestic purposes especially for drinking. Water is the source of all biological lives and their sustenance too. Water for different purposes has its own requirements

for the composition and purity and each body of water has to be analysed on a regular basis to confirm the suitability. Drinking contaminated water can cause diarrhoea, cholera, dysentery, and various other diseases like Typhoid, Amoebiasis, Jaundice, Enterobacteriaceae, etc. (Mishra, 2010). Many infectious diseases are transmitted by water through the fecal-oral route. Diseases contacted through drinking water kill about 5 million children annually and make 1/6<sup>th</sup> of the world population sick (WHO, 2003).

The safety of drinking water can be monitored in a number of ways because the constituents of drinking water (such as chemicals and microbes) which can compromise human health can be measured directly. The reason for monitoring drinking water quality is to determine whether the water supply system is being operated correctly, implying that the water is safe for drinking or not. Indicator microorganisms survive better and longer than the pathogens with a uniform and stable properties and may easily be detected by standard laboratory techniques (Chatterjee *et al.*, 2007). Ideally, drinking water should not contain any microorganisms known to be pathogenic or any bacteria indicative of faecal pollution. Detection of faecal indicator bacteria in drinking water provides a very sensitive method of quality assessment and it is not possible to examine water for every possible pathogen that might be present (WHO, 2006).

In India, many researchers constantly undertake work on assessment of physiochemical and microbiological quality of water bodies (Singh 2006; Mishra and Bhatt, 2008) however, in Meghalaya; bacteriological examination of water for drinking purposes is very limited. The probability of ingesting infective dose of disease causing microorganism is very high considering the fact that water borne pathogens generally have low infective dose. The objective of this work is to evaluate

the general bacteriological and physico-chemical parameters of the Umiam Lake, Barapani which acts as the main source of drinking water to local people apart from storing water for electricity generation.

## Materials and Methods

### *Study site description*

The study was carried out on the Umiam Lake, which is located around 15 Km from Shillong the capital of Meghalaya, North-Eastern region of India. The lake which spread over an area of 10 square km has the distinction of being primarily an artificial reservoir for the first hydel project in the region. The principal catchment area of the lake and dam is spread over 220 square km, which includes Shillong and its adjoining areas, besides a portion of Ri Bhoi district. Apart from storing water for electricity generation, the lake also provides downstream irrigation, fisheries and drinking water which cater to the local anthropogenic needs. The Lake is also a popular venue for the water sport and adventure facilities. The lake has been developed by the Meghalaya Tourism Department in spite of the fact that the management of the lake lies completely with the Meghalaya State Electricity Board.

On the basis of land use, the study area can be demarcated into four categories: agriculture, human settlement, vegetation cover, and water bodies. The catchment area is densely populated because of rapid urbanization during the past few decades. The main sources of water pollution include most of the drains and gutters in the entire township that are channeled into the lake through the rivers and their tributaries.

### *Sample collection and analysis*

Thirty six water samples were collected from three different locations of Umiam lake i.e Site 1, Site 2 and Site 3, Samples were examined throughout 7 months

i.e. October 2010 to April 2011. To avoid contaminations, sterile disposable gloves were worn during water sampling. The water samples were kept in airtight large plastic ice-cold containers and were transported to microbiology laboratory within 6 h of their collection for further processing.

pH were measured on the field at the time of sampling. The experimental methods for other parameters such as dissolved oxygen (DO), phosphate, nitrate, are carried out as outlined in Standard methods for examination of water and waste water (APHA, 1998).

#### ***Bacteriological examination***

The bacteriological examination of water samples includes most probable number (MPN) of presumptive coliforms, faecal coliforms and faecal streptococci (MPN/100 ml water) using the Multiple Tube Fermentation Technique (APHA 1998). Suspected colonies of coliform groups were also identified on the basis of morphological, cultural and biochemical characteristics.

#### ***Statistical analysis***

The relationships between bacteriological and physico-chemical parameters for all the study sites were analyzed by calculating Pearson's correlation coefficient ( $r$ ) values. Standard error was also calculated using XLSTATS 2009.

### **Results and Discussion**

#### ***Physico-chemical analysis of water samples***

The physico-chemical analysis carried out from the different site during the study period has been presented in (Fig.1 - 4). The pH values did not show remarkable differences between sampling sites and ranged 7.02 to 8.84 (Fig- 1). The range for pH in water for

domestic use is 6.5 to 8.5 (WHO 2003). All of the values of pH obtained for the streams fell within this range but were slightly above the natural background level of 7.0. This increase in pH of the water samples above the normal background levels may be due to the presence of dissolved carbonates and bicarbonates which are known to affect pH of almost all surface water (Chapman, 1996).

The value of DO is remarkable in determine the water quality criteria of an aquatic system. In the system where the rates of respiration and organic decomposition are high, the DO values usually remain lower than those of the system, where the rate of photosynthesis is high. The mean value of the dissolved oxygen ranged from 2.1 to 8.7 mg/l (Fig - 2). The low DO values at the various sampling points might be attributed to the fact that the waste discharge within the watershed contains high concentration of organic matter and nutrients that are highly oxygen demanding (Chapman, 1996).

Nitrate concentration in the three study sites ranges from 0.011 to 0.058 mg/l (Fig - 3), with all samples falling within the desirable limit of 45 mg/L. As such, the water of Umiam Lake does not pose any nitrate hazard to humans. Nitrate is an effective plant nutrient and is moderately toxic. A limit of 45 mg/L has been prescribed by WHO (2006) and BIS (1991) for drinking water supplies. Its concentration above 45 mg/L may prove detrimental to human health. The concentration of phosphate in the study area is also quite low at all the locations. The values of phosphate range from 0.06 to 0.62 mg/l in all the three sites (Fig - 4). The concentration of phosphate in ground water is usually low, but various chemical processes in soil strata may induce the mobility of phosphate in sub-soil and ground water.

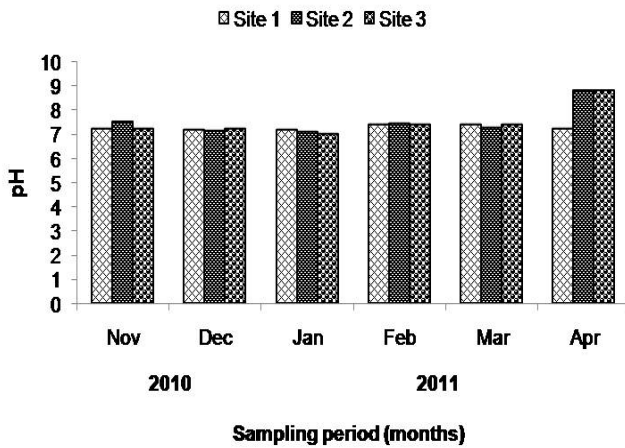


Fig – 1. Variations of pH at three different sites

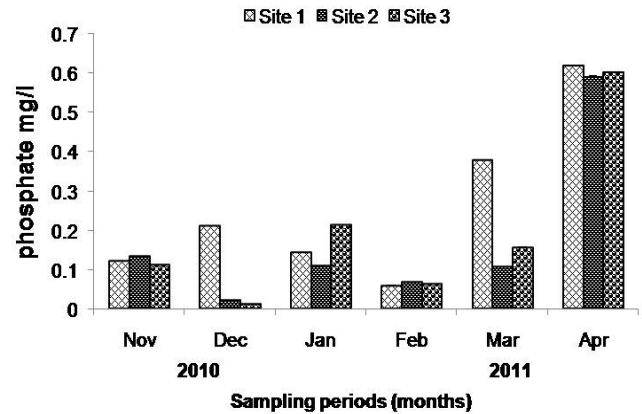


Fig – 4. Variations of phosphate at three different sites

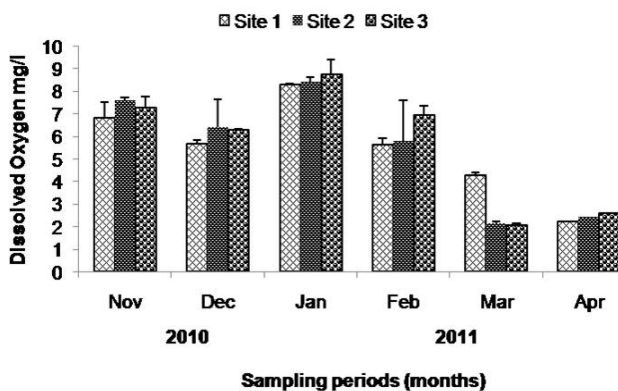


Fig – 2. Variation of dissolved oxygen at three different sites

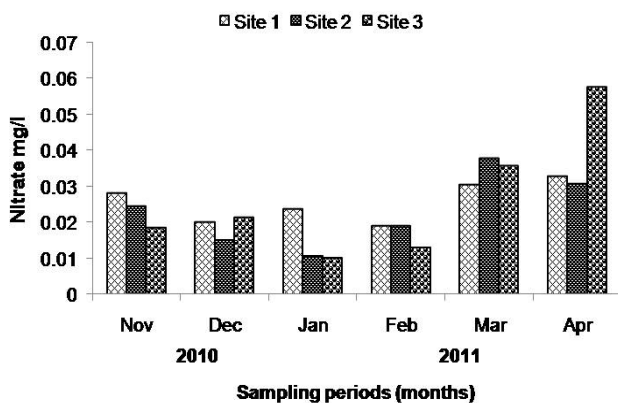


Fig – 3. Variations of nitrate at three different sites

### Bacteriological analysis

MPN or multiple tube method was used to detect and count indicators bacteria as they are considered as an evidence of faecal contamination and presence of pathogens (Sanderson *et al.*, 2005; Akoachere *et al.*, 2008). Of 36 water samples examined from all three locations, 72.2 % showed an account above the standard (10 coliform per 100 ml) level of low risk for total coliforms. On the other hand 91.6% of total coliform have expressed faecal coliform count above the standard (zero faecal coliform per 100 ml) for drinking water. Whereas, 32.4% of all samples have shown *Enterococcus* group count above the standard (zero *Enterococci* per 100 ml) for drinking water (Table - 1).

Enteric bacteria isolated in total were *Escherichia coli* (35.85%), *Enterococcus faecalis* (27.72%), *Klebsiella* (15.78%), *Staphylococcus* (4.55%) and *Pseudomonas* (3.6%). In all three sites, the most frequently isolated bacteria were *E. coli* (12.35%) and *E. faecalis* (12.1%) with the highest contamination in Site 3. This was followed by *Klebsiella* with the highest contamination (7.86%) in Site 1. *Staphylococcus* was isolated from Site - 1 and site - 2, but not from Site 3, whereas

Table – 1. Indicators Bacterial count per 100 ml of all samples

Total coliform count			Faecal coliform count			Enterococci group count		
MPN	Freq	%	MPN	Freq	%	MPN	Freq	%
≤ 10.TC/100 ml	10	27.8	≤ 10.FC/100 ml	3	8.4	≤ 10.EC/100 ml	23	67.6
≥ 10.TC/100 ml	26	72.2	≥ 10.FC/100 ml	33	91.6	≥ 10.EC/100 ml	11	32.4
Total	36	100		36	100		34	100

MPN most probable number of bacteria, TC= total coliform, FC= faecal coliform, EC = Enterococcus group

Table – 2. Bacteria isolated from three different sites

Site	Bacteria				
	<i>E. coli</i>	<i>Enterococcus faecalis</i>	<i>Klebsiella</i>	<i>Pseudomonas</i>	<i>Staphylococcus</i>
Site 1	9.32	6.44	7.86	0	1.66
Site 2	9.18	9.18	3.8	1.14	2.89
Site 3	12.35	12.1	4.12	2.46	0
Total	35.85	27.72	15.78	3.6	4.55

Table – 3. Correlation coefficient (r) values between bacteria and various physico-chemical and water samples in the three different sites ( $p < 0.05$ ).

Study Site	Water properties	DO	pH	NO <sub>3</sub>	PO <sub>4</sub>
Site 1	TC	0.84	0.91	-	0.76
	FC	0.76	-	0.62	0.85
	EC	0.86	-	0.67	0.63
Site 2	TC	0.93	-	-	-
	FC	-	-0.63	-	0.76
	EC	0.76	-	0.67	-
Site 3	TC	0.56	-	0.76	0.83
	FC	0.71	-	0.80	-
	EC	-	-	0.56	0.76

NB: DO=Dissolved oxygen, NO<sub>3</sub>= nitrate, PO<sub>4</sub>= phosphate, TC= total coliform, FC= faecal coliform, EC= Enterococcus group

*Pseudomonas* was isolated from Site 2 and Site 3 but not from Site 1. Though not frequently isolated, highest contamination observed for *Staphylococcus* was 2.89% and *Pseudomonas* was 2.46% respectively. Site 2 showed continuous level of contamination by all bacteria through the study period (Table - 2).

According to WHO (2006) *E. coli* or *Faecal coliform* should not be present in drinking water. *Faecal coliform* are found abundantly in the intestine of human and warm-blooded animals and their presence in different source is of no doubt reflect faecal contamination since they represent a more specific indicator of faecal contamination (Djuikom *et al.*, 2006). *Faecal coliform* exceeding the limits indicates recent contamination of the water sources with faecal matter and hence the possible presence of intestinal pathogens. Laboratory analysis of water samples in this study showed that faecal matter heavily contaminated water samples in the Lake. Poor sanitary practices could be one of the main causes of indicator bacteria from faeces being introduced into stored water (Ologe, 1989).

In this study, *Enterococcus* group count was above zero per 100 ml. *Enterococcus* group provide supplementary data on bacteriological quality of water and augment the faecal contamination of water (Laukova and Juris 1997). Results suggest contamination is widespread during the entire study period. This report was in accordance with Rajurkar *et al.* (2003). High prevalence of *E. coli* and *E. faecalis* was observed in this study in all the three sites; other coliform such as *Klebsiella*, *Staphylococcus* and *Pseudomonas* species isolated in drinking water increases the possibility of the presence of pathogenic bacteria. In terms of public health significance, *E. coli* has frequently been reported to be the causative agent of traveler's diarrhoea, urinary tract infection, *haemorrhagic colitis* and *haemolytic uraemia* syndrome, while *Klebsiella*

is associated with pneumonia and upper respiratory tract infection. Presence of pathogenic bacteria like *Pseudomonas* and *Staphylococcus* in water also, may cause acute to severe disease on getting suitable host and condition (Fewtrell and Bartram, 2001; Kistemann, *et al.*, 2002 and Mishra *et al.*, 2009).

#### ***Relationship between Coliform Bacteria and physico-chemical parameters***

Table - 3 shows positive correlation between physico-chemical parameters with the faecal Coliform content of the surface waters, thereby confirming continuous pollution of the lake. Negative health effects have been detected in association with the use of raw or poorly treated waste water for irrigation, recreational activities and other purposes (Crowther *et al.*, 2001). This finding correlates with the study of Mishra *et al.*, (2009) who conducted a study to detect seasonal and temporal variations in physico-chemical and bacteriological characteristics of river Ganga in Varanasi.

#### **Conclusion**

In conclusion, the bacteriological quality of the water was unacceptable, and would pose serious health risks to consumers who use them without treatment. The percentages of the three indicator bacterial count detected were above the permissible limits for drinking water in all samples. Data suggested the importance of greater attention for household contamination, environmental sanitation control and the raise of awareness about water contamination. Improvement in water quality and availability will aid hygienic practices and interrupt the transmission of enteric pathogens through contaminated water in the study area. Provision of sewerage systems and public health education aimed at improving personal, household and community hygiene is imperative.

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