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Assessment of Water Quality Deterioration in Sacred Ponds of Varanasi: Impact of Urbanization, and Pollution

Mandakini Gupta[1,*], Adeeti Rai[2], AnjaliYadav[3], Ritu Singh[4], Rishi Sahu[4], Samta Singh[5]

Abstract

Water scarcity, pollution, political unrest, and population growth have made it imperative to manage water resources, including surface water, responsibly in the twenty-first century. The ponds deteriorate due to development, urbanization, and the burden of many polluting sources. Varanasi had roughly 110 pounds and kunds in the 1980s; today, there are only 56. The physical and chemical quality parameters of five significant sacred ponds that have existed in Varanasi from ancient times are examined in this paper during the academic year 2012–2013. The primary water quality indicators that were looked at were temperature, pH, conductivity, total dissolved solids (TDS), acidity, hardness, nitrate, phosphate, dissolved oxygen (DO), and biochemistry. The findings of the experiment indicate that the levels of nitrate (52 mg/L), BOD (2.5 mg/L), TDS (2420 mg/L), and phosphate (7.5 mg/L) were significantly higher than the allowable limit of the water quality standard for drinking and irrigation (BIS, IS-10500, FAO). Out of the five ponds, the water quality at the Durga Kund, Lahartara, and Adityanagar sites is unacceptable, particularly in terms of human health, biotic life, and the ecosystem as a whole. The investigation of the catchment region to determine the primary cause of the decline in the quality of the water in these ponds has shown a number of ritualistic practices, municipal wastewater, washing discharge of temple effluents, and animal wastes.

Keywords: Water quality, sacred ponds, Varanasi, pollution, nitrate levels, urbanization impacts

***Author for Correspondence**
Mandakini Gupta
E-mail: mandakini1710@gmail.com

[1]Assistant Professor, Department of Chemistry, Sunbeam Women's College, Varuna, Varanasi, Uttar Pradesh, India
[2]Student, Department of Botany, Sunbeam Women's College, Varuna, Varanasi, Uttar Pradesh, India
[3]Student, Department of Chemistry, Sunbeam Women's College, Varuna, Varanasi, Uttar Pradesh, India
[4]Assistant Professor, Department of Botany, Sunbeam Women's College, Varuna, Varanasi, Uttar Pradesh, India
[5]Research Scholar, Department of Chemistry, K.S. Saket P.G. College, Ayodhya, Uttar Pradesh

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INTRODUCTION

Owing to the increasing rate of urbanization and population growth, water resources are depleting daily and more quickly. The degradation of water quality is an international issue [1]. In most of India, tiny bodies of water, such as ponds and kunds, have been used to store rainfall since ancient times. Throughout the year, this body of water serves as a reservoir for a variety of uses [2]. India's holiest city was Varanasi. Throughout the year, pilgrims travel to this historic city in Uttar Pradesh, India for ritualistic purposes. Religious ceremonies are frequently held at sacred kunds (a body of water close to the temple) and significant ponds. In Varanasi, there are several well-known ponds, including Laxmi Kund, Sarang Talab, and Iswargangi. According to recent reports by Pal et al., a number of ponds in Varanasi are severely contaminated as a result of several anthropogenic activities [3]. According to Chaurasia and Pandey (2007), [4] anthropogenic activities in ponds eventually degrade water quality, accumulate hazardous chemicals and silt, and reduce the catchment area, which results in a loss of aesthetic value [5]. Pond water degradation is primarily caused by pilgrims and the ritualistic behavior of the local populace [6].

In India, washermen and villagers have used artificial ponds as a replacement for natural water sources for bathing and laundering. Ponds in Varanasi are usually found next to the temples. Consequently, bathing, especially for visitors to temples for religious purposes, and the removal of rubbish from temples are two of the main sources of pollution (Chaturvedi and Kumar, 2011) [7]. The trophic status of aquatic ecosystems is largely determined by their physicochemical parameters [8]. The current study was conducted to examine the water quality of the Varanasi Pond because it is crucial for irrigation, drinking, and groundwater replenishment. The physical and chemical characteristics of any water body can be studied, but doing so mostly depends on the weather at the time and the structural state of the catchment area. Sampling sites and sample collection.

Five ponds located throughout Varanasi city provided water samples that were used for the investigation of physicochemical parameters (Figures 1 and 2). For sample analysis, the American Public Health Association (APHA) 2005 standard protocols were adhered to [9]. Samples were gathered into five-liter plastic containers that had been rinsed twice with double-distilled water. Following agitation, containers from each of the five sampling locations were submerged two feet below the pond's surface for sampling. The water samples were transported to the laboratory and refrigerated at 40°C so that a few parameters could be analyzed.

MATERIAL AND METHOD

Samples were collected from five different Kunds of Varanasi. The pH, hardness, acidity, chloride content, and total alkalinity of the water samples from each pond were measured using titrimetric techniques. The total suspended solids and dissolved solids were estimated using a calculation approach. The chemical oxygen demand, biochemical oxygen demand, and dissolved oxygen values were estimated using Winkler's method. A comparison was made between the experimental results and the standard for acceptable drinking and irrigation water quality [10].

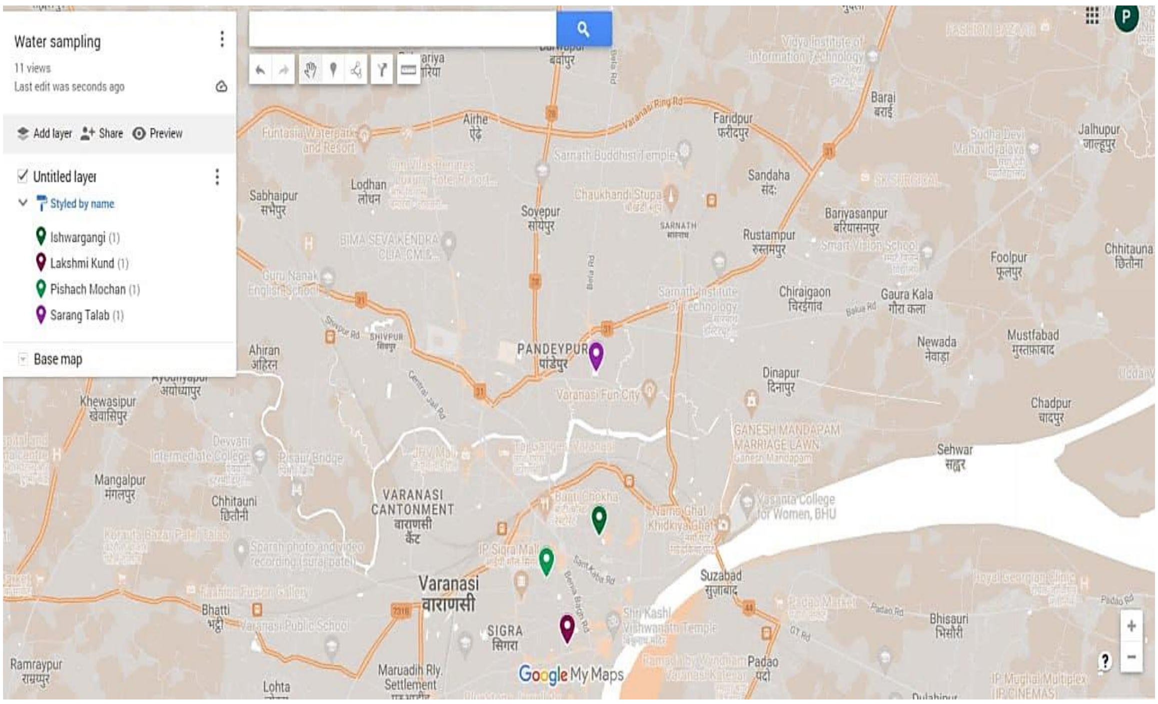

Figure 1. Collection sites of water samples (Google Map Satellite Image).

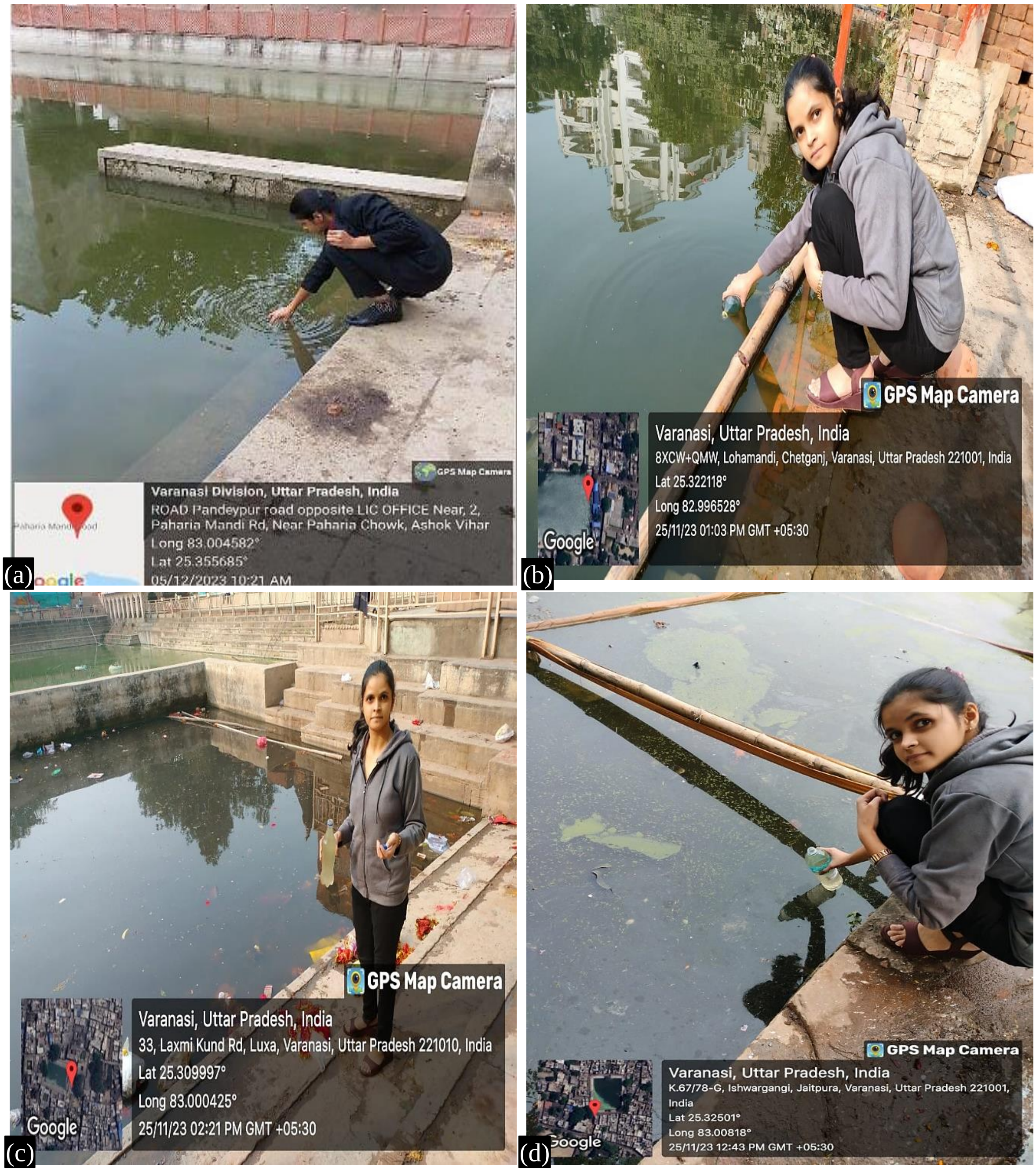

Figure 2. Collection of water samples from (a) Sarang Talab, (b) Pishach Mochan Talab, (c) Laxmi Kund, (d) Ishwargangi Pond.

Reagents: EDTA, Eriochrome Black-T, NH_2CL, Ammonia Buffer, Magnesium Carbonate, 90% ethyl alcohol, and distilled water.

Reagent Preparation

EDTA solution: Distilled water (800 ml of distilled water was mixed with 0.1 g of magnesium bicarbonate and 4 g). 100 milliliters of 95% ethyl alcohol should be mixed with 0.4 grams of Ericochrome Black-T and 4.5 grams of hydroxylamine hydrochloride. Ammonia Diversion: 16.9 g of NH4CL in 143 ml of concentrated NH4OH is Stock A. 1.25 g of EDTA magnesium salt dissolves in 50 ml of distilled water is Stock B. Combine the two stock solutions, then use DDW to dilute to 250 ml. Using DDW, 10 ml of this solution was diluted to 100 ml.

Total Dissolved Solid

Water is an excellent solvent that can readily absorb contaminants. Pure water, which has no taste, color, or odor, is commonly referred to as a universal solvent. "Dissolved solids" are minerals, salts, metals, cations, or anions that dissolve in water. Total dissolved solids (TDS) are created when organic matter dissolves in water. TDS is mostly composed of trace amounts of organic matter and inorganic salts, primarily calcium, magnesium, potassium, sodium, bicarbonate, chlorides, and sulfates. Positively charged cations and negatively charged anions together constitute the total concentration of dissolved solids in water. Therefore, the total dissolved solids test only provides a qualitative estimate of the quantity of dissolved ions, rather than revealing their composition or ion connections. Elevated TDS levels do not pose health concerns. The TDS content is regulated as a secondary drinking water standard because it is more of an aesthetic concern than a health concern. A greater TDS implies the following: Many have elevated ion concentrations, such as those of nitrate, arsenic, aluminum, copper, and lead, which are higher than the Primary or Secondary Drinking Water Standards. The concentration of dissolved ions can lead to scale formation, alter and lower the efficiency of water heaters, and give the water a brackish, salty, or caustic flavor [11, 12].

Procedure

The water sample was filtered through Whatman filter paper and the filtrate, along with rinse water, was collected in a flask. The weight of an empty dried container (ceramic dish or evaporating dish) was recorded. The filtrate was then placed in a container and baked for 24 h at 103°C. To enable the sample to dry for a maximum of eight hours, the drying oven temperature was increased to 180°C.

After drying, the container was removed gently from the oven. The sample was then placed in a desiccator with dry air for at least three or four hours. After cooling, the container was weighed three or more times. The final result for TDS was given in milligrams per liter.

A TDS concentration of less than 500 mg/L in water satisfies the drinking water criteria set by the Environmental Protection Agency. While a high TDS may suggest unappealing aesthetic attributes in terms of color, taste, smell, etc., it does not always mean that water is harmful to drinking. To address concerns about the safety of drinking water, professional testing is recommended.

Total Hardness

The cause of hardness in water is the presence of dissolved magnesium and calcium salts. It is not suitable for bathing, washing, or drinking, and causes boiler scales. Therefore, it is necessary to estimate the quantity of chemicals that cause hardness in water samples. The quantity of chemicals required for water treatment can be computed once it has been estimated. Complexometric titration is the basis of hardness estimation. Titration with a standard ethylene diamine tetra acetic acid (EDTA) solution, a complexing agent, was used to measure the hardness of water in this experiment; EDTA's disodium salt was used because the chemical is insoluble in water. EDTA can create four or six coordination connections with a metal ion. Water has two types of hardness: transient and permanent. The presence of calcium and magnesium ions caused the temporary hardness. Boiling can be removed readily. The presence of chlorides and sulfates in the calcium and magnesium ions causes permanent hardness. This type of hardness cannot be eliminated by boiling [13].

Procedure

The burette was filled with a standard EDTA solution. A 50 mL sample of water was collected in a flask. Samples containing a high concentration of calcium were diluted to 50 mL with a lower amount.

Next, 1 mL ammonia buffer was added to each sample. Following this, five to six drops of Eriochrome Black-T indicator were added, causing the solution to turn a wine red color. An initial reading of the burette is noted. The sample was then titrated with EDTA solution until the endpoint was reached, as indicated by a color change from wine red to blue (Figure 3). The process was repeated after the final reading was recorded until concordant values were reached.

Figure 3. Estimation of total hardness by EDTA method.

A second 50 mL sample was obtained and cooked in a different flask. The final volume was obtained by the addition of distilled water. Steps 3–7 were then repeated for the boiled sample.

pH Measurement

The measurement of hydrogen ion activity in a solution is referred to as "pH." Since it is exceedingly difficult to detect pH directly, certain electrodes are required to determine pH quickly and accurately. On a scale of 0 to 14, the pH is expressed as follows: lower numbers represent high H+ (more acidic), whereas higher values represent low H+ ion activity (less acidic) is regarded as the neutral pH. The concentration of hydrogen ions increases or decreases by ten times for each full pH unit. The pH range of most natural waters is 5.0 and 8.5. Rainwater has a pH range of 5.4 to 6.0. Because of its reactions with minerals and soils, the concentration of H+ ions are reduced, resulting in an alkaline pH of 8.0–8.5. Increased acidity (pH9) and other abrupt variations in the hydrogen ion concentration (pH) indicate that the presence of hazardous pollutants in water bodies has a negative impact on the quality of water. The pH meter consists of three parts: a detecting unit consisting of a glass electrode, a reference electrode (typically a calomel electrode connected by a KCl Bridge to the pH-sensitive glass electrode), and an indicator unit that displays the pH corresponding to the electromotive force that is then detected. Before taking measurements, the pH meter must be calibrated using a minimum of two buffers [14–19].

Procedure

The electrode tip was rinsed with deionized water. The reference electrolyte at the tip of the electrode was released by pressing the dispenser button on top of the electrode until a click was heard. The readings were monitored until they became steady, as indicated by the "READY" indicator and meter beeping once. The results, including temperature, were recorded. If the readings became erratic, additional electrolyte was dispensed.

RESULTS AND DISCUSSION

The following parameters were used in the study's analysis of differences in physico-chemical features; the findings are discussed below.

Total Dissolved Solid

The TDS of collected water samples is mentioned in Table 1.

Weight of dry filter paper - 2.155

TDS= (Weight of filtrate) - (weight of the filter paper)

Table 1. Total dissolved solids in different water samples.

S.N.	Samples	Weight of filtrate	TDS
1	Lakshmi Kund	6.905	4.75
2	Pisachmochan	6.850	4.695
3	Ishwargangi	7.335	5.18
4	Sarang talab	6.215	4.06
6	Tap water	6.180	4.025
7	Drinking water	7.065	4.91

Table 2. Total hardness in different water samples.

S.N.	Water sample (50ml)	Total hardness
1	Lakshmi Kund	210
2	Pisachmochan	172
3	Ishwargangi	253
4	Sarang Talab	155
5	Tap water	80
6	Drinking water	75

Table 3. pH of different water samples.

Sample	Lakshmi kund	Pisachmochan	Ishwargangi	Sarang talab	Tap water	Drinking water
pH	7.20	6.92	7.05	6.93	7.36	7.60

Total Hardness

The total hardness of different water samples is mentioned in Table 2.

When Erichrome Black-T was introduced, the color of soluble distilled water and RO water rapidly changed to blue, but the color of tap and pond water turned wine red and eventually turned blue when titrated against EDTA solution.

pH Measurement

The pH was determined by the electrode method as shown in Figure 4.
The pH of different water samples is mentioned in Table 3.

Figure 4. Determining pH using a pH meter.

CONCLUSION

Analysis of the physicochemical parameters of several ponds in Varanasi makes it abundantly evident that water is unsuitable for human consumption and that aquatic life is also in danger of disappearing. Therefore, to benefit people and the environment, these hidden water bodies urgently need to be improved, restored and managed properly. Based on the current research, we discovered that Ishwargangi had the highest TDS, followed by Lakshmi Kund, Pisachmochan, and Sarang Talab. At 253 ppm, Ishwargangi exhibited the highest overall hardness. The most acidic water samples were obtained from Pisachmochan, followed by samples from Ishwargangi and Lakshmi Kund. Thus, it can be concluded that the physicochemical characteristics of the experimental waterbodies varied significantly from one another. The majority of water quality metrics, such as TDS, were the highest in Lakshmi Kund, Ishwargangi had the highest total hardness, and Pishachmochan Kund had the highest pH. The high degree of anthropogenic activity and inadequate upkeep of this water body could be the cause. There should be strict implementation of recommendations from municipal authorities in guarding the sanctity of ponds by preventing any practices that degrade water quality. A special task force must be formed to oversee the protection of these natural resources.

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