



Water Quality and Microbial analysis of water collected from the ponds nearby a Cement Plant through WQI and PCA

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ABSTRACT: The present paper aims to analyze the water quality from the samples collected from the periphery of one of the cement plants located in Bhilai. Three different samples were collected in the summer season, covering the area around the cement plant considered. The samples were characterized by means of physicochemical parameters such as pH, TDS (mg/L), Turbidity (NTU), Total alkalinity (mg/L), Chloride (mg/L), Total hardness (mg/L), Fluoride (mg/L), and Nitrate (mg/L). The Water Quality Index (WQI) for the 03 samples collected was done and was found to be 166.264, 22.207, and 46.997, respectively. The dependency of WQI on various physicochemical parameters, along with the interdependency between the individual parameters, was analyzed using the loading plot obtained using Principal Component Analysis (PCA). It could be noticed that pH and fluoride contribute more to WQI in comparison to the other parameters included in this study. Z-score variance was also plotted to analyze the comparative stretching of the values of various individual parameters recorded. In addition, microbiological analysis was conducted using serial dilution, culturing, Gram staining, and biochemical testing. The presence of *Bacillus spp*, *Escherichia coli*, *Klebsiella spp*, *Micrococcus spp*, *Pseudomonas spp.*, and *Staphylococcus aureus* was detected, indicating microbial contamination and possible health risks.

KEYWORDS: Bacteria, Cement Industry, Soil, WQI, PCA, Physicochemical.

1. INTRODUCTION

Environmental contaminants, as well as pollutants, are chemicals that are present at higher levels than in any section of the environment [1, 2, 3]. The environment is the surroundings where humans, plants, animals, and micro-organisms live or work. It is composed of the land, the Earth's atmosphere, and the water. The quality of water bodies can be further affected by industries like cement manufacturing, which can introduce chemicals and heavy metals into the water [4]. It has been observed that the existence of various factories sometimes affects the local environment in an adverse manner. Here, the focus is on the effect of the existence of one of the prime cement factories, "ACC Limited," Jamul, Chhattisgarh, on the quality of pond water of the places located nearby the plant. The Cement Company, ACC Limited, proposes to expand its clinker manufacturing to 3.0 MTPA (Million Tonnes per Annum), based on obtaining environmental clearance from the Indian government's Ministry of Environment & Forests. The projected expansion won't involve obtaining additional real estate or implementing any resettlement or rehabilitation efforts; it will be executed beyond the currently existing 269.95 ha mine lease area [5]. The cement company, in particular, is an important factor in water pollution that causes enormous issues with the environment. When deposited into surrounding water bodies, industrial effluents' potentially dangerous blends of suspended and dissolved particles can degrade the overall integrity of the drinking water. Particulate matter, heavy metals, chlorides, sulfates, sodium and potassium hydroxides, and calcium carbonate constitute some of the principal pollutants. Major medical issues like breathing disorders, water-borne diseases, skin and eye irritations, and even long-term negative effects such as genetic mutations and persistent medical issues can be inflicted by these pollutants [6-7]. Water pollution by harmful microorganisms is now a global problem. Pollution can also be caused by a wide variety of inorganic and organic compounds. Municipal wastewater is a primary contributor of bacteria to the aquatic environment [8]. Fecal coliform bacteria are the most commonly used indicators of fecal pollution in water and food. The fecal-oral diseases may be transmitted by direct person-to-person contact, by contaminated food, or by contaminated water [9]. Pond waters are also getting polluted due to various domestic activities, by the discharge of effluents from factories and industries, agricultural activities, etc. Bacterial analysis is based on the detection of coliform bacteria, *E. coli*. It is an indicator organism used in water analysis. Its presence in water shows that the water is polluted with the fecal material of humans and other warm-blooded animals [10]. Water pollution is caused by a wide variety of organic and inorganic substances. Water also gets polluted by harmful microorganisms. Water pollution is becoming

a big problem day by day. The primary source of water pollution by bacteria is municipal waste [11]. Pond waters are also getting polluted just like other water bodies. As a result of the discharge of effluents from various industries, domestic wastes, and land and agricultural drainage, the quality of pond water gets degraded [12]. In the present work, an effort was made to identify the effect of the cement industry on the water quality of nearby ponds by calculating the water quality index and principal component analysis of the samples collected. Microbial analysis of the samples was conducted in the Microbiology Laboratory of Shri Shankaracharya Professional University, Bhilai. Isolation of heterotrophic bacteria was done by serial dilution of pond water separately for all three samples up to 10^{-5} dilution as described by A. P. H. A. 1998. 0.1 ml aliquots of dilutions 10^{-3} to 10^{-5} are now spread in nutrient agar medium by the spread plate technique.

The plates were incubated at 37°C for 24 hours in an inverted position. Colonies that emerged were counted and colony - forming units, or CFU/mL, were calculated. After incubation, bacterial colonies were subculture for obtaining pure cultures of bacteria used for further identification. Morphological and biochemical characterization of various isolates was done as per the criteria in Bergey's Manual of Determinative Bacteriology [13].

A total of 7 genera of bacteria were isolated from three ponds in the present study. These bacteria were Bacillus, Escherichia, Klebsiella, Micrococcus, Pseudomonas, Salmonella, and Streptococcus. Bacterial count ranges from low 7 (Salmonella) to high 21 (Escherichia) in sample 1. In sample 2, bacterial count ranges from low 8 (Klebsiella) to high 28 (Pseudomonas), while in sample 3, bacterial count ranges from low 6 (Klebsiella) to high 28 (Pseudomonas).

2. MATERIALS AND METHODS

2.1. Description of Study Area, Water Sampling

The geographical location of consideration was ACC Cement Ltd., Jamul, Bhilai, District – Durg (Chhattisgarh), which is (21.24 N, 81.39 E), and the said is one of the prime industries of the state Chhattisgarh. Three nearby ponds were chosen to collect the water samples. The locations were marked as Sample 01, Sample 02 and Sample 03 in the map of the location considered. Three surface water samples were collected from ponds located within a 5 km radius of a cement manufacturing plant in **Bhilai, Durg district, Chhattisgarh, India** (Latitude: 20.5937°N , Longitude: 78.9629°E) during the **post-monsoon season in March 2024**. The selected sampling sites included: **Jamul Pond** ($21.260562^{\circ}\text{N}$, $81.388368^{\circ}\text{E}$), **Gashidas Pond** (21.2195°N , 81.3951°E), **suryakhund Pond** (21.2103°N , 81.3847°E), **Jamul Pond** ($21.260562^{\circ}\text{N}$, $81.388368^{\circ}\text{E}$). Figure 01: Map

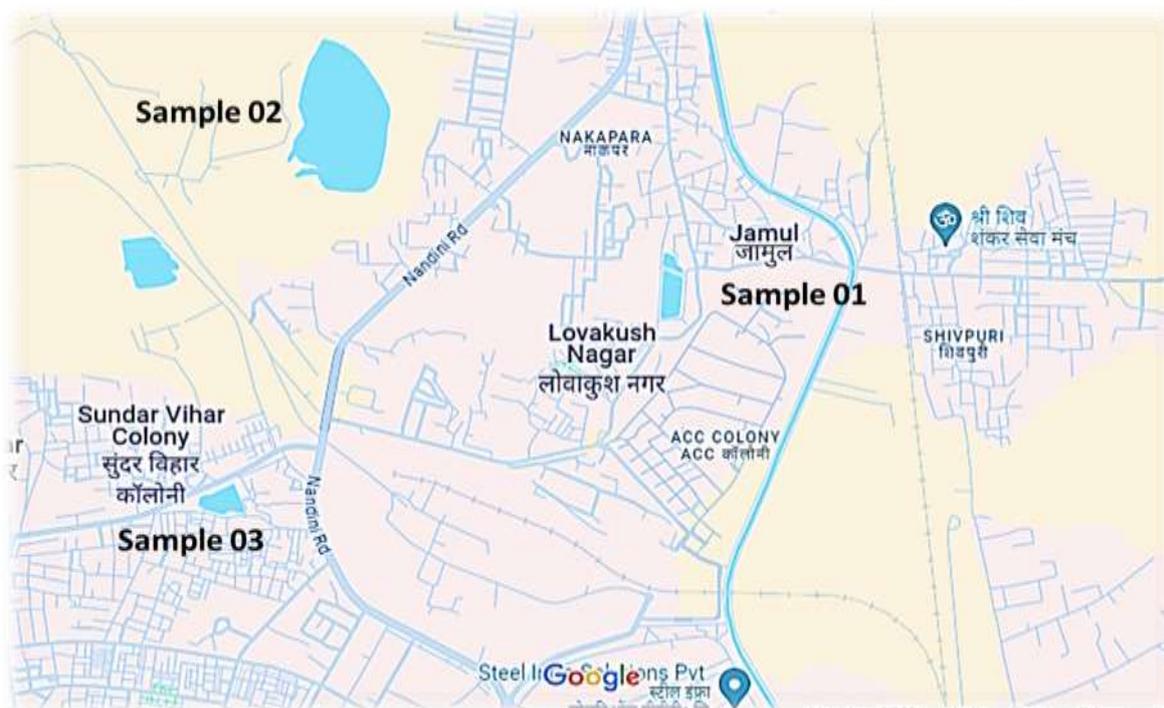


Figure 01 Map of the location considered



2.2. Experimental Design

Water samples were collected from the surface layer (0–15 cm depth) using **pre-cleaned and sterilized 1-liter borosilicate glass bottles**, rinsed sequentially with **10% nitric acid** and **deionized water** prior to use. Immediately after collection, all samples were stored in an **icebox at 4°C** and transported to the laboratory under cold chain conditions. **Physicochemical and biological analyses** were conducted **within 24 hours** of sampling to minimize microbial activity or chemical alterations. All procedures adhered to the **Standard Methods for the Examination of Water and Wastewater (APHA, 2017)**. The objective of the study was to determine the physicochemical parameters of water sources in the vicinity of ACC Cement Jamul to assess their acceptability for various uses, comparing these parameters with international standards for watering and potable water.

Physicochemical parameters' analysis

In order to understand the comparative impact of individual physicochemical parameters on the value of the Water Quality Index (WQI) of the samples collected, Principal Component Analysis was also done. For calculation of WQI, pH, TDS (mg/L), turbidity (NTU), total alkalinity (mg/L), chloride (mg/L), total hardness (mg/L), fluoride (mg/L) and nitrate (mg/L) were estimated experimentally.

Colour: To determine the true colour of water, visual comparison was made against a standard Platinum–Cobalt scale. If turbidity was present in the sample, it was first removed by centrifugation. The clear supernatant was then compared visually to the colour standards

Odour: Odour was assessed immediately after sample collection. Clean bottles were filled halfway with the water samples, sealed, and shaken vigorously for 2–3 seconds. The stopper was removed, and the odour was observed at room temperature to detect any objectionable smells.

pH (Electrometric Method): The pH was measured using a calibrated pH meter. Calibration was performed using two standard buffer solutions. Electrodes were rinsed with distilled water and wiped dry before immersing them in the sample. Readings were taken with gentle stirring. If drift was observed, a fresh aliquot was used without stirring for accurate results.

Taste: Taste evaluation was conducted using a sensory panel. Each panelist was provided with randomized water samples, including a reference. After rinsing with distilled water, panelists tasted half of each sample, held it in the mouth briefly, and discarded it. The process was repeated twice per sample with a 1-minute interval between samples. Final taste ratings were recorded.

Turbidity (Nephelometric Method): Turbidity was measured using a calibrated turbidimeter. For samples with turbidity below 40 NTU, the sample was shaken, air bubbles allowed to dissipate, and the sample was read directly. For turbidity above 40 NTU, the sample was diluted with turbidity-free water and the reading of the diluted sample was used to compute the original turbidity using a dilution factor.

Total Dissolved Solids (Gravimetric Method): A pre-weighed, clean evaporating dish was heated at 180°C for 1 hour, cooled in a desiccator, and stored. A suitable volume of filtered sample (yielding 100–200 mg residue) was evaporated on a steam bath. The residue was dried at 103–105°C until constant weight was achieved. The difference in weight was used to calculate the TDS content.

Nitrate (Devarda's Alloy Distillation Method): Sample was diluted to 500 mL and adjusted to pH 9.5 with borate buffer and NaOH. After discarding initial distillate (250–300 mL), 1 g of Devarda's alloy was added. The second distillate was collected in boric acid, and ammonia was determined by Nesslerization or titration.

Chloride (Argentometric Method): Samples were titrated directly in the pH range 7–10 after adjustment using acid or alkali. Potassium chromate indicator was added, and the solution was titrated with standard silver nitrate until a pinkish yellow endpoint was observed. Silver nitrate was standardized before use.

Fluoride (Zirconium Alizarin Method): Chlorine-free samples were mixed with zirconium alizarin reagent. The resulting colour was compared after 1 hour against a standard series in Nessler tubes. The fluoride concentration was matched with the closest standard tube value.

Total Hardness (EDTA Titrimetric Method): Sample aliquots were treated with hydroxylamine hydrochloride and buffer to maintain pH ~10, followed by Eriochrome Black T indicator. The sample was titrated with standard EDTA until the endpoint changed to sky blue. A blank titration was also performed for comparison.

Alkalinity (Titrimetric Method): A known volume of water sample was titrated with standard sulphuric acid using phenolphthalein and mixed indicators. The volume used up to pH 8.3 gave phenolphthalein alkalinity, while further titration to pH 3.7 gave total alkalinity.



Residual Free Chlorine (DPD Photometric Method): Chlorine was determined using DPD indicator and buffer reagents. The developed colour was measured at 515 nm using a photometer. For free chlorine, only DPD was used; for monochloramines and dichloramines, successive additions of KI were made and colour measured accordingly.

Microbiological water quality analysis

All 3 pond samples were sieved separately to remove large pieces of particles and debris.

Isolation and Estimation of bacteria

Bacterial 1mL of Water were estimated by using the dilution plate method for each type of Water samples as described by Biyik et al. (2005). For each amendment three replicates of Petri plates were prepared. After Incubation at ambient temperature of 28- 30oC for 2 days for bacteria, the average colony forming units (CFU) per mLof was calculated by using colony counter. The different isolates were identified on the basis of their morphological, microbiological and biochemical characteristics as outlined in (Aneja, 2003;).

3.1 Water Quality Index (WQI)

The value of the WQI was calculated using the weighted arithmetic index method, and the formula used is given in Equation (1).

$$WQI = \frac{\sum Q_i W_i}{\sum W_i} \tag{1}$$

Where Q_i is the water quality rating of the i^{th} water quality parameter, and W_i ($\sum W_i=1$) is the unit weight of the i^{th} water quality parameter. The quality rating, Q_i , can be calculated using Equation (2) [12].

$$Q_i = \frac{100(V_i - V_o)}{(S_i - V_o)} \tag{2}$$

Where V_i is the actual amount of the i^{th} parameter, V_0 represents the ideal value of the parameter ($V_0=0$), except for the pH ($V_0=7$) and DO ($V_0=14.6$ mg/L), and S_i is the standard allowable value for the i^{th} parameter. The unit weight (W_i) is calculated using Equation (3).

$$K = \frac{1}{\sum \frac{1}{S_i}} \tag{3}$$

$$W_i = \frac{K}{S_i} \tag{4}$$

The term K is a proportional constant and is calculated as per Equation (4). [12]. The water quality status (WQS), based on the WQI rating, is presented in **Table 1**. The intended use based on the WQS is also given in the same table. The range of WQI to estimate the ratings (Bureau of Indian Standard BIS) [13] of the water samples is provided in Table 2.

Table 2. Water quality index scale.

Range of Water	Rating of water
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very poor
Above 100	Unsuitable

4. RESULTS AND DISCUSSION

4.1 Water Quality Index (WQI) Values

As per the method mentioned in the Material and Method section of the manuscript, WQI of all three samples was calculated using pH, TDS (mg /L), turbidity (NTU), total alkalinity (mg/L), chloride (mg/L), total hardness (mg/L), fluoride (mg/L) and nitrate (mg/L) parameters. The details are provided in Table 01. It is observed that the WQI for the samples 01, 02 and 03 was found to be 166.264, 22.207, and 46.997, respectively. It can easily be concluded that the value of WQI for the sample was around 166, and it was absolutely unsuitable for drinking purposes (refer to be Table 01); however, the same for the other two samples were around 22 and 47, which are in the excellent and good quality range. If we observe the map provided in Figure 01, it can be noticed that the pond from where the sample 01 was collected is much closer to the ACC cement plant, whereas the other two samples were collected from comparatively far places. Therefore, it can be said that the existence of the ACC plant greatly affected the water quality of the nearby pond.

4.2.1. Principal Component Analysis (PCA)

The principal components (PCs) are the uncorrelated (orthogonal) variables, obtained by multiplying the original correlated variables with the eigenvalues (loadings or weightings). The eigenvalues of the PCs are the measure of their associated variance. The participation of the original variables in the PCs is given by the loadings, and the individual transformed observations are called scores (Vega et al. 1998; Helena et al. 2000; Wunderlin et al. 2001; Singh et al. 2004). PCA was performed on normalized (z-scale transformation) variables for eight parameters after sorting out the highly correlated variables from the data sets. PCs with eigenvalue > 1 were retained. The contribution of each factor at every site (factor scores) was computed, and score plots of the first two PCs (PC1 and PC2) were constructed. PCA was performed with a view to assess the compositional differences among different hydrochemical parameters, spatial variations in water quality, and the influence of anthropogenic activities.

4.2.2 Scree Plot

Scree plot for sample 01 is provide us Figure 03. The Scree plot helps us in selecting the component for the PCA loading plot. In the Scree plot provided, it can be observed that the eigenvalue corresponding to component 1 to 2 changes rapidly, and so in the case of component 02 to component 03. It may also be noticed that the Eigenvalues corresponding to further components from 03 to the remaining do not change significantly. Therefore, taking components 1 and 2 will provided us the best possible loading plot. Hence, the loading plot is plotted between the component 1 and 2.

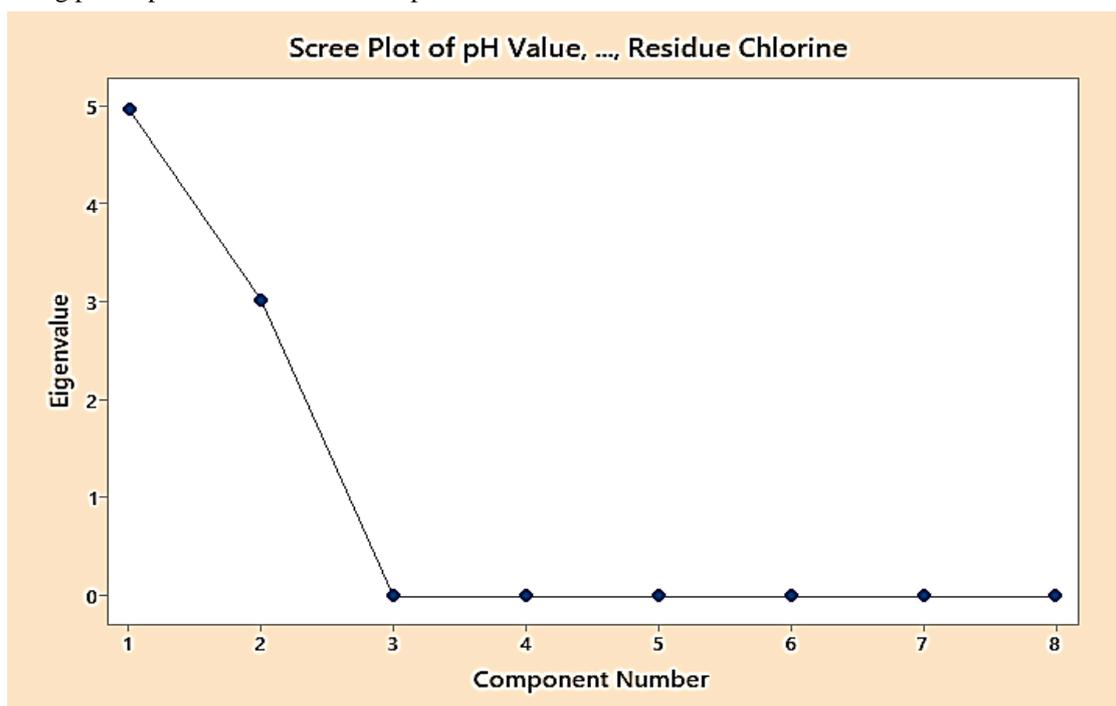


Figure 02 Scree Plot



4.2.3 Loading Plot

In order to obtain the interdependency of each of the physicochemical parameters and also to determine the dependency of other parameters on the value of WQI, principal component analysis was done. The loading plot provides the required information and is provided in Figure 02.

The PCA loading plot of the WQI parameters is shown in Figure 03. The correlation between any two parameters can be determined using the said plot. All the parameters, including WQI values, are expressed using the blue line. An acute angle between the two parameters indicates that there is a positive correlation between the parameters considered; a right angle is the indicative of no correlation, and an obtuse angle expresses the existence of a negative correlation. If the angle between the two blue lines is 0°, the correlation is +1 whereas when the angle is 180° the correlation is -1 [14]. In order to understand the dependency of WQI on other parameters, the angle created by the corresponding lines with the line assigned to WQI was observed. It may be seen that the angle between the lines assigned to Alkalinity and pH is almost 0° which indicates the highest dependency of pH on WQI value. There were two more parameters that highly affect the value of WQI, which are fluoride and total hardness. Therefore, the ways to decrease the counts of these parameters need to be researched in order to reduce the dangerous - looking WQI. Table 03 provides the correlation between the various parameters. The Scree and the Loading plot were obtained using Minitab.v19.1.

Table 03 Correlation between various physicochemical parameters

Correlation	pH Value	TDS	Alkalinity	Chloride	Total Hardness	Fluoride	Iron as Fe ⁺⁺	Res. Chlorine	WQI
pH Value	1.000								
TDS	-0.309	1.000							
Alkalinity	-1.000	0.309	1.000						
Chloride	-0.254	0.998	0.254	1.000					
Total Hardness	0.731	0.423	-0.731	0.474	1.000				
Fluoride	0.988	-0.157	-0.988	-0.100	0.828	1.000			
Iron as Fe ⁺⁺	-1.000	0.309	1.000	0.254	-0.731	-0.988	1.000		
Res. Chlorine	0.500	-0.978	-0.500	-0.965	-0.225	0.359	-0.500	1.000	
WQI	1.000	-0.304	-1.000	-0.249	0.734	0.989	-1.000	0.496	1.000

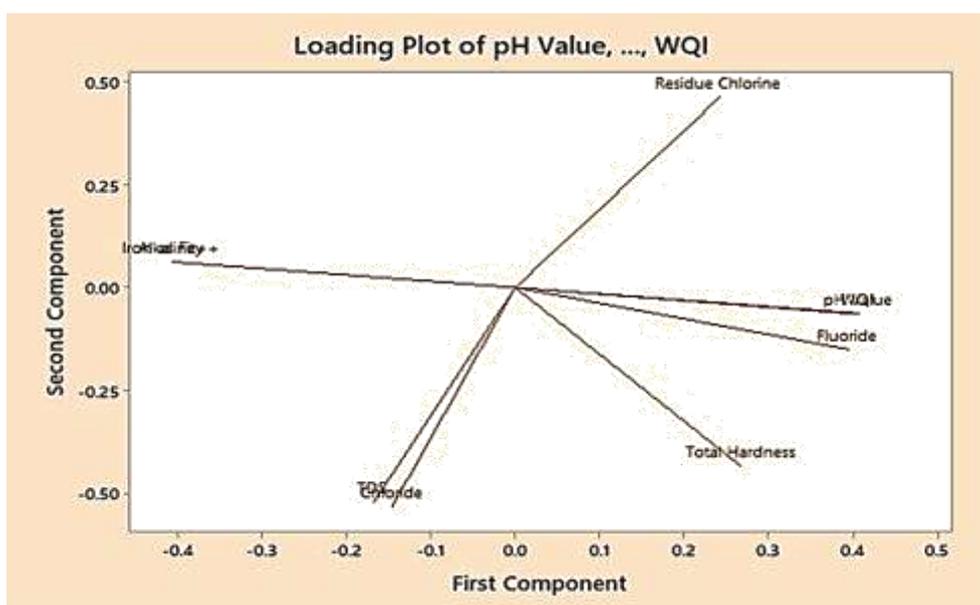


Figure 03 Loading Plot

4.4 Z – SCORE VARIANCE ANALYSIS

To analyse the comparative stretching of the data found for various individual parameters, Z- score variance analysis was done. The Figure 04 provided the Box plot of the Z-score of all the parameters considered in this work.

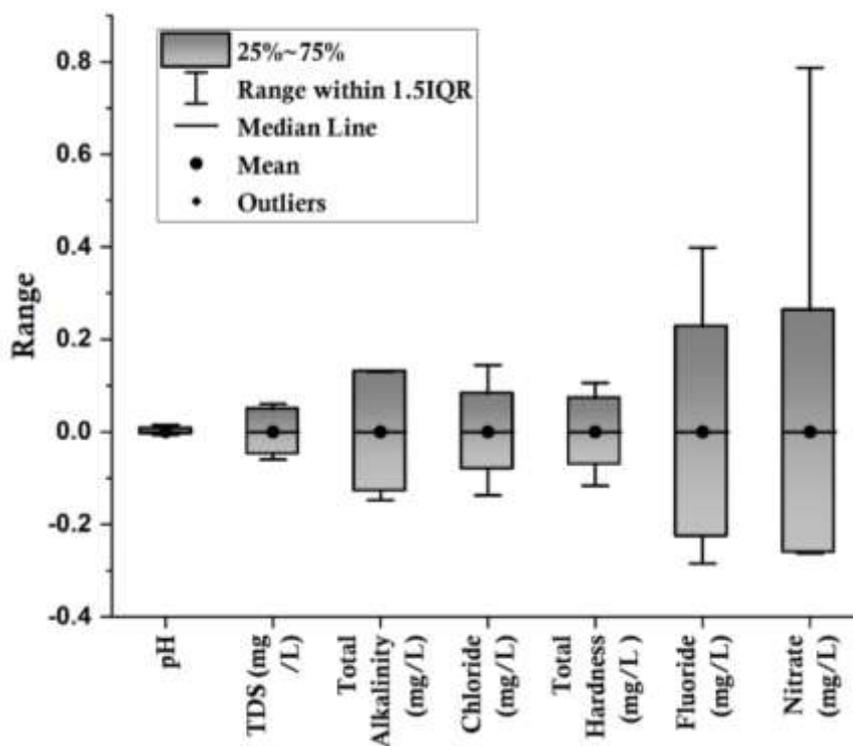


Figure 03 Z-Score Variance Plot

The length of the boxes provided the stretching of particular parameters within the Inter Quartile Range (25–75 percentile). Hence, from Figure 03, it may easily be noticed the value of pH did not vary a lot in various samples collected (including standard value). Similarly, the variation in the values obtained for TDS Chloride and Total Hardness is also significantly low. On the other hand, the variation in the case of Total alkalinity is comparatively high and the same for fluoride and nitrate is quite large.

The plates were incubated at 37°C for 24 hours in an inverted position. Colonies that emerged were counted, and colony-forming units, or CFU/mL, were calculated. After incubation, bacterial colonies were subcultured for obtaining pure cultures of bacteria used for further identification. Morphological and biochemical characterization of various isolates was done as per the criteria in Bergey’s Manual of Determinative Bacteriology [15].

Table: Bacterial count of pond water on nutrient agar media

Bacterial Genera	Bacterial Count (cfu/mL)		
	Sample 1	Sample 2	Sample 3
<i>Bacillus sp.</i>	17 1.7×10 ⁸ CFU/mL	23 2.3×10 ⁸ CFU/mL	13 1.3×10 ⁸ CFU/mL
<i>Escherichia sp.</i>	21 2.1×10 ⁸ CFU/mL	26 2.6×10 ⁸ CFU/mL	14 1.4×10 ⁸ CFU/mL
<i>Klebsiella sp.</i>	8	8 8×10 ⁷ CFU/mL	6



	8×10^7 CFU/mL		6×10^7 CFU/mL
<i>Micrococcus sp.</i>	11 1.1×10^8 CFU/mL	10 1.0×10^8 CFU/mL	13 1.3×10^8 CFU/mL
<i>Pseudomonas sp.</i>	19 1.9×10^8 CFU/mL	28 2.8×10^8 CFU/mL	16 1.6×10^8 CFU/mL
<i>Salmonella</i>	7 7×10^7 CFU/mL	11 1.1×10^8 CFU/mL	9 9×10^7 CFU/mL

Bacterial Identification Table: -

Bacteria	Morphology	Biochemical Tests	Remarks
Bacillus sp.	Gram-positive, rod-shaped, endospore-forming	<ul style="list-style-type: none"> Catalase: Positive Oxidase: Negative Voges-Proskauer (VP): Positive Motility: Motile 	Often found in soil, produces spores
Escherichia coli	Gram-negative, rod-shaped	<ul style="list-style-type: none"> Catalase: Positive Oxidase: Negative Indole: Positive Methyl Red (MR): Positive Voges-Proskauer (VP): Negative Lactose Fermentation: Positive Catalase: Positive Oxidase: Negative Indole: Negative Lactose Fermentation: Positive Urease: Positive 	Common gut flora, fecal indicator
Micrococcus sp.	Gram-positive, spherical, tetrads/clusters	<ul style="list-style-type: none"> Catalase: Positive Oxidase: Positive Non-fermenter 	Known for pneumonia and urinary tract infections



Pseudomonas sp.	Gram-negative, rod-shaped, motile	<ul style="list-style-type: none"> Catalase: Positive 	Often associated with hospital-acquired infections
		<ul style="list-style-type: none"> Oxidase: Positive 	
		Fluorescein Production: Positive	
		<ul style="list-style-type: none"> Non-lactose fermenter 	
		<ul style="list-style-type: none"> Uses citrate as sole carbon source 	
Salmonella sp.	Gram-negative, rod-shaped, motile	<ul style="list-style-type: none"> Catalase: Positive 	Causes food poisoning, gastrointestinal diseases
		<ul style="list-style-type: none"> Oxidase: Negative 	
		<ul style="list-style-type: none"> H₂S Production: Positive 	
		<ul style="list-style-type: none"> Indole: Negative 	
		<ul style="list-style-type: none"> Motility: Motile 	
		<ul style="list-style-type: none"> Lactose: Negative 	

Test	Purpose	Positive Result	Example Positive Bacteria
Catalase Test	Detects enzyme catalase (breaks H ₂ O ₂)	Bubble formation	Bacillus, E. coli, Micrococcus
Oxidase Test	Detects cytochrome oxidase enzyme	Purple/blue color on reagent	Pseudomonas, Micrococcus
Indole Test	Detects tryptophan breakdown to indole	Red/pink layer (after reagent)	E. coli
Methyl Red (MR)	Detects stable acid production from glucose	Red color after adding indicator	E. coli
VP Test	Detects neutral end product (acetoin)	Red color after reagents	Klebsiella, Enterobacter
Lactose Ferment.	Checks for acid/gas from lactose fermentation	Yellow medium / gas in Durham tube	E. coli, Klebsiella
Urease Test	Detects urease enzyme (converts urea to ammonia + CO ₂)	Pink color in medium	Klebsiella, Proteus
H ₂ S Production	Detects hydrogen sulfide production from sulfur compounds	Black precipitate in medium	Salmonella, Proteus
Citrate Test	Detects use of citrate as sole carbon source	Blue color in Simmons' citrate agar	Klebsiella, Salmonella
Motility Test	Checks for bacterial motility	Diffuse/hazy growth away from stab line	E. coli, Salmonella, Pseudomonas



Table: Biochemical Profiles

Test	Bacillus	E. coli	Klebsiella	Micrococcus	Pseudomonas	Salmonella
Gram Stain	+ rod	- rod	- rod	+ cocci	- rod	- rod
Catalase	+	+	+	+	+	+
Oxidase	-	-	-	+	+	+
Indole	-	+	-	-	-	-
MR	+	+	-	-	-	+
VP	-	-	+	-	-	-
Citrate	+	-	+	-	+	+
Urease	-	-	+	-	-	-
H ₂ S	-	-	-	-	-	+
Motility	+	+	-	-	+	+
Lactose Ferm.	-	+	+	-	-	-

S. N.	Tests	Results Bacillus sp.	Escherichia sp.	Klebsiella sp. (pneumoniae)	Micrococcus sp.	Pseudomonas. (<i>Pseudomonas aeruginosa</i> (PsA15))	Salmonella. (Bongori)
1.	Growth at 37 °C	+ve	+ve	+ve	+ve	+ve	+
2.	Gram staining	+	-	-	+	-	-
3.	Catalase	+	+	+	+	+	+
4.	Oxidase	Variable	-ve	-ve	+	+	-
5.	Methyl red	-	+	-	-	-	+
6.	Arginine	-ve	-ve	-ve	-ve (decarboxylase)	+	-
7.	Ornithine	-ve	-ve	-ve	- (decarboxylase)	-	+
8.	Leucine	+ve	-ve	-ve	+ve (arylamidase)	-	-
9.	VP	+	-	+	-	-	-
10.	Nitrate	+ reduction	+	+ve	(variable among species)	-	
11.	ONPG	-ve	+ve	+ve	-ve (beta-galactosidase)	-	+ (beta-galactosidase)
12.	Indole	-ve	+ve	-ve	-ve	-ve	-ve
13.	Citrate	+ utilization	-ve	-ve	+ve	+ve	+ve
14.	Sucrose	+ve	+ve	-ve	+ve	-ve	- ve
15.	Glucose	+ve	+ve	+ve	+ve	+ve	+ (fermentative)
16.	Arabinose	+ve	-ve	+ve	- ve	-ve	+ ve
17.	Salicin	+ve	-ve	-ve	- ve	- ve	+ ve
18.	Mannitol	+ve	-ve	+ve	- ve	-	+ ve



19.	Trehalose	+ve	-ve	-ve	+ ve (variable)	- - ve	+ ve
20.	Haemolysis	Beta-hemolytic	-ve	-ve	- ve (typically non-hemolytic)	+ (often β-haemolysis)	- ve Negative (usually non-haemolytic)
21.	Growth at NaCl 0%	+ve	+ve	+ve	+ve	+ ve	+ve
22.	1%	+ve	+ve	+ve	+ve	+ ve	+ve
23.	2%	+ve	+ve	+ve	+ve	+ ve	+ve
24.	3%	+ve	+ve	+ve	+ve	+ ve	+ve
25.	4%	+/-ve	+ve	+ve	+ve	+ ve	-ve
26.	5%	-ve	+ve	+ve	+ve	+ ve	-ve

5. CONCLUSION

The water quality from the samples collected from the periphery of one of the Cement Plant located in Bhilai was assessed using WQI. Three different samples were collected in the summer season, covering the area around the Cement plant considered. The Water Quality Index (WQI) for the 03 samples collected was experimentally determined and was found to be 166.264, 22.207, and 46.997, respectively. This result shows that water collected in sample 01 is not at all suitable for drinking purposes. The PCA-loading plot indicated that WQI is mostly dependent on pH value in particular. In all, it could be noticed that pH and fluoride contribute more to WQI in comparison to the other parameters included in this study. Z-score variance was also plotted to analyze the comparative stretching of the values of various individual parameters recorded. In normal circumstances, water used by humans should not contain any harmful chemicals or any pathogenic bacteria whose presence indicates fecal pollution. According to WHO guidelines, the occurrence of pathogenic microorganisms in surface water depends mainly on the range of human activities and animal sources that release pathogens to the environment. Thus, pond water is not safe for drinking and bathing.

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Table 01 Detailed calculation of WQI

Parameters	Standards	Sample (01)					Sample (02)					Sample (03)				
	S_n	V_n	Q_n	$W_n = K/S_n$	$1/S_n$	$Q_n W_n$	V_n	Q_n	$W_n = K/S_n$	$1/S_n$	$Q_n W_n$	V_n	Q_n	$W_n = K/S_n$	$1/S_n$	$Q_n W_n$
pH	8.500	8.000	66.667	0.127	0.118	8.486	7.900	60.000	0.127	0.118	7.638	7.900	60.000	0.127	0.118	7.638
TDS (mg /L)	500.000	361.000	72.200	0.002	0.002	0.156	331.000	66.200	0.002	0.002	0.143	468.000	93.600	0.002	0.002	0.203
Turbidity (NTU)	10.000	10.000	100.000	0.108	0.100	10.820	10.000	100.000	0.108	0.100	10.820	10.000	100.000	0.108	0.100	10.820
Total Alkalinity (mg/L)	120.000	150.000	125.000	0.009	0.008	1.127	350.000	291.667	0.009	0.008	2.630	350.000	291.667	0.009	0.008	2.630
Chloride (mg/L)	250.000	500.000	200.000	0.004	0.004	0.866	425.000	170.000	0.004	0.004	0.736	700.000	280.000	0.004	0.004	1.212
Total Hardness (mg/L)	300.000	450.000	150.000	0.004	0.003	0.541	200.000	66.667	0.004	0.003	0.240	375.000	125.000	0.004	0.003	0.451
Fluoride (mg/L)	1.500	3.000	200.000	0.721	0.667	144.269	0.000	0.000	0.721	0.667	0.000	0.500	33.333	0.721	0.667	24.045
Nitrate (mg/L)	45.000	0.000	0.000	0.024	0.022	0.000	0.000	0.000	0.024	0.022	0.000	0.000	0.000	0.024	0.022	0.000
Water Quality Index (WQI)		166.264					22.207					46.997				

Cite this Article: Sandhya, Dewangan, N. (2025). Water Quality and Microbial analysis of water collected from the ponds nearby a Cement Plant through WQI and PCA. International Journal of Current Science Research and Review, 8(7), pp. 3784-3796. DOI: <https://doi.org/10.47191/ijcsrr/V8-i7-68>