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# Drinking Water Quality Status & Treatment needs for Drinking Water Supply: A Case Study

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***Abstract*:To know the quality of water supplied for drinking purpose at Bhisi village, Chandrapur district, in Maharashtra, India a study was undertaken for raw water quality and also at water treatment plant. People residing in this village are dependent on Dhaparla reservoir (surface water) for their drinking water source. However, water quality has become a serious concern due to high turbidity and the presence of yellowish colour in the water sample, which persists even after treatment. Turbidity was found to be 40 NTU in the Dhaparla reservoir before treatment. To resolve this issue, a jar test study was conducted by using different dosages of coagulants and disinfectants by which turbidity was reduced up to 17.3 NTU after the treatment of Poly Aluminium Chloride (PAC) and bleaching powder. Though turbidity of the water sample surpassed allowable limits which is the false turbidity caused by algal growth (blue-green algae). The O&M of the water treatment plant become a challenge due to turbidity of raw water. Bacterial contamination in the water samples is attributed to unprotected catchment and due to animal grazing, bird droppings, open defecation, en-route contamination like pipeline leaks. The study emphasizes the necessity of protecting raw water sources, optimizing Water Treatment Plant (WTP) operations including chemical dosing, and improving disinfection practices in order to supply safe drinking water to the community.**

***Keywords*:drinking water quality, Poly Aluminium Chloride (PAC), coagulant doses, cyanobacteria, turbidity, Jar test.**

## I. INTRODUCTION

Freshwater is essential for life, but it accounts for only 1% of the water on Earth, (Gowri et al. 2021). Out of total water reserve of about 1.4 billion km$^3$, only 35 million cu.m. is being freshwater. Out of this, approximately 91,000 km$^3$ is usable for everyday consumption, which comes to about 12,000 litres per person for the 7.5 billion people on Earth. (Georg et al. 2021). The quality of the drinking water impairs while collection & storage (Andrew et al. 2005) therefore it is very much essential to test water quality parameters such as physical, chemical, biological and metals at regular intervals of time (Baboo 2019; Khadse et al. 2011a, b, c).

Cyanobacteria and algae in water can disrupt treatment, affect taste, and impacting drinking water safety and health (WHO 2008). Cyanobacteria can increase turbidity in water due to gas vesicles (Porat et al. 1999) and also it is responsible for the production of cyanotoxins, which are hazardous secondary metabolites. Coagulation/flocculation is the most important process in conventional WTPs for removing cyanobacterial cells, but it can only remove up to 90% of intracellular cyanotoxins. Cyanobacteria can also cause false turbidity, which cannot be completely removed by coagulation/flocculation (Bouaidi et al.2022). For effective removal of turbidity caused by cyanobacteria various advanced methods such as microfiltration (Tim et al. 2017), slow sand filtration (Silvano et al. 2012), and floating media (Dae-Young et al.2014) are suggested by various researchers.

In this study, the water quality at source and at different treatment stages was monitored to know the water quality and treatment options to remove the turbidity from water caused due to suspended particles along with cyanobacteria for safe potable water supply.

## II. MATERIAL & METHODS

### Study area

The study was undertaken at Bhisi village which is located 17 km away from Chimur, the sub-district headquarters, and 117 km away from Chandrapur, the district headquarter in Maharashtra state of India. It is situated at 20° 29' 53.016" N latitude and 79° 22' 41.4696" E longitude. Bhisi village has a total population of 11,179 people as per 2011 census.


IndiaMaharashtra Chandrapur District

Fig. 1 Study area map

**Methodology**

Water samples were collected from raw water source (Bhisi-1) located at Dhaparla village, water treatment plant (Bhisi-2) located near Bhisi village, and consumer end (Bhisi-3) from the Bhisi village (Table 1) and tested for physicochemical, bacteriological, and biological characteristics, as well as heavy metals, according to standard methods (APHA, 2017).

Temperature, pH, EC and TDS were measured at the site itself. Water samples were kept for additional metrics by preserving with suitable reagents. The water samples were analyzed for major cations and anions. Sodium and potassium were estimated using flame photometer, while chloride, total hardness, and total alkalinity were determined using titrimetric analyses. Sulphate, nitrate, and phosphate were determined using a spectrophotometer. Bacteriological analysis was done using standard membrane filtration technique (APHA, 2012) for the *total coliforms* and *faecal coliforms*.

Water samples for phytoplankton were collected in sterile polythene bottles and preserved instantly with Lugol's iodine solution. Water samples for zooplankton were obtained by filtering 40 liters of surface water through a plankton net (64 µm) and preserved with a 5% formaldehyde solution. Both the plankton samples were concentrated with batch centrifugation. Microscopic analysis was conducted on multiple transects of the 1 mL concentrated sample for identification of plankton. Phytoplankton counting was done with Lackeydrop method (Kankal & Warudkar, 2012) while zooplankton were assessed using the Sedgewick-Rafter cell. The composition and diversity of the plankton were evaluated using the Shannon-Weiner Diversity Index (Shannon & Weaver, 1949). The Palmer Pollution Index was worked out based on pollution-tolerant algae and their assigned index factors (Person, 1989; Palmer, 1969).

TABLE 1
Locations of water samples

| S.N. | Sample code | Locations |
|---|---|---|
| 1 | Bhisi-1 | Dhaparla reservoir |
| 2 | Bhisi-2 | Before treatment at WTP |
| 3 | Bhisi-3 | After treatment at WTP |

## III. Results & Discussion

**Physicochemical parameters**

Physicochemical characteristics is helpful in recognizing the level of pollution but variation in trophic conditions of water are observed in the biotic community: structure, species types, their pattern, distribution and diversity (Kaushik and Saksena, 1995).The physicochemical characteristics of water are given in Table 2. The pH ranged between 7.9 and 8.1. Electrical conductivity ranges from 270 to 305 µS/cm, indicating the presence of inorganic ions. TDS levels ranged between 162 mg/L and 183 mg/L. The turbidity of 40 NTU for source water, 23 NTU before treatment at WTP, and 25 NTU for treated water, all of which could have been impacted by cyanobacteria. The total hardness (92 mg/L), calcium, magnesium, and alkalinity were within the acceptable limit as per BIS guidelines (BIS, 2006). Chloride, nitrate, phosphate, sulphate, sodium, potassium, and fluoride levels were all below the permissible limits of BIS, assuring the acceptability of water.Majority heavy metals are below the limit of detection (BDL) or below permissible limit as per BIS guideline values (Table 3).

**Bacteriological parameters**

The total coliforms and thermotolerant coliforms were counted in each sample and expressed as Colony-Forming Units (CFU/100ml). Total Coliforms (TC) levels range from 80 to 520 CFU/100mL. Meanwhile, all samples show modest FC counts ranging from 1 to 10 CFU/100mL (Table 2), implying negligible faecal contamination. The potential bacterial contamination may occur as a result of animal grazing, bird droppings, pipeline leaks, and, to a lesser extent, open defecation.

The water quality data gives useful information about the water quality highlighting the potential environmental implications.

**Phytoplankton**

The Shannon Weiner Diversity Index (SWI) is used to assess the phytoplankton composition and diversity, as well as their interactions and impact on water quality. The water samples contain ten different genera pf phytoplankton. Cyanobacteria, Dinoflagellates, Diatoms, and Chlorophyta are the principal phytoplankton groups. Bhisi-1 sample had a phytoplankton density of 3,277/100 mL, Bhisi-2 sample had a density of 5294/100 mL, and Bhisi-3 sample do not have any phytoplankton. Organic contamination was indicated by a SWI ranging from 0.48 to 1.91. Zygnema and Craticula were the prominent species. Microcysts are phytoplankton that create powerful liver poisons.

The SWI for phytoplankton in Dhaparla reservoir is 0.48 indicate pollution of raw water. As this water comes to water treatment plant SWI is 1.91 shows moderate pollution indicating improvement in water quality during its transportation from source to water treatment plant due to aeration and oxidation.

**Zooplankton**

Enumeration of zooplankton was done using Sedwick-Rafter (S-R) counting cells. The planktons were identified and the total number of zooplankton was reported as a number per liter. Bhisi-1 and Bhisi-2 water samples were found to contain 35 plankton/L and 30 plankton/L respectively and Zooplanktons were absent in Sample Bhisi-3 water sample.

TABLE 2
Water Quality

| S.N. | Parameters | Sample code | | | BIS 10500:2012 (Acceptable/ Permissible limit) |
|---|---|---|---|---|---|
| | | Bhisi-1 | Bhisi-2 | Bhisi-3 | |
| 1. | pH | 8.1 | 7.9 | 7.9 | 6.5-8.5 |
| 2. | EC (µS/cm) | 270 | 303 | 305 | - |
| 3. | Turbidity (NTU) | **<u>40</u>** | **<u>23</u>** | **<u>25</u>** | 1-5 |
| 4. | Total Dissolved Solids | 162 | 182 | 183 | 500-2000 |
| 5. | Total Alkalinity (as $CaCO_3$) | 108 | 108 | 108 | 200-600 |
| 6. | Total Hardness (as $CaCO_3$) | 92 | 92 | 92 | 200-600 |
| 7. | Calcium (as $Ca^{2+}$) | 11 | 5 | 13 | 75-200 |
| 8. | Magnesium (as $Mg^{2+}$) | 15 | 19 | 14 | 30-100 |
| 9. | Chloride (as $Cl^-$) | 14 | 16 | 16 | 250-1000 |
| 10. | Sulphate (as $SO_4^{2-}$) | 34 | 53 | 47 | 200-400 |
| 11. | Sodium (as $Na^+$) | 30 | 28 | 28 | - |
| 12. | Potassium (as $K^+$) | 4 | 4 | 4 | - |
| 13. | Fluoride (as $F^-$) | 0.4 | 0.3 | 0.4 | 1.0-1.5 |
| 14. | Phosphate as ($PO_4^{3-}$) | 0.4 | 1.7 | 1.6 | - |
| 15. | Nitrate as ($NO^-_3$) | 1.0 | 0.3 | 1 | 45 |
| 16. | Total Coliforms (TC) | **<u>80</u>** | **<u>520</u>** | **<u>160</u>** | Shall not be detectable in any 100 mL sample |
| 17. | Thermotolerant coliforms (FC) | **<u>10</u>** | **<u>10</u>** | **<u>1</u>** | |
| *Unit from S.N. 4-15 is in mg/L, whereas for S.N. 16-17 it is in* CFU/100mL | | | | | |
| *Note: Results mentioned in Table as* ***<u>Bold & underlined</u>*** *are above Permissible limits of BIS 10500-2012* | | | | | |

TABLE 3
Metal content in water

| S. N. | Sample | As | Al | Co | Cd | Cr | Cu | Fe | Mn | Ni | Pb | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mg/L | | | | | | | | | | |
| 1 | Bhisi-1 | 0.006 | 0.9 | BDL | BDL | 0.006 | 0.007 | 0.9 | 0.3 | BDL | BDL | 0.2 |
| 2 | Bhisi-2 | BDL | 1.9 | 0.001 | BDL | 0.007 | 0.007 | 0.8 | 0.2 | BDL | BDL | 0.04 |
| 3 | Bhisi-3 | 0.01 | 1.7 | BDL | BDL | 0.009 | 0.004 | 0.7 | 0.2 | BDL | BDL | 0.04 |
| *ND- Not Detected; Unit for parameters is in mg/L* | | | | | | | | | | | | |

TABLE 4
Phytoplankton Content in Water Samples

| Sr. No. | Sample Code | Name of Species | Name of Genus | Pollution Index (PPI) | SWI | Pielou's Evenness Index |
|---|---|---|---|---|---|---|
| 1 | Bhisi-1 | Zygnema<br>Pleuro sigma<br>Craticula<br>Leptocylindrusspp | Green Algae (Chlorophyta)<br>Diatoms<br>Diatom<br>Diatom | 0 | 0.48 | 0.03 |
| 2 | Bhisi-2 | Cylindrothicaspp<br>Naviculaspp<br>Zygnema<br>Silico Flagellate<br>Microcysts<br>Durinskia<br>Craticula<br>Cyclotella | Diatom<br>Diatom<br>Green Algae<br>Dinoflagellate<br>Cyanobacteria<br>Cyanobacteria<br>Diatom<br>Diatom | 4 | 1.91 | 0.090 |
| 3 | Bhisi-3 | - | - | 0 | 0 | 0 |

SWI: < 1: maximum pollution; 1–2: medium pollution >2: minimum pollution

Table 5
Zooplankton Content in Water Samples

| Sr. No. | Sample Code | Name of Species | Zooplanktons/L |
|---|---|---|---|
| 1 | Bhisi-1 | Chaoborus<br>TricoserraCapucina<br>Barnacle Naupalis | 35 |
| 2 | Bhisi-2 | TricoceraSimili<br>Difflugia urceolata<br>Filiniaopoliensis | 30 |
| 3 | Bhisi-3 | 0 | 0 |

TABLE 6
Experimental characteristics of Jar test study

| Characteristics | Description |
|---|---|
| Flash mix time & and rpm | 1 min/ 100 rpm |
| Slow mix time & and rpm | 20 min/ 30 rpm |
| Settling time | 30 min |

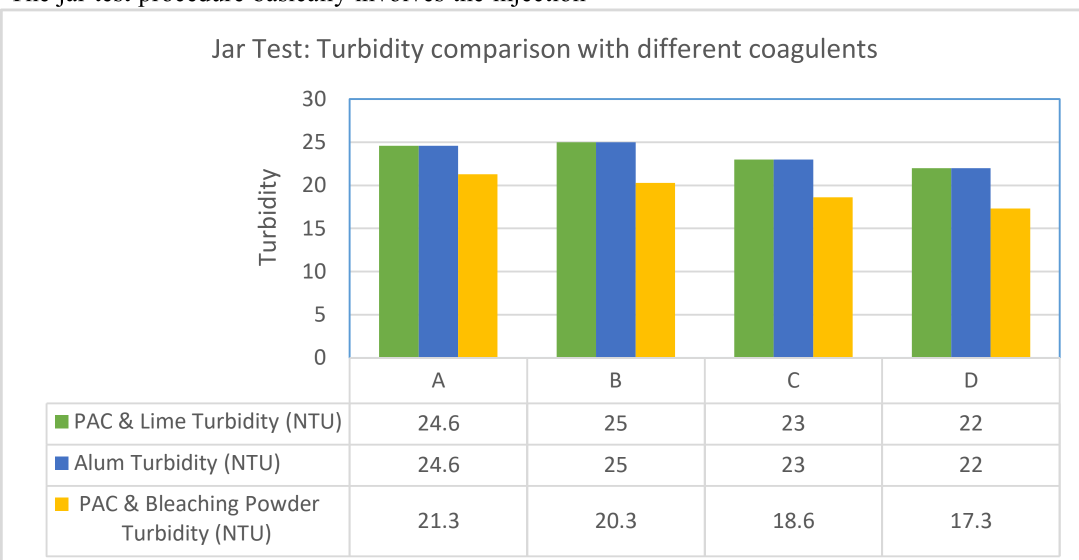
**Jar Test Study**

The effect of different coagulants and disinfectant doses in removal of the turbidity from the raw water from Dhaparla reservoir was investigated experimentally. It consists of a high turbidity of 40 NTU which is above the permissible limit of BIS 10500-2012.

The graph 1 presents data from an experiment with four different jars labelled A, B, C, and D. Each jar was treated with specific doses of coagulant such as Poly Aluminium Chloride (PAC) and alum, lime and bleaching powder in different combinations of doses in a different set of jars test experiments.

To ensure consistency in the testing process, all the jar test characteristics share common operational parameters given in Table 6. The jar test procedure basically involves the injection of coagulant dose, rapid mix for one minute at 100 rpm, slow mix for twenty minutes at 30 rpm and settling period of thirty minutes. After settling period, samples can be taken from jars to analyze the water's clarity.

Turbidity values represent the clarity of treated water, and the maximum observed turbidity clearance occurred at a coagulant and disinfectant dose of 16 mg/L Poly Aluminium Chloride (PAC) and 3 mg/L bleaching powder respectively, resulting in a turbidity reduction effectiveness of more than 85%. The results reveal that the PAC & bleaching powder treatment consistently produces lower turbidity values, indicating greater efficacy in water clarification which is reduced from 40 NTU to 17.3 NTU than the PAC & Lime and Alum treatments across all jar features.




Graph 1 Jar Test: Turbidity comparison with different coagulants

## IV. Conclusion

Water quality with respect to physicochemical parameters are found within permissible limits as per BIS guidelines except for turbidity. The turbidity in water is because of suspended mineral particles as well as cyanobacteria.

The Jar test studies with PAC and bleaching powder revealed that the coagulation process efficiently reduced turbidity from the Bhisi-1 sample when applied at doses ranging from 16 mg/L to 3 mg/L. For PAC and bleaching powder, the maximum turbidity removal efficiency was near 85%.

Turbidity removal effectiveness was not adequate at the measured doses. Occurrence of cyanobacteria (blue-green algae) in raw water may be creating misleading turbidity, which has an impact on lowering removal efficiency to some level. Water sources containing cyanobacteria would necessitate extra treatment methods to remove the cyanobacteria for removal of turbidity from the water. It is important to note, however, that these preliminary results show that additional study is required to achieve turbidity levels below the permitted range by incorporating multiple ways of cyanobacteria removal from the water sample. The water is not suitable for drinking purpose with these treatment options. However proper pre-oxidation and optimization of coagulant dose is essential in order to remove the cyanobacteria from the raw water.

## V. Recommendations

To provide safe drinking water to consumers the suggested measures are:

- Safeguarding the integrity of raw water sources.
- Ensuring optimal functionality of water treatment plant (WTP) unit operations.
- Utilizing poly-aluminium chloride (PAC) for enhanced results.
- Prioritizing adequate disinfection.
- Implementing pre-chlorination.
- Proper handling and quality assessment of chemicals.
- Maintenance and renewal of pumping mains and transportation pipelines.
- Promoting public awareness.
- These recommendations are essential in ensuring potable and good quality drinking water to consumers.

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