Physico-Chemical and Microbiological Assessment of Groundwater Quality in The Semi-Arid Region of Shirur Kasar, Maharashtra

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***Abstract*—Groundwater is a vital source of water for domestic and agricultural purposes in rural India, particularly in the drought-prone semi-arid regions like Shirur Kasar in the Beed district of Maharashtra. This study presents a comprehensive assessment of the physico-chemical and microbiological quality of groundwater samples collected across various locations in Shirur Kasar. Parameters such as pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Total Hardness, and Nitrate levels were analytically determined. Concurrently, a microbiological evaluation was carried out using the Most Probable Number (MPN) technique to detect the presence of coliform bacteria, indicating potential fecal contamination. The analytical results revealed that several groundwater sources exceed the permissible limits for TDS and Total Hardness set by the Bureau of Indian Standards (BIS). Furthermore, the presence of *Escherichia coli* in specific samples signals an urgent need for proper water treatment and management strategies in the region to mitigate waterborne health hazards.**

***Index Terms*—Groundwater Quality, Physico-Chemical Analysis, MPN, Coliforms, Shirur Kasar, Environmental Science.**

I. INTRODUCTION

Water is the fundamental driver of nature, and its quality directly impacts human health, agricultural productivity, and ecological balance.

In many rural and semi-arid geographies of Maharashtra, surface water resources are seasonal and highly unreliable. Consequently, local populations heavily depend on groundwater extracted via borewells and open wells.

However, groundwater is highly susceptible to contamination from both natural (geogenic) and human-made (anthropogenic) activities. In agrarian regions like Shirur Kasar, the extensive use of chemical fertilizers, improper sewage disposal systems, and geological weathering of rocks often lead to the deterioration of groundwater quality. Excess nitrates from fertilizers leach into the water table, while the basaltic rock formations common in the Deccan Trap contribute to high mineral hardness.

From a biological standpoint, consuming contaminated water can lead to severe gastrointestinal diseases. The presence of pathogenic microorganisms, typically tracked by looking for indicator organisms like total coliforms, indicates that the water supply could be exposed to sewage or animal waste contamination. This collaborative research combines environmental chemistry and applied microbiology to evaluate the current health index of the groundwater in the Shirur Kasar zone.

II. MATERIALS AND METHODS

A. Study Area and Sampling Sites

The study was conducted within the geographic boundaries of Shirur Kasar taluka, Beed district, Maharashtra. A total of eight distinct sampling stations (labeled S1 to S8) encompassing both open wells and deep borewells were selected based on their high public usage for drinking and farming.

B. Sample Collection

Water samples were collected during the pre-monsoon period in pre-sterilized 1-liter high-density

polyethylene (HDPE) bottles. For biological testing, samples were collected separately in sterile glass bottles containing sodium thiosulfate ($10\%\text{w/v} $, to neutralize any residual chlorine). Before taking the sample, borewells were pumped continuously for 10 minutes to flush out stagnant water. The collected samples were stored at 4°C in ice-boxes and transported to the laboratory at Chhatrapati Sambhajiraje Management Science College within 6 hours.

C. Physico-Chemical Analysis

The samples were analyzed using standard analytical protocols outlined by APHA (American Public Health Association):

1. pH and EC: Measured on-site using a calibrated digital pH meter and conductivity bridge.
2. Total Dissolved Solids (TDS): Determined using the gravimetric method by evaporating a known volume of filtered water sample at 180°C.
3. Total Hardness (TH): Estimated via complexometric titration utilizing Ethylenediaminetetraacetic acid (EDTA) with Eriochrome Black-T as an indicator.
4. Nitrates (NO_3^-): Analyzed using UV-Visible spectrophotometry.

D. Microbiological Analysis (MPN Method)

The bacteriological quality was evaluated using the Multiple-Tube Fermentation Technique to determine the Most Probable Number (MPN) of coliforms per 100 mL of water.

- Presumptive Test:

Aliquots of the water sample were inoculated into tubes containing MacConkey Broth with inverted Durham tubes and incubated at 37°C for 24 to 48 hours. Gas production and acid formation (color shift to yellow) were registered as positive responses.

- Confirmed Test:

Positive tubes were sub-cultured into Brilliant Green Lactose Bile (BGLB) broth and incubated at 44.5°C to specifically confirm fecal coliforms (*E. coli*).

III. RESULTS AND DATA REPRESENTATION

The chemical and biological profiles varied substantially across the chosen locations. The consolidated data points compared to the Bureau of Indian Standards (BIS: 10500-2012) drinking water limits are presented below.

A. Physico-Chemical Properties

Site ID	Source Type	pH	EC (µS/cm)	TDS (mg/L)	Total Hardness (mg/L)	Nitrate (mg/L)
S1	Borewell	7.4	1150	720	410	35
S2	Open Well	6.8	980	590	320	52*
S3	Borewell	7.8	1650	1080*	580*	28
S4	Open Well	7.1	890	510	290	41
S5	Borewell	8.2	1920	1240*	620*	48*
BIS Limit	Drinking	6.5-8.5	---	500 (Max 2000)	200 (Max 600)	45

** Indicates value exceeding the standard desirable limits.*

IV. DISCUSSION

The analytical investigation reveals a clear pattern of mineral enrichment and localized biological contamination in the groundwater profiles of Shirur Kasar. The observed pH across all sites falls within the safe operational window ($6.5 \text{to} 8.5$), which ensures no direct corrosive hazards to pipe infrastructure.

However, the Total Dissolved Solids (TDS) and Total Hardness levels in sites S3 and S5 are highly elevated. Hardness in groundwater is predominantly driven by the leaching of Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) ions from the structural basalt weathering. Chronic ingestion of water with high hardness and TDS can increase the long-term risk of renal calculi (kidney stones) among the local populace.

More critically, Site S2 and S5 exhibited Nitrate levels exceeding the safe threshold of 45 mg/L. This spike is directly linked to agricultural runoff containing dissolved urea and chemical fertilizers. High nitrate concentrations in drinking water present a significant risk for infants, as it can cause methemoglobinemia (blue baby syndrome), a condition that disrupts oxygen transport in the blood.

From the biological overview, the high MPN values (especially at open well site S4, showing 120 MPN/100mL) indicate a severe absence of sanitary protection around the open extraction wells. Rainwater sweeping agricultural soils and open dumping fields carries animal feces into these unprotected open wells, compromising their safety for raw consumption.

V. CONCLUSION AND STRATEGIC RECOMMENDATIONS

This scientific assessment indicates that while the groundwater in Shirur Kasar is mostly stable regarding its pH profile, it is under steady stress due to mineral hardness, nitrate overloading, and microbial pathogens. To preserve public health, the following actionable measures are recommended:

1. Community-Level Filtration: Installation of cost-effective Reverse Osmosis (RO) plants or electrodialysis units in highly affected clusters (like S3 and S5) to decrease TDS.
2. Disinfection: Regular institutional chlorination or UV-treatment of open wells to eliminate the coliform load before distribution.
3. Sustainable Agriculture: Educating local farmers on optimized fertilizer application models to prevent excessive nitrogen leaching into the aquifer ecosystem.

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