Evaluation of Monsoon Impact and Drinking Water Quality from Public Places of Sambhal City, U.P.: A Mathematical Approach

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Abstract
The current investigation aims to understand the quality of underground water and assess its suitability for both irrigation and domestic use. Water quality is a critical issue for humanity as it directly impacts human health. In many parts of India, groundwater serves as the primary source for both drinking and irrigation, making it an invaluable resource. To evaluate the groundwater quality in Sambhal city, this study calculates the Water Quality Index (WQI) for twelve different sites by comparing observed parameters with WHO standards. The WQI represents a composite rating that reflects the overall impact of different parameters of the water quality, helping determine the suitability of surface water for human consumption. Access to clean drinking water is necessary for good health, and it is widely recognized as a fundamental need for all individuals. The study findings reveal that groundwater at twelve of the sampled locations is severely contaminated, with only one site meeting the criteria for human consumption, while other sites show moderate levels of pollution. This underscores the urgent health risks associated with drinking contaminated water for residents relying on these sources. Consequently, stringent water quality monitoring and control measures are necessary in the catchment area to ensure public health safety and prevent adverse health outcomes. The research emphasizes the importance of ongoing water quality assessments and the implementation of management strategies to safeguard and improve the availability of safe groundwater in the region. Immediate attention is required to address the contamination and mitigate risks, providing the community with a reliable supply of fresh, clean drinking water.

Key words: drinking water, water quality and WQI

Introduction

Every live plant and animal species both influences and is influenced by its surroundings. The environment's inherent ability to purify and clean itself was intact several thousand years ago. In the recent past, man has had a significant impact on his surroundings due to the scientific and industrial revolutions, urbanization, and rapid population expansion. These are among the many, many others that contribute to the so-called pollution of the environment.

Among the many causes of the environmental deterioration we observe, man is the primary culprit. As everyone knows, having clean water is crucial to a healthy lifestyle (CGWB 2018). All people on the planet have a basic need: a sufficient quantity of clean, fresh drinking water. The issues of managing water quality, conserving water, and contaminating drinking water have become extremely complicated. Water contamination and its management have become urgent issues due to the extensive effects on human health (Khan 2015).

When the Earth was created by God, it was the result of cutting-edge technology. Seven days following the blueprint, the Earth was prepared and its quality was 100% confirmed. This was due to the careful calculations of the laws of gravity, the cyclic order, and the cosmic forces. The environment's inherent ability to purify and clean itself was intact several thousand years ago. In the recent past, man has had a significant impact on his surroundings due to the scientific and industrial revolutions, urbanization, and rapid population expansion. Without a question, environmental issues have woken man, and public concern about environmental quality has peaked emotionally (Ekbal 2022). To conserve our environment, scientists, climatologists, and environmentalists have set a good pace, but this pace must be maintained for a long time. About 90% of the fresh water on Earth meets the criteria for ground water, with over 98% of it being beneath the surface. These days, industrial, household, and agricultural wastes are being added to underground water by human activity. In most cases, contamination of ground water cannot be reversed. Instead of depending on tools to purify water as of a polluted resource, it is always preferable to safeguard ground water first (Rastogi 2024).

Water is one of the most vital resources for human survival, agriculture, and industry, serving as the backbone for social and economic progress. Access to clean, high-quality water is considered a fundamental human right, and the United Nations General Assembly (UNGA) has included universal access to clean water and sanitation as a key objective in its Sustainable Development Goals for 2030. Water quality is determined by its physical, chemical, biological, and aesthetic properties, which influence its suitability for various uses, including human health protection and ecosystem preservation (Goldman 1983). These characteristics can be impacted by both naturally occurring and human-induced substances that are suspended or dissolved in water.

Water security refers to a population's ability to consistently access sufficient and quality water for socioeconomic growth, health, protection against pollution and water-related hazards, and ecosystem conservation, all within a stable and peaceful political context. Although many people around the world have access to water, in many areas it is often not safe for consumption and is insufficient to meet basic health requirements (Herojeet 2017). The World Health Organization (WHO) estimates that over 1.1 billion people globally rely on contaminated water, with inadequate hygiene, poor sanitation, and unhygienic practices contributing to 88% of diarrheal illnesses worldwide. Additionally, urbanization, global warming, and climate change present significant challenges to the water supply sector. The limited availability and poor quality of water hinder sustainable development, especially in developing countries, impacting public health and economic stability (Khan 2017).

Despite the fact that water is a renewable resource, its availability and quality are being seriously threatened by poor management and careless usage of water infrastructure. Testing the water supply in and around any residential area is the responsibility of scientists. It is essential as a component of society. Given the extensive effects on human health, attention to water pollution and its control has become urgent (Kumar 2023).

The Indian state of Uttar Pradesh contains the district of Sambhal. Bahjoi town serves as the district headquarters. The Moradabad division includes the Sambhal district. Amroha, Moradabad, Rampur, Badaun, Aligarh, and Bulandshahr are the districts that border Sambhal in a clockwise direction from the north. The Indian state of Uttar Pradesh contains the city of Sambhal in its Sambhal district. The city is roughly 355 kilometers northwest of the state capital, Lucknow, and 158 kilometers east of New Delhi. It is approximately 666 feet above sea level. The coordinates are 28°35'N 78°33'E. According to the 2011 Census, the Sambhal District has a total area of 2453.30 square kilometers and a population of 21.9 lakh.

The land of Sambhal is ideal for mint cultivation, hence they specialize in producing these plants. Spearmint is widely cultivated for its oil. Summer temperatures in Sambhal's tropical environment can rise to as high as 35 degrees. April is when the average summer temperature reaches its highest, which is 32 degrees. This place experiences particularly cold winters, with lows of 7 degrees Celsius. Here, the typical winter temperature is 8 degrees, which is typical in December. Sambhal receives an average amount of rainfall every year, with August seeing the most intense downpours with an average of 200 mm (Manahan 1994).

It is well-known for its mentha production and sightings. The production of silver foil is also common. In South Asia, Sambhal has the biggest menthol market. China and Western Europe receive the majority of menthol oil exports. Calico printing, hand-loom weaving, and sugar refinement are some of its industries (Kumar 2022). Oil from the Mentha or spearmint plant is extracted and manufactured by a number of firms, making it a large industry. This oil is available as an essential oil and is mostly used for therapeutic purposes. These oils are sold to other nations worldwide and utilized in medications and perfumes (Verma 2020).

A well-known approach and one of the best instruments for communicating water quality is the water quality index, which provides a straightforward, reliable, and repeatable unit of measurement and informs policymakers and concerned individuals about water quality (Kumar 2021). Thus, it turns into a crucial metric for surface water management and assessment. WQI is a rating that takes into account the combined effects of various water quality metrics. WQI is determined by considering whether surface water is suitable for human consumption. One of the best methods for evaluating the quality of water is the Water Quality Index (WQI). Water quality indices that have been calculated have been used to express the quality of water from various sources. Water quality indices are computed using the estimated quantitative values of water quality parameters and associated WHO standards (Horton 1965, Tiwari 1985). The current study's goal is to evaluate Sambhal City's drinking water quality while it is being conducted.

The objective of this research work is to highlight a study focused on assessing the influence of the monsoon season on drinking water quality in Sambhal City, Uttar Pradesh. The research aims to quantify changes in water quality due to seasonal variations using mathematical and statistical methods.

By applying a structured, analytical approach, the study seeks to determine how monsoon rainfall impacts various water quality parameters, including chemical, physical, and biological characteristics. This evaluation is crucial for understanding potential public health risks, addressing water safety concerns, and proposing effective water management strategies in the city (Sinha and Kumar 2006). The mathematical modeling aspect underscores a rigorous and data-driven analysis, providing evidence-based insights for stakeholders to implement better water quality monitoring and management during monsoon-affected periods (Selvam 2014).

Materials and Methods

Using conventional sampling and estimate techniques, ten locations of India Mark-II (IM2) hand pumps in public areas at Sambhal had their underground water samples taken and quantitatively examined. The primary source of life in this region is underground water samples (APHA 1998). Following three hours of operation time for each site samples were taken and filled to the brim of 500 mL high-density polyethylene bottles, which were then promptly sealed to prevent air exposure. Every chemical was of analytical quality. Before being used, the used glassware was rinsed in 10% diluted nitric acid for an entire night. It was then thoroughly cleaned with distilled water multiple times. Three separate analyses of the water were performed. To guarantee accuracy, blank and spikes were also taken into account (Kumar 2022).

Conductivity, pH, alkalinity, total dissolved solids, chemical and biological oxygen demands, total hardness, calcium, fluoride, and chloride are the estimated parameters. Table 1 provides a brief description of the sampling locations. One of the best methods for communicating water quality is the Water Quality Index (WQI). Numerous national studies have evaluated the water quality of various natural resources using water quality indicators that have been calculated. Water quality indices are computed using the information gathered from quantitative analysis and WHO water quality standards (WHO 1984). Sambhal city's underground drinking water contamination is to be evaluated by computing WQI and comparing it to the standards. Based on the determined values of water quality indicators, the current study also aims to investigate the variation in drinking water quality following the start of the monsoon (Ouyang 2005).

Using the values of estimated parameters and WHO standards (WHO 2004), the water quality index (WQI) of subterranean underground drinking water collected at all sites was computed using the techniques suggested by Sinha and Kumar (Kumar 2008). The rating scales were set in terms of the ideal values of various parameters based on the role of different parameters based on their significance and incidence on the overall quality of underground drinking water. They may not be the decisive element even if they are present. As a result, they received zero values. The following formulas are used to calculate WQI:

1. The quality rating, $Qn = 100[(Vn - Vi) / (Vs - Vi)]$
   where Vn is the actual value of the nth parameter, Vi is its ideal value, and Vs is its standard
2. For different parameters, the unit weight (Wn) is inversely proportional to the standard (Sn) that is advised for that parameter.
   $K/Sn = Wn$ where K is a constant, Sn is the suggested standard, and Wn is 1.

3. By calculating the arithmetical mean of these sub-indices, the overall WQI is determined. antilog_{10} [Wn $\log_{10}$ Qn] = WQI
   The quality status of drinking water is assessed by calculating water quality indices, which consider the combined effects of various physico-chemical factors on overall water quality (Kumar 2010). To determine the level of pollution or the quality of underground drinking water, several assumptions are made based on numerous water pollution studies. The following presumptions apply:

Values of WQI	**Level of Contamination**
0 to 50	Fit for Human Consumption
51 to 80	Moderately Contaminated
81 to 100	Excessively Contaminated
More than 101	Severely Contaminated

Results and Discussion

Table 2 lists the estimated values of water quality metrics for various sites. Table 3 lists the parameters along with their assigned unit weight (Wn) and WHO standards. Table 4 displays the WQI values that were computed. The following facts about the subterranean water quality in Sambhal public locations during the study period are revealed by critical analysis of the data and comparison with WHO standards and assumptions for WQI.

The Water Quality Index (WQI) observed in the catchment area during the study ranged from 17 to 260. The highest WQI value was recorded at site V, indicating the most severe contamination, while the lowest was noted at site XII. Across all sites, the underground drinking water was determined to be heavily polluted, as reflected by WQI values exceeding 100. This indicates that the water quality is unsuitable for human consumption due to significant contamination levels. However, the water at site XI was found to be moderately polluted, indicating some potential for use but still requiring treatment or caution. Only one site within the studied locations was deemed fit for human consumption based on its WQI. This study highlights widespread water quality issues in the area, emphasizing the need for urgent measures to manage and improve groundwater safety. The findings serve as a call to action for authorities to implement effective water treatment and monitoring to ensure safe water access.

Conclusion

In many regions of the world, groundwater is a vital freshwater resource that meets a variety of human requirements. About 43% of the water used for irrigation in agriculture worldwide comes from groundwater. In many places, including the entire nation, groundwater is also a significant supply of water for domestic purposes. Despite its significance, both natural and man-made factors are posing a growing danger to the quantity and quality of groundwater supplies. Potential effects of climate change on groundwater include groundwater level decline and ocean intrusion. This water source has also gotten worse due to anthropogenic pollutants including fertilizer residue and untreated wastewater, as well as a sharp rise in water demand.

Based on the thorough explanation above, it can be said that Sambhal city's public drinking water is seriously contaminated at practically every test location. During the study period, drinking water at one location is moderately contaminated. As a result, it can be said that the drinking water in the sampling area's watershed is extremely contaminated and unsuitable for household and human use. The estimated physico-chemical parameter data is used to calculate the water quality indexes. On the other hand, based on the water quality measures examined, it can also be claimed that drinking water is seriously contaminated.

Every human being on the planet needs an adequate supply of clean, fresh drinking water. Water conservation, water quality management, and drinking water contamination have become extremely complicated issues. Given the extensive effects on human health, attention to water contamination and its control has become urgent. After the monsoon season begins, quality of underground drinking water deteriorates. The health risks of underground drinking water contamination must be affecting those who depend on this supply. Sambhal City urgently needs to implement some stringent and efficient drinking water quality control procedures. The water quality index has once again shown itself to be a valuable instrument for evaluating the quality of water.

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Table 1: Sampling details

Site No.	Site Name	Evident Water Quality	Noticed Activity
1	Veterinary Hospital	Pale yellow on standing, odourless	Drinking & Bathing
2	Sambhal Block	Colourless, odourless	Drinking & Bathing
3	Roadways	Colourless, odourless	Drinking & Bathing
4	Samudayik Swasthya Kendra	Colourless, odourless	Drinking & Bathing
5	District Court	Pale yellow on standing, odourless	Drinking & Bathing
6	Shankar College Square	Colourless, odourless	Drinking & Bathing
7	Government Hospital	Colourless, odourless	Drinking & Bathing
8	Nagar Palika Parishad	Colourless, odourless	Drinking & Bathing
9	Sambhal Tehsil	Colourless, odourless	Drinking & Bathing
10	Railway Station	Pale yellow on standing, odourless	Drinking & Bathing
11	Bahjoi road tiraha	Colourless, odourless	Drinking & Bathing
12	Moradabad road tiraha	Colourless, odourless	Drinking & Bathing

Table 2: Estimated values for water quality parameters by site

S. No.	Parameters	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
1	Conductivity	µS/cm	0.781	0.791	0.670	0.580	0.970	0.532	0.500	1.010	1.001	0.631	0.535	0.430
2	pH	--	7.72	7.68	7.43	7.33	7.95	7.70	7.39	8.01	7.85	7.55	7.60	7.45
3	Alkalinity	mg/lit	235	238	240	210	300	180	225	320	280	160	185	310
4	Total Dissolved Solids	mg/lit	710	680	715	685	795	705	690	805	790	685	675	710
5	Chemical Oxygen Demand	mg/lit	28	23	35	20	50	18	20	42	40	35	32	34
6	Biological Oxygen Demand	mg/lit	22	16	25	15	25	15	14	25	28	17	14	13
7	Total Hardness	mg/lit	350	380	285	270	550	320	335	450	535	340	355	320
8	Calcium	mg/lit	255	280	215	220	455	280	290	410	495	255	285	265
9	Chloride	mg/lit	61	81	56	65	165	80	69	150	170	72	85	67
10	Fluoride	mg/lit	0.32	0.50	0.40	0.63	0.62	0.30	0.21	0.53	0.41	0.21	0.11	0.17

Table 3: WHO standards, parameters, and unit weights (Wn) allocated to them

S.No.	**Parameters**	**WHO standard**	**Assigned Unit Weights (W_n)**
1	Conductivity	0.300	0.469793
2	pH	7.0-8.5	0.017617
3	Alkalinity	100	0.001409
4	Total Dissolved Solids	500	0.000281
5	Chemical Oxygen Demand	10	0.014093
6	Biological Oxygen Demand	6	0.023489
7	Total Hardness	100	0.001409
8	Calcium	100	0.001409
9	Chloride	200	0.000704
10	Fluoride	1	0.469793

Table 4: Water quality index values derived by site

Site No.	**Site Name**	**Water Quality Index (WQI)**
1	Veterinary Hospital	169
2	Sambhal Block	207
3	Roadways	174
4	Samudayik Swasthya Kendra	196
5	District Court	260
6	Shankar College Square	134
7	Government Hospital	109
8	Nagar Palika Parishad	245
9	Sambhal Tehsil	216
10	Railway Station	124
11	Bahjoi road tiraha	84
12	Moradabad road tiraha	17