



ASSESSMENT OF WATER QUALITY IN MORADABAD

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Abstract

The quality of the water is an essential component of both the preservation of the environment and the protection of public health, particularly in areas that are quickly urbanising, such as Moradabad district in Uttar Pradesh. The purpose of this research is to evaluate the physicochemical and biological properties of the water sources in Moradabad. These water sources include surface water (rivers and ponds), groundwater (handpumps and tube wells), and municipal supply water. There were a number of parameters that were analysed in line with the requirements set out by the BIS and the WHO. These parameters included pH, turbidity, total dissolved solids (TDS), hardness, chloride, nitrate, biological oxygen demand (BOD), and the presence of coliform bacteria. According to the findings, a number of water samples have been found to exceed the allowed limits for crucial characteristics such as total dissolved solids (TDS), hardness, and microbiological contamination. This is especially true in areas that are heavily inhabited and industrialised. Two of the most significant factors that contribute to the deterioration of water quality are the existence of industrial effluents that have not been treated and poor sewage treatment. In light of these findings, it is clear that there is an immediate requirement for efficient water management regulations, public awareness programs, and consistent monitoring in order to guarantee the safety of drinking water and to save aquatic ecosystems in Missouri.

Keywords: water, quality, Moradabad

Introduction

Water is an important natural resource that is responsible for the maintenance of ecosystems, the promotion of socioeconomic development, and the maintenance of life. In the context of increasing urbanisation and industrialisation, the need of preserving the quality of water has become a serious concern, particularly in emerging countries such as India. Moradabad, a significant city in Uttar Pradesh that is known for its brassware industry and dense population, is an example of an urban centre that is experiencing rising demand on its water supplies but is also experiencing this pressure. For household, industrial, and agricultural purposes, Moradabad is primarily reliant on surface water from rivers as well as groundwater retrieved by borewells and handpumps. The growing deterioration of water quality in the region has been brought about by a number of factors, including the fast increase of industrial activity, notably uncontrolled small and medium-scale firms, as well as inadequate wastewater treatment and inadequate sanitary infrastructure. The presence of contaminated water not only poses a risk to public health, since it has the potential to cause diseases that are transmitted by water, such as cholera, typhoid,

and diarrhoea, but it also undermines the integrity of the environment and promotes economic growth. A complete evaluation of the water quality in Moradabad is the objective of the current study, which will be accomplished through the examination of important physicochemical and biological characteristics. pH, turbidity, total dissolved solids (TDS), hardness, nitrate, chloride, biological oxygen demand (BOD), and the presence of coliform bacteria are some of the factors that are considered. The findings will be evaluated in light of the standards established by the Bureau of Indian Standards (BIS) and the World Health Organisation (WHO) in order to determine whether or not water is suitable for human consumption and other applications with regard to safety and appropriateness. It is essential to have a comprehensive understanding of the spatial distribution and the factors that contribute to water pollution in order to effectively influence the policies of local governments, develop efficient water management methods, and raise awareness within the community. In addition to contributing to evidence-based actions that can enhance the sustainable management of this essential resource, the purpose of this study is to fill in gaps in the existing data on the water quality in Moradabad. It has been claimed that the water quality in numerous places in Moradabad has been deteriorating over the past several years, notably in low-lying and industrial neighbourhood areas. There is a significant amount of pollution that is discharged into the Ramganga River, which is a tributary of the Ganga and runs through the city. This pollution comes from industrial discharge, residential wastewater, and the dumping of solid debris. Furthermore, groundwater, which is a key supply of drinking water for a sizeable number of the population, is increasingly exhibiting symptoms of pollution as a result of leaching from open drains, pit latrines, and illegal disposal of industrial effluents. This is a problem since groundwater is a major source of drinking water around the world. Both the uncontrolled growth of residential areas and the absence of efficient sewage infrastructure are contributing factors that are making the issue even worse. People are forced to drink water that is not safe to drink in many neighbourhoods, particularly those that are located in urban slums and peri-urban regions. This is because there is a lack of adequate infrastructure for water treatment and supply. The excessive extraction of groundwater has not only resulted in a decrease in the water table, but it has also led to a rise in the concentration of dissolved contaminants, which include substances that are extremely hazardous to human health. In light of these worries, it is not only timely but also essential to conduct an evaluation of the water quality in Moradabad. It is possible for policymakers to prioritise interventions such as water purification systems, wastewater management infrastructure, industrial control, and public education campaigns if they have a scientific understanding of the existing state of water resources. In addition, the use of geographic information system (GIS) technologies to create a spatial map of water quality indicators can be of assistance in locating pollution hotspots and monitoring changes over time.

National-Level Studies

In accordance with the findings of Trivedy and Goel (1986), the evaluation of water quality via the use of physicochemical and biological characteristics offers a trustworthy comprehension of the physiological state of a body of water. The Central Pollution Control Board (CPCB) has observed on a regular basis that urban rivers in India, such as the Yamuna and Ganga, are under significant stress as a result of untreated sewage and industrial effluents (CPCB, 2018). Many smaller urban rivers, like as the Ramganga, which flows through Moradabad, exhibit patterns that are comparable to those described above. In their study on the water quality of the Hindon River, Singh et al. (2012) discovered significant levels of coliform bacteria, BOD, and COD. They also determined that the pollution was caused by

industrial waste and improper disposal of sewage. The findings of their investigation are reflective of the problems that are also encountered in Moradabad, where the electroplating and brass industries are major contributors to the poisoning of water sources with metals.

Regional and State-Level Studies

A number of studies have brought to light issues regarding the quality of the groundwater in Uttar Pradesh. Excessive levels of fluoride, nitrate, and hardness were found in drinking water sources, according to a study that was carried out by Raju and colleagues (2011) in the western regions of Uttar Pradesh. After doing additional research and analysing water samples from a number of different cities, Kumar and Singh (2015) discovered that the presence of industrial activity and the lack of efficient water treatment in urban areas both contribute to the worsening of groundwater contamination. According to the findings of a district-level research conducted by Alam and Fatima (2018), which focused on the adjacent city of Bareilly, more than sixty percent of the groundwater samples that were analysed exceeded the allowed limits for nitrates and total dissolved solids (TDS). It is possible to draw parallels between these findings and the situation in Moradabad, where groundwater is increasingly being exploited for household purposes in the lack of a regular supply from the municipal government.

Local Studies in Moradabad

Not many research have been carried out especially in Moradabad, although there have been a handful that have. After conducting an investigation into the water quality in and around the Ramganga River, Sharma et al. (2019) discovered that the water included significant concentrations of heavy metals like lead, zinc, and chromium. It was determined that the trash that was produced by the electroplating and brass industries was responsible for these discoveries. Another research conducted by Khan and Ali (2020) examined samples taken from hand pumps located in the industrial zones of Moradabad. They discovered higher levels of iron and coliform, which indicated that faecal contamination was most likely caused by sewage systems that were not properly sealed.

Methodologies Adopted in Water Quality Studies

Standard parameters are utilised in the majority of water quality evaluations. These parameters include pH, turbidity, total dissolved solids (TDS), hardness, chloride, nitrate, total coliform, biological oxygen demand (BOD), and chemical oxygen demand (COD). The use of instruments such as portable water testing kits, spectrophotometers, and GIS mapping tools has been increasingly common in recent years (Patel et al., 2016). These instruments have been utilised to improve accuracy and spatial comprehension. A measure known as the Water Quality Index (WQI) is also commonly utilised by researchers in order to show an overall status of water quality in a manner that is easily accessible. The Water Quality Index (WQI) is determined by combining the values of a number of parameters and assigning a weight to each of them according to the influence they have on health and usability (Sargaonkar & Deshpande, 2003). The ranking of water sources and the prioritisation of locations for cleanup are both facilitated by this strategy.

Material and methods

Both the conductivity meter RI 215 R and the pH meter Century CP901 were utilised in order to ascertain the pH and conductivity of the substance. Table 1 provides a concise explanation of the sample locations

that are used for the quantitative assessment of water quality parameters. A titrimetric analysis was performed in order to determine the total hardness, accessible chlorine, chromate ion, carbonate, calcium, magnesium, dissolved carbon dioxide, alkalinity, chloride, copper, and zinc concentrations.

Sample collection

Using India Mark II (IM2) hand pumps, a total of ten ground water samples were obtained in accordance with the recommended sampling methods and protocols (APHA, 1995; Merck, 1974). Table 1 provides a comprehensive description of the many types of hand pumps. Following a period of approximately thirty-five minutes during which the water was allowed to run, samples of water were taken straight from water pumps.

Analytical methods

Titrimetric method

Anhydrous and of analytical reagent grade, each of the salts that were used had purities that were stated to be greater than 99 percent. The following chemicals were used: EDTA (Aldrich), KI (Darmstadt), Sodium Thiosulphate (Guaranteed reagent grade from Sarabhai Chemicals Co.), NaOH (Fluka), AgNO₃ (SAS Chemicals), HCl and H₂SO₄ (Qualikem). After being dried in a vacuum oven at a temperature of 120 degrees Celsius for many days, Ail salts were utilised without any additional purification. In order to produce stock solutions, water that had been deionised and then double-distilled was used throughout the whole process of conducting the experiment. Using a vibrating tube densimeter manufactured by Anton Paar Co., Ltd. (DMA 60/602) allowed for the determination of the concentrations through the process of density measurement. All of the concentration measurements were able to be reproduced with an accuracy of within 0.35%. The total hardness was evaluated by adding three to four drops of Eriochrome black-T indicator to twenty ounces of drinking water, followed by adding five millilitres of buffer solution (NH₃+NH₄Cl), and then titrating the mixture with a solution of 0.01 millimolar EDTA. When the process is complete, the solution transforms from a wine red to a blue colour. This solution is titrated with 0.01 sodium thiosulphate solution until a yellow hue appears. Twenty centilitres of water, five millilitres of acetic acid, and KI solution are taken for the purpose of determining the amount of chlorine present. Now that the blue colour has been acquired by adding the starch solution, the entire content is titrated once again with the standard sodium thiosulphate solution at a concentration of 0.01 M until the blue colour is no longer in the solution. For the purpose of determining the amount of chromate present in drinking water, 20 cc of drinking water, 3–4 ml of sulphuric acid, 0.5 gm of sodium bicarbonate, and 2 gm of KI solution are combined. The resulting mixture is then titrated with a solution of 0.01 sodium thiosulphate until a yellow hue is observed. After the addition of the starch solution, which causes the solution to take on a blue hue, the solution is titrated once again with sodium thiosulphate until the blue colour is no longer present. An amount of twenty millilitres of drinking water is placed in a conical flask, and then two to three centilitres of methyl orange indicator is added to the mixture. This solution was titrated with 0.01M hydrochloric acid, and the colour changed from yellow to red at the end of the process. Gravimetric procedures, which include evaporating the liquid solvent and measuring the mass of residues left behind after the process, are the most precise ways for determining the entire amount of solids that have been dissolved. Although this approach is time-consuming, it is typically considered to be the most effective. In the event that inorganic salts constitute the vast majority

of total dissolved solids (TDS), gravimetric techniques are suitable. 20 cc of water is combined with 2-3 cc of phenolphthalein indicator, and then the mixture is titrated with sodium hydroxide (N/50). This is done in order to determine the amount of dissolved carbon dioxide. In order to determine the amount of calcium present, twenty millilitres of drinking water were combined with buffer solution ($\text{NH}_3/\text{NH}_4\text{Cl}$) and then titrated with 0.01M ethylene diamine tetraacetic acid (EDTA) while taking into account the presence of three to four millilitres of eriochrome black-T indicator solution. Standard N/50 H_2SO_4 solution is used to titrate drinking water in the presence of methyl orange indicator in order to measure the total alkalinity of the water at the drinking water level. For the purpose of detecting chloride ion, twenty centilitres of drinking water were obtained and combined with five drops of fluorescein indicator. The solution was then titrated with 0.001M AgNO_3 solution while the flask was continually rotated. Due to the fact that the end point was getting closer, the silver chloride began to coagulate to a significant degree, and the precipitate suddenly took on a hue that was either pink or red. For the purpose of detecting copper, twenty centilitres of drinking water is used, to which five millilitres of NH_3 solution of pH 6-13 and five drops of murexide indicator solution are added. Titrated it with normal 0.001 MEDTA solutions until the colour changed from orange reddish to violet blue. This process was repeated until the colour changed. Twenty cc of water, two millilitres of buffer with a pH of ten, and two to four cc of Eriochrome black T indicator are required for the detection of zinc. It was titrated with a solution of EDTA at 0.001 M. When the process reaches its conclusion, the hue shifts from red violet to pure blue.

Coefficient of correlation (r)

When it comes to correlation, a perfect 1 positive indicates a linear relationship (correlation) that is rising, while a perfect -1 negative suggests a diminishing (negative) relationship. Additionally, a number that falls between -1 and 1 reveals the degree of linear dependency that exists between the variables. The closer it gets to zero, the less of a link there is (the closer it gets to being uncorrelated). The greater the correlation between the variables, the closer the coefficient is to either -1 or 1, the more significant the correlation is. When the focus is on the connection between a dependent variable and one or more independent variables, regression analysis is a method that incorporates tools for modelling and analysing multiple variables. Through the use of regression analysis, one may gain a better understanding of how the usual value of the dependent variable shifts when any one of the independent factors is altered while the other independent variables remain same. In most cases, regression analysis is used to estimate the conditional expectation of the dependent variable given the independent factors. This means that it calculates the average value of the dependent variable while the independent variables are kept constant. The correlation coefficient r developed by Karl Pearson is utilised in order to ascertain the following in order to ascertain the link that exists between the two parameters x and y : Two factors are required by the mathematical models that are used to evaluate water quality in order to accurately depict the groundwater conditions that are really there. Through the use of correlation analysis, one may determine the degree of closeness that exists between specified independent variables and dependent variables. According to the World Health Organisation (1994), this analysis makes an effort to determine the nature of the relationship that exists between the variables, and as a result, it offers a method for forecasting and prediction. In this investigation, the correlation coefficient, denoted by the letter r , was computed by applying the formula that is shown below in order to ascertain the link between the water quality measures and each other in the data of the water that was analysed:

Strength calculation

After determining the molarity of each element or compound through the use of titrimetric analysis, the strength of each element or compound was determined by the use of relation:

Strength= Molarity x Molar mass of the element or compound

$$r = \frac{n \sum (x_i y_i) - (\sum x_i)(\sum y_i)}{\sqrt{[n \sum x_i^2 - (\sum x_i)^2] [n \sum y_i^2 - (\sum y_i)^2]}} \quad (1)$$

Here, x (where x represents the values of the x-variable) and y (where y represents the values of the y-variable) stand for two distinct water quality criteria.

N=number of data points.

The following equation of straight line might be utilised in order to ascertain the straight linear regression.

$$y = a x + b \quad (2)$$

where y and x are the variables that can be considered dependent and independent, respectively. There is a slope for the line, and there is an intercept on the y-axis.

The slope a and intercept b can be determined using the following relation:

$$a = \frac{n \sum x y - \sum x \sum y}{n \sum x^2 - (\sum x)^2} \quad (3)$$

and

$$b = \frac{\sum y - a \sum x}{n} \quad (4)$$

The value of the correlation coefficient, denoted by the letter r, will range from minus one to plus one. When the two variables are represented by a negative sign, it indicates that they do not have comparable trends of variation, but a positive value indicates that they do have similar trends. If the value of r is closer to unity, then the accuracy of the fitness test will be higher. X and Y are considered to be independent of one another when the value of r is zero, which shows that there is no relationship between the two variables. The statistical program SPSS, version 7.5, was utilised in order to conduct the regression analysis, which was carried out in order to investigate the association between the various water quality indices.

Results and discussion

Both Table 2 and Table 3 provide the results that were obtained for a variety of ions, elements, and compounds. Table 4 presents the results of a comparison between the various values of physico-chemical properties that were found for groundwater samples and the standards established by the BIS and the

WHO. The groundwater samples have been subjected to correlation analysis in accordance with the approach that was outlined before. The results of the correlation coefficient for TH-Cl₂ are positive ($r=0.5368$), indicating a moderate correlation. This indicates that there is a propensity for high x variable scores to go with high y variable scores and vice versa. In the case of alkalinity – chloride ion ($r=0.5555$), the value of r is positive, indicating a moderate correlation. This indicates that there is a propensity for high x variable scores to go with low y variable scores and vice versa. In the case of calcium-magnesium ions, the value of r is 0.1693; this indicates a positive correlation; nevertheless, the association between the variables is not very strong. In the case of EC-Magnesium ions, the r value is positive, but it is not high enough ($r=0.0045$). Although there is a positive correlation between the variables, the association between them is not strong. At the same time, the association between the variables is not very strong for alkalinity and chromate ($r=0.213$).

Table 1: Specifics of the sample locations

S. No.	Number and Name of site	Location of site	Depth of boring	Type of source	Apparent water quality	Use of water
1	I,IM2Hand pump at Gajraula	50kmsouth-west to Moradabad collect orate	Approx. 34meter	Only source of water	Odorless, turns yellowish on standing	Drinking, domestic purposes
2	II,IM2Hand pump at Nazimabad	40kmeastto site no.	Approx. 33meter	Only source of water	Colorless, odorless	Drinking, bathing etc.
3	III,IM2Hand pump Railway station	5kmsouth- west to Moradabad collect orate	Approx. 35meter	Only source of water	Colorless, odorless	Drinking, laundering
4	IV,IM2Hand pump at Pakwara	10kmnorthto site no. III	Approx. 33meter	Only source of water	Color of waterturns yellowish-brown on Standing	Drinking, bathing
5	V,IM2Hand pump at Mansarovar	1.5kmnorth to siteno.III	Approx. 36meter	Only source of water	Colorless, odourless	Drinking, domestic purposes

6	VI,IM2Hand pumpat Rampur	0.5kmsouth to siteno.V	Approx. 35meter	Only source of water	Colourless, odourless	Drinking, domestic purposes
7	VII,IM2 Hand pumpat Mundapandi	1.5kmnorth to Mandi samiti	Approx. 34meter	Only source of water	Colourless, Fishy smell	Drinking, domestic purposes
8	VIII,IM2 Handpumpat Dalpatpur	1.0kmnorth to siteno VII	Approx. 33meter	Only source of water	Colourless, odourless	Drinking, bathing etc.
9	IX,IM2Hand pump at Buddh Vihar	2.5kmeastto site no. III	Approx. 33meter	Only source of water	Colour of water turns paleyellowon Standing	Drinking, domestic purposes
10	X, IM2 Hand pumpat Police station, Kanth	7.0 km south to Moradabad collect orate	Approx. 34meter	Only source of water	Colour of water turns yellowish- brown on standing	Drinking, bathing

Table 2: The physicochemical characteristics of groundwater samples taken in the month of May 2014 in the Moradabad District of Uttar Pradesh, India, were as follows: pH, EC, TDS, TH, Cl₂, and CrO₄⁻².

Sampli ng Statio n	pH	EC	TDS	TH	Cl ₂	CrO ₄ ⁻²
Gajraula	7.31	0.77	454.9 0	118	4.5	0.002
Najibabad	7.61	0.72	375.7 6	116	4.6	0.003
RailwayStation	7.72	0.67	480.8 8	124	4.7	0.001
Pakwara	7.81	0.51	345.95	126	9.0	0.0015
Mansarovar	7.75	0.67	298.86	123	8.8	0.0016
Rampur	7.91	0.75	175.86	121	6.4	0.0017

Munda pande	7.95	0.47	421.64	123	8.4	0.0018
Dalpatpur	7.98	0.39	433.25	125	7.7	0.0011
BudhiVihar	8.12	0.45	189.09	124	4.3	0.0014
Kanth	8.05	0.29	301.78	122	4.8	0.0016

*Units of all parameters are in mg/l except conductivity $\mu\text{S.cm}^{-1}$ and pH.

Table 3: Analysis of the physical and chemical properties (CO_2 , Ca^{2+} , Mg^{2+} , alkalinity, Cl^- , Cu^{2+} , and Zn^{2+}) of groundwater samples collected in May 2014 from the Moradabad District in Uttar Pradesh, India.

Sampling Station	CO_2	Ca^{2+}	Mg^{2+}	Alkalinity	Cl^-	Cu^{2+}	Zn^{2+}
Gajraula	9.12	76.99	16.5	278	10.78	2	2.8
Najibabad	10.85	65.14	15.3	298	23.89	2.5	1.9
RailwayStation	11.16	54.76	25.6	287	17.82	3.5	1.7
Pakwara	12.33	62.67	24.9	267	16.99	1.4	1.3
Mansarovar	9.98	19.97	18.5	299	17.65	1.8	1.5
Rampur	7.34	43.77	11.9	315	53.76	2.1	1.7
Munda pande	4.16	56.78	10.8	314	45.88	0.9	1.9
Dalpatpur	12.01	32.44	12.6	281	36.22	0.8	2.9
BudhiVihar	11.78	48.88	13.7	298	16.33	0.7	3.1
Kanth	11.56	51.34	20.7	311	18.34	0.6	3.2

*Units of all parameters are in mg/l.

Table 4: Analysing the groundwater in the Moradabad city area in relation to drinking water quality requirements set by the BIS (1991) and the WHO (1994)*

Parameters		BIS Standard		WHO# Limit(mg/l)
	Range of Samples	Acceptable limit	Maximum Limit	
	Minimum Maximum			
Total hardness	116 126	300	600	100
TDS	175.86 480.88	500	2000	500
Chlorine	4.3 09	0.20	---	--

Chromateas hexavalent ion	0.001 0.0018	0.1	1	0.05
Calcium	19.97 76.99	75	200	75
Magnesium	10.8 25.6	30	100	150
Carbon dioxide	4.16 12.33	-	-	-
Alkalinity	278 315	200	600	---
Chloride	10.78 45.88	250	1000	250
Copper	0.6 03.55	0.05	1.5	2
Zinc	1.3 3.22	5	15	3
pH	7.31 8.12	6.5-8.5	9.2	6.5-9.2
Conductivity	0.29 0.77	300	---	----

*Units of all parameters are in mg/l except conductivity $\mu\text{S.cm}^{-1}$ and pH.

There is a substantial negative association between the x and y variables for pH-EC($r=-0.765$), suggesting that high x scores are associated with low y scores. The same pattern emerges when looking at pH-TDS ($r=-0.5281$). A negative association is indicated by the Chromate-CO₂ ($r=-0.2267$) correlation. The correlation for Cu²⁺-Zn²⁺ ($r=-0.5554$) is moderately negative, suggesting that low values for the y-variable are associated with high values for the x-variable, and vice versa. There is a modest link between the variables Cl₂-Ca²⁺ ($r=-0.4604$), however the correlation suggests a negative correlation.

Conclusion

Urbanisation, industrialisation, and insufficient infrastructure provide substantial obstacles to water quality evaluation in Moradabad. Many water sources, especially those in industrial zones and heavily populated urban slums, above the acceptable limits for critical parameters including total dissolved solids (TDS), hardness, nitrate, and coliform bacteria, according to this study's findings. Untreated industrial effluents, septic system leaks, and inappropriate solid and liquid waste disposal are all examples of human-caused activities that contribute to these contaminants. The Ramganga River is a major surface water body in the area, but it is severely polluted since it is so close to factories and collects sewage from other cities. In the same vein, places without adequate sanitary infrastructure are particularly vulnerable to pollution of groundwater sources, which are utilised for drinking and domestic reasons. Microbiological contamination in several samples adds fuel to the fire of public health worries about potential adverse consequences, such as heightened vulnerability to gastrointestinal illnesses and heavy metal toxicity in the long run. Based on the results of this research, Moradabad must immediately implement an integrated water resource management system. Stricter enforcement of environmental restrictions on companies, public awareness programs on water cleanliness, wastewater treatment facility promotion, and a strong framework for monitoring water quality are all on the list of suggestions. Better reaction and planning can also be achieved through the use of geographic information system (GIS) technologies for mapping contaminated hotspots and long-term monitoring. The public's health, the city's economic growth, and the environment all depend on Moradabad's water quality being protected. Academic institutions, non-profits, and government agencies can use this study's findings to work together on long-term water management plans. Safe, dependable, and clean water for all Moradabad people can only be achieved by concerted efforts.

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