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Ground Water Quality Assessment in Udham Singh Nagar, Uttarakhand, India

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Abstract

In present study the ground water qualityof Udham Singh Nagar, Uttarakhand was assessed and compared with the national and international standards. The groundwater quality waschecked by Canadian Council of Ministers of Environment Water Quality Index (CCMEWQI). This index assesses the suitability of groundwater quality for drinking in the eight sampling stations located at Kashipur, Pant Nagar, and Kichha of Udham Singh Nagar, Uttarakhand. The indexfor summer (April) season for 2019 and 2020 was computed by using the secondary data related to groundwater collected from the Uttarakhand Pollution Control Board. The water quality index (WQI) has computed using the value of temperature, electrical conductivity, hardness, magnesium,and alkalinity. It isconcluded based on CCME WQI that no sampling station comes under the category of excellent during last two years. WQI values shows that water quality improved in 2020in comparison to 2019, as the values in 2019 are56.78, 65.28, 56.21, 55.78, 47.50, 49.29, 56.16, 55.89 whereas in 2020 the values are 66.19, 74.30, 66.08, 59.57, 51.51, 66.68, 66.11, 73.53. The index improved in 2020 year because lockdown had led to partial or complete ban on the industrial activities.

KEYWORDS: *CCMEWQI, Groundwater, Groundwater pollution, water quality standards*

INTRODUCTION

Out of the total proportion of water on earth, 97.5 percent is contained by oceans where the water is saline and cannot be used for drinking, and only 2.5 percent is freshwater whose main source are glaciers melting(Awasthi et al., 2022).Now, out of the total freshwater, 79 percent is icecaps, iceland, glaciers (Antarctica and Arctics), 20 percent is groundwater, and 1 percent is easily accessible surface water (it is in the forms of lakes, solid moisture, rivers). The most significant and easily accessible form of freshwater is groundwater. Studies shows that groundwater is considered the most extensive and easily accessible available source of fresh water on earth (Duraisamy et al., 2019).Groundwater is decentralised, and it is available everywhere.In different regions of India and other countries, groundwater exploitation and subsequent depletion provide significant harm to its growth and future existence. It may get drop-off permanently since the rate of groundwater extraction from wells is higher than the rate of its replenishment, making it a big concern of the world (Ram et al., 2021). Groundwater is getting affected and contaminated by the pollution generated from industrial wastes and agricultural wastes. If groundwater once gets polluted, its quality degrades rapidly, and it becomes nearly impossible to resist the source of pollution to act further. This deterioration of groundwater has harmful ill effects on human health (Srivastava, 2016).Lot of research work was done ongroundwater pollution. Since resolving the groundwater problem is quite expensive that consume lot of time and sometimes results are also not expected, hence researchers are keenly working to protect the groundwater. In today's scenario, groundwater quality is on a declining slope. Although the process is slow, quality is undoubtedly being degraded on the regular basis. Often,water contaminationcannot be detected easily unless it appears on the surface of the used water. Many activities that take place on the surface of the earth has the potential to contaminate the groundwater.Numerous researchers (Rita and Mallam, n.d;Mishra et al., 2020; Kumar et al., 2022) found that major factors like landfills, discharge from industries, injecting chemicals into the subsurface, and hazardous wastes generated from several process industries are responsible for groundwater pollution. Other important sources are discharge released from latrines into the subsurface, septic tanks, and infiltration of hazardous polluted waste from urban areas into the ground. These sources influence the aquifer beneath the earth's surface (Agrawal, 2007). Thus, it becomes imperative to protect groundwater by implementing proper and regular surveillance and making necessary management strategies to enhance and maintain the groundwater quality for the better and safe future (Bunkar & Kumar, n.d.). Hence water quality index (WQI)isused to identify and detect groundwater quality and generally helped todecide on the use of water. The WQI tool is majorly used to make the complex analysis lucid and straightforward. WQIs are broadly classified into two types: physio-chemical indices and biological indices. The physio-chemical indices considered the values or data points obtained from physical and chemical parameters such as pH, alkalinity, calcium and magnesium, whereas biological indices are made up of values derived from bio-information. The present study'sWQI is calculated on physio-chemical parameters(Datta et al., n.d.). There are different types of WQIs which have been used so far in assessing the water quality namely, Weighted Arithmetic WQI, Oregon WQI, Canadian Council of Ministers of Environment WQI,National Sanitation Foundation WQI, Prati's Index of Pollution, Bhargava's WQI, and Dinius WQI (Zotou et al., 2018). Out of these different indices, CCME WQI is one of the most popular indicesas compared to others. The CCME WQI was first used by Canada for assessing Canadian river basins water quality (Lumb et al., 2006; Hurley et al. 2012). The CCME WQI is flexible in parameter selection and also quickly adjust and adapt to their specific conditions/concerns. In the present paper, an assessment status of groundwater quality over the consecutive two years has been carried out for three locations, namely, Kashipur, Pant Nagar and Kichha in the Udham Singh Nagar region of Uttarakhand by using CCME WQI.

Area of Study

The study area of the present workis Udham Singh Nagar that lies between the latitudes 28°52′N and 29°23′N and 78°45′N and 80°08′Nlongitudes.Eight sampling stations were selected from the three locations i.e. Kashipur, Pantnagar, Kichha of Udham Singh Nagar, Uttarakhand and details of sampling stations is shown in Table 1. Udham Singh Nagar of Uttarakhand is called "Chawal Nagri" and "Rice Bowl" due to paddy cultivation, which automatically indicates that groundwater usage is apparent here. During the summer seasons with less rain, the region encounters a water shortage. Therefore, it is necessary to keep a regular check on improving the water quality.

Table 1: Details of Ground Water (GW) Sampling Stations

Sampling Station Code	GW – Sample Station, Location	Cities in Udham Singh Nagar, Uttarakhand
SS01	GW - Handpump, Near Govt. Primary School	Kashipur
SS02	GW - Handpump, Near Damauda, Near India Glycols Ltd.	Kashipur
SS03	GW - Handpump, Near Kendriya Vidyalaya, Bazpur Road	Kashipur
SS04	GW - Handpump, Near Govt. Gurudwara, Muradabad Road	Kashipur
SS05	GW - Handpump, Near Sitarganj, Industrial Area – 2	Kashipur
SS06	GW - Handpump, Pant Nagar, Industrial Area – 1	Pant Nagar
SS07	GW - Handpump, Santipuri, Kichha -1	Kichha
SS08	GW - Handpump, Santipuri, Kichha -2	Kichha

SS means Sampling station and **GW** means groundwater

MATERIALS & METHODS

In current investigationsecondary water quality data were usedfor eight sampling stations located at Kashipur, Pant Nagar, Kichha of Udham Singh Nagar, Uttarakhand, India for summer (April) season for year 2019 and 2020 from the Uttarakhand Pollution Control Board (https://ueppcb.uk.gov.in/pages/display/100-ground-water).These stations are selected because they are more prone to groundwater pollution due to increasing industrialisation and urbanisation in these areas. To analyse the water quality of these places, several physio-chemical parameters i.e. pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), alkalinity, hardness, calcium (Ca), magnesium (Mg), chloride (Cl), and biological oxygen demand (BOD) were compared with the acceptable limits recommended by national and international drinking water quality standards as depicted in table 2.

Table 2: Desirable limitof Physio-chemical parameters by national/ international bodies

Physical Parameters	**Desirable Limit**	**Recommended agencies**
pH	6.5-8.5	BIS*
Temperature (°C)	25	WHO**
Total hardness (mg/L)	200	BIS
EC (μmho/cm)	300	ICMR***
Ca	75	BIS
Mg	30	BIS
Cl	250	BIS
BOD	5	CPCB****
Alkalinity	200	BIS
TDS	500	BIS

**Bureau of Indian Standards; ** World Health Organization; ***Indian Council of Medical Research, ****Central Pollution Control Board*

In the present study, CCMEWQI was calculated usingtemperature, electrical conductivity, hardness, Mg and alkalinity. This index is used because of its various advantages like it is easy to manipulate and calculate. CCME WQI contains the guidelines for assessing the water quality of any area or source. The purpose of the CCME WQI method is to convert the water analytical data into single value data, which will finallyembody the complete water quality of the study area. To achieve that single value data, the three significant elements of CCME WQI, namely Scope(F1),Frequency(F2) and Amplitude(F3) are calculated.

The formula to calculate these elements is provided below.

Step – 1 calculating the scope value (F1 Value)

$$F1 = \frac{Numberoffaieldvariables}{Totalnumberofvariables} x(100)$$

Step – 2 calculating the frequency value (F2 Value)

$$F2 = \frac{Numberoffailedtests}{Totalnumberoftests} x(100)$$

Step – 3 calculating the Amplitude value (F3 Value)

Three sub-sets:

Step – 3.1 when the test value must not exceed theobjective:

$$Excursion = \frac{Failedtestvalue}{Objective} - 1$$

For the case where the test value must not fall below the objective

$$\text{Excursion} = \frac{Objective}{Failedtestvalue} - 1$$

Step – 3.2 Normalised Sum Excursion Value (nse)

$$\text{nse} = \frac{\sum_{i=0}^{n} excursion}{Totalnumberoftests}$$

Step – 3.3

$$\text{F3} = \frac{nse}{0.01\,nse + 0.01}$$

Overall Calculations –

$$\text{CCME WQI} = 100 - \frac{\sqrt{(F1)(F1) + (F2)(F2) + (F3)(F3)}}{1.732}$$

A final index value is calculated from the above equation. Further on the final index valueis a rank provided to the water. CCME has already have rank for different index value. Table 3 depicts water quality rank based onthe final CCMEWQI value.

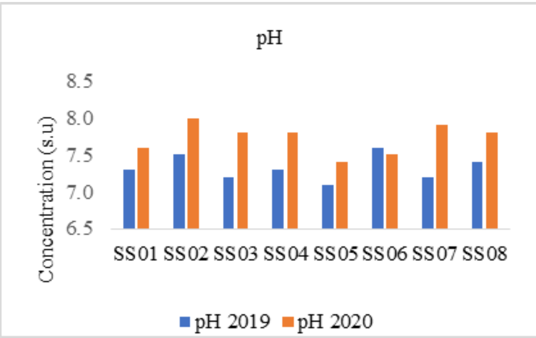
Table 3: Water quality ranking as per CCME

CCME WQI Value	Rank
95 to 100	Excellent
80 to 94	Good
65 to 79	Fair
45 to 64	Marginal
0 to 44	Poor

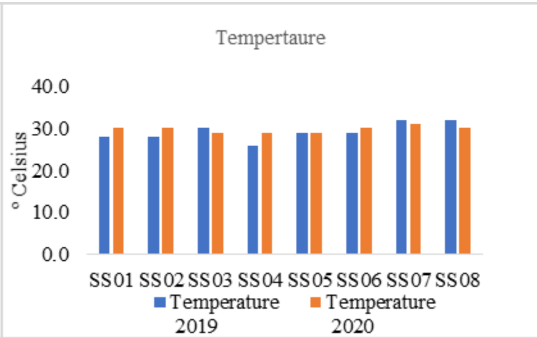
Source: Winnipeg, 2001

RESULT & DISCUSSIONS

By analysing the groundwater quality for the period 2019 to 2020, a clear picture of variations in all the locations is observed. Also, the reasons and factors for the changes in trends of graph are discussed in the coming section. The data from different sampling stations of mentioned cities for various physico-chemical parameters during the summer season for 2019 and 2020 has been studied and depicted graphically in figure 1(a-j).



1(a)



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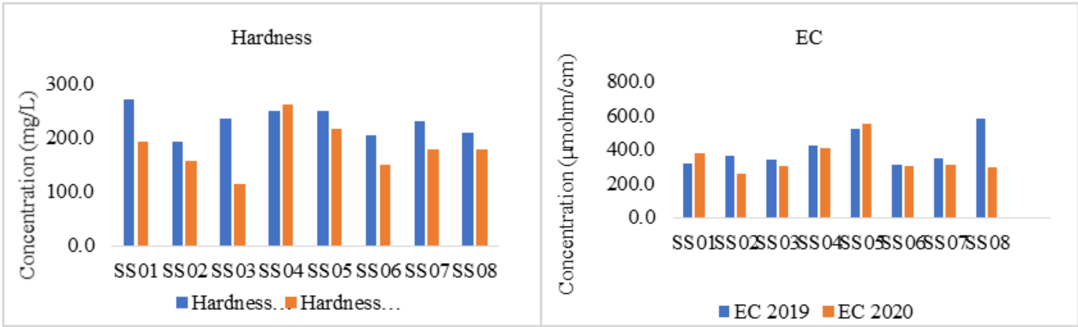

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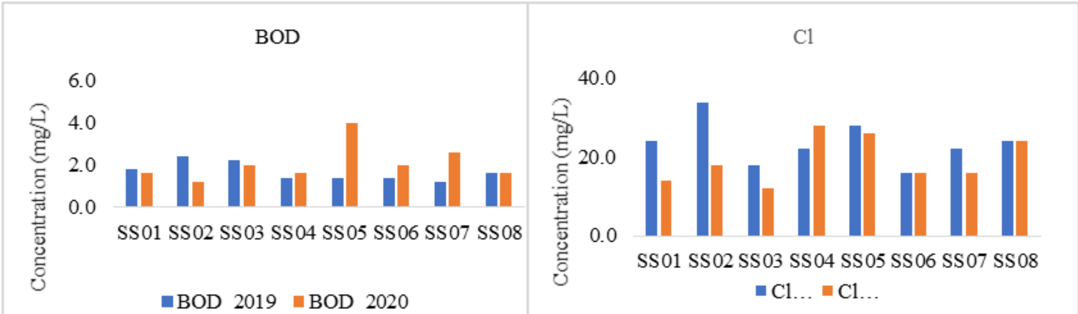
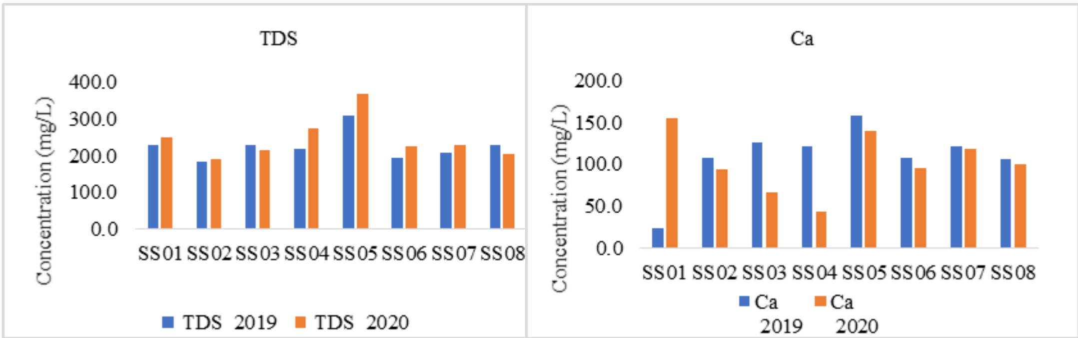
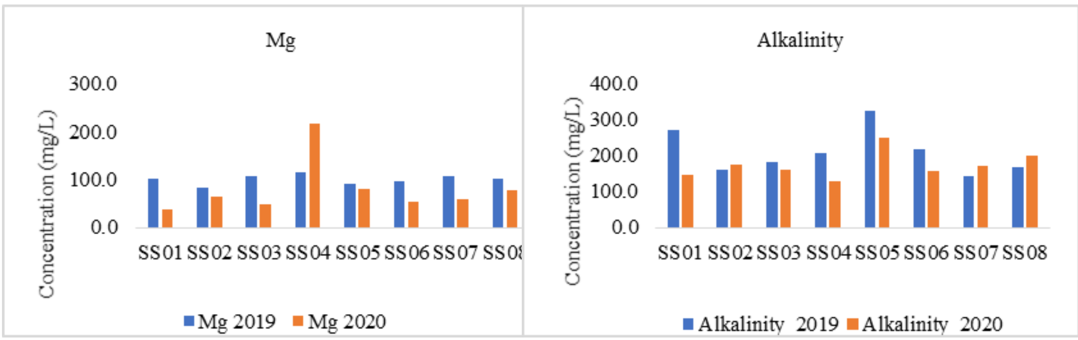


1(e) 1(f)



1(g) 1(h)



1(i) 1(j)

Figure 1: Spatial variation in a) pH, (b) Temperature, (c) hardness, (d) EC, (e) BOD (f) Cl, (g) TDS, (h) Ca, (i) Mg (j) Alkalinity of different stations (Table 1) from April 2019 to 2020.

pH: pH help in knowing the suitability of water quality for various uses (Yogendra & Puttaiah, 2008).In 2019 and 2020 the pH values range from 7.1 to7.6 and 7.4 to 8.0 (Figure 1a). pH value of all samples was found within the acceptable limit of BIS. Based on pH value, groundwater quality at all stations is alkaline in nature.

Temperature: The desirable temperature as per the WHO standard is 25 degrees Celsius. In 2019 and 2020, it was observed that temperature is above the desirable at all the station. as depicted in Figure 1b.

Hardness: In 2019, the hardnessof groundwater of all sampling stations is between192mg/L to 270mg/L. Similarly, in 2020 the values range from 115 to 260 mg/L. As per BIS standard, theacceptable value for hardness is 200 mg/L. Hardness values at all sampling stations except at station 2 reported to be higher than the prescribed limit in 2019, but in 2020 the hardness values were below the acceptable limit of BIS at all stations except at station 4 and 5. Maximum hardness was reported at station 1 in year 2019 and at station 4 in 2020. Both stations 1 and 4 were in Kashipur. The minimum hardness value was measured at sampling station 2 in 2019 and at station 3 in 2020. (Figure 1c).

EC: EC plays a significant effects on the water quality used for drinking and irrigation (Shah & Joshi, 2017)**.** According to ICMR standard, the permissible limit of electric conductivity is 300 µmho/cm. In 2019, the EC values of groundwater of the mentioned sampling stations between 306 µmho/cm to 580 µmho/cm. In comparison to the recommended ICMR values, this was found to be substantially greater. Similarly, in 2020, the values are between 258 µmho/cm to 549 µmho/cm. Figure 1d depicts that in 2019 maximum EC was reported at station 8 and minimum EC at station 6. In 2020 maximum EC was reported at station 5. Station 5 islocated ina highly industrialized area i.e. Sitarganj, Kashipur. In 2020 minimum EC was recorded at station 2 respectively. Station 2 is located at India Glycols, Kashipur.

BOD: BOD refers to how much organic matter is present in water that can be oxidised by bacteria. If the value of BOD is more, that indicates organic waste is more in water. The primary contributors to a rise in the BOD level of water are the discharge of wastewater, runoff from agricultural land, and effluent from industrial processes. Eutrophication in river bodies is caused by high levels of BOD, which leads to anaerobic conditions and an increase in the concentration of nutrients such as nitrogen and phosphorus (Soo et al., 2016). In 2019, the BOD values of groundwater of the mentioned sampling stations ranging from 1.4 mg/L to 2.4 mg/L (Figure 1e). Similarly, in 2020 the values ranging from 1.2 mg/L to 4.0 mg/L. As per CPCB standard, the permissible value of BOD is 5 mg/L. Hence the BOD value is under the prescribed level as shown in figure 1(e). Only station 5 indicates eutrophic nature of water quality in 2020. Station 5 is situated in the Sitarganj, Industrial area, Kashipur.

Cl: Cl concentration found under the BIS acceptable limit i.e. 250 mg/L as shown in figure 1(f) in all water quality samples in 2019 and 2020. Chloride is the indicator for domestic sewage contamination. Hence this shows that groundwater in Udham Singh Nagar is not polluted with domestic sewage.

TDS: TDS is also expressed as total salinity. It is the sum of anions and cations in water, and it comes from natural resources, sewage, and industrial wastes. High TDS affects the taste of food and is a health risk. TDS of the ground water samples ranged from 182mg/L to 309 mg/L and 190mg/L to 368 mg/L in 2019 and 2020 as shown in figure 1(g) which falls within BIS acceptable limit (500mg/L).

Ca: According to BIS, Ca acceptable limit is 75 mg/L. In figure 1(h) it was found that concentration of Ca in all stations except station 1 was found above the desirable level in 2019 whereas in 2020 at all stations except station 3&4 the concentration of Ca falls above the acceptable limit.

Mg: As per the BIS, the acceptable limit of Mg is 30 mg/L. In figure 1(i) it was found that concentration of Mg in all stations was found above the desirable level in 2019 and 2020.

Alkalinity: The presence of hydroxide and carbonates develop alkalinity in the water. In 2019, the alkalinity values of groundwater of the mentioned sampling stations ranged from 142 mg/L to 324 mg/L. Similarly, in 2020 we can see a trend 128 mg/L to 250 mg/L. As per the BIS standard the acceptable limit is 200 mg/L. In 2019 and 2020, maximum alkalinity was recorded at station 05. Minimum alkalinity was recorded at station 07 in year 2019 and at station 04 in 2020.as shown in Figure 1(j)

In figure 2,WQI for all sampling stations for 02 years are compared. In 2019,WQI at sampling station 1,2,3,4,5,6,7 and 8 is 56.78, 65.28, 56.21, 55.78, 47.50, 49.29, 56.16, 55.89 whereas in year 2020 the values are 66.19, 74.30, 66.08, 59.57, 51.51, 66.68, 66.11, 73.53. It is found that in 2019 sampling station 02 (GW-Handpump, Near Damauda at Kashipur Near India Glycols Ltd.), contributes the highest WQI amongst allthe sampling stations, i.e. 65.28. According to the water quality guidelines provided by CCME (Table 3), the groundwater sample whose CCME WQI values lies between65 to 79, it falls in “fair” category. Ground water of such quality isoccasionally threatened or impaired; and they often depart from their natural or desirable levels.Again, sampling station 02 in year 2020, contributes the highest WQI i.e. 74.30, which is a spike of 12.14% in the year 2020 as compared to 2019.

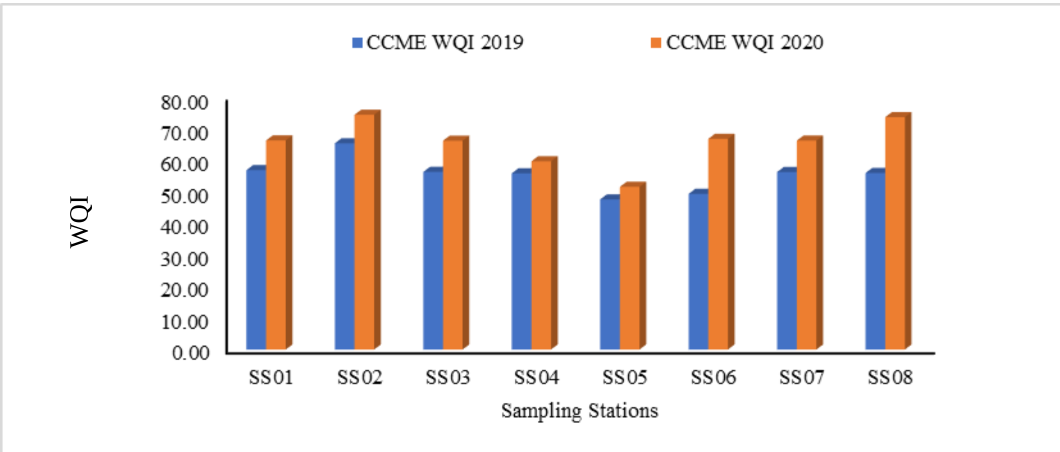


Figure. 2: Variation of CCME WQI of different stations for 2019 and 2020

It has been observed based on WQI, that thegroundwater quality has been increased in all sampling stations in 2020 as compared to 2019 where the water quality reachedin category of fair or more as compared marginal in 2019**.** Sampling station 01, 03,06,07,08 has improved its groundwater qualityand reachedto “Fair” category as per CCME.

CONCLUSION

The groundwater quality in 08 sampling stations situated in Udam Singh Nagar was studied. Udham Singh Nagar is facing problems of rapid, urbanization and industrialization, poor maintenance of septic tanks that leads to the generation of large quantity wastewater. This wastewater then percolates and contaminates the groundwater. Further WQI are calculated as per CCME guidelines to evaluate the quality of water at varied locations in different years. Based on the values of WQI and different physio-chemical parameters, no sampling station in Udham Singh Nagar rank under the category of poor. Mostly all the sampling station sustain fair and marginal rank. It is observed that the water quality improved in years 2020 in comparison to year 2019. Its probably due to COVID-19 pandemic i.e., year 2020, the movement of people outside was minimal, industries were either partially closed or shut down and hence the quality of groundwater was not being altered up to that extent and as a result the quality of water did not diminish during this period. So, the enhancement of the quality of water is temporary because of the lockdown restrictions imposed during the COVID-19. So, it will be crucial to test the groundwater periodically, so that based on these results necessary plans and short- and long-term strategies could be designed to reduce and control the addition of pollutant in the groundwater.

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