Eco. Env. & Cons. 26 (November Suppl. Issue) : 2020; pp. (S397-S407)
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ISSN 0971–765X

Assessment of water quality of Choyyia Nadi (River) Catchment area in Bijnor District, Uttar Pradesh, India

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(Received 23 February, 2020; Accepted 8 June, 2020)

ABSTRACT

In present study, we selected two types of fresh water resources; one is surface water known as Choyyia Nadi (River) and another one is groundwater of the catchment area of Choyyia Nadi. Total number of six sampling locations are identified to perform the current study, out of which three locations for ground water and three for river water. During assessment pH is ranging between a range of 7.9 to 8.07, TDS is 821.33 to 908.33 mg/L and Turbidity is 325.33 to 341.33 NTU. Depending upon the assessment WQI are calculated and found unsuitable for drinking for river water. While in groundwater analysis, parameters are ranging within acceptable limits during the study period with certain heavy metals with BDL, (Below Detectable Limits) except arsenic which is ranging from 0.021 to 0.03 mg/L. With the current groundwater assessment WQI calculated for ground water quality was observed with good quality during the study period.

Key words : *River Management, Wastewater, Ground water, Physio-chemical, Quality, Choyyia-Nadi, Bijnor*

Introduction

Water is most crucial things for the survival of all living including plants and animals. The Quality of surface water resources such as rivers, pools and ponds are deteriorating day by day at very high rate due to rapid industrialization, urbanization and population load (Samitha *et al*., 2013; Matta *et al*., 2020c). Increasing water pollution causes not only the change of water quality but it also affects the human health and the balance of aquatic ecosystems, economic development, and social prosperity (Shrivastav and Kanungo, 2013). Freshwater is an essential commodity for survival, so the freshwater resources require the regular monitoring to assess the quality of water whether it's good or not good for drinking purpose. Such types of study support the well-being of society (Matta *et al*., 2015; Matta *et al*., 2018b).

Various human activities along the river banks, contribute to the heavy level of pollution of the river and day by day. The pollution level increases which affects both aquatic animals and aquatic vegetation (Otieno, 2008; Matta *et al.,* 2020a). In Ganga River water at Haridwar during rainy season water quality index (WQI) increases due to increased concentration of sodium and dissolved solids due to high concentration of sodium, several diseases can be caused including cardiovascular diseases and in women toxemia associated with pregnancy (Joshi *et al.,* 2009; Matta *et al.,* 2018c; Matta *et al*., 2018d).

Water is a valuable asset which includes surface water (waterway and lakes), ground water, marine and ice capped. In spite of the fact that water is accessible in the universe in gigantic amount with avolume of 1400×10^6 km^3, which is just 3% of the total water availability on the earth (Matta *et al*., 2020b). The all out water asset accessible in India is 1850 km^3, which is generally 4% of the world's new water assets (EPA-PWD, 2001; Samitha *et al.,* 2013; Matta and Uniyal, 2017). Water quality is surely influenced by point and non-point sources of contamination. The term water quality was created to give a sign of how reasonable the water is for human utilization (Vaux, 2001). This fresh waterresources need to lead great research. Yet, lamentably freshwater has turned into a small to product due to over abuse and contamination. Developing populace and its necessities has led to the decay of surface and subsurface water quality (Matta, 2018). Due to basic water availability billions of people are underprivileged. India is the country with artistic reasonably good land as well as water resources.

Water quality investigation at various stations gives details of bothersome and unacceptable change in water parameters. The National Sanitation Foundation (NSF) Water Quality Index (WQI), which was developed in the mid-1970s, can be utilized to screen water quality changes in a specific water supply extra time, or it very well may be utilized to compare a water supply quality with other water supplies in the local from around the globe. Assessments of water quality are significant for knowing it's reasonable for various purposes. A WQI gives the component for well introduction of aggregately inferred, numerical articulation characterizing a specific dimension of water quality parameter (Matta *et al.,* 2018a). The goal of WQI is to turn complex water quality information into data that is reasonable and usable publicly; such a rating scale takes into consideration straight forwardness and buyer lucidity. WQI includes the expectation of water contamination utilizing numerical instruments and procedures. It can likewise be utilized to anticipate water quality as far as the genuine watched information at a high recurrence and over a long timeframe. Up-to this point, various water quality models have been broadly connected to evaluate water quality (Prasad *et al*., 2012; Matta, 2020a; 2020b).

Through agricultural activity the potential of water contamination is very high (Lal and Stewart, 1994). In intensive rainfall events probable is higher (Takeda *et al*., 2009). With respect to nature of surface water, microbiological pollution is an essential issue to worry of creating nations. Furthermore, inorganic contaminants, concerning both well-being and stylish perspectives, can be available in the waters. Fluoride and arsenic have incredible medical issue around the world (Walker *et al*., 2019). The general wellbeing weight of these two synthetic compounds far surpasses that of other substance contaminants in surface-water, however all-inclusive it is conceal by the general wellbeing effect of microbial pollution. A checking program executed in Cambodia (Feldman *et al.,* 2007) detailed raised dimensions of lead, selenium, molybdenum and chromium just in a predetermined number of cases. Mercury was insignificantly recognized in some surface and ground waters in Ghana (Quagraine andAdokoh, 2010). Another examination led in Ghana (Rossiter *et al.,* 2010) additionally discovered groupings of lead, uranium and boron over the World Health Association (WHO) Guide Values (GVs) in limited regions. Low metallic substance was watched for most water tests broke down in Bangladesh (Rahman *et al.,* 2011).

The Bijnor District is a part of Indo – Gangetic alluvium sloping from north to south)(Budhauliya 2013). The Holy Ganga and Ramganga rivers and its tributaries are controlled the whole district drainage system. In Bijnor district Malin River, Choyyia Nadi, Khoh River, Phika Nadi, Ban and Gangan Nadi are the tributaries of Ganga and Ramganga River. Ground water is one of the main source to supply the demand of habitation and agriculture (Budhauliya 2013).

Choyyia Nadi is a natural drain flowing in Bijnor district, Uttar Paradesh, India. This is a tributary of Ganga River. Along the choyya drain bank many industries are located and releasing their treated effluent in to it. The flowing water of choyyia Nadi is utilizing for irrigation for crops by the local farmers. This study is required to ensure the surface water quality as well as ground water quality for drinking and other purposes. The groundwater quality may have affected by the surface water due to percolation process. In present study area there is groundwater is one and only source of drinking. That is why, such type of study is required frequently. The aim of this study is to evaluate the water quality of Choyyia Nadi and groundwater resources (hand pump water) of study area with the applicability of WQI, which will be helpful for future studies and water resource management. The importance of this study is so high because this is tributary of Holy Gange River. The Prime Minister of India has launched Namami Gange project (National Mission for Clean Ganga) to make the Ganga Clean in 2014. In NMCG, the government has formed eight pillars namely as Sewerage Treatment Infrastructure, River-Surface Cleaning, Afforestation. Industrial Effluent Monitoring, River Front Devlopment, Bio-Diversity, Public Awareness and Ganga Gram. (NMCG.NIC,IN). As The choyyia Nadi carry the effluent of nearby located industry (Agarwal and Deswal 2017), It is necessary to monitor its water quality on regular basis so that the aim of NMCG can be fulfill.

Materials and Methods

The Bijnor district occupies the area around 4561 Sq. Km (Budhauliya, 2013). There are two major rivers which pass through the Bijnor district, namely The Ganga and Ramganga both of the river have their own watershed but Ramganga is also a tributary of Ganga River (Khan *et al*., 2017). Total population of Bijnor district is about 3,682,713 no. of Individuals as per 2011 census. Major portion of Bijnor district population depend upon agriculture occupation, besides it a few sugar factories, distilleries, Pulp and Paper industry and food process unit supports to the economic health of district Bijnor (Agarwal and Deswal, 2017).

Selection of Sampling Sites

The criteria of choosing surface water sampling sites were based on the industrial effluent discharge into the Chhoyyia Nadi and the criteria for choosing ground water sample on population density to check the groundwater quality in Chhoyyia Nadi catchment. In the current study, three sampling locations is identified for surface water quality to show the representative water quality of Choyyia Nadi and in same manner three sampling site are chosen to collect the groundwater sample on monthly basis throughout the ful year. Geo-coordinates of all surface and Groundwater sampling sites are given in following Table 1.

Sampling Sites

In the present study, the three surface and three ground water sampling sites were selected to evaluate the surface as well as ground water quality of Chhoyyia Nadi and its catchment aera. The first surface water sampling site was chosen near Chhoyyai bridge on Binor to Nagina road, apart this the first ground water sampling site was selected at village Fareedpur chandan which located near the upstream of Chhoyia nadi from first surface water sample site. The first surfacewater sample point is that where the treated effluent of Mohit Paper join the Chhoyia. The gio-coordinates of both sampling site have been mentioned in Table 1.

The second one sampling sites is Aagri village for surface as well as ground water, whose gio-coordinates are mentioned in Table 1. This is village which is located on the bank of Chhoyia Nadi. The elevation of this village is 236 meter from sea level.

The third and last sampling site is Chhachri mode whose gio-coordinate is mentioned in Table 1.

Table 1. Showing geo-coordinates of all Surface and ground water sampling sites.

S. No.	Surface water (SW) Sampling Sites	Geo-coordinates	Groundwater (GW) sampling sites	Geo-coordinates
1.	Choyyia Bridge Nagina Road Bijnor	29°24′01.9"N 78°12′57.9"E	Fareedpur chandan	29°24′13.2"N 78°12′33.0"E
2.	Aagri	29° 20' 7.1484′N 78° 10' 30.0576′′ E	Aagri	29°24′13.2"N 78°12′33.0"E
3.	Chhachri Mod	29°14′53.2"N 78°10′12.1"E	Chhachri Mod	29°14′53.2"N 78°10′12.1"E

In down stream of this sampling site there is no industry is situated whose effluent join the Chhoyia nadi.

Collection of samples: To investigate the spatial and temporal variations in surface and ground water quality of Choyyia Nadi and its catchment area, three samples are collected from surface water source and three samples are collected from Indian Mark government hand pumps through grab sampling methods prescribed in Trivedy and Goel (1986) in sterilized acid-washed polyethylene Terephthalate (PET) containers, some parameters like pH, DO and TDS have been analyzed at the time of sample collection on the sampling site with help of (TOSHCON TMULTI 27) a portable water testing instrument and all samples immediately transported to the laboratory for further analysis. Rest physico-chemical parameters such as TSS, COD, BOD and Turbidity have been measured based on the standard methods for examination of water and wastewater APHA (2012) and Trivedy & Goel (1986).

Results and Discussion

pH: pH of any water body plays a critical role for aquatic environment. The pH of any solution is defined as the logarithm to the base 10 of the reciprocal of the (H^+) ion concentration (Barrett *et al.*, 2010). BIS set the standard 6.5 -8.5 for drinking water. If the pH observed with in prescribed range, it is good indicator of water quality of that aquatic body. In present stud the mean range of pH of site -1, 2 and 3 for surface water is found 8.0, 7.9 and 8.07 respectively, which is lie under the BIS guideline 6.5-8.5, which shows that the pH of surface water is not found harmful at any sampling sites which is within permissible limits set by BIS. It is observed that the pH of star paper mill effluent around 7.44 (Matta *et al.,* 2016a). Besides the surface water quality, the average pH of ground water of sampling site – 1, 2 and 3 are observed 7.34, 7.21 and 7.07 respectively, which is lie under the permissible limits of 6.5-8.5 set by BIS In a smiller study pH is observed 6.42 to 7.9 in pre monsoon season (Srivastava *et al.,* 2011).

Total Dissolved Solids (TDS): The average concentration of TDS at all three sampling sites 1,2 and 3 of surface water observed 908.33, 803.33 and 821.33 mg/L respectively, which is beyond the acceptable limits 500 mg/L set by BIS. The concentration of dissolved solids in industrial effluent may be high because many cations and anions are used in industrial process. Besides surface water the TDS the average concentration in groundwater of all three sites-1, 2 and 3 are found 308.3, 311.66 and 276.33 mg/L which lies under the acceptable limits of 500mg/L set by BIS for drinking water In an other surface water quality monitoring the TDS is observed upto 1432 mg/L (Srivastava *et al*., 2011).

Total Suspended Solids (TSS): The observed concentration of TSS in surface water at all three sampling sites 1, 2 and 3 are 529.83, 512.13 and 483.80 mg/L respectively. Still there is no standard is available for surface water for TSS concentration but CPCB set the acceptable limits 100 mg/L of Industrial effluent discharge, in comparison of this standard the observed result is too higher than acceptable limit.

Dissolved Oxygen (DO): The sufficient availability of DO in drinking water is necessary, The need of optimum DO concentration in drinking water 6-8 mg/L (Lenntech 2014a). Dissolved oxygen of surface water is not found good as must be. The average DO of all three sites -1, 2 and 3 are found 1.63 mg/L, 1.37 mg/L and 1.27 mg/L. DO in Star Paper Mill effluent is observed around 2.81 mg/L (Matta *et al.,* 2016b).

The low concentration of DO in surface water may be due to presence of organic and microbial load (Sharma *et al.,* 2014).

Chemical Oxygen Demand (COD): The mean concentration of COD in surface water at all sampling sites 1,2 and 3 are observed 530.1, 489.80 and 392.17 mg/L. it is observed. It is observed in a study conducted in Dhampur region COD is recorded 22 to 990 mg/L in surface water (Matta *et al.,* 2017a, 2017b). COD indicating the deterioration of the water quality caused by industrial effluent (Mamais *et al.,* 1993). Still there is no standard for COD in fresh water but CPCB has issued the guide lines for COD 250 mg/L in industrial effluent discharge. A significance increase of COD and BOD in surface water bodies increase their pollution (Effendi *et al.,* 2015). The result of this study shows the higher concentration of COD at all sites during whole study higher than the CPCB Guidelines.

Biochemical Oxygen Demand (BOD): Biochemical Oxygen Demand is the amount of oxygen consumed by the bacteria to decompose the present organic content in that water sample in a particular time period. In this current study the average range of BOD at all three sampling sites 1, 2 and 3 are observed 105.5, 93.97 and 71.63 mg/L. In a study the concentration of BOD in surface water is observed upto 120 mg/L. This is a sign of presnse of organic load comes through industrial or sewerage waste (Srivastava *et al*., 2011).

CPCB has issued the guide lines for industrial effluent discharge 30 mg/L. But the BOD concentration is observed much high than CPCB Guidelines.

Turbidity: Turbidity is a primary parameter, which affect the light penetration into the water which leads to the effects on aquatic life (Verma and Saksena, 2010). Turbidity plays a critical role while analyzing the water quality. During this study the average Turbidity in surface water sample at all three sampling sites 1,2 and 3 are found 341.67 NTU, 325.33 NTU and 335.67 NTU respectively, which too much higher than the acceptable limit 1 by BIS. Turbidy may be increase due to dissolved of particulate matter such as Clay, silt and finely separated organic matter, phyto-plankton andother microscopic organism (Srivastava *et al*., 2011).Besides the surface water the value of Turbidity in Ground water sample is observed within acceptable limits. During this present study the average value of turbidity at all three sampling sites are observed 0.56 NTU, 0.53NTU and 0.3 NTU in whole study.

Alkalinity: In the current study the alkalinity in groundwater observed within acceptable limit 200mg/L set by BIS for drinking water. The average value of alkalinity at all three sampling sites 1, 2 and 3 during whole study are found 127.85 mg/L, 129.52 mg/L and 112.52 mg/L respectively. During whole study the minimum average value of alkalinity value observed at sampling site – 3 and highest is observed at sampling site -2. In a study the concentration of alkalinity in surafec water is observed upto 655 mg/L. Alkalinity is increased due to increase of cations.

Iron: In present study the concentration of Iron in groundwater samples found within acceptable limit 0.3mg/L set by BIS. The average concentration of Iron at all three sampling sites -1, 2 and 3 are observed 0.26 mg/L, 0.18 mg/L and 0.12 mg/L during whole study period respectively. The highest average concentration of Iron is found at sampling site -1 and lowest concentration is found at sampling site -3 during whole study period.

Total Hardness (TH): Hardness consists of polyvalent cations dissolved in water. Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) are the most common polyvalent cations that are mostly present in ground water. Manganese (Mn^{2+}) and Ferrous (Fe^{2+}) ions also contribute to groundwater hardness (Jain and Jain, 1990). In present study, the average TH of all three sampling sites is found within acceptable limit 200mg/L set by BIS during the whole study. The highest average TH is observed at site-2 with an average value 168.43 mg/L and the lowest concentration of TH is observed at site – 3 with a value of 151.35 mg/L. (Samitha *et al*., 2013) observed the hardness upto 131 mg/L in surface water.

Calcium as (Ca) and Magnesium as (Mg): Calcium and magnesium are most highly alkali metal occurring naturally in the environment (Grochowska and Tandyrak, 2009). The concentration of Calcium and magnesium in surface as well as in ground water increase due to washed out from the bedrock (Ga³czyñska *et al*., 2013). In current study, the average Calcium concentration at all sampling sites is found within limit set by BIS. The highest average calcium concentration is found at sampling site -2, and the lowest concentration is observed at site -3 with a value of 48.86 mg/L and 39.82 mg/L respectively.In present study the average Magnesium concentration is observed at site-2 and lowest concentration is found at site-3 with a value of 12.53 mg/L and 10.1 mg/L respectively during whole study period. Overall the Magnesium concentration is observed under the acceptable limit 75mg/L set by BIS.

Sulfate: In current study, the average concentration of sulfate is observed within limit 200mg/L set by BIS during whole study at all three sampling sites. The average lowest concentration of Sulfate is found at site-3 and the highest concentration is found at site -2 with a value of 78.67 mg/L and 89.39 mg/L respectively. Sulfate concentration may be range from 0 to 230 mg/L in groundwater (WHO 2004).

Heavy Metals: In present study four heavy metals have been selected to analyze namely Arsenic, Copper, Lead and Nickel in ground water samples. Lead is an naturally occurring substance present in small amount in earth crust. Apart the naturally occurrence of Lead many anthropogenic activities such as burning of fossil fuels, mining and manufacturing sector release the rich concentration of Lead. Lead is used in many kind of application in Industry, agriculture and Domestic (Tchounwou *et al*., 2014; Matta and Gjyli, 2016). Copper is count as micronutrients which is incorporated with a number metabolic enzymes involve in formation of hemoglobin, carbohydrate metabolism, cross-linking of collagen and catecholamine biosynthesis (Tchounwou *et al*., 2014).

BIS have set the standard for all these four heavy metals. The acceptable limit of Arsenic is 0.01 mg/L, BIS standard for Copper is 0.05 mg/L, BIS standard for Lead is 0.01 mg/L and the BIS standard for Nickel is 0.02 mg/L. In this current study except Arsenic rest of all three heavy metals are observed below detectable limit (BDL) but Arsenic observed more than acceptable limit at first two sampling sites with a value of 0.023 mg/L and 0.03 mg/L respectively, but at sampling site - 3 the average concentration of Arsenic found within acceptable limit during the study. Ae environmental pollution perspective the Arsenic occurrence is a result of natural phenomena such as volcanic eruption, soil erosion and anthropogenic activities (ATSDR 2000). Several industries are producing arsenic containing product and have been using arsenic to manufacturing the products for agricultural applications such as insecticides, weedicide, herbicides, algaecide, fungicides (Tchounwou *et al*., 1999). Arsenic concentration in groundwater was found more than acceptable limits in many states of India along with Uttar Pradesh, the concentration of Arsenic is found > 0.05 mg/L in some area's of District Gazipur and µg/L to Varanasi (Mukherjee *et al*., 2006). Arsenic is found in Groundwater sample in Bijnor (Times of India).

Water Quality Index (WQI): Water Quality Index is an statistical tool by which water quality data is summarized to present the water quality to the public in easy way. Water quality Index is just like other index such as Air Quality Index (AQI), In other words (WQI) is a tool use to turn the complex water quality data into easily understandable and usable information.

Selection of Parameters: While we calculate water quality Index, Firstly, We have to study the Indian Standard for drinking water of physiochemical specification along with desirable limits and related health effects.

For computing water quality Index, three steps to be taken.

In first step, we assigned the weight (w_i) for each selected parameters according to their relative im-

Table 2. Showing average variation of surface water quality at all three sampling sites-1, 2, 3 during whole study period.

S. No.	Parameters	BIS Guideline: Acceptable Limit	BIS Guideline: Permissible Limit in the Absence of Alternate source	Spatial and Temporal Variation: Average Site -1	Average Site-2	Average Site-3
1.	pH	6.5-8.5	No Relaxation	8	7.9	8.07
2.	TDS	500 mg/l	2000 mg/l	908.33	803.33	821.33
3.	TSS	-	-	529.83	512.13	483.8
4.	DO	-	-	1.63	1.37	1.27
5.	COD	-	-	530.1	489.80	392.17
6.	BOD	-	-	105.6	93.90	71.63
7.	Turbidity	1	5	341.67	325.33	335.67

Table 3. Water quality Index for surface water quality at sampling site-1

S. No.	Parameters	Weight (w_i)	Relative Weight (Wi)	Ci Site-1	Si for Site-1	qi=(Ci / Si) × 100	Subindex (SI)= Wi*qi
1.	pH	4	0.4	8	7	114.29	45.716
2.	TDS	4	0.4	908.33	500	181.67	72.668
3.	Turbidity	2	0.2	341.67	1	34167	6833.4
4.		Σ wi= 10		ΣWi=1			ΣSIi=6951.78

WQI = Σ SIi = 6951.7

Table 4. Water quality Index for surface water quality at sampling site-2

S. No.	Parameters	Weight (w_i)	Relative Weight (Wi)	Ci	Si	qi=(Ci / Si) × 100	Subindex (SI) = Wi*qi
1.	pH	4	0.4	7.9	7	112.86	18.89
2.	TDS	4	0.4	803.33	500	160.60	64.24
3.	Turbidity	2	0.2	325.33	1	32533	6506.60
4.		Σ wi = 10	Σ Wi=1				Σ SIi=6589.73

WQI= Σ SIi = 6589.73

Table 5. Water quality Index for surface water quality at sampling site-3

S. No.	Parameters	Weight (w_i)	Relative Weight (Wi)	Ci	Si	qi=(Ci/Si) × 100	Subindex (SI)= Wi*qi
1.	pH	4	0.4	8.07	7	115.286	46.114
2.	TDS	4	0.4	821.33	500	164.27	66.91
3.	Turbidity	2	0.2	335.67	1	33567	6713.4
4.		Σ wi = 10	Σ Wi=1				Σ SIi=6826.42

WQI = Σ SIi = 6589.73

Table 6. Surface water quality classification based on WQI value

WQI Value	Water Quality	Sample Description	Site-1	Site-2	Site-3
<50	Excellent	NA	×	×	×
50-100	Good water	NA	×	×	×
100-200	Poor water	NA	×	×	×
200-300	Very poor water	NA	×	×	×
>300 water	Water unsuitable for drinking	During whole study period at all sampling Sites	√	√	√

Table 7. Showing average of ground water quality at all three sites 1, 2 and 3 during whole study.

Parameters	BIS Standard for Drinking water		Site 1: Average	Site 2: Average	Site 3: Average
	Acceptable limits	Permissible Limit			
pH	6.5-8.5	No Relaxation	7.34	7.21	7.07
TDS (mg/L)	500	2000	308.3	311.66	276.33
Alkalinity (mg/L)	200	600	127.85	129.52	112.52
Turbidity (mg/L)	1	5	0.56	0.53	0.3
Iron (mg/L)	0.3	No Relaxation	0.26	0.18	0.12
Total Hardness (mg/L)	200	600	160.36	168.43	151.35
Calcium (mg/L)	75	200	46.87	48.86	39.82
Magnesium (mg/L)	30	100	11.53	12.53	10.1
Sulphate (mg/L)	200	400	87.53	89.39	78.67
Arsenic (mg/L)	0.01	0.05	0.023	0.03	0.021
Copper (mg/L)	0.05	1.5	BDL	BDL	BDL
Lead (mg/L)	0.01	No Relaxation	BDL	BDL	BDL
Nickel (mg/L)	0.02	No Relaxation	BDL	BDL	BDL

portance in the over quality of water for drinking purpose between 1 to 5.

In second step, we compute the relative weight (Wi) for all selected chemical parameters by using the following equation:

$Wi = wi / \Sigma wi$ (i =1 to n)

Where, Wi is relative weight, wi is the weight of each parameters and n is number of parameters,

Third Step, we compute the quality scale (qi) for each parameter by the help of following equation

$qi = (Ci / Si) \times 100$

Where, qi is the quality rating, Ci is the concentration of each chemical parameter in mg/l and Si is the standard given in Indian drinking water standard (BIS, 2004).

For computation of WQI, the sub index (SI) is first determined for each selected chemical parameters as followed,

$SIi = Wi \times qi$

$WQI = \Sigma SIi\text{-}n$

Where, SIi is the sub index of ith parameters, Wi is relative weight of the ith parameters, qi is quality rating based on concentration of ith parameters and 'n' is the number of chemical parameters.

The calculated WQI values are categorized into five categories: excellent water (WQI < 50); good water (WQ=50–100); poor water (WQI=100–200); very poor water (WQI=200–300); and water unsuitable for drinking (WQI >300). (Batabyal and Chakraborty, 2015)

Conclusion

The finding in the present study is summarized as: The WQI values for surface water quality during whole study at all sampling sites is found more than 300 value with a WQI value of 6951.7, 6589.73 and 6589.73 respectively. Which represent that the water is unsuitable for drinking which clearly illustrate in Table 6. Besides the surface water quality, the WQI for all sampling sites for ground water is lie between 50 to 100 WQI ranges with a WQI value of

Table 8. Water quality Index for sampling site no. 1 during Whole Study.

S. No.	Parameters	Weight (w_i)	Relative Weight (Wi)	Ci	Si	qi = (Ci/Si) × 100	Subindex (SI)= Wi*qi
1.	pH	4	0.16	7.34	7	104.857	16.78
2.	TDS	4	0.16	308.3	500	61.660	9.866
3.	Alkalinity	1	0.04	127.85	200	63.925	2.557
4.	Turbidity	2	0.08	0.56	1	56.000	4.48
5.	Iron	4	0.16	0.26	0.3	86.667	13.867
6.	Total Hardness	2	0.08	160.36	200	80.180	6.4144
7.	Calcium	2	0.08	46.87	75	62.493	4.999
8.	Magnesium	2	0.08	11.53	30	38.433	3.074
9.	Sulphate	4	0.16	87.53	200	43.765	7.0024
10.		Σwi=25	ΣWi=1				Σ SIi = 69.04

WQI = ΣSIi = 69.04

Table 9. Water quality Index for sampling Site no.-2 during Whole Study

S. No.	Parameters	Weight (w_i)	Relative Weight (Wi)	Ci	Si	qi=(Ci / Si) × 100	Subindex (SI)= Wi*qi
1.	pH	4	0.16	7.21	7	103.00	16.48
2.	TDS	4	0.16	311.66	500	62.33	9.973
3.	Alkalinity	1	0.04	129.52	200	64.76	2.59
4.	Turbidity	2	0.08	0.53	1	53.00	4.24
5.	Iron	4	0.16	0.18	0.3	60.00	9.6
6.	Total Hardness	2	0.08	168.43	200	84.215	6.7372
7.	Calcium	2	0.08	48.86	75	65.146	5.217
8.	Magnesium	2	0.08	12.53	30	41.766	3.3412
9.	Sulphate	4	0.16	89.39	200	44.69	7.15
10.	Σ wi=25	ΣWi=1				Σ SIi = 65.34	

WQI= Σ SIi = 65.34

Table 10. Water quality Index for sampling Site no.-3 during Whole Study

S. No.	Parameters	Weight (w_i)	Relative Weight (Wi)	Ci	Si	qi=(Ci / Si) × 100	Sub index (SI) = Wi*qi
1.	pH	4	0.16	7.07	7	101.00	16.16
2.	TDS	4	0.16	276.33	500	55.266	8.842
3.	Alkalinity	1	0.04	112.52	200	56.26	2.250
4.	Turbidity	2	0.08	0.3	1	30.00	2.40
5.	Iron	4	0.16	0.12	0.3	40.00	6.40
6.	Total Hardness	2	0.08	151.35	200	75.675	6.054
7.	Calcium	2	0.08	39.82	75	53.093	4.247
8.	Magnesium	2	0.08	10.1	30	33.666	2.693
9.	Sulphate	4	0.16	78.67	200	39.335	6.2936
10.		Σwi=25	ΣWi=1				Σ SIi=55.34

WQI= Σ SIi = 55.34

Table 11. Ground water quality classification based on WQI value

WQI Value	Water Quality	Sample Description	Site-1	Site-2	Site-3
<50	Excellent	NA	×	×	×
50-100	Good water	NA	×	×	×
100-200	Poor water	NA	×	×	×
200-300	Very poor water	NA	×	×	×
>300 water	Water unsuitable f or drinking	February during whole study period at all sampling Sites	√	√	√

69.04, 65.34 and 55.34 which indicates that the ground water quality is Good at all sampling sites during whole study period. The concentration of Heavy metal in ground water observed with in permissible limit set by BIS at all sampling sites during whole study period. Apart Arsenic metal all selected heavy metals are observed Blow Detectable Limit (BDL). The Arsenic concentration at first two sampling sites are observed more than acceptable limits set by BIS with a value of 0.023 mg/L and 0.03 mg/L respectively. The arsenic concentration at third sampling sites is found within acceptable limit with a value of 0.01 mg/L. Dozens of villages located near the tributary of Ganga in Bijnor under the cancer attack (TOI-2016). As in current study Aresenic is found in groundwater samples which is a serious threat for human being. Arsenic is a well-known carcinozen. This study recommends that there must be enforcement of pollution prevention law so that the surface water quality of Chhoyia Nadi can be good and regular monitoring of industrial effluent which join the Chhoiya Nadi. As per surface water monitoring the surface water quality was found polluted, by this mean government must take strict step control the water pollution. Government should release the Hot Line in that reasons by which the local people can inform or send the water sample photos along-with Choyyia Nadi.

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