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Groundwater Contamination in Perspective of Different Elements, Water Quality Index and Health Implications

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Abstract

The physico-chemical properties of groundwater and its plausible health threats are of enormous significance at the current situation worldwide. The present research work determines the degree of pollution in addition to accompanied health menaces to the local inhabitants at Aiho village of Malda district, West Bengal, India. In the present study wetlands and groundwater sources in the locale vicinity have been associated with common health issues among the local populace who consume aquatic animals and drink groundwater is a cause for concern. In view of that, overall 17 samples of groundwater were selected from distinct sources from the studied village. The physico-chemical analysis results in presence of various ions like Calcium (Ca^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Magnesium (Mg^{2+}), Bicarbonate (HCO_3^-), Sulphate (SO_4^{2-}), Chloride (Cl^-), Nitrate (NO_3^-), Fluoride (F^-) and few elements; Manganese (Mn) and Zinc (Zn) in the samples. Few ions; Ca^{2+}, Mg^{2+} and F^- are detected to surpass the acceptable border in some investigated samples. Some physical parameters; pH and TH were not found to be within the allowable range but TDS range was suitable for all the samples. Excess amount of different elements in the groundwater samples results in health threats to local inhabitants, though, the hazards due to Mn and Zn are inconsequential. Since water quality index (WQI) signifies the excellence of surface as well as ground water especially water used for domestic purpose, WQI was measured ranging from 69.29682 to 175.40829 for the experimental samples indicating good to poor quality but not excellent or very poor to unsuitable for domestic use. Further, Dermal acquaintance was found to be quiet hazardous for all occupants, however, the oral contact was supposed to be precarious to some extent. Children and youths are prone to both the ions NO_3^- and F^- as contaminants, and adult persons are affected by NO_3^- pollutants comparatively.

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Introduction

Only around 2.5% of the entire water on earth is considered as a source of fresh *water.*[1] Moreover, utmost fresh water sources occur in the forms of ice that cannot be utilized by human society readily. Ecological as well as social consumers access the surface and also ground water as the chief sources of *water.* Due to both factors space with time accessibility, virtuous constancy, affluent availability, noble feature, confrontation with contamination and so forth, groundwater has incomparable advantages in context of surface water sources.[2] Water contamination may occur when undesirable materials come into the water body resulting in change of water quality resembling physical and chemical characteristics that may cause several health diseases to human and affect the environment as well. As a consequence, socio economic development support primarily for the groundwater resources.[3] It has been observed that more than 50% of this entire world populace depend on groundwater resource for diurnal household works and other requirements. On the other hand, hydrochemical quality signifying the presence of NO_3^-, F^-, Mn, Zn etc., is the necessary criterion of ground water application that is vital to vigor of humanoid noteworthy for the entire social progress.[4]

This is very important to study the chemistry of groundwater and its accompanied dangers to human beings for the civilization and human sustainable development, specifically in the areas those are suffering from paucity of surface water as water effluence endures worldwide predicament and the entire community is on the threshold of worst consequences because of contaminated *water.* Key aquatic resources toxicity cause emancipation of household and agricultural debris, increasing populace evolution, frequent usage of chemical pesticides, composts etc. In the course of the long habitation period, it takes abundant period to interrelate with the adjacent means of aquifers,[5] furthermore different destructive rudiments along with other toxic elements can be miscible too.[6] In addition, numerous peripheral rudiments and external toxic components are observed to be raised in groundwater resources in current periods in different areas around the world.[7-8] As for example, nitrogen containing elements like ammonia, nitrates, nitrites present in aquifers have got elevated in countryside including urban regions throughout this world.

It is to be noted that not only rural but people of urban areas also defecate in open areas. Urbanization can also cause various infectious diseases. In this context, overpopulation, polluted conditions, precarious drinking water create a major problem regarding health issues specifically in urban regions. The extent of noxious metal components exist in groundwater sources also reveals prompt growth in several locales like landfill, waste water and domesticated water irrigation domains, mining regions and manufacturing sites.[9] The day by day deterioration of water excellence are being reported in several aquifers worldwide. Mainly eviction of domiciliary and manufacturing sewage trashes, seepage deriving out of water reservoirs, seafaring disposal, radioactive surplus and atmospheric accumulation are significant sources of aquatic adulteration.

Human beings and animals get affected directly or indirectly by the heavy metals that are disposed of in terms of industrial wastes as they can accumulate in nearby water bodies, lakes and rivers. Infectious diseases as for example cholera, enteric fever[10] and like distinct diseases like dysentery, vomiting, gastroenteritis, dermatological difficulties, renal difficulties are increasing by means of contaminated water sources.[11] Human well-being is supposed to be in danger because of the agrarian expansion predominantly regarding extreme practice of manures as well as contaminated circumstances.[12] Due to anthropogenic activities associated with wide-ranging urbanization, agronomic works, industrial development along with populace growth have resulted in water feature deterioration all concern of the world.[13] A large extent of association between pollution and health issues is proved. A number of diseases which are water borne, can spread man to man.[14] Also a downpour rainfall, overflows those are allied to utmost weather conditions may cause discrete illnesses for advanced and emergent nations in our world.[15] In view of World Health Organization, a total of 10% populace intake the foodstuff, herbages those are produced in polluted *water.* According to Jabeen *et al.*, mortality rate because of cancer is greater in country side in comparison to urban regions due to use of treated water for drinking by the urban inhabitants whereas rural people can not avail the facility to have treated water and have to use unprocessed water for daily work and other necessities.[16] In this context comparatively impoverished individuals are at higher threat of affliction owing to inappropriate immaculateness, asepsis and water supply.

Further, adulterated water devours a large negative impact on the pregnant women who are exposed to chemicals directly or indirectly that ultimately causes the augmenting degree of low natal weight resulting in antenatal physical condition of the new borns.[17]

Analysis of WQI presents an inclusive representation of surface including ground water excellence especially used for domestic works. WQI is enumerated as a grade which reveals the combined effect of different water eminence factors.[18] It is a very imperative tool to judge water excellence of ground water and also review its felicitous for consumption purposes.[19-22] A single numerical expression of the water quality index that encapsulates the various physico-chemical features of the tested water that can measure the overall water quality. WQI means that if its value is less deviated from the standard value, the water quality is fairly maintained and can be used for human consumption. In view of the present circumstances regarding water quality, study on water pollution is being selected as a remarkable research area for the researchers and scientists. From different sources of the village, overall 17 samples of groundwater were collected. The results obtained from the present analysis display the amount of various ions present in the samples; Calcium (Ca^{2+}), Sodium (Na^+), Potassium (K^+), Magnesium (Mg^{2+}), Bicarbonate (HCO_3^-), Sulphate (SO_4^{2-}), Chloride (Cl^-), Nitrate (NO_3^-), Fluoride (F^-) and elements; Manganese (Mn) and Zinc (Zn) including pH, TH, and TDS values. This paper focuses on the quality index of groundwater, hydrochemical features and groundwater toxicity, potential health risk for the population by pollutants and sources of impurities causing the deterioration of water eminence. For this work, selected 14 parameters were used for determining WQI value for this present study and these parameters were collected from a total of 17 different locations. By determining this WQI values, the variations in water quality at 17 different locations were reviewed and compared.

The chemistry of groundwater and its probable health hazards are of immense importance at the present scenario worldwide. This present study was carried out to ascertain the extent of impurity and accompanying health risks to the local people at Aiho village of Malda district, West Bengal, India. Few ions are observed to exceed the permitted limits in some samples. Presence of excess amount of studied elements may cause health threats to local inhabitants, however, the hazards of Mn and Zn are insignificant. Dermal exposure was found to be quiet unsafe for all residents, whereas, the oral pathway was thought to be unsafe to some extent. Infants and youngsters are prone to F^- pollutants, and adult people are affected by NO_3^- ions predominantly. Anthropogenic as well as geogenic activities and sources are liable for the raised levels of the different ions in the studied samples. Therefore, purified water supply, waste management, practice of rational irrigation is to be encouraged in the studied village. Access to unpolluted potable water is crucial for good health, but dirtied water can be detrimental to the body and cause physical ailments. So it is decisive to examine the physico-chemical parameters of drinking water to regulate its safety. This study can help local inhabitants make informed decisions about the adequacy of water from different sources, as well as take steps to purify it or obtain purified drinking water to prevent diseases. By raising awareness about the importance of pure water and advocating for its provision, we can ensure a healthier sustenance for the locals. The results of the study may be used to inform local policies and practices related to water management and public health.

Study Area and Sampling Sources

The study area, i.e., Aiho village of Malda district is predominantly agronomy centered settlement of West Bengal, India. The area is located at 24.96ºN 88.24ºE and sandwiched between two rivers Mahananda and Tangon as depicted in Figure 1. Groundwater samples for their analysis were collected from 12 (sample 1-12) wells and 5 tube wells (sample 13-17) having the depth scale of 30–50 m downwards respectively in the studied village for the period of the month of October 2018 as all the wells and tube wells used by local inhabitants of the studied area for drinking water considered for examination are located in the 17 different nearby residential places of the studied populace. The collected groundwater samples were carried in glass bottles of 500 ml volume that were carefully prewashed by means of distilled water and afterwards target water samples and finally considered for the laboratory analysis within maximum 24 hours.

Fig. 1: Map of Aiho, Malda, West Bengal, India showing the study area

(Source: https://www.veethi.com/places/west-bengal-malda-district-625-9.htm & https://www.google.com/maps/@24.9603273,88.2375495,1540m/data=!3m1!1e3?entry=ttu)

Materials and Methods

The present amount of anions; NO_3^-, SO_4^{-2}, Cl^-, F^-, HCO_3^- ; cations; K^+, Na^+, Ca^{2+}, Mg^{2+} and trace elements (Mn, Zn) in the water samples were evaluated by the method as described by APHA.[23] The water pH and Total Dissolved Solids (TDS) were observed by the HANNA pH and TDS Meter (HI9814). Total Hardness was analyzed through a titration process by a standard solution of 0.01N EDTA.

A cross-sectional study was conducted for the present research, which included 131 inhabitants of Aiho, comprising 2.22 percent of the total population (5898; 2011 Census of India), including males, females, and children of 38 families living in an area attached to agricultural land, suffering from potable water who were interviewed using a list of prepared questionnaires. Local gram panchayat members, administrative bodies were also taken into consideration for getting other related information.

Water quality index is an extremely important and proficient process to get a perfect indication about the quality of water examined by using some essential constraints. In this work, the WQI was estimated by means of the process; weighted arithmetic index as Cude (2001) and Brown *et al.* (1970).[24-25] To determine the WQI, quality rating; Qi and unit weight; Wi were considered and sub-index for all variables were determined through multiplication of the unit weight; Wi and quality rating; Qi. The inclusive WQI was determined by using sum up with regard to sub index for respective parameters by dint of following equation:

$$WQI = \frac{\sum_{i=1}^{n} WiQi}{\sum_{i=1}^{n} Wi}$$

To determine the WQI a total of 14 physical characteristics or parameters were selected for this study using BIS standards. Where, Wi denotes a unit weight factor, evaluated through the equation;

Wi = K/Si. Si signifies ith parameter's standard value and K stands for constant of proportionality. Qi is assessed through the help of the equation: Qi = 100 (Vi – V_{10}) / (Si – V_{10}) indicating quality rating regarding parameter of nth water quality.

Vi signifies assessed magnitude of the nth parameters for a specified sampling station. Si denotes standard approved value based on nth parameter. V_{10} stands for ideal or model value of the nth parameter for uncontaminated *water.* For the potable water, the entire ideal values; V_{10} are ruminated as '0' excluding for pH value of 7.0.

Hydrochemical Features

The leading cation present in most of the water samples is (Ca^{2+}), with the concentration range between 23 mg/L to 169.2 mg/L. In view of BIS 2009[26] the tolerable border of Ca^{2+} ions are subordinate than 75 mg/l and this is not adhered to any of the studied samples of water in the area except sample 8, 12 and 16. Das *et al.* (2020) discovered a remarkably similar range of analogies.[27] The sodium ion (Na^+) intensity of the tested water differed from 2.9 to 121 mg/L in the present study. Sodium ions help to maintain blood pressure, fluid levels and even play a significant role in maintaining normal nerve and muscle function. BIS 2009[26] educes an anticipated sodium intentness of 200 mg/L in potable *water.* The level of Potassium (K^+) ion in water samples diverged from 2.1 to 11.6 mg/L which is within the permissible limit as mentioned by BIS 1991[28]: 50 mg/L. Among all the significant studied, Mg^{2+} ions are acquired to have relatively low concentration, ranging from 4.9 mg/L to 71.5 mg/L as also depicted by Das *et al.* (2020)[27] which exceeds the permissible threshold value of BIS 2012[29]: 30 mg/L except for sample 2, 4, 6, 8 and 9. Further from the physico-chemical study it was reported that HCO_3^- anion is one of the prevailing anions, alongside concentrations varying from 81 mg/L to 187 mg/L which is within the range of acceptable limit by BIS 2009[26], 200 mg/L, followed by the anion SO_4^{2-} with concentration of 29.5 mg/L, 87.2 mg/L which is also in the suitable range (BIS 2012[29]: 200 mg/L) as the minimum and maximum values, respectively. The Cl^- anion concentrations range from 5.8 mg/L to 74 mg/L which is in the permissible limit as the approbation border for the ion Cl^- is 250 mg/l as per BIS, 2009.[26]

Nitrogen as one of the important element was identified in the under groundwater samples in the studied locale. The extent of NO_3^- ion presents in the experimental water samples assorted from 0.09 to 10.7 mg/L as represented by Das *et al.* (2020)[27] too, was detected within the tolerable limits as per BIS 2012[29], 45 mg/L. The presence of NO_3^- ions may be caused by elevated intrusion of soil crust including anthropogenic endeavors. In the drinkable water, occurrence of intense nitrate ion concentration may cause intestinal malignancy and some other prospective threats to the expecting other. The involvements of anthropogenic sources in these studied areas are also responsible to elevate the TDS concentration of ground *water.* The amount of F^- anions is supposed to be in the range of 1.4–4.6 mg/L in the samples signifying not within permitted range as guided by BIS 2012[29]: 1 mg/L. The concentrations of Na^+, SO_4^{2-}, and F^- ions were found to be higher, while HCO_3^- and Cl^- ions were smaller, with K^+ ions being relatively consistent in the present study in comparison to the investigation conducted by Batabyal *et al.* (2015).[30] Presence of the above cations including anions are depicted in Table 1, and Figure 2.

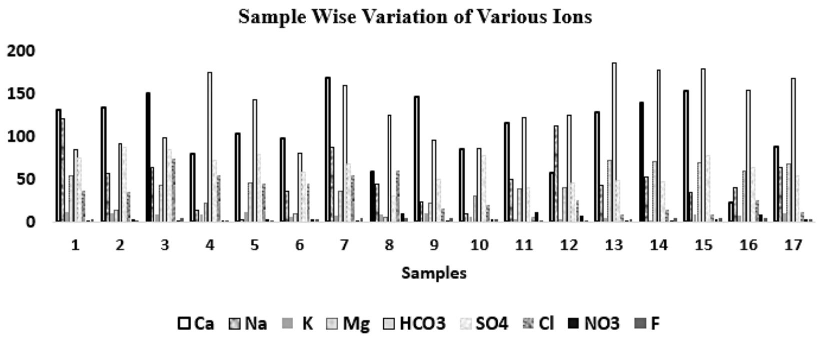

Fig. 2: Sample wise variation of ions present in the investigated water samples

Table 1: Amount of various ions present in the investigated groundwater samples

Sample No.	Concentration of Cations and Anions in mg/L								
	Ca^{2+}	Na+	K^{+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	NO_3^-	F^-
1	131.5	121	11.1	54.2	84.2	74.3	36.8	0.09	2.3
2	134.8	56.2	9.3	13.5	91.5	87.2	35.3	2.4	2.1
3	151.1	64.2	8.2	42.6	99.1	84.3	74	1.9	3.8
4	79.4	12.8	8.3	21.2	175.2	72.1	54.1	0.9	1.8
5	103.4	2.9	11.6	45.8	143.7	79.5	44.2	3.4	1.4
6	98.1	35.7	5.5	9.4	81	58.4	45.1	2.5	2.6
7	169.2	87	7.5	36.4	159.4	68.3	54.8	0.9	4.1
8	59.2	44.2	9.1	4.9	125.1	29.5	59.7	9.8	3.8
9	147.2	23.5	10.2	21.7	96.2	49.7	15.4	1.4	3.7
10	85.1	9	6.4	30.5	85.4	78.1	19.5	3.1	2.6
11	115.8	49.2	3.1	38.7	121.6	39.7	5.8	10.7	1.9
12	57	112.7	3.6	40.5	125.4	45.3	25.9	7.5	1.5
13	128.5	42.5	4.8	71.5	187	48.9	8.3	1.2	3.3
14	139.1	52.7	2.1	71	178.1	47.4	13.6	0.4	4.6
15	154.2	33.8	8.2	69.5	179.6	78.2	9.1	3.2	3.7
16	23	40	7.3	59.9	154.9	64.3	24.8	8.7	4
17	87.4	63.8	10.3	67.4	168.3	53.7	10.7	2.7	2.8

Table 2: pH and amount of TH, TDS, Mn and Zn present in the studied groundwater samples

Sample No.	pH	Physical parameters in mg/L			
		TH	TDS	Mn	Zn
1	7.2	67	147	0.04	0.003
2	7.4	174	158	0.08	0.003
3	7.5	185	245	0.03	0.005
4	7.3	165	308	0.04	0.001
5	7.4	214	387	0.08	0.005
6	7.1	205	428	0.05	0.004
7	7.5	206	451	0.07	0.006
8	6.7	95	347	0.03	0.004
9	7.6	185	254	0.04	0.003
10	5.8	59	108	0.04	0.007
11	7.2	174	318	0.08	0.008
12	6.8	64	142	0.05	0.005
13	7.6	198	398	0.06	0.008
14	7.7	217	452	0.1	0.006
15	7.4	201	401	0.08	0.003
16	6.4	87	254	0.06	0.003
17	7.3	208	487	0.04	0.002

The ground water samples for majority of the experiments as depicted in Table 2, Figure 3 (sample: 1-7, 9, 11, 13-15, 17) are alkaline in nature with a pH range of 7.1–7.7.

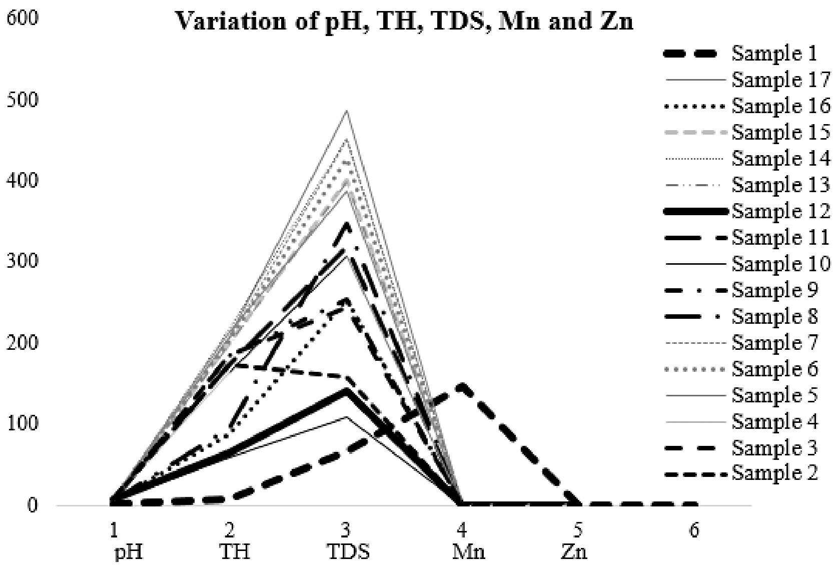

Fig. 3: Sample wise variation of pH and amount of TH, TDS, Mn and Zn present in the studied groundwater samples

Whereas sample 8, 10, 12, 16 are found to be acidic in nature to some extent with pH ranging from 5.8-6.8. pH values for sample 10 and 16 are only not within permissible limit as described by BIS 2012[29]: 6.5-8.5. Total hardness (TH) of the experimental water samples ranges within 59 mg/L and 217 mg/L. For this case sample 5, 6, 7, 14, 15 and 17 shows the values not suitable as per BIS 2012[29]: 200 mg/L. The amount of total dissolved solids (TDS) are determined from the range 108–487 mg/L which is within permissible limit as maximum of the aquatic bionomic entities regarding various fish, species can be capable in tolerating TDS concentration maximum to 1000 mg/l[31] (BIS 2012[29], 500 mg/L). These results are closely related to the work done by Chatterjee *et al.* (2007).[32] The relatively high concentration of TDS existing in the ground waters were mainly distributed in the agricultural areas along with some sporadic domestic parts of the village. Ground waters of all the sites under investigation are considered as fresh water by the US Geological Survey centered on TDS (TDS in clean water <1000 mg/L; marginally saline water range: 1000–3000 mg/L, fairly saline water range: 3000–10,000 mg/L and highly saline water range: 10,000–35,000 mg/L).[33]

The presence of these above parameters are represented in Table 2. Also for certain toxic metals as mentioned in Table 2, the concentrations are investigated within 0.03–0.1 mg/L indicating permissible range by BIS 2012[29], 0.1-0.5 mg/L for Mn, 0.001–0.008 mg/L, for Zn (BIS 2012[29]: 5 mg/L) and were comparable to the findings of Karmakar *et al.* (2024).[34] Ground water with NO_3^- anions beyond the allowed perimeter is commonly persuaded by the anthropogenic involvement of nitrogen as depicted by Xiao *et al.* (2017).[3] It has also been seen that the greater concentration of NO_3^- ions in ground waters are predominantly distributed in the inhabited areas of the village specifying discharge of domestic sources like sewages, wastes of septic tanks etc. Further the higher TDS in ground waters in the studied area are noticed in agricultural areas indicating a connection with agronomic work like use of manures, insecticides etc. The higher quantity of Zn in ground waters is also correlated with anthropogenic activities and pollutants; F^- ions, Mn elements present in samples of groundwater instigate from geogenic concerns.

As the WQI denotes a distinct expression which reviews several parameters and determines the water characteristic, WQIs were measured for all the water samples utilizing the 14 parameters; Ca^{2+}, Na^{+}, K^{+}, Mg^{2+}, HCO_3^-, SO_4^{2-}, Cl^-, NO_3^-, F^-, pH, TH, TDS, Mn, and Zn for 17 different samples presented in Table 3-11.

Table 3: Computed water quality values for samples 1 and 2

Parameters in mg/L Sample No. 1	Wi	Qi	WQI	Wi	Qi	WQI
				Sample No. 2		
Ca^{2+}	0.00117	175.333	69.2968	0.00117	179.733	115.48752
Na^{+}	0.00044	60.5		0.00044	28.1	
K^{+}	0.00175	22.2		0.00175	18.6	
Mg^{2+}	0.00292	180.667		0.00292	45	
HCO_3^-	0.00044	42.1		0.00044	45.75	
SO_4^{2-}	0.00044	37.15		0.00044	43.6	
Cl^-	0.00035	14.72		0.00035	14.12	
NO_3^-	0.00194	0.2		0.00194	5.33333	
F^-	0.08748	230		0.08748	210	
pH*	0.01029	84.7059		0.01029	87.0588	
TH	0.00029	22.3333		0.00029	58	
TDS	0.00017	29.4		0.00017	31.6	
Mn	0.87482	40		0.87482	80	
Zn	0.0175	0.06		0.0175	0.06	

Table 4: Computed water quality values for samples 3 and 4

Parameters in mg/L Sample No. 3	Wi	Qi	WQI	Wi	Qi	WQI
				Sample No. 4		
Ca^{2+}	0.00117	201.467	93.6001	0.00117	105.867	71.19391
Na^{+}	0.00044	32.1		0.00044	6.4	
K^{+}	0.00175	16.4		0.00175	16.6	
Mg^{2+}	0.00292	142		0.00292	70.6667	
HCO_3^-	0.00044	49.55		0.00044	87.6	
SO_4^{2-}	0.00044	42.15		0.00044	36.05	
Cl^-	0.00035	29.6		0.00035	21.64	
NO_3^-	0.00194	4.22222		0.00194	2	
F^-	0.08748	380		0.08748	180	
pH*	0.01029	88.2353		0.01029	85.8824	
TH	0.00029	61.6667		0.00029	55	
TDS	0.00017	49		0.00017	61.6	
Mn	0.87482	30		0.87482	40	
Zn	0.0175	0.1		0.0175	0.02	

Table 5: Computed water quality values for samples 5 and 6

Parameters in mg/L	Wi	Qi	WQI	Wi	Qi	WQI
Sample No. 5				Sample No. 6		
Ca^{2+}	0.00117	137.867	109.653	0.00117	130.8	73.5082
Na^{+}	0.00044	1.45		0.00044	17.85	
K^{+}	0.00175	23.2		0.00175	11	
Mg^{2+}	0.00292	152.667		0.00292	31.3333	
HCO_3^-	0.00044	71.85		0.00044	40.5	
SO_4^{2-}	0.00044	39.75		0.00044	29.2	
Cl^-	0.00035	17.68		0.00035	18.04	
NO_3^-	0.00194	7.55556		0.00194	5.55556	
F^-	0.08748	140		0.08748	260	
pH*	0.01029	87.0588		0.01029	83.5294	
TH	0.00029	71.3333		0.00029	68.3333	
TDS	0.00017	77.4		0.00017	85.6	
Mn	0.87482	80		0.87482	50	
Zn	0.0175	0.1		0.0175	0.08	

Table 6: Computed water quality values for samples 7 and 8

Parameters in mg/L	Wi	Qi	WQI	Wi	Qi	WQI
Sample No. 7				Sample No. 8		
Ca^{2+}	0.00117	225.6	131.2	0.00117	78.9333	79.77653
Na^{+}	0.00044	43.5		0.00044	22.1	
K^{+}	0.00175	15		0.00175	18.2	
Mg^{2+}	0.00292	121.333		0.00292	16.3333	
HCO_3^-	0.00044	79.7		0.00044	62.55	
SO_4^{2-}	0.00044	34.15		0.00044	14.75	
Cl^-	0.00035	21.92		0.00035	23.88	
NO_3^-	0.00194	2		0.00194	21.7778	
F^-	0.08748	410		0.08748	380	
pH*	0.01029	88.2353		0.01029	78.8235	
TH	0.00029	68.6667		0.00029	31.6667	
TDS	0.00017	90.2		0.00017	69.4	
Mn	0.87482	70		0.87482	30	
Zn	0.0175	0.12		0.0175	0.08	

Table 7: Computed water quality values for samples 9 and 10

Parameters in mg/L Sample No. 9	Wi	Qi	WQI	Wi	Qi	WQI
				Sample No. 10		
Ca^{2+}	0.00117	196.267	107.91	0.00117	113.467	138.25542
Na^{+}	0.00044	11.75		0.00044	4.5	
K^{+}	0.00175	20.4		0.00175	12.8	
Mg^{2+}	0.00292	72.3333		0.00292	101.667	
HCO_3^-	0.00044	48.1		0.00044	42.7	
SO_4^{2-}	0.00044	24.85		0.00044	39.05	
Cl^-	0.00035	6.16		0.00035	7.8	
NO_3^-	0.00194	3.11111		0.00194	6.88889	
F^-	0.08748	370		0.08748	260	
pH*	0.01029	89.4118		0.01029	68.2353	
TH	0.00029	61.6667		0.00029	19.6667	
TDS	0.00017	50.8		0.00017	21.6	
Mn	0.87482	40		0.87482	40	
Zn	0.0175	0.06		0.0175	0.14	

Table 8: Computed water quality values for samples 11 and 12

Parameters in mg/L Sample No. 11	Wi	Qi	WQI	Wi	Qi	WQI
				Sample No. 12		
Ca^{2+}	0.00117	154.4	100.632	0.00117	76	70.80273
Na^{+}	0.00044	24.6		0.00044	56.35	
K^{+}	0.00175	6.2		0.00175	7.2	
Mg^{2+}	0.00292	129		0.00292	135	
HCO_3^-	0.00044	60.8		0.00044	62.7	
SO_4^{2-}	0.00044	19.85		0.00044	22.65	
Cl^-	0.00035	2.32		0.00035	10.36	
NO_3^-	0.00194	23.7778		0.00194	16.6667	
F^-	0.08748	190		0.08748	150	
pH*	0.01029	84.7059		0.01029	80	
TH	0.00029	58		0.00029	21.3333	
TDS	0.00017	63.6		0.00017	28.4	
Mn	0.87482	80		0.87482	50	
Zn	0.0175	0.16		0.0175	0.1	

Table 9: Computed water quality values for samples 13 and 14

Parameters in mg/L	Wi	Qi	WQI	Wi	Qi	WQI
Sample No. 13				Sample No. 14		
Ca^{2+}	0.00117	171.333	122.373	0.00117	185.467	175.40829
Na^{+}	0.00044	21.25		0.00044	26.35	
K^{+}	0.00175	9.6		0.00175	4.2	
Mg^{2+}	0.00292	238.333		0.00292	236.667	
HCO_3^-	0.00044	93.5		0.00044	89.05	
SO_4^{2-}	0.00044	24.45		0.00044	23.7	
Cl^-	0.00035	3.32		0.00035	5.44	
NO_3^-	0.00194	2.66667		0.00194	0.88889	
F^-	0.08748	330		0.08748	460	
pH*	0.01029	89.4118		0.01029	90.5882	
TH	0.00029	66		0.00029	72.3333	
TDS	0.00017	79.6		0.00017	90.4	
Mn	0.87482	60		0.87482	100	
Zn	0.0175	0.16		0.0175	0.12	

Table 10: Computed water quality values for samples 15 and 16

Parameters in mg/L	Wi	Qi	WQI	Wi	Qi	WQI
Sample No. 15				Sample No. 16		
Ca^{2+}	0.00117	205.6	130.079	0.00117	30.6667	128.24211
Na^{+}	0.00044	16.9		0.00044	20	
K^{+}	0.00175	16.4		0.00175	14.6	
Mg^{2+}	0.00292	231.667		0.00292	199.667	
HCO_3^-	0.00044	89.8		0.00044	77.45	
SO_4^{2-}	0.00044	39.1		0.00044	32.15	
Cl^-	0.00035	3.64		0.00035	9.92	
NO_3^-	0.00194	7.11111		0.00194	19.3333	
F^-	0.08748	370		0.08748	400	
pH*	0.01029	87.0588		0.01029	75.2941	
TH	0.00029	67		0.00029	29	
TDS	0.00017	80.2		0.00017	50.8	
Mn	0.87482	80		0.87482	60	
Zn	0.0175	0.06		0.0175	0.06	

Table 11: Computed water quality values for sample 17

Parameters in mg/L Sample No. 17	Wi	Qi	WQI
Ca^{2+}	0.00117	116.533	80.4288
Na^{+}	0.00044	31.9	
K^{+}	0.00175	20.6	
Mg^{2+}	0.00292	224.667	
HCO_3^-	0.00044	84.15	
SO_4^{2-}	0.00044	26.85	
Cl^-	0.00035	4.28	
NO_3^-	0.00194	6	
F^-	0.08748	280	
pH*	0.01029	85.8824	
TH	0.00029	69.3333	
TDS	0.00017	97.4	
Mn	0.87482	40	
Zn	0.0175	0.04	

*no unit

Calculated values of WQI signifies that 41.2% of the investigated water samples are of good and 58.8% of the water samples defines poor quality water for intake purposes. The WQI values represented in The WQI of the samples were observed to be in the range of 69.29682 to 175.40829 was found to be comparable to those obtained in the study done by Batabyal *et al.* (2015)[30] and was compared with the water grade categorization for intake purposes depending on the values of WQI as mentioned by Boateng *et al.* (2016)[22] who categorized the quality of water into five categories as excellent, good, poor, very poor, and unsuitable for human consumption subject to WQI as represented in Table 12.

Table 12: Categorization of potable water hinged on the WQI values (Boateng *et al.* 2016)[22]

Range	Type of water
<50	Excellent
50-100	Good
100.1-200	Poor
200.1-300	Very poor
> 300	Unsuitable

Table 3 indicates that the Sample 1 is the best in quality among all the 17 water samples and the worst water quality is observed for sample 14. Figure 4 might be useful to compare the overall excellence of the water concerning different sources and maintain proper use of the *water.*

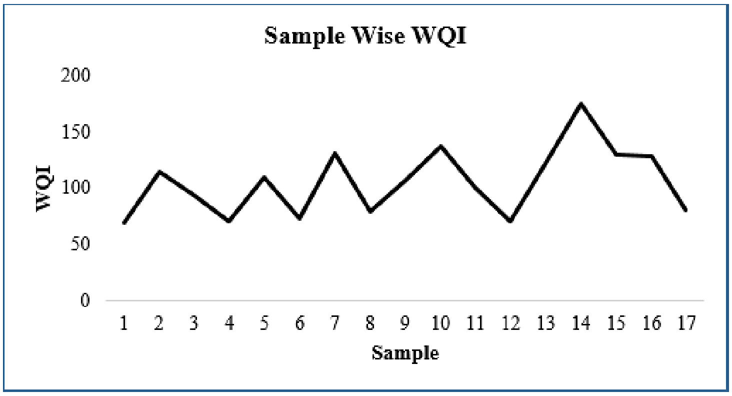

Fig. 4: Water Quality Index values of the water samples

Health Implications

The higher amount of NO_3^-, F^-, Zn, Mn in the ground water beyond the accepted border may cause severe health hazards to human health. Non carcinogenic threats to human robustness should be taken into consideration if subjected to large extent of NO_3^-, F^-, Zn and Mn in everyday living mentioned by USEPA, 2008.[35] There is a greater connotation between contamination and health difficulties. Health hazards related to uncleaned water include distinctive ailments such as lung disease, dysentery, neural disorder, cancer and cardiac vascular disease.[36] Polluted water can have the capability to destroy the production of crops. It may also infect food and vegetables which is harmful for aquatic living organisms as well as human life.[37] Pollutants present in water disrupt the food chain. Heavy metals for example Fe may cause difficulties in respiratory system of fishes which if eaten by human beings may lead to several health issues. Metal polluted water results in different health problems like liver cirrhosis, renal failure, hair loss, neural syndrome etc.[38]

F^- in water is crucial to strengthen of the bones and to protect against dental carries. Concentration of fluoride ions lower than 0.5 mg/l instigates tooth decay and weakening of tooth but greater concentration of more than 0.5 mg/l for about 5-6 years may result in hostile consequences on human health bringing about fluorosis disease.

Several toxic rudiments may be assimilated in the food web from the polluted water bodies. Thus, aquatic animals are also getting affected directly due to the contaminated ground waters.[39] Pollution of ground waters also affects the animals of surrounding areas of the polluted ground water sources. Drinking water excellence must meet specific guidelines of organizations such as WHO, IS etc. If drinking water quality is appropriately controlled and within desirable limits, it may not cause waterborne diseases in humans and have no adverse effect on the environment.[40-41] Residents of the studied village reported that ingestion of aquatic animals including fishes of the nearby wet lands, lakes, rivers creates frequent health difficulties. During the study it was reported that different diseases like nausea, vomiting, indigestion, diarrhea, fever, cancer, dermal problems, vertigo, itching, burning sensation, liver problems etc. were found to increase to a greater extent in comparison to previous years. These problems were suffered by the local people to a higher degree who use the ground water as drinking water directly without purification, instead those dwellers of the villagers do not use untreated water from the ground water sources are more or less not affected to some extent. It was noticed that among the inhabitants those were interviewed for conducting the present study, 12 percent had indigestion problem, 7 percent were suffering from vomiting problems, 2 percent had fever, 7 percent were having severe diarrhea, nausea like health issues were found in 4 percent cases, vertigo type difficulties were shown in 1 percent cases, 9 percent people were going through itching and burning sensation, liver related difficulties were faced by 21 percent people, dermal problems were found in case of 18 percent people. The disease cancer was found in four inhabitants of the studied area. According to the local dwellers the health issues were found to increase day by day irrespective of genders. Although a number of people also reported that after using treated water for drinking purpose and other house hold works, their health problems were under control to some extent. The health issues were seen more problematic for the children under 14 years and pregnant women. Therefore, the people are now may be aware of the water pollution and associated diseases. They are trying to cope up with the situation for the betterment of livelihood and to protect the nearby water sources from being polluted. It is imperative for every villager to develop a profound knowledge of water pollution and take action to inhibit contagion. The study's test results can provide valuable insights into water quality basics, but it is important to note that the presence of chemical and biological components determines the extent of water pollution and how it leads to diseases. Therefore, it is crucial to identify the responsible water component for illnesses and apply newer technologies and analytical methods to quantify various compounds in *water.* By raising awareness and taking necessary precautions, a safe and healthy drinking water source for the community can be ensured.

Despite facing certain challenges during the study, such as the absence of a laboratory in close proximity to the water sources and difficulties in transporting the samples over long distances without compromising their quality, the findings provide valuable insights and highlight the importance of further research in this field. Due to the fact that a majority of the villagers in the study area are engaged in agriculture, conducting the study required a significant amount of time and effort as they were not always available for interviews. However, it was not possible to accurately educate everyone about water pollution as not all the local people are concerned. Additionally, it is not always apparent that everyone is fully aware of their physical ailments and actively seeking treatment.

Conclusion

Water contamination is a universal concern and whole community is fronting most awful outcomes of diseased *water.* Major causes of water effluence are to be identified so as to protect ground water and prevent pollution in terms of several health issues of human beings. WQI values specify about the water excellence in the studied area designating good to poor class of *water.* There is a need of consciousness among the people of the area and urgent requirement to procure the apposite measures to defend the overall water quality in the study area. Various bacterial, viral as well as parasitic diseases are increasing through contaminated water and causing normal to acute problems to human health. There should be appropriate waste discarding method and discharge of waste matters should be processed prior to dumping in the ground or entering in to water bodies. In every sectors of people educational in addition to awareness programs may be organized to aware the inhabitants about the paucity of the pollution specifically raising awful situation due to contaminated *water.* Cost effective and reasonably priced water purifiers may be supplied to the dwellers from the gram panchayat or better to plant for a water purifier for safe drinking water and cooking purposes in the village by the government agencies. In this regard, local panchayats can play a pivotal role in monitoring the purity of drinking water and ensuring that every household in the village has access to purified *water.* It is imperative for villagers to prioritize the health of their drinking water and for the authorities responsible for managing the village to adopt appropriate and feasible measures to guarantee that every family of the studied village can avail of clean potable water and prevent common physical ailments to some extent.

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Conflict of Interest

There is no conflict of interest.

Data Availability Statement

The research is based on primary data and all primary data obtained from laboratory experiments and field-based interviews were included in this study. Additionally, the data used for comparison can be found in the references.

Ethics Approval Statement

The privacy of the participants in this study was respected as their names were not published upon their request. Prior approval from the Gram Pradhan was obtained to carry out the study, and the local Panchayat of Aiho village in the Malda district of West Bengal, India ultimately authorized the present study.

Author's Contribution

As the corresponding and principal author of this study, all aspects of the research and manuscript preparation were completed solely by the author herself.

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