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Determination of Water Quality Index of Drinking Water Sources and Health Risk Assessment of Arsenic-Contaminated Rural Areas in Basirhat-1 Block of West Bengal

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Abstract: ***Arsenic (As) contamination in groundwater is a major environmental problem in West Bengal. People in rural West Bengal are mostly dependent on community deep tube wells for drinking purpose. North 24 Praganas in West Bengal is one of the most Arsenic affected districts in India. Most of the deep tube wells currently being used in North 24 Praganas have already been declared to be contaminated with Arsenic. Time to time evaluation of suitability of these water sources for drinking purposes and the assessment of health risk are very essential for knowing the severity of the condition and accordingly take timely mitigation measures. In this paper, the Water Quality Index(WQI) has been determined and Health Risk Assessment has been done for drinking water sources currently in use in one of the chronically Arsenic affected Basirhat-1 block of North 24 Praganas. For calculating WQI, the weighted arithmetic water quality index method has been adopted by taking pH, TDS, Sulphates, DO(Dissolved Oxygen), total Alkalinity, Total hardness, EC, Chloride and total Arsenic as parameters. The Health Risk Assessment has been done by considering the total Arsenic found in the water samples. For Health Risk Assessment, cancer and non-cancer risk assessment were done by following the deterministic method of risk assessment recommended by US EPA (Environmental Protection Agency). The WQI results indicates that all the sampled deep tube wells of the studied area are highly unsuitable for drinking purpose. Arsenic content was found to be 4 to 24 times higher than the permissible limit. The Hazard Quotient of the sampled studied sources was calculated to be in the range of 2 to 9 which signifies the vulnerable health risk due to non-carcinogenic effect due to Arsenic. The cancer risk assessment gives a further alarming picture of the area with 1-4 persons for every 1000 population in Basirhat-1 block are prone to Cancer risk due to Arsenic. The study recommends immediate measures in the area to make all the current drinking water sources Arsenic free.***

Keywords: ***Drinking water, Arsenic, Physico-chemical parameters, Water Quality Index, Health Risk Assessment***

I. INTRODUCTION

Arsenic contamination in groundwater is the major environmental challenge in West Bengal. Most of the rural people depend on deep tube well for drinking purpose in rural West Bengal. As per the Ministry of Drinking Water and Sanitation, Government of India, as on 19th December 2017 17918 habitations in India were Arsenic contaminated. 10928 habitations were Arsenic contaminated only in West Bengal. Arsenic in drinking water causes cancer and many chronic diseases. People from low economic background suffer most due to the lack of availability of proteinous food (WHO,2000). As per EPA (Environmental Protection Agency) Arsenic is under the carcinogenic group A. Water quality of the used deep tube well poses great importance for the health of the rural people. By considering the gravity the issue, it is very essential to time to time measure the Water Quality Index of drinking water sources and the assessment of health risk due to Arsenic especially in chronically affected areas for assessing the challenge to public and designing proper risk mitigation strategy. This study aims at finding the water quality index of community drinking water sources mostly being used in a chronically Arsenic affected Block of West Bengal.The study also aims at assessing health risk; both cancer and non-cancer due to the presence of Arsenic in Drinking water.

II. STUDY AREA AND METHODOLOGY

A. Study Area

North 24 Praganas of West Bengal is one of the most Arsenic affected districts of India. The study has been conducted in Basirhat-1 block of North 24 Praganas.Basirhat-1 is one of the worst arsenic affected blocks of North24 Paraganas. It is located near the border of India and Bangladesh. The area is situated adjacent to the Ichamati-Raimangal plain of lower Gangetic plain. Lattitude and longitude of Basirhat-1 block are 22.6574 N and 88.8672 E.There are seven Gram Panchayats (GP) in the block, namely Gachha Akharpur, Gotra, Itinda Panitore, Nimdaria Kodalia, Pifa, Sangrampur Shibhati and Sankchura Bagundi. Total 14 villages were selected for the study with two villages randomly selected for each of the GP. Out of the currently functional common drinking water sources, for the purpose of the study one common drinking water source was randomly selected for each of the 14 villages.

B. Water sample collection and testing

Drinking water samples of 14 common deep tube wells were collected in May 2019. Water samples were collected after ten minutes of pumping of the sampled deep tube wells. Groundwater samples were collected in a 2-litre acid-washed plastic container. pH, TDS (Total dissolved solids), Electrical Conductivity,

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DO (Dissolved oxygen), Total hardness, Total alkalinity, Sulphate (SO4-) and Chloride (Cl-) concentration were estimated (APHA,2005). pH, TDS, DO and EC were measured at the respective sampling sites. Sulphate, Chloride, Total hardness, Total alkalinity and total Arsenic were measured in the laboratory. Total arsenic (As) was estimated by AAS (Atomic Absorption Spectrometer).

C. *Heath Risk Assessment*

Health risk assessment due to Arsenic was estimated as per the deterministic method by EPA (Environmental Protection Agency). Average total dose, chronic daily intake, CR (cancer risk), Hazard quotient (HQ) were calculated as per EPA guideline. The health risk due to non-carcinogenic and carcinogenic effects were evaluated based on the Total Arsenic content found in the test results for all the 14 sampled locations.

The average intake of Arsenic per day was calculated by the equation:

Average total dose (ATD)=As in mg/lt × Ingestion rate (lt/day). (1)

For the calculation of Cancer Risk as per USEPA guideline for adults, the ingestion rate was taken 2 litres per day. The laboratory test result of As concentration of sampled sources were considered for calculating the ATD.

The chronic daily intake was calculated by the equation:

Chronic daily intake (CDI) in mg/kg/day =ATD/Body weight (2)

As per USEPA guideline, body weight was taken as 70 kg.

The Cancer Risk due to Arsenic was calculated by the equation:

Cancer Risk (CR) = CDI × Potency factor (3)

Potency factor for arsenic for oral route is 1.5 $(mg/kg/day)^{-1}$ (established by USEPA's Integrated Risk Information System-IRIS).

HQ =CDI ×RfD (4)

Where; RfD is the reference dose for As (mg/kg d), i.e., 3×10^{-4}

For assessing health risk due to non-carcinogenic effects, HQ<1 is considered as not much significant.

For assessing health risk due to carcinogenic effect, CR between 10^{-4} to 10^{-6} is considered as acceptable.

D. *Water Quality Index*

Water Quality Index (WQI) is an overall representation of influences of all parameters on the overall quality of water (Horton RK, 1965). The suitability of water for human consumption can be calculated by the weighted arithmetic index method (Brown et al. 1972). Weighted arithmetic water quality index method is applicable for both surface and groundwater (Tyagi et al. 2013)

The Water Quality Index (WQI) has been calculated by using the following equation:

$$WQI = \sum Q_i W_i / \sum W_i \quad (5)$$

The quality rating scale (Q_i) for each parameter is calculated by using the following equation:

$$Q_i = 100[(V_i - V_0)/(S_i - V_0)] \quad (6)$$

Where,

V_i =estimated concentration of ith parameter in the analysed water sample

V_0=the ideal value of this parameter in pure water

V_0= 0 , except pH =7.0 and DO =14.6 mg/l

S_i = recommended standard value of the ith parameter

The unit weight (W_i) for each water quality parameter is calculated by using the following formula:

$$W_i = K/S_i \quad (7)$$

Where K= proportionality constant.

K can be calculated by using the following equation:

$$K = 1/\sum(1/S_i)$$

The rating of water quality as per weighted arithmetic WQI method is given in Table-1.

Table-1: Water Quality Rating as per weighted arithmetic WQI method

WQI value	Rating of Water Quality	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very poor water quality	D
Above 100	Unsuitable for drinking purpose	E

For the calculation of water quality index, physicochemical parameters were taken along with Arsenic as heavy metal. For this study pH, TDS (Total dissolved solids), Electrical Conductivity (EC), DO (Dissolved oxygen), Total hardness, Total alkalinity, Sulphate ($SO4^{-2}$) and Chloride (Cl^-) have been considered as physic-chemical parameters. At first each parameter wise WQI was calculated for all the location. Then WQI for each location was calculated by considering all parameters. As mentioned in Table-1, the WQI of all the sampled locations were compared with water quality rating.

III. RESULTS AND DISCUSSIONS

The experimental results of pH, TDS,EC, DO, Total hardness, Total alkalinity, Sulphate, Chloride and Arsenic for all the 14 locations are given in the Table-2.The mean, range and standard deviation of test results have been compared with the permissible Limit (BIS IS 10500:2012) in Table-3. TDS parameter of all the sources was within 1000 mg/lt that implies within the acceptable limit. TDS parameter has no specific health impact (WHO Guidelines for drinking water quality). Sulphate concentration of all the sampling points was in within acceptable limit (WHO Guidelines for drinking water quality). Chloride has no toxic impact on health. Human body can consume a high amount of chloride (WHO Guidelines for drinking water quality). The alkalinity of all the sampling points was within 400 mg/l. So the risk of unpalatability was reduced in drinking water (Parameters of water quality EPA).

The arsenic concentration of all the tube wells exceeded the maximum permissible limit of 0.01 mg/L. These water sources are in use for drinking for more than ten years. This may cause many harmful effects on the human body. Chronic exposure of arsenic may cause coronary heart disease, myocardial infarction, increased blood pressure on the human body (WHO Guidelines of for drinking water quality).

Table-2: Test results of all 9 parameters for all the 14 locations

Station	TDS (mg/L)	Electrical Conductivity (µS/cm)	pH	Total Alkalinity (mg/L)	Total Hardness (mg/L)	Chloride (mg/L)	Sulphate (mg/L)	Arsenic (mg/L)	Dissolved Oxygen (mg/L)
1	385	788	7.1	293	313	269	31.26	0.081846	4.78
2	332	680	8.1	334	278	231	27.67	0.073648	1.3
3	318	654	6.9	284	263	223	37.98	0.04325	1.09
4	315	598	7.8	322	398	203	56.42	0.05767	4.78
5	360	738	7.7	317	324	251	61.53	0.022294	4.56
6	350	717	8.1	332	249	244	80.75	0.037711	1.42
7	326	668	7.3	301	328	227	75.62	0.05911	2.19
8	444	934	7.7	316	345	318	40.74	0.061959	1.13
9	656	1320	7.7	317	281	447	37.6	0.067879	4.53
10	302	621	7.7	320	378	211	58.3	0.066153	1.07
11	907	1805	7.7	318	365	610	64.82	0.043741	1.03
12	735	1473	7.7	327	361	500	28.8	0.05376	1.34
13	856	1708	7.2	297	260	577	60.81	0.096027	3.38
14	519	1053	6.9	284	328	358	37.2	0.074637	4.14

Table-3: Analysis of 9 water quality parameters for all sampled 14 sources

Parameter	Range	Mean	SD(+/-)	Permissible Limit (BIS IS 10500:2012)
TDS (mg/L)	302-907	486	214	500
Electrical Conductivity (µS/cm)	598-1805	983	422	250
pH	6.9-8.1	7.6	0.4	6.5-8.5
Total Alkalinity (mg/L)	284-334	312	7	200
Total Hardness (mg/L)	249-398	319	47	200
Chloride (mg/L)	203-610	334	142	250
Sulphate (mg/L)	27.67-80.75	49.96	17.6	200
Arsenic (mg/L)	0.0223-0.0960	0.06	0.0192	0.01
Dissolved Oxygen (mg/L)	1.03-4.78	2.62	1.62	5

Table-4: Water Quality Index of all 14 deep tube wells for TDS (in mg/L)

Station	Standard value	Ideal value	Monitored value	Sub-Index	Weightage unit	WQI
1	500	0	385	77.0	0.0000198	0.001525
2	500	0	332	66.4	0.0000198	0.001315
3	500	0	318	63.6	0.0000198	0.001259
4	500	0	315	63.0	0.0000198	0.001247
5	500	0	360	72.0	0.0000198	0.001426
6	500	0	350	70.0	0.0000198	0.001386
7	500	0	326	65.2	0.0000198	0.001291
8	500	0	444	88.8	0.0000198	0.001758
9	500	0	656	131.2	0.0000198	0.002598
10	500	0	302	60.4	0.0000198	0.001196
11	500	0	907	181.4	0.0000198	0.003592
12	500	0	735	147.0	0.0000198	0.002911

13	500	0	856	171.2	0.0000198	0.00339
14	500	0	519	103.8	0.0000198	0.002055

Table-5: Water Quality Index of all 14 deep tube wells for Electrical Conductivity (µS/cm)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	250	0	788	315.2	0.0000396	0.0124819
2	250	0	680	272.0	0.0000396	0.0107712
3	250	0	654	261.6	0.0000396	0.0103594
4	250	0	598	239.2	0.0000396	0.0094723
5	250	0	738	295.2	0.0000396	0.0116899
6	250	0	717	286.8	0.0000396	0.0113573
7	250	0	668	267.2	0.0000396	0.0105811
8	250	0	934	373.6	0.0000396	0.0147946
9	250	0	1320	528.0	0.0000396	0.0209088
10	250	0	621	248.4	0.0000396	0.0098366
11	250	0	1805	722.0	0.0000396	0.0285912
12	250	0	1473	589.2	0.0000396	0.0233323
13	250	0	1708	683.2	0.0000396	0.0270547
14	250	0	1053	421.2	0.0000396	0.0166795

Table-6: Water Quality Index of all 14 deep tubewells for pH

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	8.5	7	7.1	6.6666667	0.001164	0.00776
2	8.5	7	8.1	73.3333333	0.001164	0.08536
3	8.5	7	6.9	6.6666667	0.001164	0.00776
4	8.5	7	7.8	53.3333333	0.001164	0.06208
5	8.5	7	7.7	46.6666667	0.001164	0.05432
6	8.5	7	8.1	73.3333333	0.001164	0.08536
7	8.5	7	7.3	20.0000000	0.001164	0.02328
8	8.5	7	7.7	46.6666667	0.001164	0.05432
9	8.5	7	7.7	46.6666667	0.001164	0.05432
10	8.5	7	7.7	46.6666667	0.001164	0.05432
11	8.5	7	7.7	46.6666667	0.001164	0.05432
12	8.5	7	7.7	46.6666667	0.001164	0.05432
13	8.5	7	7.2	13.3333333	0.001164	0.01552
14	8.5	7	6.9	6.6666667	0.001164	0.00776

Table-7: Water Quality Index of all 14 deep tubewells for Total Alkalinity (mg/L)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	200	0	293	146.5	0.0000825	0.012086
2	200	0	334	167	0.0000825	0.013778
3	200	0	284	142	0.0000825	0.011715
4	200	0	322	161	0.0000825	0.013283
5	200	0	317	158.5	0.0000825	0.013076

6	200	0	332	166	0.0000825	0.013695
7	200	0	301	150.5	0.0000825	0.012416
8	200	0	316	158	0.0000825	0.013035
9	200	0	317	158.5	0.0000825	0.013076
10	200	0	320	160	0.0000825	0.013200
11	200	0	318	159	0.0000825	0.013118
12	200	0	327	163.5	0.0000825	0.013489
13	200	0	297	148.5	0.0000825	0.012251
14	200	0	284	142	0.0000825	0.011715

Table-8: Water Quality Index of all 14 deep tubewells for Total Hardness (mg/L)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	200	0	313	156.50000	0.000033	0.005165
2	200	0	278	139.00000	0.000033	0.004587
3	200	0	263	131.50000	0.000033	0.00434
4	200	0	398	199.00000	0.000033	0.006567
5	200	0	324	162.00000	0.000033	0.005346
6	200	0	249	124.50000	0.000033	0.004109
7	200	0	328	164.00000	0.000033	0.005412
8	200	0	345	172.50000	0.000033	0.005693
9	200	0	281	140.50000	0.000033	0.004637
10	200	0	378	189.00000	0.000033	0.006237
11	200	0	365	182.50000	0.000033	0.006023
12	200	0	361	180.50000	0.000033	0.005957
13	200	0	260	130.00000	0.000033	0.00429
14	200	0	328	164.00000	0.000033	0.005412

Table-9: Water Quality Index of all 14 deep tubewells for Chloride (mg/L)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	250	0	269	107.6	0.0000396	0.004261
2	250	0	231	92.4	0.0000396	0.003659
3	250	0	223	89.2	0.0000396	0.003532
4	250	0	203	81.2	0.0000396	0.003216
5	250	0	251	100.4	0.0000396	0.003976
6	250	0	244	97.6	0.0000396	0.003865
7	250	0	227	90.8	0.0000396	0.003596
8	250	0	318	127.2	0.0000396	0.005037
9	250	0	447	178.8	0.0000396	0.00708
10	250	0	211	84.4	0.0000396	0.003342
11	250	0	610	244.0	0.0000396	0.009662
12	250	0	500	200.0	0.0000396	0.00792
13	250	0	577	230.8	0.0000396	0.00914
14	250	0	358	143.2	0.0000396	0.005671

Table-10: Water Quality Index of all 14 deep tube wells for Sulphate (mg/L)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	200	0	31.26	15.630	0.0000495	0.000774
2	200	0	27.67	13.835	0.0000495	0.000685
3	200	0	37.98	18.990	0.0000495	0.00094
4	200	0	56.42	28.210	0.0000495	0.001396
5	200	0	61.53	30.765	0.0000495	0.001523
6	200	0	80.75	40.375	0.0000495	0.001999
7	200	0	75.62	37.810	0.0000495	0.001872
8	200	0	40.74	20.370	0.0000495	0.001008
9	200	0	37.6	18.800	0.0000495	0.000931
10	200	0	58.3	29.150	0.0000495	0.001443
11	200	0	64.82	32.410	0.0000495	0.001604
12	200	0	28.8	14.400	0.0000495	0.000713
13	200	0	60.81	30.405	0.0000495	0.001505
14	200	0	37.2	18.600	0.0000495	0.000921

Table-11: Water Quality Index of all 14 deep tubewells for Arsenic (mg/L)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	0.01	0	0.081846	818.460	0.99	810.2754
2	0.01	0	0.073648	736.484	0.99	729.1192
3	0.01	0	0.04325	432.504	0.99	428.179
4	0.01	0	0.05767	576.695	0.99	570.9281
5	0.01	0	0.022294	222.942	0.99	220.7126
6	0.01	0	0.037711	377.106	0.99	373.3349
7	0.01	0	0.05911	591.099	0.99	585.188
8	0.01	0	0.061959	619.589	0.99	613.3931
9	0.01	0	0.067879	678.785	0.99	671.9972
10	0.01	0	0.066153	661.533	0.99	654.9177
11	0.01	0	0.043741	437.410	0.99	433.0359
12	0.01	0	0.05376	537.601	0.99	532.225
13	0.01	0	0.096027	960.267	0.99	950.6643
14	0.01	0	0.074637	746.370	0.99	738.9063

Table-12: Water Quality Index of all 14 deep tubewells for Dissolved Oxygen (mg/L)

Station	Standard value	Ideal value	Monitored value	Quality Rating Scale	Weightage unit	WQI
1	5	14.6	4.78	102.29167	0.00198	0.202538
2	5	14.6	1.3	138.54167	0.00198	0.274313
3	5	14.6	1.09	140.72917	0.00198	0.278644
4	5	14.6	4.78	102.29167	0.00198	0.202538
5	5	14.6	4.56	104.58333	0.00198	0.207075
6	5	14.6	1.42	137.29167	0.00198	0.271838
7	5	14.6	2.19	129.27083	0.00198	0.255956

8	5	14.6	1.13	140.31250	0.00198	0.277819
9	5	14.6	4.53	104.89583	0.00198	0.207694
10	5	14.6	1.07	140.93750	0.00198	0.279056
11	5	14.6	1.03	141.35417	0.00198	0.279881
12	5	14.6	1.34	138.12500	0.00198	0.273488
13	5	14.6	3.38	116.87500	0.00198	0.231413
14	5	14.6	4.14	108.95833	0.00198	0.215738

Table-13: Water Quality Index of all 14 sampled sources by considering all 9 water quality parameters

Station	WQI Value	WQI Category
1	816	Unsuitable for drinking purpose
2	734	Unsuitable for drinking purpose
3	431	Unsuitable for drinking purpose
4	575	Unsuitable for drinking purpose
5	222	Unsuitable for drinking purpose
6	376	Unsuitable for drinking purpose
7	589	Unsuitable for drinking purpose
8	618	Unsuitable for drinking purpose
9	677	Unsuitable for drinking purpose
10	660	Unsuitable for drinking purpose
11	436	Unsuitable for drinking purpose
12	536	Unsuitable for drinking purpose
13	957	Unsuitable for drinking purpose
14	744	Unsuitable for drinking purpose

Table-14: Health Risk Assessment due to Arsenic for all 14 samples sources

Station	As conc in mg/L	ATD in lt/day	CDI in mg/kg/day	HQ	CR
1	0.081846	0.163692	0.002338457	7.794857	0.003507686
2	0.073648	0.147297	0.00210424	7.014133	0.00315636
3	0.04325	0.086501	0.001235726	4.119086	0.001853589
4	0.05767	0.115339	0.0016477	5.492333	0.00247155
5	0.022294	0.044588	0.000636977	2.123257	0.000955466
6	0.037711	0.075421	0.001077446	3.591486	0.001616169
7	0.05911	0.11822	0.001688854	5.629514	0.002533281
8	0.061959	0.123918	0.001770254	5.900848	0.002655381
9	0.067879	0.135757	0.001939386	6.464619	0.002909079
10	0.066153	0.132307	0.001890094	6.300314	0.002835141
11	0.043741	0.087482	0.001249743	4.16581	0.001874614
12	0.05376	0.10752	0.001536003	5.12001	0.002304004
13	0.096027	0.192053	0.00274362	9.1454	0.00411543
14	0.074637	0.149274	0.002132486	7.108286	0.003198729

Each parameter wise weighted WQIs for all the 14 locations are given in Table-4 to Table-12. The WQI of all the sampled sources by considering all the nine water quality parameters are given in Table-13.WQI of all the sampling points ranged from 222 to 957. Water quality index of all the sampling points was above 100 that implies unsuitability for drinking purpose. Arsenic concentration has a great impact on the water quality index.

The water sources are contaminated, and people are using it for more than ten years.

From the field visit, it was found most of the people depend on community tube wells for drinking purpose and people are suffering from the unavailability of sufficient drinking water in summer. Villagers are preferring to drink water from the common deep tube wells. Though declared, contaminated people are still using the same source for drinking. Villagers are not preferring the piped water supply and vendor water for drinking purposes. Due to leakage in the pipes, various water insects and worms are entering the pipes. Also, villagers are perceiving that both piped water and bottled water are not fresh, whereas the deep bore well water is freshwater. People are also not using piped water supply for cooking also. In terms of taste also villagers preferring the deep bore well water.

The Hazard Quotient (HQ) and Cancer Risk (CR) for each of the sampled stations are given in the Table-14.HQ is greater than 1 for all the stations which signifies that health risk due to non-carcinogenic effects are very much significant. The HQ is coming in the range of 2 to 10, which is signifying the alarming status of non-carcinogenic effect due to the presence of Arsenic much above the permissible limits. The CR of all the locations are above $1x10^{-4}$ which signifies the dangerous level of health risk due to carcinogenic effect of Arsenic in drinking water.1 to 4 persons per 1000 in Basirhat-1 block are at risk of being affected with cancer which is significantly high for any habitation.

IV. CONCLUSION

The WQI of all the sampled sources signifies the very much unsuitability of all the sampled water sources for drinking purposes.The Health Risk due to non-carcinogenic and carcinogenic effects of Arsenic in drinking water are also much higher than the accepted limits.It is alarming that 100% of the sampled water sources are As contaminated and the water sources are in use for more than 10 years.The population is having long term exposure to this hazard and drinking slow poison daily throughout their life. People are preferring freshwater and till now there is no alternative to deep bore wells. The piped water supply and bottled water are not being much preferred by the villagers. This study validates that the populations are under great risk of cancer and non-cancer diseases. The study has been conducted in such pockets which are rural and also the community are socio-economically backward. All generations are under great life risk and the situation is alarming. Other physicochemical parameters and other heavy metal concentration could be considered in further studies in such areas. Assessment of seasonal WQI and Health risk can give further insight into the gravity of the situation. The study recommends immediate measures in the area to make all the current drinking water sources Arsenic free.

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