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 Pragas 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 Pragas 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-I block of North 24 Pragas. 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-I 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 Pragas of West Bengal is one of the most Arsenic affected districts of India. The study has been conducted in Basirhat-I block of North 24 Pragas. Basirhat-I 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. Latitude and longitude of Basirhat-I 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 Shihbati 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, 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. Health 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:

\[
\text{Average total dose (ATD)} = \text{As in mg/L} \times \text{Ingestion rate (L/day)}.
\]

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:

\[
\text{Chronic daily intake (CDI)} = \text{ATD/Body weight}.
\]

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

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

\[
\text{Cancer Risk (CR)} = \text{CDI} \times \text{Potency factor}
\]

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

\[
\text{HQ} = \text{CDI} \times \text{RfD}
\]

Where: RfD is the reference dose for As (mg/kg d), i.e., 3 X 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:

\[
\text{WQI} = \sum Q_i W_i \div \sum W_i
\]

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

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

Where,

\[
V_i = \text{estimated concentration of ith parameter in the analysed water sample}
\]

\[
V_0 = \text{ideal value of this parameter in pure water}
\]

\[
S_i = \text{recommended standard value of the ith parameter}
\]

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

\[
W_i = K/S_i
\]

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 | 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 (SO\(_4\)\(^2\)) and Chloride (Cl\(^-\)) have been considered as physico-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/L 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 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|
### 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             | 6.66666667          | 0.001164       | 0.00776 |
| 2       | 8.5            | 7           | 8.1             | 73.3333333          | 0.001164       | 0.08536 |
| 3       | 8.5            | 7           | 6.9             | 6.66666667          | 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 |
| 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           | 0.02294         | 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 |
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 l/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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