# Status of Drinking-water in Nadia district, West Bengal, India – a Two-year Surveillance Report for Chemical Contaminants

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**Abstract**— A study was undertaken to determine the status of drinking water in Nadia district, West Bengal, India with regards to chemical contaminants which are capable of causing serious health hazard, if not within permissible limit. Total 56 water samples were collected from different households in Nadia for two years 2017-2018 and were analysed for chemical contaminants. In 2017, the water samples were analyzed for eleven parameters – Total Alkalinity (TA), pH, arsenic (As), iron (Fe), fluoride ion ($F^-$), chloride ion ($Cl^-$), residual chlorine (Res. $Cl_2$), phosphate ($PO_4^{3-}$), nitrate ($NO_3^-$), nitrite ($NO_2^-$) and ammonium ($NH_4^+$). In 2018, the water samples were analyzed for thirteen parameters - Total Hardness (TH) and sulphite/residual sulphite ($SO_3^{2-}$/Res. $SO_3^{2-}$) were determined in addition to the previously mentioned eleven parameters. An analysis was carried out to determine the trends of the chemical contaminants - arsenic, fluoride and nitrate in drinking water for the surveillance report.

**Keywords**: Chemicals, contaminant trend, drinking-water, health hazard, surveillance.

## I. INTRODUCTION

In India, the availability of surface water is greater than groundwater but still, India is the largest ground water user in the world.[1] This is due to the decentralised availability of groundwater, hence, it is easily accessible and forms the largest share of India's agriculture and drinking water supply.[2] As per reports of the Central Ground Water Board (CGWB) of India, 89% of groundwater extracted is used for irrigation, followed by that for domestic use (9%), whereas industrial use of groundwater is 2%. It is also estimated that 50% of urban and 85% of rural domestic water requirements, including drinking water, are also fulfilled by ground water.[3] Therefore, the quality of groundwater of a region, used as drinking water, can determine the health of population of the region. Assurance of the quality of drinking water is a foundation for prevention and control of vector-borne and pollutant-induced diseases. In recent years, the increasing threat to groundwater quality due to human activities has become a matter of great concern.[4]

According to the WHO *Guidelines for drinking-water quality*, "access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection".[5] Indeed, 'clean water and sanitation' is one of the seventeen 'sustainable development goals' adopted by the United Nations. As per the *Global Sustainable Development Report 2023*, 'universal safe drinking water' is still moderate distance away from the target.[6] It is pertinent to mention here that periodical monitoring of the drinking water sources i.e. "drinking water supply surveillance" is of utmost importance to detect and inform the population against unsafe parameters of water. Importance of 'surveillance and quality control' has been stressed in the Guidelines.[5]

The WHO *Guidelines* has described in depth the microbial and chemical hazards in drinking water. [5] Microbial hazards can be easily removed by adopting measures such as boiling or disinfection. Chemical hazards are not easily removed. However, most chemicals are of health concern only after extended exposure of years, rather than months, with the exception of nitrate. There are some naturally occurring chemicals for which no optimum concentration is established, e.g. iron, chloride, bromide, sulphate, etc. For other naturally occurring chemicals like arsenic, fluoride, chromium, etc., which have been shown to cause adverse health effects, specific optimum concentration is established. In the regional or local level, it is important to select the monitoring parameters for surveillance based on the regional or local hydrogeology and environmental impacts.

In regards to the state of West Bengal, several extensive studies have established that there is severe arsenic contamination in the Gangetic plain region[7-9], and Nadia district is the worst affected (71% population affected) out of nine districts.[10] Furthermore, ground water in all the blocks of Nadia is arsenic contaminated, with elevated levels of other ions found as well.[11] The water, soil, plant and human health impact of the contamination has also been established[12-13]. Fluoride-contaminated groundwater was first detected in West Bengal in 1997 in the district of Birbhum and according to reports of Public Health Engineering Department, West Bengal, seven districts are affected.[10] Excessive exposure to fluoride ion can give rise to a number of adverse effects including teeth decay, osteoporosis, harm to kidneys, etc.[14] The presence of nitrate ion in drinking water is of another major concern, since there is strong evidence for relationship between nitrate consumption through drinking water and adverse health outcomes (besides methemoglobinemia) like colorectal cancer, thyroid disease and neural tube defects.[15] In this scenario, regular monitoring and analysis of drinking water at the microlevel becomes of utmost importance to the health and wellbeing of people of the locality and region.

## II. LOCATION AND STUDY AREA

Water samples were collected by students of Krishnagar Government College, who were in their first year of Undergraduate study, from their households in their native villages or towns of Nadia district. Water samples used for drinking were collected from total 56 households in 2017 and 2018, from total 11 blocks of Nadia district. The distribution of samples collected are shown in Table 1 and the locations of sample collection are shown in Fig. 1. As per the map, the sampling area was spread throughout the district. Also, since the distribution of students admitted to the first year is random, the samples collected from the households is a random sample.

| Block | Police Station | No. of Samples collected | |
|---|---|---|---|
| | | 2017 | 2018 |
| Chakdah | Chakdah | 2 | -- |
| Hanskhali | Hanskhali | -- | 1 |
| Kaliganj | Kaliganj | 2 | -- |
| Karimpur I | Karimpur | 1 | -- |
| Krishnanagar I | Bhimpur | -- | 1 |
| Krishnanagar I | Kotwali | 17 | 12 |
| Krishnaganj | Krishnaganj | 1 | 1 |
| Nabadwip | Nabadwip | 1 | 2 |
| Nakashipara | Nakashipara | 3 | -- |
| Ranaghat I | Ranaghat | 1 | 2 |
| Ranaghat I | Taherpur | 2 | 3 |
| Santipur | Santipur | 1 | 2 |
| Tehatta I | Tehatta | -- | 1 |

**Table 1.** Block-wise distribution of samples collected for study.

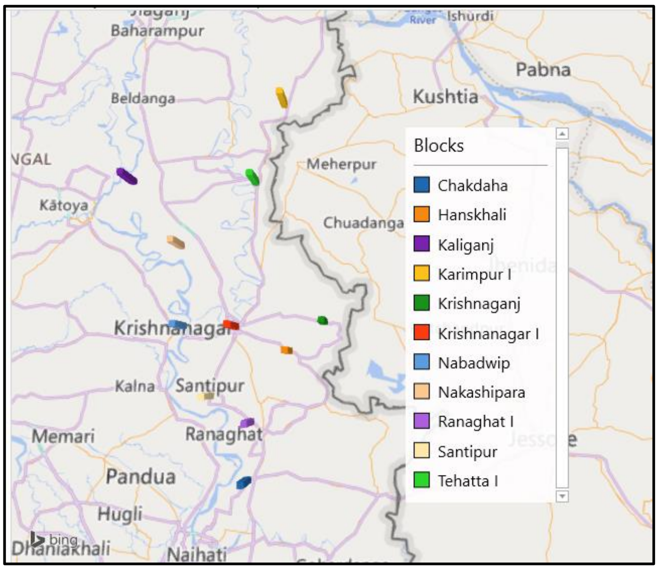


**Figure 1.** Location of sampling points of study area.

## III. OBJECTIVE OF THE STUDY

The objective of the study was to determine the status of drinking-water in households of Nadia district with respect to 11 parameters or chemical contaminants, mentioned in the WHO Guidelines, namely, Total alkalinity (TA), pH, arsenic (As), fluoride ($F^-$), chloride ($Cl^-$), residual chlorine (Res. $Cl_2$), iron (Fe), phosphate ($PO_4^{3-}$), nitrate ($NO_3^-$), nitrite ($NO_2^-$) and ammonium (NH4+) ions in 2017. In 2018, two parameters were additionally measured, namely, Total hardness (TH) and Sulphite ($SO_3^{2-}$)/residual sulphite (Res. $SO_3^{2-}$). There are safe limits of the chemicals established by the WHO *Guidelines*[16] as well as by the *Bureau of Indian Standards* (BIS)[17]. The acceptable and or tolerable limits of the ions beyond which they are a cause of concern for health, are shown in Table 2.

| Parameter | Acceptable/Tolerable Limit (mg/L or ppm) | |
|---|---|---|
| | **WHO** | **BIS** |
| Total Alkalinity (in terms of $CaCO_3$) | **300*** | **300** |
| Total Hardness (in terms of $CaCO_3$) | **121-180 (Hard); >180 (Very Hard)** | **-** |
| pH | **6.5-8.5*** | **6.5-8.5** |
| Arsenic | **0.01** | **0.05** |
| Iron | **0.3*** | **0.3** |
| Fluoride | **1.5** | **0.6-1.2** |
| Chloride | **250*** | **250** |
| Residual Chlorine (used for disinfection) | **5** | **0.2** |
| Sulphite/ Residual sulphite (in terms of $CaCO_3$) | # | **-** |
| Phosphate | **5** | **5** |
| Nitrate | **50** | **45** |
| Nitrite | **3** | **3** |
| Ammonium | # | **5** |

*EPA standard; #Not of health concern at levels found in drinking water.

**Table 2.** Water quality guidelines as per WHO and BIS.

## IV. MATERIALS AND METHODS

Water samples were collected in 250 mL narrow mouth, plastic bottles, KASABLANCA. After collection, the samples were analysed within 2-3 days. Commercially available water-testing kits, which are a low-cost, easily available, easy-to-use and rapid means to detect inorganic ions, were used to analyse the water samples. Their application, usefulness and limitations are given in the WHO *Guidelines*.[5] Water-testing kits were purchased from NICE Chemicals Pvt. Ltd., Kochi, Kerala. Seven different types of kits, either for a single ion or for more than one ion (combination kit) were used, viz., one kit for Total Alkalinity and pH, one for Total Hardness, one for Arsenic, one for Iron and Phosphate, one for Fluoride, Chloride and Residual Chlorine, one for Nitrate, Nitrite and Ammonium and one for Sulphite/residual sulphite.

*General Procedure*: Approx. 200 mL of water sample was collected, either from a tubewell, house reservoir or municipality tap, in 250 mL of a standard plastic bottle and analysed as such within 2-3 days of collection. Each sample was given a unique sample number and the source of water in each case was noted. The samples collected with their source are shown in Table 3. The samples were analysed following strictly the procedure given in each testing kit and using the reagents provided in the kit.

*Detection Method*: The chemical reaction by the reagents in a given water sample produced some observable change, either different colours (e.g. in case of pH) or different intensities of a particular colour (e.g. yellow in case of arsenic). The produced colour or intensity of colour was then matched with the range of concentration of that particular ion given in the chart in the kit. In order to determine whether a water sample contains harmful ions in the tolerable or above tolerable range, it is not necessary to know the absolute value of concentration but rather whether the concentration is above the “acceptable range” or not. This can be easily detected by the water-testing kit.

| Year : 2017 | | | | Year : 2018 | | | |
|---|---|---|---|---|---|---|---|
| **Sample No.** | **P.O.** | **P.S.** | **Source** | **Sample No.** | **P.O.** | **P.S.** | **Source** |
| **S-1** | Krishnagar | Kotwali | Tap water | **S-32** | Bhaduri | Taherpur | Tap water |
| **S-2** | Krishnagar | Kotwali | Tubewell, 72 ft | **S-33** | Hanskhali | Hanskhali | Tubewell, 80 ft |
| **S-3** | Krishnagar | Kotwali | Tap water | **S-34** | Krishnagar | Kotwali | Tubewell, 60 ft |
| **S-4** | Krishnagar | Kotwali | Tubewell, 60 ft | **S-35** | Krishnagar | Kotwali | Tubewell, 40 ft |
| **S-5** | Debagram | Kaliganj | Tubewell, 45 ft | **S-36** | Nabadwip | Nabadwip | Tubewell, 252 ft |
| **S-6** | Krishnagar | Kotwali | Tubewell, 60 ft | **S-37** | Karuigachhi | Tehatta | Tubewell, 102 ft |
| **S-7** | Bhaluka | Kotwali | Tubewell, 70 ft | **S-38** | Santipur | Santipur | Tap water |
| **S-8** | Bethuadahari | Nakashipara | Tubewell, 41 ft | **S-39** | Joania Bhaluka | Kotwali | Tubewell, 60 ft |
| **S-9** | Nabadwip | Nabadwip | Tubewell, 50 ft | **S-40** | Badkulla | Taherpur | Tubewell, 200 ft |
| **S-10** | Krishnagar | Kotwali | Tubewell, 70 ft | **S-41** | Joania Bhaluka | Kotwali | Tubewell, 60 ft |
| **S-11** | Saktinagar | Kotwali | Tap water | **S-42** | Saktinagar | Kotwali | Tubewell, 30 ft |
| **S-12** | Krishnagar | Kotwali | Tubewell, 80 ft | **S-43** | Majdia | Krishnaganj | Tubewell, 80 ft |
| **S-13** | Krishnagar | Kotwali | Tubewell, 36 ft | **S-44** | Tarapur | Ranaghat | Tubewell, 60 ft |
| **S-14** | Badkulla | Taherpur | Tubewell, 100 ft | **S-45** | Pritinagar | Ranaghat | Tubewell, 440 ft |
| **S-15** | Ranaghat | Ranaghat | Tubewell, 68 ft | **S-46** | Badkulla | Taherpur | Tubewell, 40 ft |
| **S-16** | Bethuadahari | Nakashipara | Tubewell, 64 ft | **S-47** | Bhimpur | Bhimpur | Tubewell, 440 ft |
| **S-17** | Debagram | Kaliganj | Tubewell, 60 ft | **S-48** | Nabadwip | Nabadwip | Tubewell |
| **S-18** | Ghurni | Kotwali | Tubewell, 60 ft | **S-49** | Krishnagar | Kotwali | Tubewell, 60 ft |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S-19** | Gopalpur | Karimpur | Tubewell, 50 ft | **S-50** | Krishnagar | Kotwali | Tubewell, 60 ft |
| **S-20** | Ghurni | Kotwali | Tubewell, 60 ft | **S-51** | Krishnagar | Kotwali | Tubewell, 60 ft |
| **S-21** | Bishnupur | Kotwali | Tubewell, 60 ft | **S-52** | Krishnagar | Kotwali | Tap water |
| **S-22** | Joypur | Kotwali | Tubewell, 72 ft | **S-53** | Fulia | Santipur | Tubewell, 40 ft |
| **S-23** | Bethuadahari | Nakashipara | Tubewell, 65 ft | **S-54** | Krishnagar | Kotwali | Tubewell, 380 ft |
| **S-24** | Santipur | Santipur | Tubewell, 80 ft | **S-55** | Krishnagar | Kotwali | Tubewell, 80 ft |
| **S-25** | Majdia | Krishnaganj | Tubewell, 80 ft | **S-56** | Krishnagar | Kotwali | Tubewell, 60 ft |
| **S-26** | Badkulla | Taherpur | NA | | | | |
| **S-27** | Chakdaha | Chakdaha | Tubewell, 55 ft | | | | |
| **S-28** | Krishnagar | Kotwali | Tubewell, 30 ft | | | | |
| **S-29** | Chakdaha | Chakdaha | Tubewell, 68 ft | | | | |
| **S-30** | Krishnagar | Kotwali | Tubewell, 50 ft | | | | |
| **S-31** | Krishnagar | Kotwali | Tubewell, 70 ft | | | | |

**Table 3.** Source of water samples collected with their locations and sample numbers.

## V. RESULTS AND DISCUSSION

The results of the water samples analyzed in 2017 are shown in Table 4 and that of the water samples collected in 2018 are shown in Table 5 respectively.

| Sample No. | TA | pH | As* | Fe* | $F^-$* | $Cl^-$* | Res. $Cl_2$* | $PO_4^{3-}$* | $NO_3^-$* | $NO_2^-$* | $NH_4^+$* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **S-1** | 360 | 9 - 10 | 0 | 1 | 0 | 70 | 0 | 0 - 0.5 | 0 - 5 | 0 - 0.5 | 0 - 0.5 |
| **S-2** | 455 | 7 | 0 | 3 - 5 | 0 | 90 | 0 | 0 - 0.5 | 0 - 5 | 0.5 - 1 | 0 - 0.5 |
| **S-3** | 390 | 8 - 9 | 0 - 0.05 | 1 | 0 | 70 | 0 | 0 - 0.5 | 0 - 5 | 0.5 - 1 | 0.5 - 1 |
| **S-4** | 550 | 8 | 0 | 1 | 0 | 100 | 0 | 0 | 50 | 0.5 - 1 | 0 - 0.5 |
| **S-5** | 510 | 8 | 0 - 0.05 | 1 | 0 | 90 | 0 | 0 | 0 - 5 | 0.5 | 0 - 0.5 |
| **S-6** | 410 | 6 - 7 | 0 - 0.05 | 5 | 0 | 100 | 0 | 0 | 0 - 5 | 0 - 0.5 | 3 |
| **S-7** | 230 | 8 | 0 | 0.3 | 0 | 40 | 0 | 0 | 0 - 5 | 0 - 0.5 | 0 |
| **S-8** | 340 | 8 - 9 | 0 | 0.3 | 0 | 100 | 0 | 0 | 5 | 0 - 0.5 | 0 |
| **S-9** | 255 | 8 - 9 | 0 | 0.3 | 0 | 80 | 0 | 0 | 5 | 0 - 0.5 | 0 |
| **S-10** | 465 | 8 | 0 | 0.3 - 1 | 0 | 150 | 0 | 0 - 0.5 | 0 - 5 | 0 | 0 - 0.5 |
| **S-11** | 350 | 8 - 9 | 0 - 0.05 | 1 | 0-1 | 60 | 0 | 0 | 0 - 5 | 0 - 0.5 | 0 |
| **S-12** | 315 | 8 - 9 | 0 - 0.05 | 1 | 0 | 60 | 0 | 0 | 5 | 0 - 0.5 | 0 |
| **S-13** | 465 | 8 - 9 | 0 | 0 - 0.3 | 0 | 120 | 0 | 0 | 5 | 0.5 - 1 | 0 - 0.5 |
| **S-14** | 265 | 8 | 0 | 0 - 0.3 | 0 | 50 | 0 | 0 | 0 | 0 | 0 |
| **S-15** | 470 | 7 | 0 - 0.05 | 3 - 5 | 0 | 130 | 0 | 0 | 0 | 0 | 0.5 |
| **S-16** | 480 | 7 | 0 | 5 | 0 | 130 | 0 | 0 | 0 - 5 | 0.5 | 0 - 0.5 |
| **S-17** | 455 | 7 - 8 | 0 - 0.05 | 0.3 | 0 | 80 | 0 | 0 | 0 | 0 - 0.5 | 0.5 |
| **S-18** | 325 | 7 - 8 | 0 | 0 - 0.3 | 0 | 80 | 0 | 0 | 10 - 20 | 0.5 | 0.5 |
| **S-19** | 365 | 8 | 0.05 | 0 - 0.3 | 0 | 70 | 0 | 0 | 0 | 0.5 | 0 |
| **S-20** | 375 | 8 - 9 | 0 | 0 - 0.3 | 0 | 130 | 0 | 0 | 10 - 20 | 0.5 - 1 | 3 |
| **S-21** | 435 | 7 - 8 | 0 | 0 - 0.3 | 0 | 120 | 0 | 0 | 5 | 0 | 0 - 0.5 |
| **S-22** | 340 | 7 - 8 | 0 | 0 - 0.3 | 0 | 50 | 0 | 0 | 0 | 0 | 0 - 0.5 |
| **S-23** | 405 | 7 | 0 | 1 | 0 | 100 | 0 | 0 | 0 | 0 - 0.5 | 0 |
| **S-24** | 395 | 8 | 0 | 0.3 | 0 | 120 | 0 | 0 | 5 | 0 | 0 |
| **S-25** | 325 | 7 | 0 | 5 | 0 | 50 | 0 | 0 | 0 | 0 - 0.5 | 0 - 0.5 |
| **S-26** | 450 | 9 | 0 | 5 | 1 | 80 | 0 | 0 | 0 | 0 | 0.5 |
| **S-27** | 350 | 7 - 8 | 0 - 0.05 | 1 | 0 | 50 | 0 | 0 | 0 - 5 | 0 | 0 - 0.5 |
| **S-28** | 275 | 8 | 0 | 0.3 | 0 | 50 | 0 | 0 | 0 | 0 - 0.5 | 0 - 0.5 |
| **S-29** | 420 | 7 | 0.05 | 3 - 5 | 0 | 90 | 0 | 0 | 0 | 0 | 0 - 0.5 |
| **S-30** | 445 | 7 - 8 | 0 | 0 | 0 | 60 | 0 | 0-0.5 | 5 | 0 | 0 |
| **S-31** | 400 | 8 | 0 | 0.3 - 1 | 0 | 120 | 0 | 0-0.5 | 5 | 0 | 0 |

*Ion concentrations are in mg/L or ppm. Red colour indicates concentration range above acceptable limit.

**Table 4.** Results of water sample analysis in 2017.

| Sample No. | TA | TH | pH | As | Fe | $F^-$ | $Cl^-$ | Res. $Cl_2$ | $SO_3^{2-}$/ Res. | $PO_4^{3-}$ | $NO_3^-$ | $NO_2^-$ | $NH_4^+$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | $SO_3^{2-}$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S-32** | 375 | 235 | 7 - 8 | 0 - 0.05 | 1 | 0 | 30 | 0.5 | 10 | 0 - 0.5 | 0 - 5 | 0 | 0 - 0.5 |
| **S-33** | 390 | 245 | 8 | 0 | 3 - 5 | 0 - 1 | 30 | 0.5 | 8 | 0 - 0.5 | 0 | 0 | 0.5 |
| **S-34** | 390 | 210 | 8 | 0 | 1 | 0 - 1 | 110 | 0 | 8 | 0 - 0.5 | 0 - 5 | 0.5 | 0 |
| **S-35** | 385 | 215 | 7 | 0.05 - 1 | 5 | 0 - 1 | 70 | 0 | 8 | 0 | 0 | 0 | 3 |
| **S-36** | 395 | 240 | 8 | 0 | 1 - 3 | 0 | 30 | 0 | 6 | 0 | 0 - 5 | 0 - 0.5 | 0 - 0.5 |
| **S-37** | 390 | 295 | 7 | 0 | 0 | 0 | 40 | 0 | 8 | 0 | 0 | 0 | 0 |
| **S-38** | 305 | 125 | 8 | 0 - 0.05 | 0 - 0.3 | 0 - 1 | 30 | 0 | 10 | 0 | 0 - 5 | 0 | 0 |
| **S-39** | 400 | 390 | 8 | 0 | 0 | 0 | 40 | 0 | 16 | 0 - 0.5 | 5 | 0 | 0 |
| **S-40** | 405 | 370 | 7 - 8 | 0 | 0 | 0 | 170 | 0 | 10 | 0 | 50 | 0 - 0.5 | 0 |
| **S-41** | 400 | 390 | 8 | 0 | 0 | 0 | 40 | 0 | 16 | 0 - 0.5 | 5 | 0 | 0 |
| **S-42** | 360 | 380 | 8 | 0 | 3 | 0 - 1 | 40 | 0 | 10 | 0 - 0.5 | 0 | 0 - 0.5 | 0 |
| **S-43** | 585 | 380 | 9 | 0 | 5 | 0 - 1 | 70 | 0 | 8 | 0 - 0.5 | 0 | 0.5 | 0 - 0.5 |
| **S-44** | 425 | 350 | 8 | 0 | 0.3 | 0 | 150 | 0 | 8 | 0 - 0.5 | 30 - 50 | 0 - 0.5 | 0 |
| **S-45** | 340 | 300 | 9 | 0 | 3 | 0 | 30 | 0 | 10 | 0 | 0 | 0 | 0.5 |
| **S-46** | 460 | 375 | 7 - 8 | 0 | 1 | 0 | 130 | 0 | 6 | 0 | 50 | 0 - 0.5 | 0 |
| **S-47** | 225 | 205 | 8 | 0 | 3 | 0 - 1 | 30 | 0 | 6 | 0 | 0 | 0 | 0 - 0.5 |
| **S-48** | 380 | 300 | 7 - 8 | 0 | 0.3 | 0 | 20 | 0 | 8 | 0 - 0.5 | 0 | 0 | 0 - 0.5 |
| **S-49** | 360 | 375 | 8 - 9 | 0 | 0 | 0 - 1 | 30 | 0 | 14 | 0.5 | 5 - 10 | 0 | 0.5 |
| **S-50** | 325 | 265 | 7 - 8 | 0 - 0.05 | 5 | 0 - 1 | 40 | 0 | 8 | 0 | 0 | 0 | 0 - 0.5 |
| **S-51** | 365 | 260 | 7 - 8 | 0 | 3 | 0 - 1 | 40 | 0 | 8 | 0 - 0.5 | 0 - 5 | 0 | 1 - 3 |
| **S-52** | 375 | 310 | 8 | 0.05 | 3 | 0 | 50 | 0 | 6 | 0 | 0 - 5 | 0 - 0.5 | 0 |
| **S-53** | 330 | 275 | 8 | 0 | 0 | 0 | 60 | 0 | 8 | 0 - 0.5 | 30 - 50 | 0 | 0 |
| **S-54** | 420 | 250 | 9 | 0.05 | 0.3 | 0 | 10 | 0 | 4 | 0 | 0 | 0 | 0 - 0.5 |
| **S-55** | 570 | 600 | 8 - 9 | 0 | 5 | 1 | 20 | 0 | 6 | 0.5 | 0 | 0 | 1 |
| **S-56** | 355 | 265 | 8 | 0 | 1 | 0 | 40 | 0 | 6 | 0 | 0 | 0 | 0 |

*Ion concentrations are in mg/L or ppm. Red colour indicates concentration range above acceptable limit.

**Table 5.** Results of water sample analysis in 2018.

From the Table 4, it can be seen that in 2017, 87% of samples tested (Nos. **S-1-6, 8, 10-13, 15-27, 29-31**) had high Total alkalinity, 32% of samples (Nos. **S-3, 5-6, 11-12, 15, 17, 19, 27, 29**) had arsenic in the range above acceptable limit, 55% samples (Nos. **S-1-6, 10-12, 15-16, 23, 25-27, 29, 31**) had high iron content, 6.5% samples (Nos. **S-26**) had fluoride ion in the borderline concentration (1 mg/L) and nearly 10% of samples (Nos. **S-4, 18, 20**) had nitrate ion concentration equal to or above 10 mg/L. Sample **S-4** had nitrate ion concentration beyond acceptable limit (50 mg/L).

From Table 5, it can be seen that in 2018, 97% of samples tested (Nos. **S-32-46, 48-56**) had high Total alkalinity, 19% of samples (Nos. **S-32, 35, 38, 50, 52, 54**) had arsenic in the range above acceptable limit, 60% (Nos. **S-32-36, 38, 42-43, 45-47, 50-52, 55-56**) of the samples had high iron content, 4% of the samples (Nos. **S-55**) had fluoride ion in the borderline concentration (1 mg/L) and nearly 16% of samples (**Nos. S-40, 44, 46, 53**) had nitrate ion concentration equal to or above 10 mg/L. **S-40**, **44** and **53** had nitrate concentration beyond acceptable limit. The results are summarised in Fig. 2.

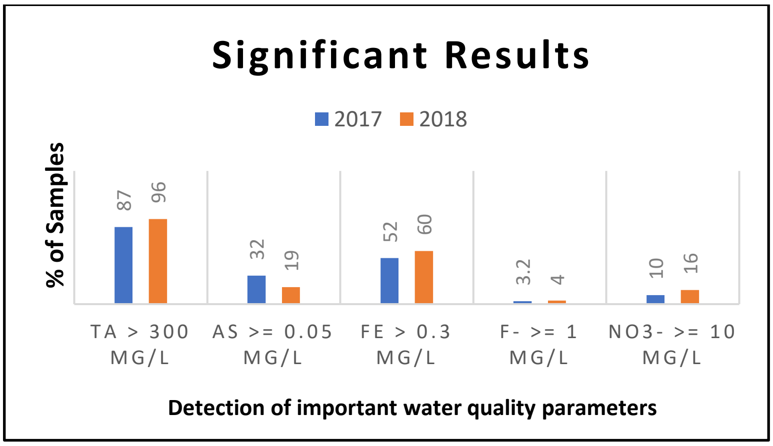


**Figure 2.** Summary of detection of some important water quality parameters.

In order to assess the trends of chemical pollutants, the contaminants arsenic, fluoride and nitrate were taken be indicators of pollution since these have maximum impact on the health of the population. Percentage of samples which were found to be positive in the "unsafe" range in 2017-18 were compared with the data for 2015-16 for a particular block. The data from a selected block, viz. Kotwali for 2015-16 were available from a previous study of the present author[18]. The detection trends for these ions are shown in Fig. 3, Fig. 4 and Fig. 5, respectively.

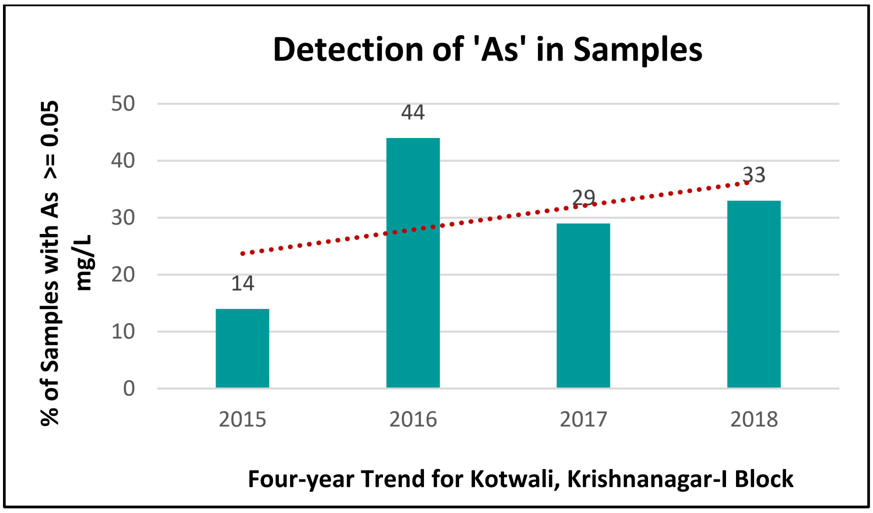


**Figure 3.** Trends of detection of 'As' in samples in Kotwali P.S.

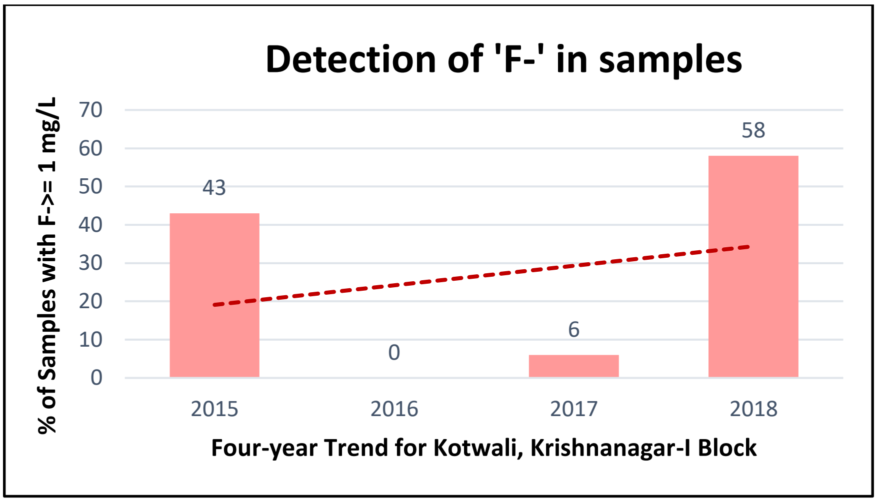


**Figure 4.** Trends of detection of '$F^-$' in samples in Kotwali P.S.

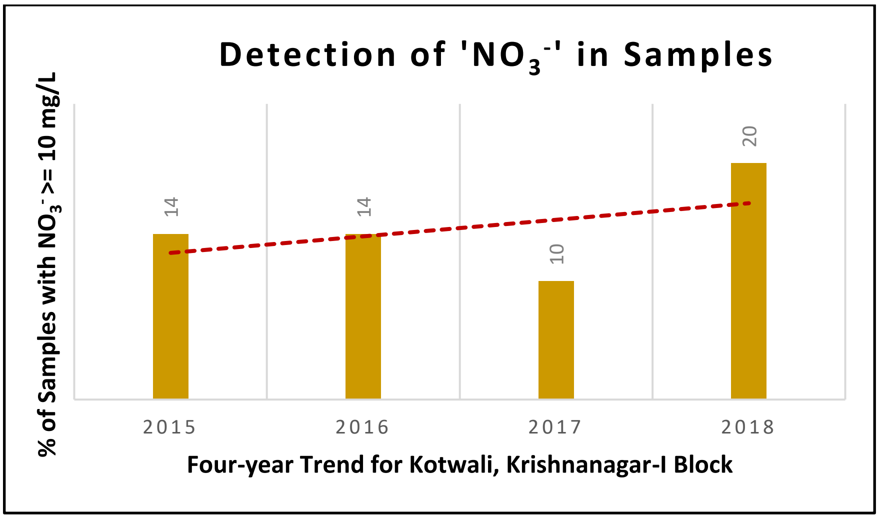


**Figure 5.** Trends of detection of '$NO_3^-$' in samples in Kotwali P.S.

From Figs. 3, 4 and 5, it can be seen that, there is upward trend for detection of arsenic, fluoride and nitrate for Kotwali, Krishnanagar-I block.

## VI. CONCLUSION

In the present study, 56 water samples were collected from 56 different households in Nadia district, West Bengal for two years in two separate batches. The samples were collected randomly each year from the households of the students of the study area. The samples were analyzed each year by water testing kits for 11 selected parameters of chemical contaminants in 2017 and for 13 parameters in 2018. The full results of the analysis have been presented which served to prepare a surveillance report of the drinking-water of the study area. Further, to assess the trends of arsenic, fluoride and nitrate contamination, percentage of samples near or above acceptable range of concentration for the respective ions were compared year-to-year for a particular police station. From the data of Kotwali, Krishnanagar-I block, it was seen that there was upward trend for presence of all three ions in water samples. This surveillance report and trend analysis is therefore significant since it points to increasing concentration of the ions in groundwater. This further highlights the need for routine analysis of groundwater since the concentrations of harmful ions may change from ‘safe’ to ‘above acceptable’ limits over time in a particular locality.

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