HYDROGEOLOGY OF MURSHIDABD DISTRCIT

WEST BENGAL, INDIA

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Submitted by

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Introduction:

Today the global population can broadly be divided into two categories in terms of their ease of access to safe and sustainable water supply. 1) people suffering for water and 2) people suffering from water. The teeming millions of Murshidabad district fall under the second category. Being located amidst bounties of the Gangetic alluvial plain they have never faced any dearth of water resources, especially groundwater, to sustain their lively hood, but the quality problem associated with such precious common pool resources have rendered it venomous. The present article is meant to portray some glimpses of the hydrogeological situations of Murshidabad district of West Bengal with due emphasis on the problem of Arsenic contamination in the area.

The Murshidabad district of West Bengal, India, is bounded by latitude24°50’20”N to 23°43’30”N and longitude 88°46’00”E to 87°49’17”E and cover 5324 Sq.km area on the southern bank of river Bhagirathi in southern West Bengal (District Census Handbook 2011) It occupies the central plain of West Bengal and is surrounded by Malda district in the north and Burdwan district in the south, Nadia district in the south east and Birbhum district in the west. The state boundary between West Bengal and Jharkhand lies to the north-west whereas in the north east and east it shares international boundary between India and Bangladesh (Figure 1).

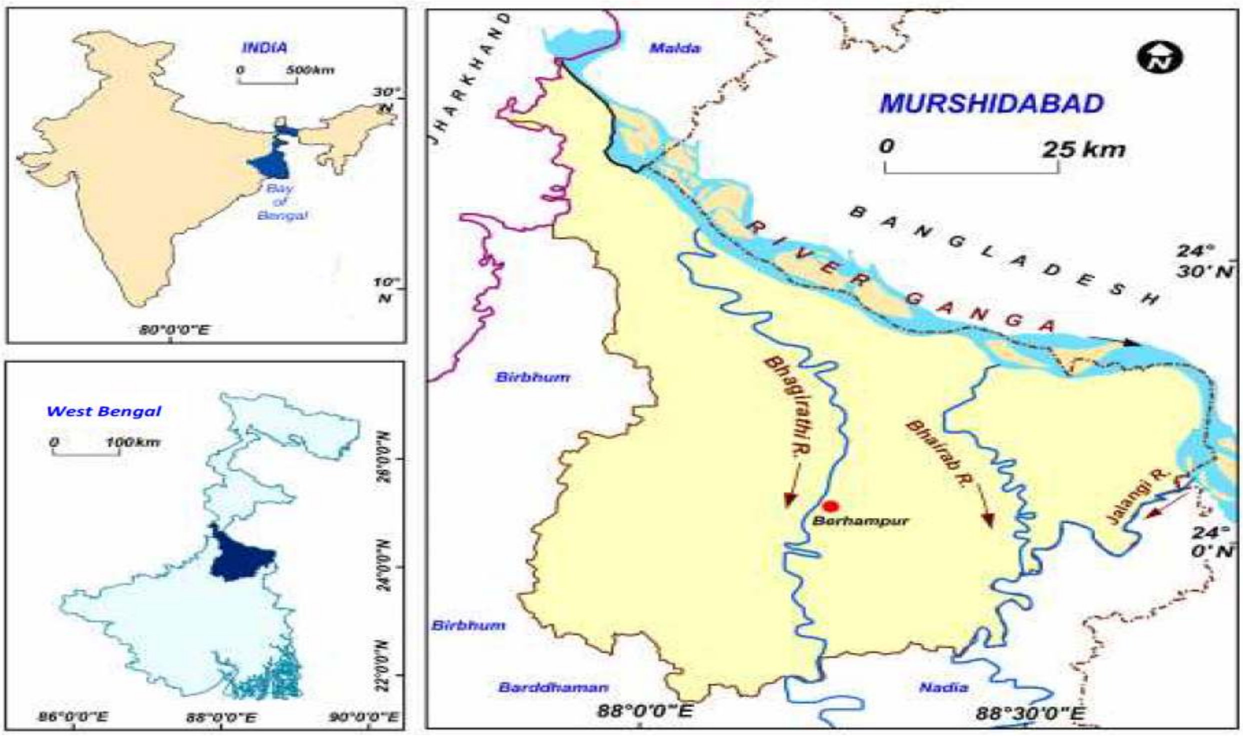


Figure1; Location map of Murshidabad district of West Bengal.

*The river Bhagirathi bi-furcated the triangle shaped district into two broad geographical regions of almost equal area having striking difference in their Geology and soil types. The **Rarh** found in the western side of the Bhagirathi River, is a continuation of the sub-Vindhyan region of lateritic clay and calcareous nodules. This part is covered by the older alluvium (Barind surface?) of Pleistocene age, deposited by the Ajoy-Damodar-Mayurakshi river system in the west of Bhagirathi River. These older alluvium is characterized by the argillaceous sediments (clay and calcareous material).The clays are very stiff and plastic in nature. This region is* *characterized by brown sediment aquifers (Datta et. al 2014). The **Bagri** found in the eastern side of Bhagirathi River, is characterized by light alluvial fertile soil comprising of huge thickness of recent to sub-recent sediments of Ganga River system. These Quaternary sediments of the Ganga river system have been deposited in and around wide deltaic flood plain. The recent fluviatile sediments consist of succession of clay, silt, sand and gravel and are characterized by grey sediment aquifers containing high Arsenic, total Iron and low Manganese (Datta et. al 2014).*

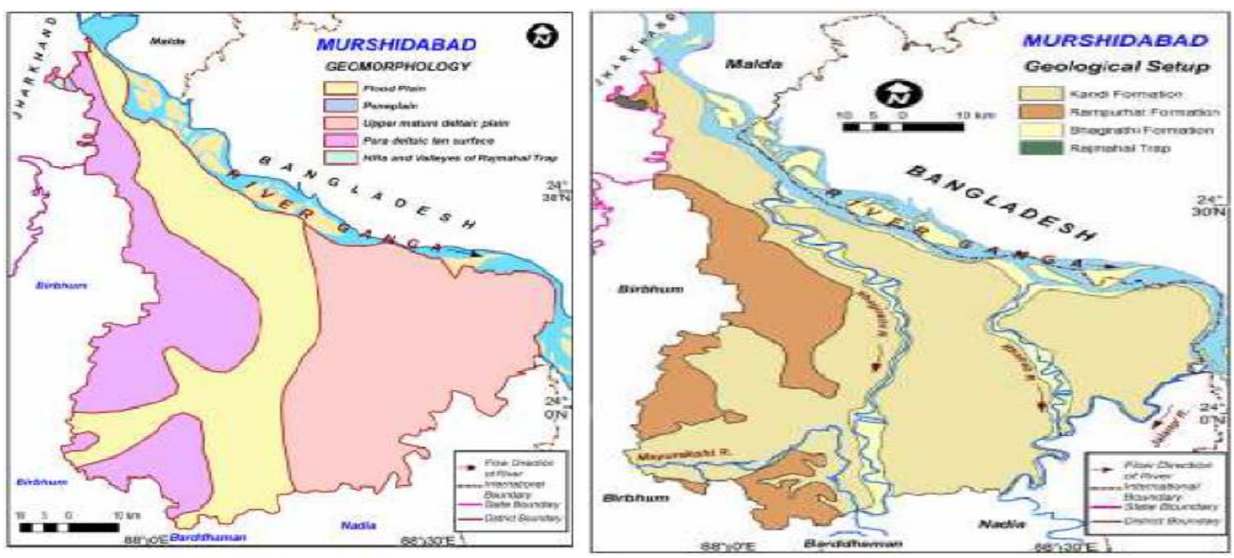
The Murshidabad district experiences a tropical wet-and-dry climate; with temperatures are varying between 300C to 400 C. During May-June the temperature often exceeds 40^0C. Here the mean annual temperature is 27^0C and it receives annual rainfall of about 1600 mm (CGWB 2015).

Geomorphic & Geologic set up;

Bhattacharya and Banerjee 1979 and Misra and Ghosh 2008; classified the triangle shaped Ajay-Bhagirathi valley into four geomorphic plains. All these geomorphic units is correlatable with the major Geologic horizons of the region.The correlation, as such can be ascribed as follows in the table below:

Geomorphic Plain	***Geologic soil-stratigraphic formation***
Bhagitahi recent surface	*Bagri region of Murshidabad district.*
Younger Deltaic Plain or Kandi Plain	*Late Pleistocene or Rarh region of Murshidabad district near Bhagirathi River.*
Older Deltaic Plain or Rampurhat plain	*Upper Pleistocene or western parts of Rarh region of Murshidabad and parts of Birbhum district.*
Lateritic upland or Ilambazar plain	*Lower to middle Pleistocene i.e., Birbhum district, Extreme western part of Farakka,Samserganj and Suti-II blocks of Murshidabad district.*

Source: Bhattacharya and Banerjee 1979 & Misra and Ghosh 2008.



(a) (b)

Figure 2: (a) Geomorphic setting (b) Geologic setting of Murshidabad District. (Source: District Resource map, Murshidabad, West Bengal 2008).

The whole district is covered by unconsolidated sediments of the Late Pleistocene to Holocene times. The Quaternaries mainly belong to Rampurhat, Kandi and Bhagirathi *formations whereas the older formations belong to the Rajmahal trap. The Rarh region is dominated by Rampurhat formation with sandy and silty clays making the predominant lithology. The Rarh region, mostly of higher elevation is occupied by the older Alluvium of Pleistocene age (upper Tertiary) age deposited by the Ajoy-Damodar-Mayurakshi river system. These are characterised by preponderance of clay and calcareous material. At the surface laterisation of clay is also seen at places. The clays are very stiff and plastic forming hard soil. On the other hand the eastern section or the Bagri region is covered by recent to sub-recent fluviatile sediments deposited by the Ganga river system. The sediment consists of clay, silt, sand and gravel. Sand size varies from fine to very coarse, light grey to white in colour and micaceous. The gravels are associated with sand and sub-rounded in shape (Misra and Ghosh 2008).*

In Gazetteer of India (1979),West Bengal, District Census handbook, Murshidabad, A. Mitra, classified the geological formations of the district in three parts; viz.,

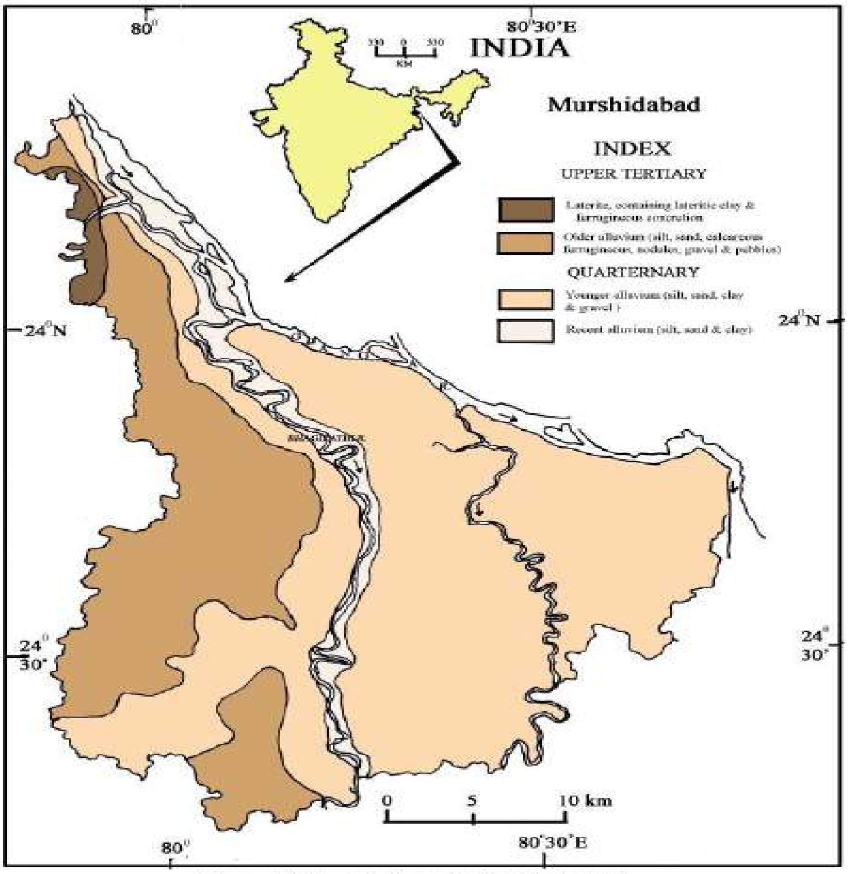
1) ***Recent alluvium.***
2) ***Pleistocene-recent older alluvium and lateritic clay.***
3) ***Jurassic Rajmahal Trap.***

The entire Bagri region is covered by the thick pile of recent alluvium wherein the soils are composed of sands and the clays brought down by Ganges river system. The area is extremely fertile and produces all kinds of crops. These recent fluviatile sediments consist of succession of silt and gravel. The sand size varies from fine to coarse. The sand is light grey in colour and highly micaceous. The gravels are rounded to sub-rounded in shape (Groundwater information booklet, CGWB, 2015).

A major part of the Rarh region is occupied by the Pleistocene-recent older alluvium and lateritic clay. These are characterised by argillaceous sediments. Laterisation is observed of such sediments are also observed at the surface clay. The clays are very stiff and plastic in nature. It may be the continuation of the continuation of the sub-Vindhyan lateritic clay and nodular limestone. Scattered occurrences of Kankar beds are also found at different parts of this Rarh region. The Quaternaries of the district, deposited in and around wide deltaic flood plain, and are co-relatable with the geomorphic entities of the district, as suggested by Bhattacharya and Banerjee (1979); such correlation can be ascribed as follows;

Chronostratigraphic unit	**Geomorphic unit**	**Lithology**
Recent -Pleistocene	*Younger Deltaic Plain (YDP)*	*Alluvial sediments with soils containing soft ferrugineous nodules, occurring on recent river terrace surfaces.*
	Older Deltaic Plain (ODP)	*Alluvial sediments with soils containing Calcareous nodules.*
	Lateritic Formation	*Hard lateritic and mottled clay underlain by alluvial sediments.*

The stratigraphy of the area stars with the deposition of the pre-Jurassic Gondwana deposits, which are overlain by the late Jurassic to Early Cretaceous amygdaloidal basalts and andesites and the ~250m thick Late Cretaceous alternating sandstones and mudstone sequence of the Rajmahal group (Biswas ,1963; Lindsay et al.,1991) The Rajmahal group is followed upward by a thick ,uninterrupted aranaceous-argillaceous sedimentary sequence from the early Palaeocene to the end of the Pliocene period, comprising the Jaintia Group (Palaeocene-Eocene) and the Bhagirathi Group (Late Eocene to late Pliocene). The sediments of the Bhagirathi Group are overlain by the Pliocene-Pleistocene Barind formation. This Holocene sediment of Bengal alluvium forms the surficial lithostratigraphic and geomorphic unit throughout the Bengal basin. The fluvial processes have formed extensive Holocene flood plains with a dominance of coarser grained sediments overlapping a number of sub-deltas (Morgan and Mc Intire, 1959). Within the area, instantly under consideration, avulsion from major streams have resulted in a thick layer (Allison et al., 2003) of recent overbank silt and clay incised by channel sands (Coleman,1969;Umitsu,1987; Goodbred and Kuhel,2000). River Bhagirathi's recent surfaces or terraces have sediments confined to the present channels and comprises of a narrow belt of terraces about 3-5 km in width, slope 0.2 per km (Bhattacharya and Banerjee 1979). Such terraces can be mapped either as lowest level along the river bed, excessively flattened due to erosion or as little elevated ones. Such surfaces are composed of loose and unconsolidated sediments and do not show any sign of pedogenesis (Refer Photo;). Large meanders, scars,cut off backwaters,ox box lakes,abandoned channels and natural levees are some the common sedimentary structures of the area.



(Source: State water investigation directorate)

Figure 3: Geologic set up of Murshidabad District.

Hydrological set up:

The main drainage (Figure 4) of the district is controlled by the Ganga-Padma river system. Tributaries and distributaries of these two rivers, viz: the Jalangi, the Bhairav, the Dwarka& the Mayurakshi act as the main drainage channels. The Bhagirathi emanates from Ganga near Jangipur and leaves the district in the south. The Padma acts as the north eastern boundary of the district and part of India-Bangladesh International boundary. Jalangi and Bhairav are two channels within the interfluve region of Padma and Bhagirathi. Dwarka, Mayurakshi, Behula and Babla are the rivers from the western parts of the District. These rivers originate from the north-western uplands of Rajmahal and fall into the Bhagirathi or the Ganga. The Farakka feeder canal diverts some water from Ganga and drains it into the Bhagirathi. Practically a great amount of water during lean season only comes through feeder canal. The drainage has reached the base level of erosion with the result that the rivers have lost much of their activity and thus have become sluggish, resulting into shifting of course and deposition of sediments in the plain (SWID, 1998).

Figure 4: Drainage of Murshidabad District.

There are several other smaller rivers which drain the district. Bansloi, a tributary of Bhagirathi which enters from Birbhum district and after flowing in the eastward direction it meets river Bhagirathi. To the south of Bansloi there is another tributary of Bhagirathi i.e., Pagla, which flows in the same direction and meets the river. Apart from these there are small ponds as well locally *known as Bills, which are found mostly in the eastern part of the district. These bills are mostly used for aquaculture and irrigation. Some important bills are Hijal, Telkar, Basiar, Motijheel, Laldighi, Gobranala, Patan, Baloler, Mundmala, Damos, and Ahiron etc.*

Ground water in the area occurs in a thick zone of saturation in the alluvium deposited by the river system. The aquifers made up of different grades of sand and gravel, extends down to a depth of 90-350m bgl in the east and 140 to 150m bgl in the west of Bhagirathi river, respectively. Groundwater generally occurs under water table condition in the east. However, in the western part, thick clay bed, particularly in blocks of Kandi, Khargram, Nabagram, Sagardighi, Raghunathganj-I and Samserganj blocks. The hydrostratigraphy of the Bhagirathi sub-basin comprises clay/sandy clay of 20-30 m thickness followed by a shallow aquifer within 60 m depth containing sands of various grades. Below the sand impersistent clay lenses occur which is followed by sand and then by a thick clay. The shallow aquifer at places contains high Arsenic groundwater.

The average pre-monsoon depth to water level during 2011 was 1.3 to 15.2m bgl in dug wells and 4.5 to 23.1m bgl in piezometers whereas the average post-monsoon depth to water level during 2011 was 1.195 to 17.26m bgl in dug wells and 1.93 to 17.21m bgl in piezometers. The long term water level trend in 10 years (2002-2012) in m/yr has been declining to the tune of 0.007 to 0.761m/yr and rising trend to the tune of 0.006 to 2.192.

River Bhagirathi acts as a natural groundwater divide here. The area east of it is characterized by shallow water table conditions that generally lie in between 4-7m bgl in the peak summer. Impervious clay layers which act as confining beds are rather absent, but wherever present it is sandy clay or silty clay forming partially/ semi-confining/confining conditions. This is a mono-aquifer area having tremendous groundwater potentialities, and is highly suitable for sinking of both LDTW and HDTW.

*Groundwater in the western part of Bhagirathi River occurs under both unconfined and confined conditions. In the confined condition, the aquifers are sometimes separated by lenticular clay beds at depths and are regionally connected resulting in artesian conditions. Here groundwater extraction is done by judicious construction of MDTW and LDTW fitted with submersible pump by tapping both confined and unconfined aquifers and are capable to yield 150m3/hr with a drawdown ranging between 4-5m.Transmissivity ranges from3000-7000m2/day and the storativity ranges from 1.16*10-4to 4.98*10-4.*

The overall stage of groundwater development in the district is around 79%.However the groundwater development status is not uniform throughout the district. It is extensive in the Bagri region. Whereas the stage of groundwater development is comparatively lower in the blocks lying on the Rarh region. As per the guideline of GEC 1997, 10 numbers of blocks of the district are categorized under safe and 17 blocks are under semi-critical stage.

The chemical quality of the groundwater is generally Ca-Mg-HCO3 facies type. The chloride content in groundwater is generally low. The water is mainly neutral to mildly alkaline in nature wherein the pH value ranges between 6.5-7.7.The overall chemical quality of groundwater in both shallow and deeper aquifers is good, but prolific occurrences of Arsenic contamination in groundwater have been encountered in 22 blocks thereby making it one of the most thickly affected districts in West Bengal (PHED, 2010) . Average As concentration in ground water varies from 0.001-1.85mg/l and a population of approximately 40084840(CGWB 2013) numbers is residing in risk zone infested by Arsenic contaminated ground water. The contaminated aquifers occur at depths of 35-40m (Datta et al., 2014). Surface waters from Murshidabad are highly contaminated by anthropogenic pollutants, including enteric bacteria, due to overuse and additions of waste streams to the streams/channels (Mc Arthur et al. 2012a, b).

Status of Geogenic Contamination in the district;

Twenty-three incidents of groundwater arsenic contamination have been reported so far in different parts of the world. The largest population at risk is in Bangladesh (Van Geen et al.2000) followed by the state of West Bengal in India (Guha Mazumdar et al. 1992).Total area of West Bengal is about 89,193 km2 and the population is about 80 million. Arsenic Concentration above the permissible limit prescribed limit by BIS(0.05mg/l) is noted in 9 districts of West Bengal viz. Malda,Murshidabad,Nadia,North-24 Parganas,S-24 Parganas ,Barddhaman, Howrah, Hooghly & Kolkata (PHED, GoWB). The areas affected from arsenic toxicity cover about 38,865 km^2 and the population is about 50 million (Rahaman et al., 2005). SWID & PHED conducts groundwater quality monitoring in all such districts (Pre & Post monsoon) on a regular basis. A summary of such results are furnished below in the appended tables:

Table: 1 Arsenic affected districts of West Bengal (PHED):

Concentration of Arsenic	**Affected Districts**
Above 0.05 mg/l	Most parts of Murshidabad, Nadia, Malda, N-24 Parganas,S-24 Parganas, Kolkata and parts of Howrah.
0.05 mg/l to 0.03 mg/l	Howrah, Kolkata, parts of Hooghly, Darjeeling, Cooch-Behar, Uttar Dinajpur, Dakshin Dinajpur.
Below 0.03 mg/l	Birbhum, Purulia, Purbamedinipur, Paschim Medinipur, Bankura and parts of Barddhaman.

Almost similar observation had been found by Rahaman et al. Wherein on the basis of 16 years of water analysis data from nine arsenic affected districts of West Bengal they have found that more than 8 million people are drinking arsenic contaminated water of concentration above 10 µg/l and more than 6 million above 50 µg/l and about 0.5 million people are suffering from arsenical skin lesions in the affected districts. On the basis of such studies the districts of 24 Pgs (north), Nadia, Murshidabad and Malda may be considered as highly contaminated,24 Pgs(s) as moderately affected and the districts Barddhaman, Howrah, Hooghly & Kolkata as less affected.

Table: 2 Summary of water quality status of the spot sources in the Arsenic affected districts of West Bengal (PHED)

		Percentage of Tubewells Having Arsenic Content (in mg/l)						Max Arsenic (ppm)	Total TW
		<=0.01		>0.01 <=0.05		>0.05			
		%	Count	%	Count	%	Count		
DISTRICT	MALDAH	44.74	8,625	26.51	5,111	28.72	5,537	1.04	19,279
DISTRICT	MURSHIDABAD	31.17	12,654	38.12	15,476	30.66	12,446	3.00	40,593
DISTRICT	BARDHAMAN	84.75	5,524	8.75	570	6.46	421	0.84	6,518
DISTRICT	NADIA	32.92	9,757	41.20	12,213	25.85	7,662	1.16	29,640
DISTRICT	NORTH 24 PARAGANAS	42.95	11,162	31.10	8,083	25.92	6,736	3.77	25,987
DISTRICT	HOOGHLY	63.54	1,326	24.25	506	12.22	255	0.51	2,087
DISTRICT	HOWRAH	99.32	873	0.34	3	0.34	3	0.16	879
DISTRICT	SOUTH 24 PARAGANAS	80.79	5,885	12.56	915	6.60	481	2.72	7,284
	STATE TOTAL	42.19	55,806	32.42	42,877	25.36	33,541		132,267

So it is evident that the Murshidabad district depicts the ***maximum average concentration of arsenic amidst its intrinsic complex geologic and hydro geologic set-up****. Hydrological, analytical, clinical and epidemiological researches have conducted on Arsenic related issues found that KING OF POISION finds its gateway to human system either through drinking water or through food chain.*

During the post independence era the district along with many other parts of the world have witness the proliferation in tube well construction, which abstract sub-soil waters from alluvial aquifers, through various government and non-government aided agencies with a view to supply pathogen-free drinking water to the lion's share of the population. This effort not only secured everyone's rights for access to safe drinking water but also had reduced the incidences of waterborne diseases. However at the same time water from many of these tube wells found to get contaminated with naturally occurring Arsenic, (Saha and Chakraborty, 1995, Dhar Et al., 1997, Nickson et al., 2000) According to Nickson et al., 2000, Arsenic present within the pedo-sphere enters in to the drinking water from soil through reductive dissolution of Iron Oxy-hydroxide and release of its sorbed Arsenic. Sankar et al. (2014) established that the regions of Murshidabad to the west of river Bhagirathi are occupied by Suja Formation and in this region ground waters are low in Arsenic but high in Manganese concentrations. Whreas the east of Bhagirathi River is represents a series of paleo-oxbow lakes, wherein the sediments belong to the active flood plain-deltaic deposits, the villages are mainly built on top of natural or artificial levees to protect them from monsoonal flooding and here the ground waters are high in Arsenic but low in Manganese. the contaminated aquifers of Murshidabad district exist mostly at depths between 35-40 meters and are composed of fine to medium grained sand with substantial amount of clays and sedimentary organic matter (~10-20% organic matter by weight) (Datta et.al. 2011: Moharejeinet.al. 2014).Kulkarni et al.,2017, on the basis of their study at 4 sites of Murshidabad district opined that higher concentrations of Arsenic have been observed in groundwaters from reduced

Holocene(grey) aquifers , found on Rarh region of Murshidabad district; when compared to oxidized Pleistocene(orange) aquifers found the Bagri region of the Murshidabad district. According to them sediment derived Dissolved Organic Matter (DOM) play significant role in enhancing the mobility of Arsenic through reductive dissolution. Their study indicated that DOM IN THE GROUNDWATER FROM THE Holocene aquifers had higher humification index and low freshness index values, whereas groundwater in the Pleistocene aquifer comprised more labile and microbial DOM sources.

Roychowdhury et al., 2002, investigated total Arsenic in food composites collected from Domkol and Jalangi blocks of Murshidabad district, where groundwater forms the major source of irrigation and have found that Arsenic content is generally high in the skin of most vegetables and the same is also observed in cooked food stuff compared to their raw variety. In another study Roychowdhury et al., 2008 evaluated that the impact of sedimentary Arsenic through irrigated groundwater on soil, plants, crops on human well being of Murshidabad district of West Bengal and have found that food chain provides a significant pathway to get into the human system. Brief of such findings are tabulated below. Bhattacharya et al., 2011 concluded that the high Arsenic content in food grains is mainly due to extensive uses of Arsenic contaminated groundwater for irrigation.

Table 3: Mean Arsenic content in various food materials of the district (Source: Roychowdhury et al., 2002, Bhattacharya et al., 2010a, Rajmohan, N.; Prathapar ,S.A.2014)

Category	Domkol Block(Murshidabad)		Jalangi Block(Murshidabad	
	n	As(µg/Kg)	n	As(µg/Kg)
Beans	4	17	2	66
Brinjal	3	131	-	-
Garlic(Flesh)	3	0.8	3	0.04
Garlic(Chilli)	20	7.76	6	6.92
Leafy Vegetables	9	58.9	9	38.6
Lentil	3	41.1	5	4.39
Onion(Flesh)	6	60	6	60
Potato(Flesh)	5	2.32	5	2.32
Pulses	3	152	2	3.56
Rice	23	233	11	232
Turmeric Powder	10	-	2	435
Wheat	5	31.3	2	5.22
White cumin	4	199	4	48.7

Concluding Remarks;

Significant strides have been made since the identification of Arsenic threat as most dread full mass poisoning in the history of mankind. Some nations have taken up the issue as a matter of their national agenda like India, Bangladesh, Combodia etc. According World Bank It has been identified through research that three simple steps may help these countries to address the problem more effectively;

1) *Encourage further research in potential areas of high Arsenic risk to understand the extent of the problem.*
2) *Include the threat of Arsenic in the process of decision making on water related matters.*
3) *Develop options and ameliorative measures for populations already living under the aegis of the problem.*

In the local context, the identification of arsenic and other geogenic contaminant free aquifers may, present local people and planners with definite knowledge of where wells are arsenic-free and where they are not. In the longer term, our work will quantify the aquifer characteristics in terms of the quality and quantity assessment over time. A vivid understanding of the degree and extent of arsenic contamination in West Bengal will help the agrarian community and planners involved therein to develop improved agro-practices.