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Groundwater Arsenic Contamination in Murshidabad, West Bengal: Current Scenario, Effects and Probable Ways of Mitigation with Special Reference to Majhyampur Water Treatment Plant, Murshidabad

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Abstract: *Murshidabad district, West Bengal, is one of the most affected region of Arsenic Contamination in India where around 1/3 of population are directly or indirectly affected by this catastrophe. Around 24blocks (out of 26) are severely affected by the contamination. This paper tries to investigate the causes, socio economic impacts of arsenic contamination in the Murshidabad. It also tries to find the mitigation measures from this cumulative disaster with special reference to Majhyampur Surface based piped water supply scheme in Beldanga I Block. The study reveals that the Majhyampur Water treatment project make a great impact on Beldanga I Block but it is also true that the people of these area can't afford this arsenic free water as it is costly. So a sustainable and holistic approach might free these people from this disaster.*

Keywords: *Arsenic, groundwater contamination, Majhyampur, Beldanga*

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I. Arsenic Contamination In Drinking Water

Historically arsenic is known as a poison. It does not often present in its elemental state but is more common in sulfides and sulfosalts such as Arsenopyrite, Orpiment, Realgar, Lollingite and Tennantite. Due to abundance of these arsenic bearing ores and the rarity of native arsenic, it is not an important ore itself Arsenic (AS) exists in several forms, which vary in toxicity and occurrence. The metallic form of arsenic (0 valency) is not absorbed by the stomach and intestines and does not exert adverse effects. On the other hand, a volatile compound such as AsH3 is toxic, but is not present in water or food. Moreover, the primary organic forms arsenobetanine and arsenocholine) found in fish and shellfish seem to have little or no toxicity. Arsenobetanine quickly passes out of the body through urine without being metabolized to other compounds. Arsenite (+3) and arsenate (+5) are the most prevalent toxic forms of inorganic arsenic that are found in drinking water. Arsenate As(+3) in reduced state in inorganic is a toxic pollutant in natural environment and is more soluble and mobile than the oxidized state of inorganic arsenic,

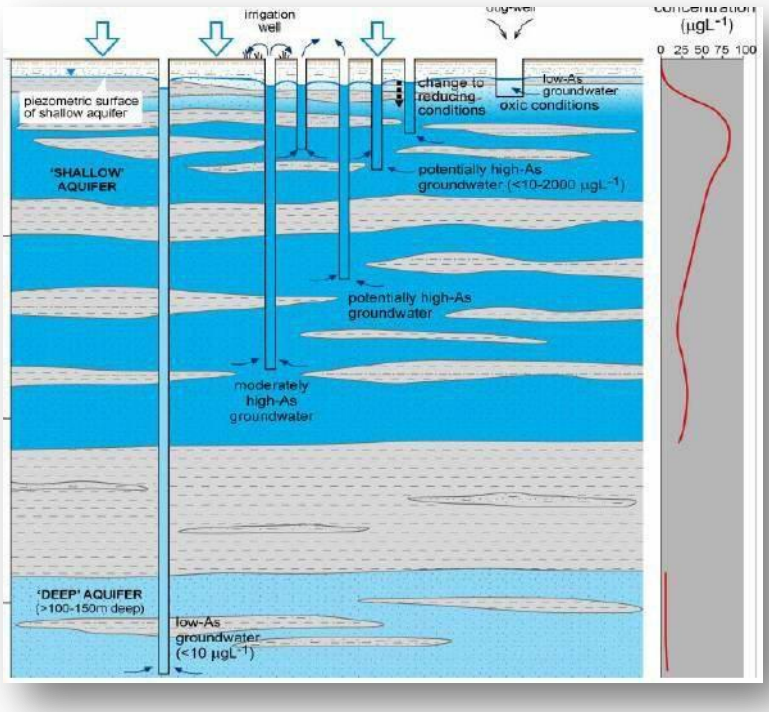


Figure 1.1: Source of Arsenic in Ground Water in West Bengal (Google images)

arsenate As(+5). Intake of drinking water having arsenic concentration beyond the permissible limit of 0.05 mg/lit has deleterious effects on human health. (Elangovan and Chalakh, 2006)

II. Sources Of Arsenic In Ground Water In West Bengal

- The source of arsenic in groundwater can be traced out by establishing the relations between the river system (drainage pattern), the area from where the rivers brought sediments to its parent materials.

- The problem of groundwater pollution by arsenic is found in the inter fluvial region of the Bhagirathi-Hugli and the Jalangi-Ichamati rivers lying mostly in the eastern part of the Bhagirathi-Hugli river of West Bengal. The arsenic contamination in ground water beyond permissible limit of 0.05mg/l has been found within the shallow aquifer (20-60m below ground level). Apart from this area, other areas where higher incidence of Arsenic has been reported are four blocks(adjacent to the river Ganga) in Malda district, Purbasthali block of Bardhaman district andBalagarh block of Hugli district

- During the phases of deltaic sedimentation in the southeastern part of West Bengal, rest of the Bengal shelf was under the influence of fresh water sedimentation. The system of rivers responsible for this fresh water sedimentation could be the precursor of the Ganga, which might have been flowing into the Bengal plains through the . Garo-Rajmahal gap.. A number of rivers like the Damodar, the Rupnarayan etc. flowing in the Bengal plains in a southeasterly direction for a considerable distance turn sharply to the south in the southern part of West Bengal. Thus the present drainage pattern responsible for recent sedimentation in West Bengal might have been caused due to 1) a regional southeasterly slope of the basin, caused to some extent, by movements on the hinge-zone located at the edge of the shelf and 2) an increasing rate of southerly tilt of the West Bengal part of the basin due to relatively greater rate of subsidence of the southern part of the hinge through the Tertiary and recent times. (Elangovan and Chalakh, 2006)

III. Arsenic Affected Area In West Bengal

The area of West Bengal is 88 752 km2with a total population of 68 million (1991 census). There are 17 districts in West Bengal out of which, during the last six years, 6 districts were found arsenic above the maximum permissible limit (0.05 mg l-1) in ground-water. About 800 000 people are drinking arsenic contaminated water and 175 000 people are suffering from arsenic related diseases. These six districts are South 24-Parganas, North 24-Parganas, Nadia, Bardhaman, Murshidabad and Malda

The total area of the affected districts is 34 000 km2 (38.47% of the area of West Bengal) with a population of 30 million (44.4% of total population of West Bengal). This does not mean that at present all of the 30 million people are drinking arsenic-contaminated water and that the whole area of 34 000 km 2 is contaminated by arsenic. However, such a possibility cannot be ruled out in the long term. In each successive year of last six years it has discovered more affected areas and an increasing population affected thereby. By the end of December 2001, this problem spreads from few villages to 2065 villages of 75 blocks in 8 districts. About 10 % of the total population of the State is exposed to the above risk.

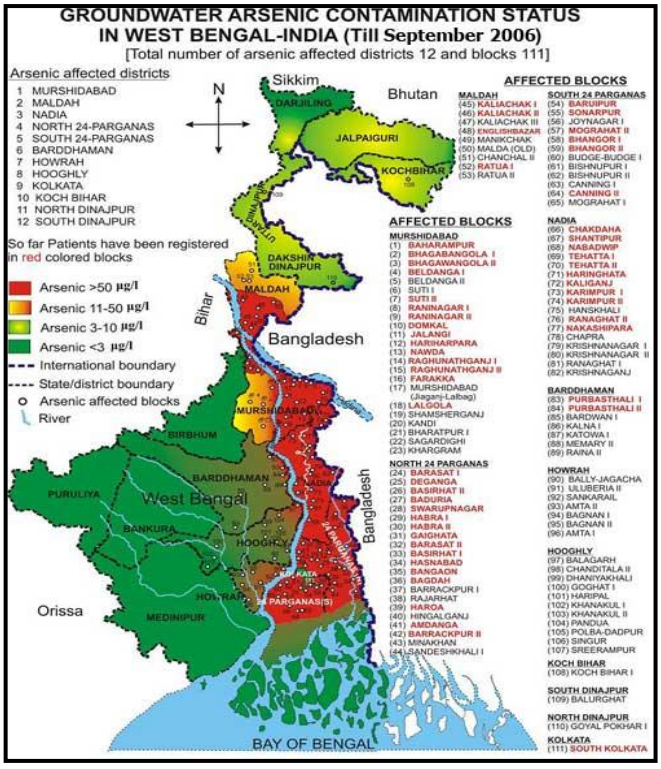


Figure 1.2: Arsenic Scenario in West Bengal (Source: PHED)

Table 1.1 : Arsenic Scenario in West Bengal (PHED)

Sl no	District	No of Block Affected	No of village affected	Population at the village
1	Malda	7	229	696822
2	Murshidabad	18	354	1343866
3	Nadia	17	541	1743889

4	North 24 Parganas	19	472	1884676
5	South 24 Parganas	9	409	96443
6	Howrah	2	4	107951
7	Hooghly	1	18	37678
8	Bardhaman	2	38	101171
	Total	75	2065	6970484

IV. Causes Of Arsenic Contamination

1. The first theory is "pyrite oxidation", &
2. The second theory is "oxyhydroxide reduction".

1. According to the "pyrite oxidation "theory the excessive withdrawal of ground water is the cause of arsenic pollution in the groundwater. For the need of extensive production of food crops the excessive rate of ground water is used for irrigation. This creates a hollow space under the earth crust and opened the bed of arsenopyrite rock.
2. The arsenic is present in the sedimentary rock strata of Bengal delta region because of some geological reasons. According to the geologists, the source of arseno-pyrite sediments deposited within last 2000 years, this sediment has been brought in the Bengal basin by the major rivers. In this reason, Arsenic is found in the inter fluvial region of the Bhagirathi-Hugli and the Jalangi-Ichamati rivers lying mostly in the eastern part of the Bhagirathi-Hugli river in the districts of Malda, Murshidabad

V. Effect Of Arsenic Contamination On Human Health

Considering the difference in the symptoms of disease the health condition of arsenic affected persons can be divided into 4 stages. The stages are-

- Pre-clinical stage,
- Clinical stage,
- Stage of complication,
- Stage of malignancy.

1. Pre-clinical stage

High quantity of arsenic is noticeable in the taste of their urine, nails, hairs, or skin.

2. Clinical stage

- Melanosis
- Spotted keratosis in palms and soles
- Diffused keratosis in palms and soles
- Dorsal keratosis

3. Stage of Complication

Infection in Lung, liver, muscles, eyes, veins, & artery.

4. Stage of Malignancy

Lung cancer, bladder cancer. (Saha et al., 2010)

Figure 1.3: Dorsal Keratosis

Figure 1.4: Squamous Cell Carcinoma On Heel

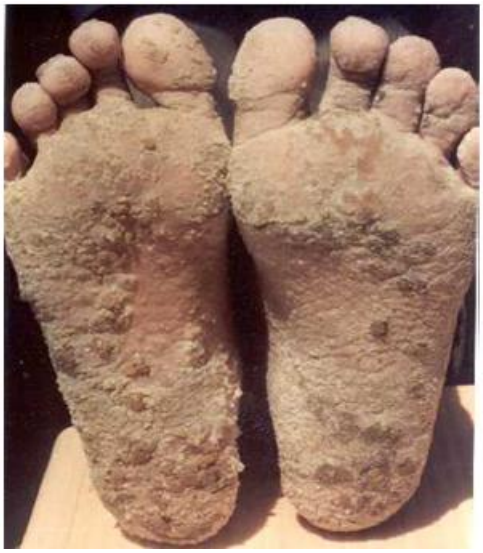


Figure 1.5: Hyper Keratosis On Sole

Figure 1.6: Arsenosis Patient In Beldanga

VI. Arsenic Scenario In Murshidabad District

Murshidabad district is one of the arsenic affected districts in West Bengal with highest number of people at risk (CGWB).The total area of the district is 5324 sq. km. and the total population is 5.9 million (2001 census). In Murshidabad district except Nabagram and Bharatpur-II, 24 blocks (out of 26) are arsenic affected. Arsenic concentration in drinking water ranges between 3-3000µg/L (SOES, JU Study). Many people suffering from arsenicosis have died.

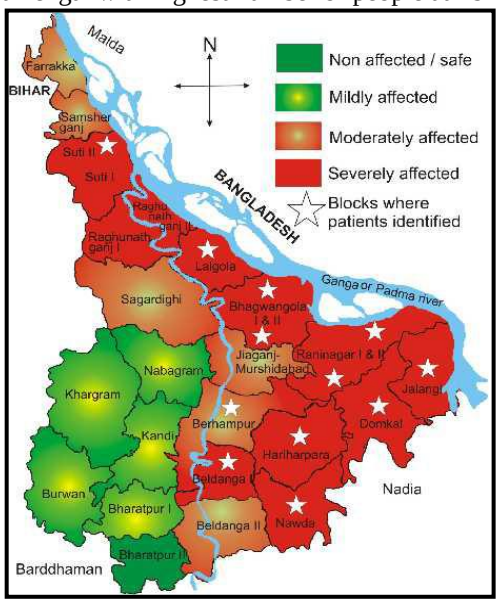


Figure 1.8: Arsenic Scenario in Murshidabad District(Google Images)

Table 1.2: Arsenic Scenario In Murshidabad (Das,2011)

Area of Murshidabad	5324 sq. km
Population of Murshidabad (in thousands)	5866569
Number of Blocks where ground water arsenic above 10 µg/L	25
Number of Blocks where ground water arsenic above 50 µg/L	24
Number of Blocks where ground water arsenic above 300 µg/L	17
Number of Villages where ground water arsenic above 10 µg/L	1320(out of total 1721)
Number of Villages where ground water arsenic above 50 µg/L	971(out of total 1721)
Number of Villages where ground water arsenic above 300 µg/L	281(out of total 1721)
Population drinking arsenic contaminated water above 50 µg/L	1.2 million
Number of registered patients with arsenical skin lesions	4813

VII. Source Of Arsenic In Murshidabad

1. The West Bengal part of Bengal Basin has sedimentary deposition from Mesozoic to Recent age. Ganga- Brahmaputra river system contributes in building up the Bengal delta. Even in the Tertiary these rivers carries a considerable amount of sediments from Himalaya (Stüben *et al.,* 2003). The study area experience the recent alluvium deposition resulted by the extensive fluvial processes (Morgan and McIntire, 1959). Sedimentologically the Bengal Delta is characterized by thick accumulation of clay layer which is in some places overlain by silt sand and gravel deposits (Deshmukh and Goswami 1973). According to the geologists, the source of arseno-pyrite sediments deposited within last 2000 years. The upper part of the Bengal plain reveals three inter connected aquifer system. The shallowest aquifer extends upto the depth of 12-15 m, typically made of sub angular, fine to medium grained sands and clay lenses. The shallow aquifer shows mixed igneous and metamorphic provinces for the eroded deposited minerals. The intermediate aquifer extends from 35-46 m and mainly metamorphic type of minerals can be observed where as the lower aquifer extended from 70 to 150 m with magmatic province. (Stüben et al., 2003). The eastern part of Bhagirathi River is composed of thick unconfined aquifer in which arsenic are found (Malda & Murshidabad). (Ghosh and Kanchan, 2011)

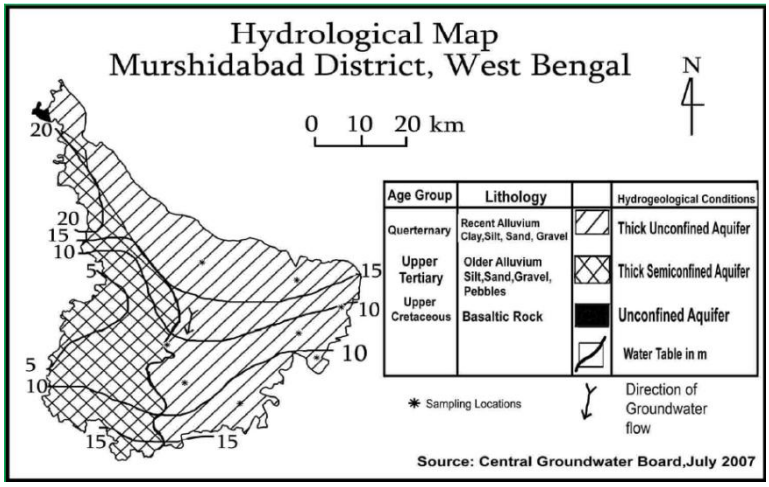


Figure 1.9: Hydrological Map of Murshidabad district (Ghosh and Kanchan, 2011)

2. But the anthropogenic activities like the excessive withdrawal of ground water worsened the situation. Lowering of water table of ground water for irrigation and other requirements lead to create a hollow space under the earth crust and opened the bed of arsenopyrite rock

3. OTHER SOURCES
   - Different microbial activities
   - The use of arsenic mixed fertilizer
   - Industrial effluents mixed with arsenic
   - Mining activities

VIII. Temporal Variation Pattern Of Arsenic In Murshidabad

Definite relationship between the behavior of arsenic and rainfall intensity exists. With increasing rainfall intensity rate of dilution increases which minimizes the arsenic concentration in the groundwater (Farooq et al., 2010). During monsoon period there is considerable decrease in the arsenic concentration. In monsoon 2009 the concentration varies between 1 to 0.01mg/l where as in 2010 the concentration rages between 0.69 to 0.004mg/l. Thus it can be said that there is a strong correlation exists between rainfall condition, dilution effect and arsenic concentration. Contrary to this, during winter a season and pre monsoon season there is an increase in the concentration which is associated with the decrease in dilution effect.

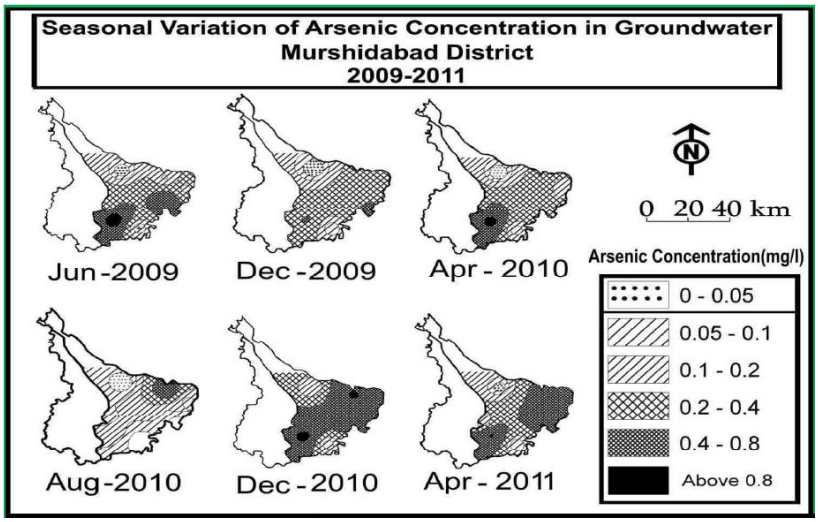


Figure 2.0: Seasonal Variation of Arsenic Concentration in Murshidabad District (Ghosh & Kanchan, 2011)

Lesser presence of rainwater in the aquifer triggers the mechanism of releasing arsenic in the shallow aquifer during Pre monsoon and winter season. (Ghosh and Kanchan, 2011)

Mitigation
Option-1: Using surface water (like pond water, river water)
Option-2: Using Ground Water
Option-3: Treatment & Removal of Arsenic from Ground Water
Option-4: New Hand pump fitted Tube well at deeper Aquifer
Option-5: Dug-well
Option-6: ATU with Existing Hand Pump Fitted Tube Well
Option-7: Domestic Filter
Option-8: CGCRI (Govt. of India) Approved Plant
Option-9: Rain Water Harvesting

IX. Mitigation Measures Taken By Government

Total tube wells allotted for public use are 2423 installed under different programmes in 19 affected blocks of Murshidabad district upto April 2007. A total of 114 dug wells (80 numbers under second action plan, 34 numbers under State funded action plan) are installed in the affected areas till 2007.

Table 1.3

Measures taken By Govt. of West Bengal	No.
Short-term Measures	8037
New hand pump fitted	166
Dug/Ring wells	
Medium-term Measures	2396
ATU with existing hand pump Fitted tube wells	12
ARP existing ground water base piped water Supply Scheme (PWSS)	8
New big diameter deeper aquifer tube well for existing PWSS	233
New ground water PWSS	01
Nadia Murshidabad ground water based PWSS	
Long term	03
Surface water base Pipe Water Supply Scheme	
Source: Public Health Engineering Department (PHED), 2007	

Both State & central Government take various steps to mitigate the arsenic contamination in the entire Murshidabad district. In the map given below it is easily identified that about 15% area under the ground water based piped water supply, 20% area will be under the ground water based piped water supply in between 2020 & 18% area under the surface water based piped water supply. But it is also true that in this district where 24 blocks (out of 26) are readily affected by the problem of Arsenic contamination and almost 1/3 of the population are suffered from arsenic related diseases. So more Government initiatives can only change the scenario.

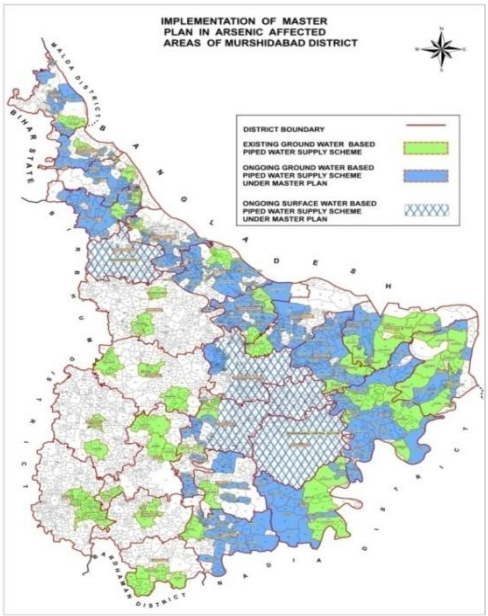


Figure 2.1: Implementation of Master Plan in Murshidabad District (Google image)

Table 1.4: Implementation of Master Plan in Murshidabad District (PHED)			
Programmes	Number of Tube wells	Installation Cost (Lakh)	Population Benefitted
Action Plan: First Phase (1994-1995)	265	66.25	66250
Action Plan: Second Phase (1997-1998)	205	51.25	51250
State Fund Action Plan (upto 2003)	10	2.5	2500
PMGY (upto 2007)	1952	488.00	488000
Total	2432	608	608000

Impact of Majhyampur Surface water based Piped water supply scheme mitigating arsenic contamination (Beldanga I block)

The Majhyampur Water supply scheme comprises of 6 Mouzas include Jalalpur, Kumarpur, Barua, Majhyampur, Giridharipur, Meliani and Mirzapur in Block Beldanga I of District Murshidabad, West Bengal. The total area covered on the scheme is about 1771.68 hector having a population density of 22.28 persons /hector (2001 census). It is approximately located at 88^0 15′ E. longitude and 24^0 08′ N. latitude people of the area are facing acute scarcity of drinking water in absence of any potable water supply system. They mainly depend on very few hand pump tube well and yield of which are totally inadequate with respect to the water demand on the locality.

Table 1.5: Salient Features of Majhyampur piped water supply scheme			
Population (2001)	MOUZA (J.L.NO.)	TOTAL	SC POP.
	ZONE-I		
	Jalalpur(42)	4228	80
	Kumarpur(44)	5222	584
	Barua(60)	6410	0
	Majhyampur(61)	8280	0
	Giridharipur(62)	1578	0
	ZONE-II		
	Meliani(63)	204	0
	Mirzapur(64)	20061	725
	TOTAL-	45983	1389
Design Population(2026)	68975		
Rate of Supply	49 lpcd (70% Street stand Post) 30% house connection		
Water Treatment plant Capacity	200M3/Hr.		
Zone Wise Population(2001)	Zone-I 25718	Zone-II 20265	
Capacity of Elevated Reservoir	Zone-I 150000 Gallon	Zone-II 100000 Gallon	
Minimum/Maximum Dia of Pipe Line-	80 mm. to 300 mm.	42730 mtr.	
Raw Water Rising Main	2600 mtr.		
Clear water Rising Main	6350 mtr.		

Majhyampur Surface water based piped water supply scheme plays a big role in eradication of Arsenic Contamination in Beldanga I block. In Murshidabad district, Beldanga, Jalangi, Raninagar fallen in the vulnerable zone of Arsenic Contamination. In Beldanga I almost everyone are more or less suffered from contamination and As(Mg/l) ranges from 0.01-0.4. Sometimes it's crosses 0.5 mg/l. The main influence area of this project were Majhyampur, Mirzapur and Giridharipur Mouza.

Figure 2.2: Majhyampur Water Treatment Plant

The main reason behind this contamination was source of drinking water. Increased use of ground water by tap and tube well may increase the level of contamination. During the primary survey in Majhyampur, Mirzapurpur & Giridharipur it is also identified that in some parts they use pond and well as a source of drinking water. Naturally incidence of morbidity and treatment cost was increasing in leaps and bound. If the data of treatment cost and morbidity from 1980-2000's is considered then it is clear that with time the melanosis, arsenosis, lung cancer diseases are constntly increases in these three mouzas. It is also mentioned that in the time period of (2000-2012) the average treatment cost rises from 100-400 per person. Previously said that the people of these localiy are too poor to afford this treatment cost. By this project the value of Iron, pH and Arsenic level were significantly reduced In this situation Majhyampur water supply system can make slight differences in this figure. By this project the value of iron reduced from 2-1 to 0.93-0.63 mg/L, pH from 6.5-7 to 7.3-8 and Arsenic from 0.4-0.1 to 0.07-0.05mg/L.

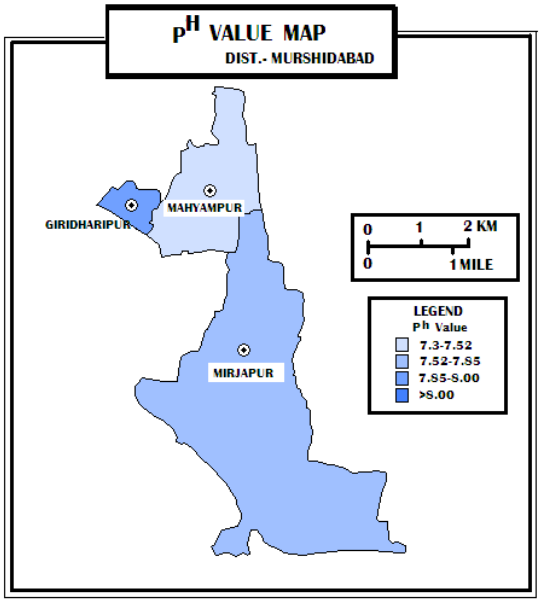
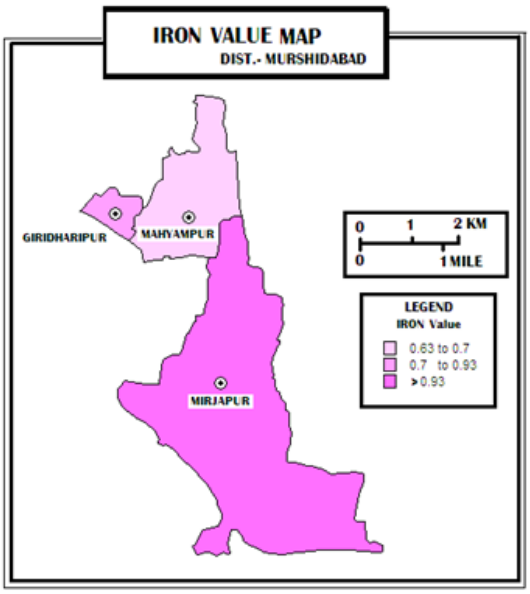


Figure 2.3



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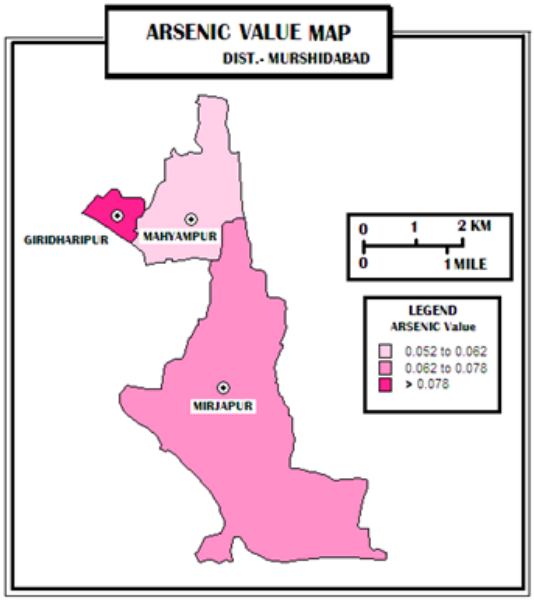

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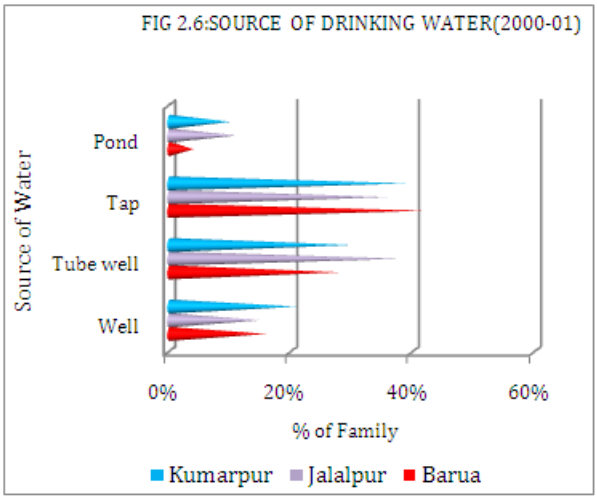

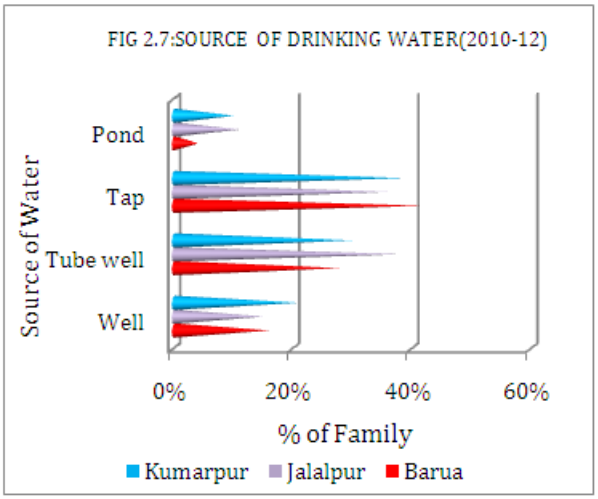

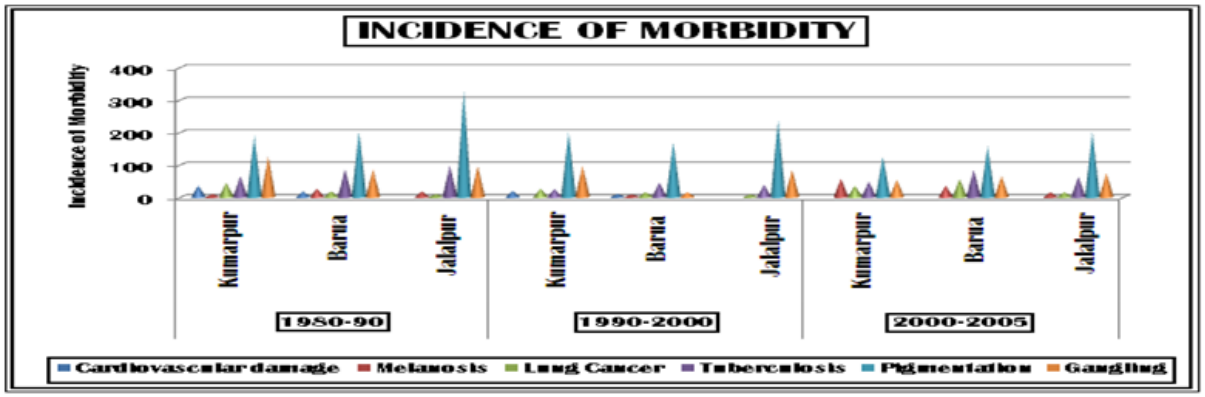

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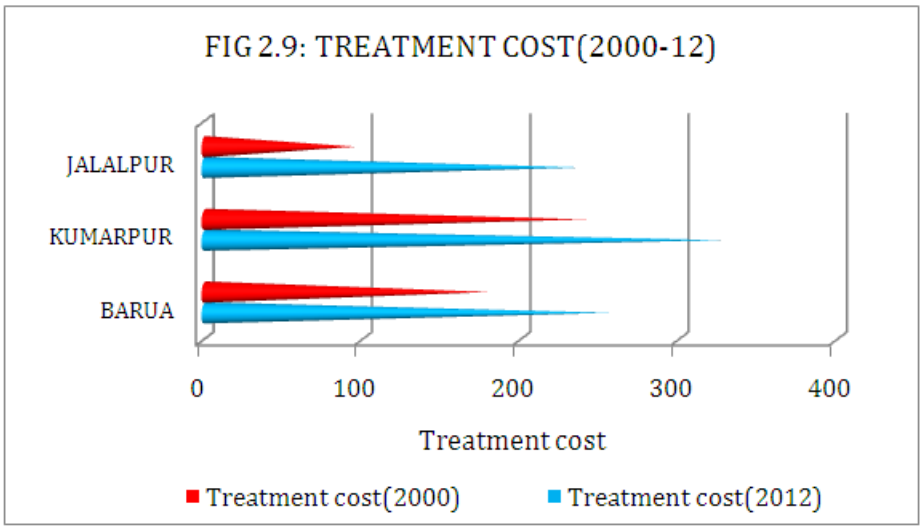

X. Activities Of Majhyampur W.S.S

- Continue water quality monitoring.
- Construct deeper aquifer tube wells.
- Provide Arsenic Treatment Unit (ATU) with hand-pump fitted tube wells and Arsenic Removal Plants for big-dia tube wells for piped water schemes.
- Implement Water Supply Schemes based on Rain Water Harvesting Structures.
- Implement large Piped Water Supply Schemes based on river water where economically and technically feasible.
- All the arsenic affected villages to be covered by piped water supply schemes.
- Areas covered by existing Short Term and Mid Term Measures such as ATU attached Hand Pump Tube wells, Replacement Tube wells etc. should also be included within the future plan of action.
- Attempts to be made to cover the affected areas with surface water wherever available.

XI. Conclusion & Recommendation

The area was mainly a underdeveloped region of Northern Bengal and the people lived under the vicious cycle of poverty. So to solve the permanently first needs holistic development over the entire region.

A huge population was dependent mainly onto groundwater based tubewell and tap. Previously said that Gangetic arseno-pyrite based sediments create this calamity but in recnt past and in present day groundwater based hege irrigation in jute cultivation make the situation horrible. So, surface water based piped line system and project like majhyampur might free from this situation.

But it is also identified during the primary survey that almost every household uses contaminated water as the people were too poor who can't afford this water and- it is also mentioned that many projects like majhyampur can make the difference.

Though Govt. have taken some effective steps by setting up different projects and setting up tap to every house. But this is not satisfactory. As, till date ¼ of the population of these area are suffering from arsenic related diseases. So, effective medical treatment was required for patients and guarantee to supply arsenic free water in every house might free these people from this disaster.

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