(2) VULNERABILITY OF POPULATION EXPOSED TO ARSENIC CONTAMINATION IN THE MID GANGA PLAIN OF BIHAR, INDIA

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Arsenic contaminated aquifers, being used for direct and indirect human consumption, have severe health implications among the rural population in the state on Bihar, India. This study covered a 10 km. belt along the Ganga river in the four districts of Bhojpur, Patna, Vaishali and Bhagalpur. The purpose of this research was to obtain the distribution and quantum of human population at risk of arsenic poisoning and population composition characteristics of the arsenic-affected belt. The methodology adopted was based upon self-generated and confirmed primary data on abnormally high arsenic concentration in ground water ranging from above 10 ppb. to 1861 ppb. Percentage of hand pumps testing with more than 10 ppb. arsenic content were calculated. This data was compared with the Census 2001 data to obtain estimates of affected population, while Topographical and Administrative Block Maps of all four districts were referred to for studying the spatial pattern of this population. The result showed that approximately 1,537,426 persons [about 47% of the population] residing in the study belt are at risk. In Bhagalpur study belt, the vulnerability extends to more than 75% of the population. Symptoms of arsenic poisoning are widespread, especially among child population. Appropriate mitigation strategies are yet to be undertaken in this study area.

INTRODUCTION –

Bihar is located entirely in the Ganga drainage basin, the geographical extent being 24^0 20'N to 27^0 31'15"N, and 83^0 19'50" E to 88^0 17'40"E longitudes. Bihar is the second most densely populated state of India having 82,878,769 persons, 89.53% of which is rural population. The rural per capita income of this economically backward state is less than Rs. 5000 [approx. £ 60] per annum, and it is largely sustained by its agriculture-driven economy. The physical geography of these plains, characterised by annual inundations and frequent meander changes in the river network, generally force rural inhabitants to relocate their habitation sites, particularly in central and north Bihar. It has also resulted in emergence of new areas of alluvial deposits. The presence of ample surface and ground water sources generally confined the problem of water resource to management of flood situations till the last decade. However, detection of arseniferous aquifers in Bihar within the past five years, apart from presenting one of the most daunting health challenges to Indian authorities, exemplify how ground water quality has been compromised with on account of its unplanned and excessive utilisation in domestic and agricultural sectors. This has impacted upon the general health conditions of the people. Arsenic level up to 1861 ppb. in drinking water hand pumps had been confirmed in 2004, and very limited epidemiological studies on arsenocosis have been conducted in Bihar till date. More important is the confirmation of the continuous extent of arsenic contaminated ground water upstream from the Bengal Basin, where population density and economic deprivation are higher .

This study is based on intensive tests carried out on water samples drawn from hand pumps that are used for direct human consumption in the rural areas of four districts of Bihar – Patna, Bhojpur, Vaishali and Bhagalpur- and an analysis of the follow-up action by the stakeholders towards mitigation of the problem.

AIM OF THIS STUDY –

To facilitate the recently introduced mitigation strategies by -

- Determining the quantum of population at risk in villages with arsenic affected aquifers.
- Classifying the villages on the basis of an ***index of vulnerability to arsenic poisoning***.
- Obtaining feedbacks regarding the sustainability of the mitigation strategies, initiated by the stakeholders in the affected areas.

METHODOLOGY –

- The ground water samples of over 28,000 hand pumps in the four districts were collected by this PROJECT ARSENIC group in 2004 – 2005. The study area was confined to 10 km. in Patna, and five km. in the remaining four districts, based upon the frequency of arsenic contamination.
- While field test kits were used for initial determination on arsenic content, subsequent confirmatory tests were carried through Atomic and UV Spectrophotometers.
- Questionnaires were distributed for obtaining information regarding the time span of ground water consumption in the affected villages, the depth of the hand pumps, nutrition and health problems.
- Census of India, 2001, of Govt. of India was referred to gauge the number of persons residing in the areas of arsenic hotspots. However, since the areas of annual inundation are also subject river bank erosion, certain villages within the study area have been relocated to adjacent higher grounds in the form of smaller compact settlements, and hence find no mention in the Census 2001 records. The population totals of such villages were obtained from the "village headman".
- Topographical maps and Administrative Block maps were extensively used to determine the spatial spread of contaminated pumps, while G.P.S. data of arsenic hotspots were recorded.
- Total population and percentage of contaminated hand pumps in each village were considered in deriving an index of population vulnerable to arsenic poisoning, ranging from 1 to 10. Villages with 10 ppb. and less arsenic contamination, and clean pumps were not included in the analysis.
- This database, along with socio-economic information obtained during field visits, were used in preparing this analysis for gaining insights into the population at risk and the sustainability of different mitigation options adopted.

FINDINGS –

The total study belt bears an approximate population of 3,590,363 persons, of which 1,676,699 [46.7%] reside in villages bearing arsenic contaminated aquifers of over 10 ppb. arsenic content. In Patna, the geographical extent of contaminated aquifers was largely confined to north-western and west central district, whereas sporadic instances of moderate to high contamination levels were found in its eastern part. Concentration of population distribution is influenced by proximity to the state capital of Patna, accounting also for the greater frequency and usage of hand pumps for drinking water purposes. Bhojpur had a much diffused spread of population away from the river bank – a feature that can be attributed to rapid erosion of the river bank in this sector. Conversely, annual inundation along the river bank forced number of villages to migrate away from the river bank in the northern district of Vaishali. Hence both flooding and bank erosion influenced habitation sites in the study area.
The accessibility of the population to contaminated sources varied with variations in the numbers and areal spread of contaminated hand pumps. Hence there were villages with over 26,000 persons with 28 contaminated drinking water hand pumps, as well as an instance where a population of only 1500 were accessing 32 contaminated hand pumps. A total of 7747 hand pumps supplying drinking water were counted, of which 3724 or 48%, were in Patna and Bhojpur. A large number of this were located in a densely populated contiguous belt from North-western Patna to Bhojpur in the west., covering a rough geographical length of about 50 kms. About 728,787 [43.5%] persons of all the arsenic affected villages were identified as vulnerable, the largest numbers inhabiting the floodplains of Bhagalpur and Patna.

MID GANGA PLAIN OF BIHAR, INDIA: POPULATION AT RISK
IN THE AREAS OF ARSENIC CONTAMINATED AQUIFERS

DISTRICTS	**No. of contaminated Sources in Affected villages**	**Population vulnerable to Arsenic toxicity [approx.]**	**% of population in study belt**
PATNA	1588	251,788	66.34
BHOJPUR	2136	117,609	33.84
VAISHALI	1513	65,062	28.75
BHAGALPUR	2510	294,338	45.35
TOTAL	7747	728,787	43.57

The index of vulnerability to arsenic poisoning in each district's study area revealed that high risk group villages peaked up, except in Vaishali where there was a progressive decline from low risk villages to high risk ones. Reversal in declining trend in the high risk group is highest in Patna followed by Bhojpur.
Although the high risk index is highest in the eastern district of Bhagalpur, the contiguous belt of the same in the two adjacent districts of Patna and Bhojpur qualifies the latter as the worst arsenic contaminated area in the study region. This is supported by the highest arsenic levels [Bhojpur-1861ppb., Patna-724 ppb] recorded in these 2 districts. Bhagalpur had larger "moderately high" population at risk, as compared to other districts. The low risk index, too, includes severely contaminated [50 ppb+] sources, but their proportion to the total village population accessing all the hand pumps is low thereby reducing number of persons at risk. However the largest number of villages surveyed belongs to this low risk group, which enhances the possibility of future aggravation of arsenic poisoning.

MID GANGA PLAIN OF BIHAR, INDIA: DISTRICT-WISE INDEX OF POPULATION
VULNERABLE TO ARSENIC POISONING

INDEX→	Upto 4 [low risk]	4 – 6 [moderate]	6 – 8 [moderately high]	8 – 10 [high risk]
PATNA	**53**	**17**	**08**	**19**
BHOJPUR	**75**	**22**	**20**	**30**
VAISHALI	**59**	**09**	**08**	**02**
BHAGALPUR	**69**	**17**	**27**	**28**
TOTAL NO. OF VILLAGES	**252**	**67**	**63**	**81**

DISTRICT –WISE ANALYSIS OF VULNERABILITY INDEX –

Patna district – The general trend of vulnerable rural population declined from west to east and away from the river bank. Sampatchak was the sole exception wherein there was widespread diffuse contamination in almost all villages, and the contamination spread to the western adjacent Phulwari block. This contamination cluster stood isolated in the area south of Patna block. Sampatchak contaminations had the largest spatial spread, covering almost 75% of the block, but its lower population concentration reduced its vulnerability index.

PATNA DISTRICT, BIHAR: BLOCK-WISE INDEX OF POPULATION VULNERABLE TO ARSENIC POISONING

INDEX→ BLOCKS	Upto 4 [population at low risk]	4 – 6 Population at [moderate risk]	6 – 8 [population at moderately high risk]	8 – 10 [population at high risk]
MANER	08	04	05	09
DANAPUR	04	-	01	04
SAMPATCHAK	06	07	01	03
PHULWARI	05	-	-	01
BAKHTIYARPUR	12	02	01	-
BARH	03	-	-	01
MOKAMA	06	01	-	-
PANDARAK	04	01	-	01
FATUA	02	02	-	-
KHUSRUPUR	03	-	-	-
TOTAL VILLAGES	53	17	08	19

The entire strip of new alluvial deposits, wherever inhabited, yielded arsenic contaminated waters at frequent intervals at shallow depths. High risk index was considerable in Maner and Danapur, putting around 50 % of the villages in this group.

Bhojpur district – Trends in Patna continued into this western district, the only difference being maximum detection of arsenic in the older alluvial terraces about 3 kms. south from the river bank. Higher agricultural productivity and increased incomes permitted the farmers to obtain drinking water from greater depths, but arsenic were detected in aquifers of different depths. Frequency of arseniferous aquifers was highest in Barhara, thereby jeopardising the general health parameters of the area. The number of villages bearing low vulnerability index was also much more in Barhara and Shahpur. More important is the intensity and areal spread of the contamination in these two blocks. Over 31% of the district population is being exposed to 47.42 % hand pumps which have arsenic ranging from 05 ppb to 1861 ppb. [AAS Data].

.BHOJPUR DISTRICT, BIHAR: BLOCK-WISE INDEX OF POPULATION VULNERABLE TO ARSENIC POISONING

INDEX→ BLOCKS	**Upto 4 [population at low risk]**	**4 – 6 Population at [moderate risk]**	**6 – 8 [population at moderately high risk]**	**8 – 10 [population at high risk]**
BARHARA	24	13	09	16
SHAHPUR	24	05	05	05
BEHEA	09	02	03	06
UDWANTNAGAR	01	01	02	-
ARA	05	-	01	02
KOILWAR	08	01	-	01
TOTAL VILLAGES	71	22	20	30

In Shahpur, the vulnerability was more in the western part and in the south where the contaminated aquifers continue into north-eastern corner of Behea, that fell within the study area. Further investigations are required into the southern spread of the contaminations for assessing the affected population in Behea. In other blocks, sporadic contaminated aquifers accounted for fewer number of villages in the population risk groups

Vaishali district - All the hand pumps of the riverine island of Raghopur tested positive for arsenic contamination. However, just 17% of the sources had more than 10 ppb. arsenic, so that a comparatively limited number of persons were in the vulnerability index in the 10 affected villages. Hajipur had the highest number of population at risk in its 34 villages in the entire district.. The risk increased towards the east in Sahdai Buzurg, where 2 villages had populations in the high risk group.

VAISHALI DISTRICT, BIHAR: BLOCK-WISE INDEX OF POPULATION VULNERABLE TO ARSENIC POISONING

INDEX→ BLOCKS	**Upto 4 [population at low risk]**	**4 – 6 Population at [moderate risk]**	**6 – 8 [population at moderately high risk]**	**8 – 10 [population at high risk]**
RAGHOPUR	10	-	-	-
HAJIPUR	29	03	02	-
BIDUPUR	07	-	02	-
SAHDAI BUZURG	10	03	02	02
DESRI	03	03	02	-
TOTAL	59	09	08	02

Bhagalpur district - Lying adjacent to the Bengal Basin, Bhagalpur exemplifies the upstream continuation of Bengal's arsenic contaminated aquifers. It had the largest number of villages above index 6. Here even open wells tested positive [Nathnagar] . This district had very few safe villages in contrast to Bhojpur, which severely limits the search for arsenic free hand pumps.

BHAGALPUR DISTRICT, BIHAR: BLOCK-WISE INDEX OF POPULATION VULNERABLE TO ARSENIC POISONING

INDEX→ BLOCKS	0.01-4.0 [low risk]	4.01 – 6.0 [moderate risk]	6.01 – 8.0 [moderately high risk]	8.01 – 10.0 high risk]
KAHALGAON	08	07	06	10
NATHNAGAR	19	02	03	06
SABOUR	09	02	06	03
PIRPAINTI	16	03	12	10
SULTANGANJ	17	03	-	01
TOTAL	69	17	27	30

IMPACT ON HUMAN HEALTH -

The general health of the people was affected by persistent poverty and lack of sufficient nutrition, facts which lowered their resistance to diseases.

During field trips it was observed that the population, in general, was suffering from itching all over their skin, and also had digestion problems. A number of people were found having spots all over their torso. Skin lesions, discoloration of skin, nodules over thickened soles and, in some cases, all over the body were recorded on camera. Initial symptoms bore stark resemblance to the pictures of bodily symptoms obtained from arsenic affected areas of Bangladesh and Bengal. However, clinical examination is urgently required to substantiate these observations. Another point to be noted is that the comparatively low frequency of visible symptoms can be attributed to the fact that arsenicosis symptoms are detected usually after prolonged exposure. Also, most of these affected habitation sites were relatively new settlements, following flooding of the older villages, that have emerged on the meander beds of the Ganga. The population of the entire study area complained of non-response of most of their health symptoms to conventional medicines.

CURRENT MITIGATION STRATEGY –

Based upon the initial intensive detection of arsenic contaminated aquifers in the 4 districts by this study group, the State Government , with financial assistance from the Centre and international organizations, initiated mitigation work based upon providing alternate sources of safe drinking water, that include –

- **Rain water harvesting** – this study group observed that villagers had a psychological barrier in drinking water collected from rooftops. Moreover, due to lack of maintenance, the stored water emitted foul smell, making the communities reject the water even for non-drinking purpose.
- **Revival of old dug wells in Bhojpur, Patna and Vaishali** – the authorities took the initiative to clean and cover the wells and install hand pumps. Here too, less number of wells have not been able to meet the demand. Moreover, the villagers were reluctant to consume well water as they were habituated in consuming bacteria-free ground water.
- **Adequate infrastructure created for drawing water from safe, deeper aquifers –** the success of this project has been severely compromised due to perennial shortage of power supply in rural areas.

RECOMMENDATIONS-

- The above mitigation measures can be improved by increasing community participation through creation of awareness of this problem, providing adequate training for maintaining the above schemes, and harnessing alternate energy sources like solar power. Community participation will also increase prospects of employability and accountability, so as to sustain these schemes
- Apart from this, district-level monitoring laboratories have been established, but more such centers are required to cope with the growing demand of water testing. Pathological laboratories and health centers need to be established to determine and treat arsenicosis symptoms.
- Additional database relating to seasonal monitoring of arsenic contamination levels, checking of safe pumps, and health statistics need to be created even to contain the population at risk.
- The stakeholders may use the target villages identified through the Vulnerability index to enable them to prioritize sustainable and cost-effective mitigation strategy in each affected area.

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