

*Mercury Contamination Of The Groundwater In Bhopal*

by

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**I. INTRODUCTION**

The world's worst industrial disaster occurred on the night of December 3, 1984. Toxic methyl iso-cyanate (MIC) gas escaped into the ambient air of Bhopal city from the premises of the Union Carbide India Limited (UCIL) factory and resulted in an unprecedented public health emergency. Thousands of people were killed instantly as the MIC gas enveloped Bhopal city. The immediate death toll was said to be about 8000 persons.<sup>(1)</sup> Studies conducted by the Indian Council of Medical Research (ICMR) between 1985 and 1994 estimated that 521,262 survivors had suffered permanent adverse health impacts due to the gas release.<sup>(2)</sup>

The UCIL factory is located in a crowded working class neighbourhood of Bhopal. It was shut down after the accident. Since then little attention has been paid to the abandoned factory even as large amounts of toxic substances continue to remain inside the plant premises. A series of studies have shown that many of these toxic substances have been leaking into the soil and the ground water. The main findings of these studies are summarized in Table 1.

Some years after the Bhopal disaster, people living in low income settlements adjacent to the UCIL plant began complaining that water from their handpumps was foul-smelling and pungent. In the absence of alternate water supplies they were forced to drink this water. At the request of the Bhopal Gas Peedit Mahila Udyog Sangathan (BGPMUS), a local voluntary organization, Peoples' Science Institute undertook to investigate this public health issue.

A review of the earlier studies revealed that almost one metric ton of mercury had been left abandoned inside the plant.<sup>(3)</sup> One study indicated mercury contamination of the groundwater in four residential colonies.<sup>(4)</sup> As a follow-up, PSI initiated an investigation to determine the

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concentration of mercury in the groundwater of the area surrounding the Union Carbide plant and its possible spread to adjacent areas.

**Table 1:**Summary results of studies of groundwater contamination undertaken in Bhopal.

Sl No.	Research Findings	Organisation
1	<ul style="list-style-type: none"> <li>Groundwater in settlements adjacent to the factory contained dichlorobenzene (722 ppb) and trichlorobenzene (24 ppb).</li> </ul>	National Toxics Campaign Fund (1990)
2	<ul style="list-style-type: none"> <li>Water quality within an area of radius 1 km. met the standards.</li> <li>Presence of volatiles and semi- volatiles in soil samples.</li> <li>Recommended the need to undertake a detailed investigation.</li> </ul>	NEERI, Nagpur and M/s Arthur D Little Inc., USA (1993)
3	High levels of <b>COD</b> were detected in the water of Arif Nagar, Kainchi Chhola, JP Nagar, Atal Ayub Nagar.	PHE Deptt., Bhopal (1996)
4	<ul style="list-style-type: none"> <li>Showed the presence of cadmium, chromium, copper, lead, manganese nickel and zinc in wastes dumped within the factory. Naphthol and other volatile organics were also detected in the same waste.</li> </ul>	IICT, Hyderabad (1996)
5	<ul style="list-style-type: none"> <li>Chloroform, carbon tetrachloride, trichloroethane, tetrachloroethane, hexachloroethane,, chlorobenzene, dichlorobenzenes and trichlorobenzenes were detected in the groundwater.</li> <li>Concentrations of chloroform, carbontetrachloride, dichlorobenzenes and trichlorobenzenes in the groundwater exceeded WHO standards at JP Nagar and Atal Ayub Nagar.</li> </ul>	Greenpeace International (1999)
6	<ul style="list-style-type: none"> <li>Concentrations of heavy metals in various handpump water samples were found to be above the BIS and WHO standards.</li> <li>Water samples at Annu Nagar, Atal Ayub Nagar, J.P.Nagar, Kainchi Chola, Nawab Colony, New Arif Nagar, Rajgarh Colony and Shakti Nagar contained nickel in concentrations higher than the WHO guidelines. High concentrations of mercury were detected in the groundwater at Annu Nagar, New Arif Nagar, Rajgarh Colony and Shakti Nagar. Concentration of lead exceeded the BIS Standard value at Kainchi Chola.</li> <li>Chloroform and dichloromethane were detected in levels higher than the WHO standards, in water samples at Annu Nagar, Atal Ayub Nagar, J.P.Nagar, Kainchi Chola, Nawab colony, New Arif Nagar, Rajgarh colony and Shakti Nagar.</li> </ul>	Other Media (1999-2000)

**Note:** This table is taken from Ref.5

## **II. METHODOLOGY**

Water samples were collected from groundwater sources used by the communities residing in several settlements around the UCIL factory. These sources included handpumps, tubewells and one open well. A sampling schedule was developed and groundwater samples were collected in September 2001 (post-monsoon period) and April 2002 (pre-monsoon period).

The tests employed for determining the concentration of mercury were done in accordance with the APHA, AWWA and WPCF Standard Methods using an Atomic Absorption Spectrophotometer (GBC 932 plus) fitted with a Hydride Generator HG 3000.<sup>(11) (12)</sup>

## **III. RESULTS AND DISCUSSIONS**

Results of the AAS analysis of the samples collected in September 2001 and April 2002 are shown in Table 2.

Results of the samples collected in September 2001 showed that mercury concentrations exceeded the Bureau of Indian Standards limit of 1µg/L at 12 out of the 16 sites sampled. Mercury concentrations in the groundwater were plotted on a map of the area (Fig 1). This figure showed that the maximum concentration of mercury was in the water from the tubewell in Arif Nagar, the area immediately adjoining the UCIL plant. It also showed that the mercury concentrations decreased with increasing distance from the factory. In the absence of any other source of mercury, it was concluded that mercury was leaching into the groundwater from a source inside the plant.

**Table 2: Mercury concentrations in the groundwater in the two study periods**

SI No	Sampling Station	Source type <sup>(a)</sup>	Direction w.r.t. UCIL	Depth in meters	Mercury conc (µg/L) Sept 2001	Mercury conc (µg/L) April 2002
1	Karod Colony	TW	NW	35	2	1
2	Nawab Colony	HP	N	70	42	12
3	Solar Evaporation Pond	Pond	NE	NA	38	12
4	Arif Nagar	TW	NW	70	70	9
5	New Arif Nagar	HP	NW	95	40	10
6	Gareeb Nagar (Old)	TW	NE	50	24	24
7	Gareeb Nagar (Chandwari)	HP	NE	65	9	*
8	Atal Ayub Nagar	HP	NE	15	56	4
9	Chhola Naka	HP	NE	35	ND	2
10	J.P.Nagar	HP	SE	70	28	*
11	MPSEB Office, J.P.Nagar	OW	S	5	17	2
12	Kainchi Chhola	TW	E	65	22	2
13	Selai Kendra, J.P.Nagar	HP	E	25	14	*
14	Risaldar Colony	TW	E	70	ND	12
15	Indira Colony	TW	NE	30	*	10
16	Panchwati Colony	HP	N	85	*	2
17	Rajendra Nagar	TW	E	60	ND	*
18	Green Park Colony	TW	W	18	ND	ND
19	Kazik Camp	TW	S	NA	*	ND
20	Bus Stand	HP	S	NA	*	ND

**Note:** (a) TW- Tubewell, HP- Handpump, OW- Openwell, ND- Not Detected, \* Not Done.

(b) Not Sampled (\*); Not detected (ND)

(c) Drinking water specification of the Bureau of Indian Standards (BIS) (IS 10500:1991) lays down a non-relax able limit of 1 µg/l of mercury in drinking water.

It can be seen from Fig 1 that the concentration of mercury follows a particular trend, decreasing progressively in sites towards the north, north-east direction from the plant. The Survey of India toposheet of the area (Fig 2) shows that in general the ground slopes in the north-northeast direction. A Central Ground Water Board report on the hydrogeology of Bhopal city suggests that the flow of groundwater is in the north-northeastern direction from the UCIL plant.<sup>(13)</sup> This suggest that contaminants from the plant site were moving with the groundwater

in the direction of its flow. Mercury was not detected in groundwater towards the west and south of the plant, i.e., in the direction opposite to the flow of groundwater of the area.

Results of the samples collected in the following pre-monsoon period (April 2002) revealed the presence of mercury at 13 out of the 16 sites sampled. In general the concentrations of mercury in the groundwater were lower than in the earlier post-monsoon period (September 2001). The spread, however, seems to be greater, extending to Chola Naka and Rajendra Nagar in the east. The diffusion seems to follow the path of the Patara Nadi (See Fig. 2). It can be surmised from this data that mercury concentrations in the pre-monsoon period are lower than the earlier post-monsoon figures because there is no addition of mercury from the source in the absence of rain.

Subsequent analyses of groundwater samples conducted by the state government laboratories confirmed the presence of mercury contamination.<sup>(14)</sup> While the official data was not released, newspaper reports claimed that the government report described the situation as "very serious".

#### **IV. CONCLUSION**

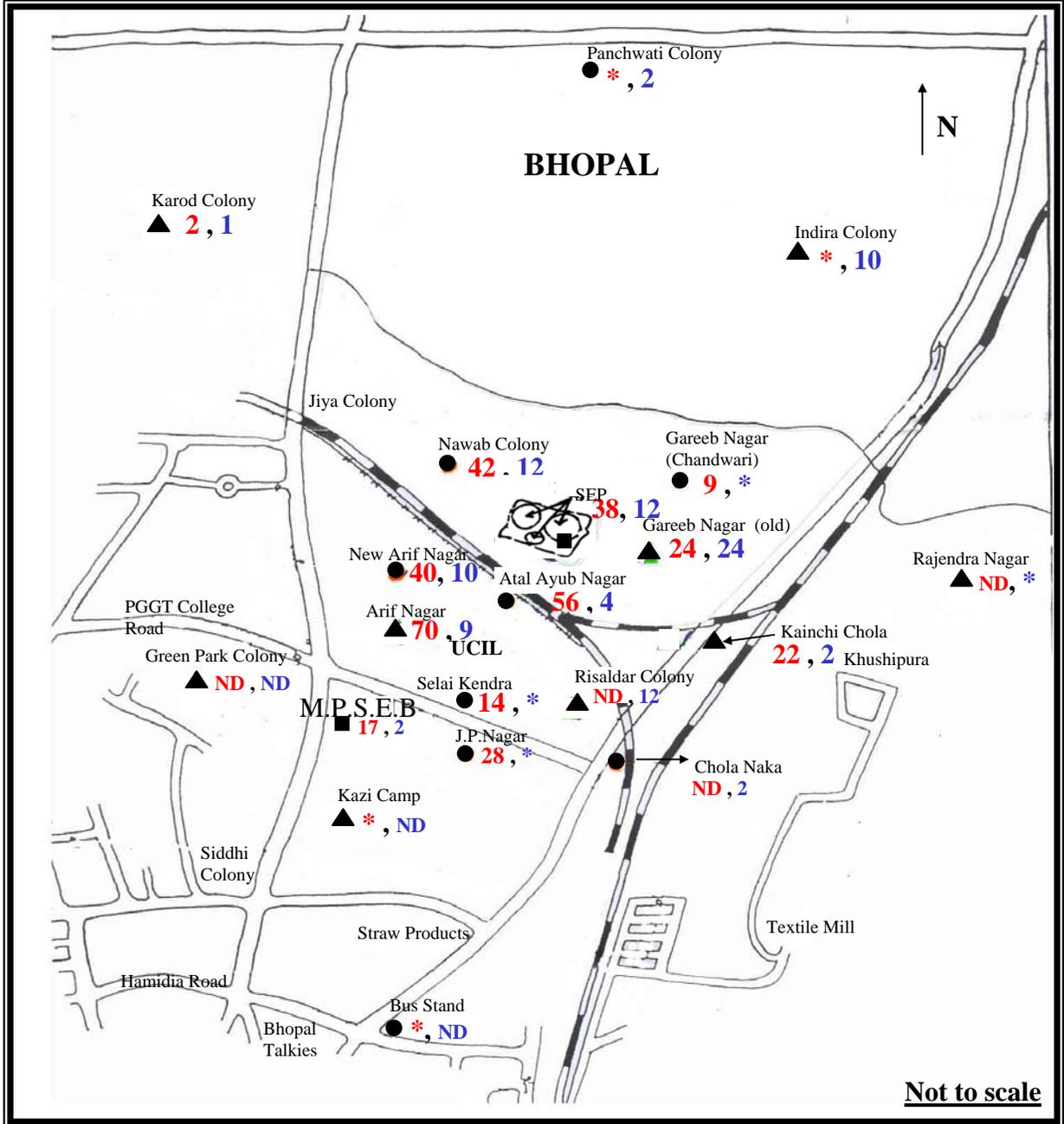
The above analyses lead to the conclusion that during the monitoring period September 2001 to April 2002, mercury, and possibly other toxic chemicals, were lying exposed and untended inside the abandoned UCIL plant and that they were leaching into the groundwater along with the rainwater.

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## REFERENCES

1. S.SARANGI: "Bhopal Gas Tragedy", in India Disasters Report, S.Parasuraman and P.V.Unnikrishnan (Eds), Oxford University Press, New Delhi, 2000, p334.
2. *Ibid.*
3. \_\_\_\_\_: "The Toxic Legacy of Union Carbide in Bhopal", Bhopal Group for Information and Action, Bhopal, 1996, p1.
4. (The Other Media) 2000.
5. Y.KABIR & R.SENGUPTA: Groundwater Contamination near the Union Carbide Plant at Bhopal, People's Science Institute, Dehra Doon, 2003. (Unpublished)
6. APHA, AWWA and WPCF (1985), "Standard Methods For The Examination of Water and Wastewater", 16<sup>th</sup> edition, pp. 42-43
7. APHA, AWWA and WPCF (1998), Standard Methods For The Examination of Water and Wastewater, 20<sup>th</sup> edition, pp. 6-36 to 6-41
8. A. Hussain & S. Gupta "Hydrological Framework for Urban Development of Bhopal City, M.P.", Central Groundwater Board, North Central Region, Bhopal, 1999, pp. 14-15.
9. H.S. Bal: "Poison Flowing in Carbide Water", The Indian Express, New Delhi, November 25,2002.

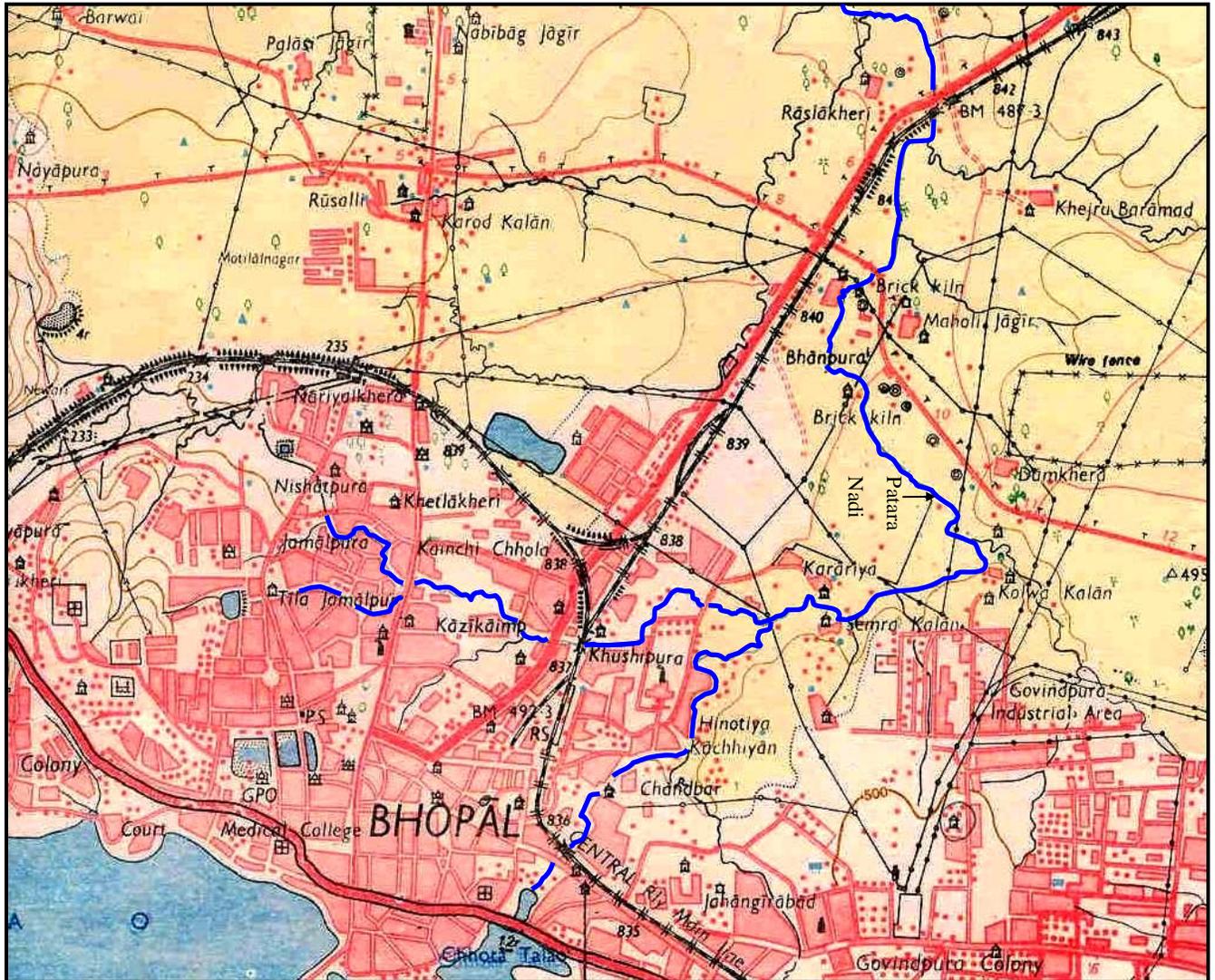
Fig. 1 : Concentrations of Mercury( $\mu\text{g/l}$ ) in the ground water (Postmonsoon 2001 & Premonsoon 2002)



**Legend**

- Handpumps
- ▲ Tubewells
- Wells
- A Postmonsoon Concentrations( $\mu\text{g/l}$ ) of Mercury (Year 2001)
- A Premonsoon Concentrations( $\mu\text{g/l}$ ) of Mercury (Year 2002)
- ND Not Detected
- \* Not Done

**Fig. 2 : Toposheet (55E/7) showing UCIL and the direction of flow of Patara Nadi**



Source : Survey of India

Scale 1 : 50,000