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Bhopal Gas Tragedy: A Revisit to pick out some lessons we have forgotten in 28 years

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Abstract: The Bhopal Gas leak was a first of its kind in the history of India. It is a tragedy which needs to be looked time and again so that process safety is never undermined ever at any stage in future in the entire globe. The tragedy had many dimensions. One important parameter was medical though others were also significant. The Indian Council for Medical Research (ICMR) organized multiple clinical research studies on the affected population. The massive figure of mortality includes approximately 5,000 children who died instantly and several hundred thousand disabled for life, including born with defects arising from the disaster. The chronology of the Bhopal incident is measured in calendars as it traces a series of connected developments that span years. So here is our attempt to revisit Bhopal and pick out some points to reestablish and restate that safety is not a company's duty it should be a part of its executing lifestyle.

Keywords: Bhopal Gas Tragedy; Methyl Isocyanide; Union Carbide Corporation; Industrial Disaster.

Background :UCIL on a Normal Day

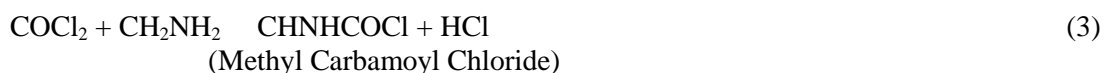
The Bhopal (23°17' North, 77°28' East) plant of Union Carbide India Ltd (UCIL) was one of the leading pesticides plants in the country and had a licensed capacity of 5000 tonnes of Pesticides. About 50.9 percent of UCIL was owned by Union Carbide Corporation. In 1984, UCIL was celebrating its 50th anniversary. In the procedure for manufacturing the pesticides Sevin and Temik, then considered an environmentally-preferred alternative to DDT, methyl-isocyanate (MIC [$\text{CH}_3\text{-N=C=O}$]) was used as an intermediate. The plant was initially approved only for formulation of pesticides from component chemicals, such as MIC imported from the parent company, in relatively small quantities¹⁰. However, pressure from competition in the chemical industry led UCIL to implement "backward integration" – the manufacture of raw materials and intermediate products for formulation of the final product within one unit. This was inherently a more sophisticated and hazardous process. . In 1979 UCIL built its own MIC unit. The company was offered a site outside the town; but it insisted instead on using the existing plant area, close to the railway station in the city. The complex specializes in methyl isocyanate (MIC) based carbamate pesticide which are claimed by the company to be safer and more effective in handling of crops. Between 1977 and 1984, Union Carbide India Limited (UCIL), was licensed by

the Madhya Pradesh Government to manufacture phosgene, mono methyl amine (MMA), methyl isocyanate (MIC), and the pesticide carbaryl marketed as Sevin⁹. The US supplied reactors, distillation towers, heat exchangers, centrifuges, filters, dryers, valves, control instrumentation safety equipments etc. Phosgene was manufactured by reacting chlorine and carbon monoxide, produced from petroleum coke and oxygen in an adjacent production facility within the plant⁹.

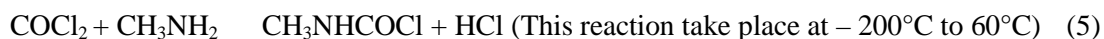
The chemical reactions involved in the process are as follows-



The mono methylamine was combined with the phosgene in the presence of chloroform to produce methyl carbamoyl chloride (MCC) and hydrochloric acid (HCl). HCl was then separated from the MCC so that it could be broken down into MIC and HCl. The MIC was then collected and transferred to stainless steel storage tanks, whereas the HCl along with residues of MCC, chloroform, and other byproducts which are not desired like MMA, carbon tetra chloride, dimethylallophanoyl chloride, cyan uric acid, dimethyl urea, trimethylbiurate etc. were collected and recycled back through the process.



MIC was manufactured with the prime aim to make the pesticide Carbaryl (Sevin) and smaller quantities of Aldicarb (Temic) and butyl phenyl methylcarbamate, all made solely for the Indian market. Carbaryl (marketed as Sevin) was produced by reacting MIC with excess of alpha-naphthol in presence carbontetrachloride⁹.



MIC is a clear, colorless liquid with a pungent odor (boiling point = 39 °C, freezing point = -80 °C, specific gravity = 0.96, molecular weight = 57.1, vapor pressure = 348 mm Hg at 20 °C). MIC is moderately soluble in water, and hydrolyzes to form carbon dioxide and methylamine⁸.

Cause of leakage of Methyl Iso Cyanate from tank 610

On December 2, 1984 at 11.00 PM, when most of the one million residents of Bhopal were sleeping, an operator at the plant noticed a small leak of methyl isocyanate (MIC) gas and pressure and heat from the vigorous exothermic reaction in the tank continued to build inside a storage tank. The vent-gas caustic soda scrubber, a safety device designed to detoxify any toxic discharge from the MIC system, had been turned off three weeks prior. It seemed a faulty valve had allowed one ton of water for cleaning internal pipes to mix with forty tons of MIC. A 30 ton refrigeration unit that normally served as a safety component to cool the MIC storage tank had been drained off its coolant for use in another part of the plant. The gas flare safety system designed to burn off gas was out of action as the connecting pipe has been removed for maintenance. In addition to it, carbon steel valves were used at the factory, despite the fact that when exposed to acid, they could corrode.

People awakened by these symptoms fled away from the plant. Those who thoughtlessly ran for their lives inhaled more than those who had a vehicle to ride. Many people died in stampedes while trying to escape. At around 1.00 AM, December 3, loud rumbling echoed around the plant as the safety valve gave way sending a plume of MIC gas into the air. The gas cloud was composed mainly of materials denser than the surrounding air, stayed close to the ground and that is why, children and other people of shorter stature inhaled higher concentrations owing to their height. Data from the Bhopal's airport suggest air temperature of 10 and a northerly wind. In such conditions, MIC would have rapidly condensed and the gas cloud would have passed

over the northern edge of the city and towards its centre². Within hours, Bhopal stood ruined and devastated littered with human corpses and the carcasses of stray animals, dogs, buffaloes, cows, and goats and other animals. Within a few days, leaves on the trees also yellowed and eventually fell off. An estimated 3,800 people died almost immediately, most of them from the poor slum colony adjacent to the UCC plant.

From all accounts and studies, it was clear that unlike leakage of a single chemical like ammonia, sulphuric acid, phosgene or hydro cyanic acid, the Bhopal gas release is not due to mere leakage of MIC³. The presence of an array of multiple chemicals was demonstrated. A toxicology project of the ICMR revealed the presence of as many as 21 chemical constituents³. The studies say products of hydrolysis(monomethylamine, carbon dioxide and various ureas) and pyrolysis(carbon monoxide, nitrous oxide and hydrogen cyanide) may also have been released in smaller quantities. Ironically, the toxicity detail of none of the compounds including MIC is known till date. Local hospitals were soon overpowered with the injured, a crisis further complexed by the lack of knowledge of exactly what gas was involved and what its effects were and what the exact treatment needed to be. The disaster at Bhopal has everywhere become a synonym for industrial catastrophes and the hazards of 'development'.

Aftermath

Health

Immediately after the disaster, the health care system in the city became badly overloaded. Within weeks, the State Government established a number of hospitals, clinics and rescue and rehabilitation units in the gas-affected area to treat the victims¹¹. No one knows exactly how many thousands died because of that doomed leak. And the count has less meaning as people are dying till date because of the gas breathed by their parents.

The literature survey on epidemiological studies of the affected approximately 42 sq. Km⁸ area has been surprisingly very redundant. It is despite the fact that countless bodies from Indian Government, the UCC, WHO and independent body of doctors and academicians from Bhopal University and other institutions had set up their clinical research and study work within weeks after the tragedy. All data about the health effects are still not available. The Indian Council of Medical Research (ICMR) was forbidden to publish health effect data until 1994¹¹.

Physiological systems affected and corresponding symptoms diagnosed are listed below:

- Ocular- Intense burning and irritation, photophobia, eye watering, blurred vision, corneal ulcer, corneal opacity, chronic conjunctivitis
- Respiratory -Breathlessness, feeling of suffocation, chest pain, severe cough(dry or wet), pulmonary edema, bronchial asthma, distress, pneumonitis⁸.
- Psychiatric and neurobehavioral toxicity-Anxiety, neurotic depression, social adjustment problem, impaired auditory and visual memory, attention response speed and vigilance
- Gastrointestinal- Persistent diarrhea, anorexia, abdominal pain³.
- Immunological -Suppressed cell mediated immunity, reduced T cell count, down regulation of phagocytic activity of lymphocytes
- Genetic- Increased chromosomal aberration
- Reproductive -Spontaneous miscarriages, prenatal and neonatal mortalities, decreased placental/fetal weight, leucorrhea, menstrual irregularities, dysmenorrhea^{3,8}.
- General- Muscle weakness, sleepiness, anxiety, loss of appetite, nausea, vomiting, fever³.

A study prepared by ICMR found that the spontaneous abortion rate following the gas leak was 24.2 per cent, about three times the national average. Immediately after the gas leak, the stillbirth rate increased by up to 300 % and the prenatal and neonatal mortality rate by 200 %. The spontaneous abortion rate increased three to four times and stayed raised for several years thereafter³.

Litigation

Immediately after the disaster, UCC, Instead of accepting responsibility and seeking to compensate the victims, tried dissociate itself from responsibility for the gas leak, in a bid to maintain a 'clean' image among its customers. Its prime tactic was to shift responsibility to UCIL, stating the plant was completely built and autonomously operated by the Indian subsidiary Unit. It also fabricated scenarios involving sabotage by

previously unknown Sikh extremist groups and disgruntled employees but this theory was questioned and in fact ruled out by numerous independent sources.

The toxic cloud of smoke had barely cleared when, on December 7, the first multi-billion dollar lawsuit (10) was filed against UCC claiming damages for the victims by an American attorney in a New York district court. This was the beginning of an endless chain of legal machinations in which the ethical implications and humanitarian crisis of the tragedy and its affect on Bhopal's people were shamelessly ignored. In March 1985, the Indian government passed and enacted the Bhopal Gas Leak Disaster Act to deal with the claims arising from the accident speedily and equitably. With this Act enacted the government now became the sole representative of the victims in legal proceedings both outside and within the country. And eventually all cases were systematically and strategically taken out of the U.S. legal system under the ruling of the presiding US District Court Judge and brought under Indian jurisdiction¹⁰ citing UCIL "separate entity, owned, managed and operated exclusively by Indian citizens in India".

In a settlement mediated by the Indian Supreme Court, UCC accepted moral responsibility and agreed to pay \$470 million to the Indian government¹⁰ to be distributed to claimants as a full and final settlement. The victims were never consulted in the proceedings and the five year worth medical compensation of UCC was an utter cry. Eventually, in an out-of-court settlement reached in February 1989, Union Carbide agreed to pay US\$ 470 million for damages caused in the Bhopal disaster as final settlement, 15% of the original \$3 billion claimed in the lawsuit¹¹.

At every point, UCC has attempted to manipulate and obfuscate scientific data pertaining to the event. Even today, the company has not stated clearly what was in the toxic cloud that enveloped the city on that December night. When MIC is exposed to 200° heat, it forms degraded MIC that contains the more deadly hydrogen cyanide (HCN). The cherry-red color of blood and viscera of some victims were characteristic of acute cyanide poisoning⁵. Moreover, many responded well to administration of amyl nitrate and sodium thiosulfate (5), an effective therapy for cyanide poisoning and not MIC exposure. Critics say that presence of HCN was vigorously denied by UCC and was a point of conjecture among researchers¹⁰.

Something to learn

The incident triggered interest from industry, legislation and the intellectual community across the globe and is acknowledged as a defining event in the course of process safety. Although accidents involving MIC or an accident of similar magnitude may or may not recur, but for a country like ours which is struggling with human, environmental and economical perils quite often, studying this disaster is of immense value while encountering future chemical disasters.

1. The event and the proceeding catastrophe in Bhopal revealed that expanding industrialization in developing countries without corresponding evolution in safety regulations could have devastating consequences. UCC's Sevin production plant was built in Madhya Pradesh not to disobey or forgo environmental regulations set and followed in the U.S. but to exploit the larger growing pesticide market here in India. However the manner in which the project was executed suggests the existence of a double standard for multinational corporations operating in developing countries. National governments and international agencies should focus on widely applicable techniques for corporate responsibility and accident prevention as much in the developing world context as in advanced industrial nations. Specifically, prevention should include risk reduction in plant location and careful design of safety legislation.
2. Existing public health infrastructure needs to be taken into account when hazardous industries choose sites for manufacturing plants. Future management of industrial development requires that appropriate resources be devoted to advance planning before any disaster occurs¹⁰. Communities that do not possess infrastructure and technical expertise to respond adequately to such industrial accidents should not be chosen as sites for hazardous industry.
3. Since 1984, individual activists have played a role in the aftermath of the tragedy. The most wellknown is Satinath Sarangi (Sathyu), a metallurgic engineer who arrived at Bhopal the day after the leakage. He founded several activist groups, as well as Sambhavna Trust, the clinic for gas affected patients, where he is the manager¹¹. Students for Bhopal, Chingari Trust, Swabhiman Kendra, Arushi, Bhopal Gas Peedit Mahila Udyog Sangthan, and International Medical Commission on Bhopal are some of the organisations engaged in long term serving to the cause of the victims.

After Bhopal

Warren Andersen, the then Chairman and CEO of UCC, was arrested and released on bail by the Madhya Pradesh Police in Bhopal on 7 December 1984. In 1991, the local Bhopal authorities charged Anderson, who had retired in 1986, with manslaughter, a crime that carries a maximum penalty of 10 years in prison. But Warren never stood even for a single trial in any Indian court¹². Orders were passed to the Government of India for his extradition from the United States. But Anderson evaded this summon as well to stand for trial in a U S court. In the 1989 trial the damage to environment and the contamination that UCC left behind were never addressed.

It has been 28 years after the tragic incident. And the miseries of the victims hasn't stopped yet as they are still plagued by 'monstrous births', cancer and respiratory and reproductive system health disorder.

In 1994, the Supreme Court of India allowed UCC to sell its 50.9 percent interest in UCIL to Eveready Industries India Limited. The Bhopal plant was later sold to McLeod Russel (India) Ltd. Dow Chemical Company purchased UCC in 2001. Chemicals abandoned at the plant continue to leak and pollute the groundwater¹⁰. Contamination at the site and surrounding area was not caused by the gas leakage. The area around the plant was used as a dumping ground for hazardous chemicals and by 1982 water wells in the vicinity of the UCIL factory had to be abandoned¹¹.

Following the events of December 3, 1984 environmental awareness and activism in India significantly increased. The Environment Protection Act was passed in 1986, creating the Ministry of Environment and Forests (MoEF). This act is definitely strengthening India's commitment to the environment. Under the new act, the MoEF has been given overall responsibility for formulating, administering and enforcing all environmental laws and policies. It established the importance of integrating environmental strategies into all industrial development plans for the country¹⁰.

Nomenclature

1. ICMR Indian Council of Medical Research
2. MIC Methyl Isocyanide
3. MMA mono methyl amine
4. MoEF Ministry of Environment and Forests
5. UCIL Union Carbide India Ltd
6. UCC Union Carbide Corporation
7. WHO World Health Organisation.

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