Editorial

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Exposure Assessment of Chemical Incidents: Lesson from Methyl Isocyanate (MIC) Gas Disaster

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Editorial

Advancement in tools and technologies in every sphere of today's development poses a potential hazard to animal and plant kingdom and the environment as a whole. Acute chemical incidents release toxicants that may cause acute illness or death and leave multiples of chronic morbidity. Lack of preparedness for accident management, including medical intervention, and rehabilitation, may lead to 'methyl isocyanate (MIC)'-type disaster and destroy the living environment. MIC-gas leak in Bhopal on 2-3 December, 1984 has become a historical event as the world's worst disaster by killing >10000 human beings within a month and disabling millions with respiratory distress, eye opacity and other long-term illness as sequel of acute effects [1-5]. The 'blame-game' between the local authorities and the parent company in USA, and involvement of the politicians created nightmares for the survivors who basically belonged to the poor socio-economic status (SES) and were battling for life with extreme health problems on one hand, and suffering from financial crisis on the other. Truly, Bhopal-incident had excited the global scientific fraternity for carrying out investigation on MIC's toxicity in different experimental systems, including the gas victims. Unfortunately, the 'grave' situation could not draw any attention of the scientific community to exposure-response estimates and risk-assessments on future health of the survivors and their progenies.

The International Medical Commission on Bhopal (IMCB) was constituted in 1993 with fifteen representatives from twelve countries, and demonstrated exposure-relationship after 10 years [6,7]. Distance as 'surrogate of exposure' was claimed by IMCB to be the authentic tool for classification of MIC-exposed population [8,9] which has challenged the mortality-based classification of Indian Council of Medical Research (ICMR) carried out in the immediate aftermath (during 3-6 December, 1984) of the tragedy. Uncertainty in atmospheric dispersion of gas and recall of activities during exposure, lack of pre-MIC-disaster health information, etc. were potential confounders for assessment of exposure index after 10 years, especially for illiterate or semiliterate people of poor SES. The two important issues such as 'windows open' and 'one-half of IMCB study-subjects either ran, walked or left home' raised question on IMCB's exposure index because it is unlikely that the residents of the thatched or 'kachha' houses would leave their windows open on a winter night. Also, survival of individuals who came out of their houses during gas leak was really up to luck because they were exposed to higher density of gas cloud if they came out, and risked instant mortality. Therefore, it is imperative that estimation of exposure index relies on some criteria, most importantly how soon to perform and how to design the program, specifically for highly reactive chemicals such as MIC. Thus, the data collected during the late phase may not predict the events that occurred during the early phase.

The data collected by ICMR on different medical conditions for initial risk-assessment and also from the follow-up health study have been published as internal reports [10] but not as peer-reviewed scientific documents and thus, remained unknown. A collaborating effort between IMCB and ICMR could have extracted reliable information on exposure index for assessment of health-risk and developed a dispersion model. Instead, a scientific debate has been generated on the topic out of conflicts. Certain short-term effects could also have been linked to the exposure status. Both ICMR and IMCB investigations did not have data on environmental sampling and dispersion, and components of environmental air other than MIC. However, ICMR had collected biological samples from mortality-based cohorts shortly after the exposure, whereas IMCB has conducted a questionnaire-based survey and spirometric investigation after a decade. Nevertheless, recall-bias, time from incidence-to-assessment and sampling along the straight line from UCIL (considering 'distance as surrogate of exposure') at 2 km intervals were significant confounders in IMCB-study for drawing an outline on mathematical calculation of exposure-index [11]. The indoor ozone quality model of Hayes et al. [12] may not be useful for Bhopal because the released substances may only be present for a limited period of time. Thus, absence of environmental sampling led to further uncertainties about the IMCB exposure-index. IMCB could have investigated few of the ICMR cases in a similar way for generating a reliable outcome of their investigation, instead of creating an unfavorable scientific debate based on the investigation carried out on small sample sizes after 10 years. The health study of Amsterdam plane crash conducted after six years was described as ‘very late’ for exposure assessment [13] which may generate inadequate and inaccurate information. Also chemical substances do not disperse uniformly in the environment. Chemicals with short half-life can only be measured in the early phase of exposure. Poor communication between different study groups was earlier reported by Dhara et al [11]. Transagency collaboration is suggested to collate information contributed by different study groups and stakeholders [14]. A retrospective analysis of the crude data generated through ICMR-investigations can still give an insight on the health hazard occurred at the early phase, and direct strategic investigation of future health and/or long-term effect of MIC, and resolve the issue of inconclusive outcome of MIC-exposure on human health.

Chemical incidents can be diverse as different chemicals can release different harmful and reactive substances after coming in contact with environmental agents. The major chemical incidents of the recent past have some or the other type of insufficient information for generating a reliable design for assessment of human health [13]. Assessment of individual exposure is not an easy task to rule out an association between exposure and observed adverse effects, which may vary for different chemicals. Thus, a method of accurate and comprehensive data collection of exposure at early and late phase will be invaluable for health studies, and combining investigational data collected through different methods may be useful to minimize bias and inaccuracy-related uncertainties. The aim of the present discussion is to control and minimize potential health risks of chemical incidents, and develop meaningful tools and strategies for future exposure assessments. An integral part of disaster management and understanding incident-related health risks relies on exposure data, which should at least include:

- Rapid exposure/risk assessment during chemical incident
- Defining/identification of the population at risk
- Individual exposure estimates for future follow-up
- Environmental sampling for identification of released components and estimation of their concentrations
- Meteorological information for making dispersion model of released substances
- Study of biological samples as early as possible after the incident for identification of biomarkers of the chemical incident
- Epidemiological health survey for surveillance with the aid of biological sampling and similar investigation for affected health-parameters in the follow-up studies.

Although rapid exposure assessment generates crude estimates, it can identify the needs and support quick tailoring of exposure assessment strategies, and all necessary information might not be possible to collect in the late phase.

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