Letter to the Editor

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Respiratory Health Risk Assessment of Exposure to Carcinogenic Chemicals: EPA Method

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Dear Editor

Human exposure and related health effects, especially cancer, is a topic that has been intensively researched in environmental studies in recent years (1, 2). Chemical exposure, which is a part of the total human exposome, is challenging to study because of the wide range of chemicals and their varying levels of exposure (3). Risk assessment methods have provided an opportunity to advance chemical hazard assessment for thousands of available chemicals (4). Environmental Protection Agency (EPA) is one of the risk assessment methods for carcinogenic compounds (5). It uses risk assessment to describe the nature and extent of risks to human health for various populations, including workers. Risk assessment is often an iterative process. Assessors review the primary information to identify factors likely to have the greatest impact on risk (6). In the following, we will describe the chemical risk assessment method of EPA for carcinogenic compounds.

EPA Chemical Risk Assessment Method Steps

Identification of chemicals

At this stage, all the chemicals that the workers are exposed to should be identified. These materials include manufactured materials, stored in the warehouse, or consumable chemicals. Also, any of the materials may be in the form of liquid, solid, gas, vapor, or fume. Regardless of their physical state and whether control measures are in place, all substances must be identified and listed. Regardless of their physical state and whether control measures are in place, all substances must be identified and listed.

Assessment of Carcinogenic Risk

Health risk assessment is a four-step process including hazard identification, toxicity assessment, exposure assessment, and risk assessment. The purpose of hazard identification is to assess toxicity and determine the adverse effects of exposure to chemicals on human health. It is possible to evaluate the toxicity of a substance through the evaluation of dose-response relationships which is mainly done through animal studies and its results are generalized to humans. These relationships are finally presented in the form of reference doses by different organizations, including EPA, for each substance separately. The evaluation of exposure is also done using parameters such as the amount and duration of exposure. After analyzing data on

exposure and toxicity, the level of risk posed by the chemical is determined, and appropriate corrective measures are recommended.

Evaluation of exposure time

The first step in exposure assessment is to determine the duration of exposure to the chemical substance. According to the EPA definition of acute exposure, it usually lasts less than 24 hours. Sub-chronic exposure lasts from 30 days to approximately ten percent of a person's life, and chronic exposure lasts for more than ten percent of a person's life.

Determining the exposure pattern

After determining the duration of exposure, the pattern of exposure should be determined. The purpose of the exposure pattern is to determine the periods of exposure to a certain concentration of the desired chemical pollutant.

Exposure assessment

To evaluate the amount of exposure, there are several approaches; one of the most important of which has been widely used in risk assessment is the average chronic daily intake (CDI). In the risk assessment guide published by the EPA in 2009 regarding inhalation exposures, this parameter was introduced as exposure concentration (EC). The concentration of exposure depends on various factors including the amount of exposure to the chemical substance, and the number of hours, days, and years of exposure of people. As it is known, the first and most important step in assessing exposure is to determine the exact amount of exposure of people to chemicals. Thus, it is necessary to determine the concentration of the chemical substance through sampling and analysis before any action. After determining the exact amount of exposure, according to the exposure pattern specified in the previous step, the concentration of exposure is determined as follows.

A: Chronic and sub-chronic exposure

$$EC = CDI = (CA \times ET \times EF \times ED)/AT \quad (1)$$

B: Acute exposure:

$$EC = CA \quad (2)$$

EC = CDI: exposure concentration (mg/m3)

CA: average concentration of the desired chemical in the air (mg/m3 of air)

ET: exposure time per day (hours/day)

EF: exposure frequency, which indicates the number of exposure days per year (days/year).

ED: exposure duration in years.

AT: average time (the period in which the exposure is averaged in terms of days).

Table 1. The default values announced in the daily consumption calculation

Parameters	Values
ET	8 hours per day
EF	250 days in the year
ED	25 years of actual work experience
AT	AT=70 year × 365 day/year × 24 hour/day

Calculation of the weighted average exposure concentration

If the employees do not have a uniform work pattern, the following formula is used to calculate the exposure concentration:

$$EC_j = \Sigma (CA_i \times ET_i \times EF_i) \times ED_j / AT_j \quad (3)$$

EC j: average exposure concentration for a certain period (mg/m3)

CAi: average concentration of the desired chemical substance in the air for a certain period (mg/m3)

ET: exposure duration to a given concentration (CAi) (hours/days)

EF: exposure frequency (days/year)

ED: exposure duration to a given concentration (years)

AT: average exposure time (hours)

Assessment of long-term average exposure concentration

When workers are exposed to different concentrations of chemicals in different periods, the average concentration in the long term is calculated through the following equation:

$$EC_{LT} = \Sigma (EC_j \times ED_j) / AT \quad (4)$$

ECLT: long-term average exposure concentration

ECj: the average exposure concentration of the pollutant in the air in a short period

EDj: the length of the exposure period in the short term

AT: total exposure time

Calculation of additional risk of carcinogenesis

The evaluation of the toxicity of a chemical substance is done through the reference limits introduced by different organizations. One of these reference limits is inhalation unit risk (IUR) which can be accessed through the following link: https://oehha.ca.gov/media/downloads/crnr/appendixa.pdf. After extracting IUR, the amount of carcinogenic risk of a substance is determined through the following formula:

$$Risk = EC \times IUR \quad (6)$$

EC: exposure concentration (mg/m3)

IUR: carcinogenic unit risk (mg/m3)

Comparison of evaluation results with permissible limits

After calculating the risk, its amount is compared with the declared permissible limits (table 2).

Table 2. Comparison of evaluation results with permissible limits

Certain risk	Probabilistic risk	Possible risk	No carcinogenic risk
Risk > 0.0001	0.00001> Risk > 0. 0001	0.000001> Risk > 0. 00001	risk < 0.000001

CONCLUSION

EPA's risk assessment method is an international method and it emphasizes reducing the amount of pollutants to the lowest possible amount to protect the environment and human health, and it makes people work in safer conditions in their daily activities in the workplace, and it is approved by the World Health Organization.

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