Risk Management of Chemical Substances in Disaster : Phased Criteria Concept

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Introduction

Exposure level of chemical substances increases once disaster happen. For the risk management, it is essential to organize the concept for disaster response.
In this research, phased criteria concept is introduced as a concept of risk management in disaster.

Conclusion

Based on the introduced concept in this research, derivation of drinking water criteria for 396 chemical substance were attempted, and the values were compared with two types of data set. As the results of the comparison, application of the values in disaster seemed to be feasible for risk management in most of the chemicals.

Phased Criteria Concept

Acceptable risk level is determined by various factors. In disaster, it may be necessary to consider the acceptable risk levels which are different from normal situation. In this concept, acceptable level is divided into four phases which are determined by time after disaster and distance from disaster site.
The range of time and distance of each phase will depend on the scale and character of disaster, but as a concept, assumption of phases shown in table below is useful in the risk management.
In this research, derivation of environmental criteria values for air and water is attempted based on phased criteria concept.

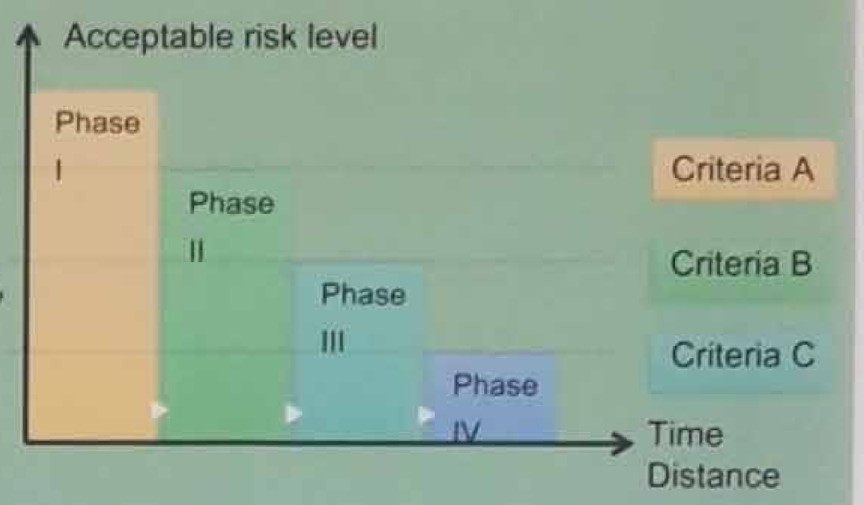

Table Draft idea of phased criteria concept

Phase	Time	Distance	Criteria for management	Acceptable risk level		Example of corresponding exposure level
				Noncarcinogen	Carcinogen	
I	Just after accident (~ few days)	Accident site (~ 10 m)	–			Higher than working environment
II	few days ~ a month	100 m	< Criteria A	No adverse effect level in general healthy people	Lower than 10^{-3} of excess lifetime cancer risk	Working environment
III	a month ~ a year	1 km	< Criteria B	No adverse effect level in all people	Lower than 10^{-4} of excess lifetime cancer risk	Lower than working environment
IV	few years	10 km	< Criteria C	No adverse effect level in chronic exposure	Lower than 10^{-5} of excess lifetime cancer risk	General environment (※Assumption of single route exposure)

Derivation of Drinking Water Criteria

For noncarcinogens, drinking water criteria values were derived, focusing on application of Uncertainty Factor (UF). Values of Point of Departure (POD) and UF were referred the data set for derivation of Reference Dose (RfD) in Integrated Risk Information System (IRIS) of U. S. EPA.

$$RfD = \frac{POD}{UF_A \cdot MF \cdot UF_H \cdot UF_L \cdot UF_S \cdot UF_D}$$

RfD : Maximum acceptable oral dose in lifetime exposure
POD: The beginning point for the low-dose extrapolation (e.g. NOAEL, LOAEL)
UF_A : Animal to human extrapolation
UF_H : Average group to sensitive subgroup extrapolation
UF_S : Subchronic to chronic extrapolation
UF_L : LOAEL to NOAEL extrapolation
UF_D : UF for database deficiency
MF : Modification factor with professional judgement

Figs. UF used for deriving each criteria for noncarcinogens.

$$\text{Criteria value (mg/L)} = RfD\ (\text{mg/kg/day}) \times 60(\text{kg}) \times 2(\text{L/day})$$

When Oral Slope Factors (OSF) for carcinogens were defined, it is assumed that corresponding excess lifetime cancer risk were 10^{-3}, 10^{-4} and 10^{-5} for criteria A, B and C, respectively.

$$\text{Criteria value (mg/L)} = \frac{\text{Cancer Risk}}{OSF(\text{mg/kg/day})^{-1}} \times 60(\text{kg}) \times 2(\text{L/day})$$

Phased criteria values for 396 chemical substances were derived, and the distribution of criteria values were shown in Fig. 1. Criteria values distributed in wide range between 10^{-8} ~ 10^{4} mg/L.

Values of each chemicals were compared with 2 types of data set.

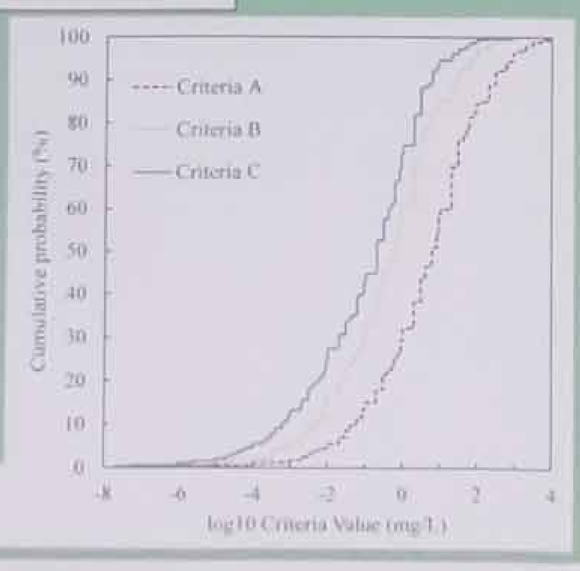

Fig.1 Cumulative log-normal distribution of criteria values.

1. Comparison with WHO Guideline Value (GV)

65 chemicals are overlapping

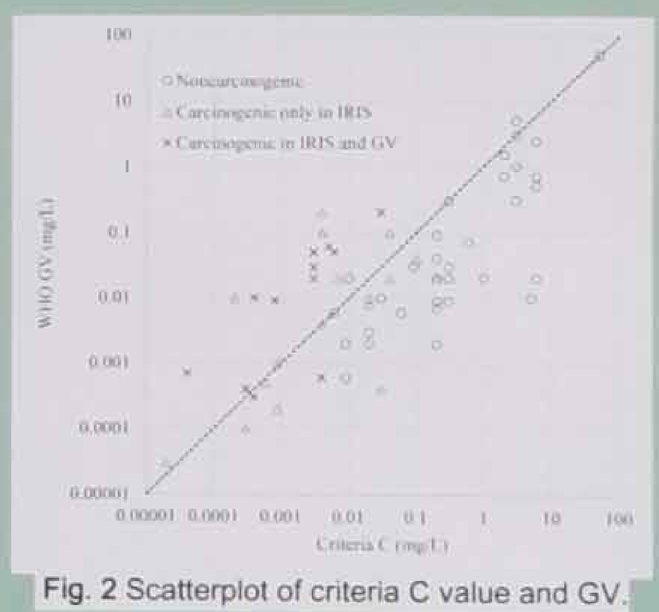

Fig. 2 Scatterplot of criteria C value and GV.

Distinctly different trend of the distribution was observed in carcinogenic and noncarcinogenic chemicals.

For noncarcinogen, criteria C tended to be larger than GV. The main factor of this difference is the consideration of application of drinking waters. Therefore, the criteria value would be enough acceptable level in case that the exposure from drinking water is main exposure route.

For carcinogens, the criteria values might need to be changed to upper side because it might be too safe level for the exposure of limited span in disaster.

2. Comparison with human oral toxicity information

Lowest toxic dose (LD) reported in TOXNET*
80 chemicals are overlapping

Range of LD /RfD ratio	Count C	B	A
10^3<	65	60	37
10^2~10^3	12	10	20
10 ~10^2	3	9	12
1~10	0	1	9
<1	0	0	2

In most chemicals, LD for human were much higher than criteria A value.

Safety in short-term exposure would be guaranteed even in the most high-risk level criteria.

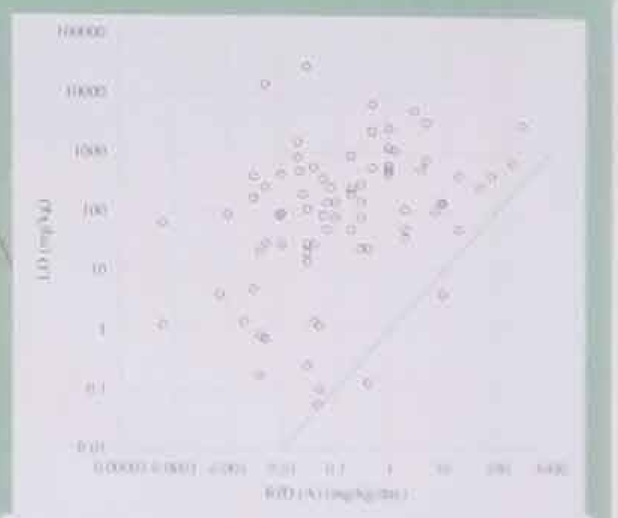

Fig. 3 Scatterplot of criteria A value and LD

*TOXNET: Toxicology databases of U.S. National Library of Medicine