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위해성 평가기법에 의한 오염지역 평가

Remedial Evaluation based on Risk Assessment

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I. Introduction

Cleanup criteria for contaminated soil and groundwater have many different forms. These include i) cleanup to background levels; ii) cleanup to existing standards or guidelines; iii) cleanup to levels protective of potentially exposed individuals as established by a health risk assessment; iv) cleanup to level established by a capability of the available remedial technologies; and v) combinations of the above.

Many countries have developed promulgated regulations defining acceptable levels of contamination in soil and groundwater. But in Korea, only soil guidelines of contamination and remediation have been established. In this paper, soil remediation criteria are essentially based on the legal limits and groundwater remediation goals are proposed based on risk assessment.

II. Risk based remediation goal

Frequently cleanup criteria are based on the specification of tolerable or acceptable health risks. This is often called Risk-Based Corrective Action (RBCA). To many, RBCA is synonymous with risk assessment, which is the scientific process for quantifying risks associated with exposure to chemicals in the

environment. To others, RBCA refers to a new philosophy for managing contaminant release sites. In this approach, decisions related to resource allocation, urgency of response, target cleanup levels, and remedial measures are based on current and reasonable potential risks to human health and environmental resources. It is this broader definition of RBCA that is utilized in the ASTM Guide for Risk-Based Corrective Action at Petroleum Release Sites. Applying the RBCA process to a given site may or may not involve the preparation of a formal risk assessment.

This may be achieved by reduction of contaminant concentrations, but it may also involve reducing the potential of exposure through the application of institutional controls, point-of-use water treatment, and the natural attenuation of contaminants. If exceeding of the selected target levels occurs and corrective action is necessary, the user develops a corrective action plan in order to reduce the potential for adverse impacts.

Ⅲ. Exposure assessment

An exposure assessment is the determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure for each potential or actual receptor population to be evaluated in the risk assessment. The exposure assessment has included i) characterizes the exposure setting to identify the potentially exposed receptors; ii) identifies exposure routes (develops a conceptual site model) and scenarios; iii) estimates the exposure concentration; and iv) calculates a chemical-specific intake or dose.

The study site is not currently used as an industrial facility. Future use is expected to remain as commercial property. The area of risk assessment is divided into 3 zones. A zone is the part of spill spots and B zone is the part of maximum plume area apart 200 m from a hot spot. And C zone is the surrounding of dormitory apart 400 m from the hot spot.

The A zone, where the petroleum storage tanks are located, currently has bare soil. The remainder of the site is covered with concrete or asphalt with partially grass. The area around the site consists of residential housing downgradient northwest of the site apart 600 m from the hot spots and commercial facilities to around the hot spots. Within the study site some wells

had been installed but all of the wells are no longer in use due to the groundwater contamination. Water for the site was supplied by a tap water onsite. There are no known nearby surface water withdrawals (for drinking water) located downstream off-site.

The nearest potentially exposed off-site receptor is the residence immediately to the northwest boundary of the site and it is also the nearest downgradient receptor. A creek flows from south to northwest direction of the site, and approximately 500 m downstream from the spill spots is the area of groundwater to surface water exposure pathway. Consumption of fish caught from the creek has not been reported. The exposure assessment for the site used existing data from the previous studies (Samsung, 1998) to determine remedial goal of groundwater. The chemical data for the site were used to determine the magnitude of exposure.

Figure 1 outlines exposure pathway of the site. Contaminated soil is the first source of the site contamination, and contaminated soil leaching to groundwater and contaminated groundwater are the second sources of contaminants. Contaminants including toluene are exposed to point of receptors by air pathways of vapors and groundwater transport pathways.

Ⅳ. Risk and remedial goal

Chemical-specific and risk-based remedial criteria are concentration goals for individual chemicals for specific medium and land use combinations. The risk-based remedial goals are derived from a specific excess lifetime cancer risk or hazard index. Risk-based remedial goals are initial guidelines that are protective of human health and the environment, based on readily available information. Risk-based remedial goals will be conducted during data evaluation of the baseline human health risk assessment as part of the identification of chemicals of potential concern (COCs). Contaminants detected above background (when available) for each exposure pathway are compared to chemical-specific, risk-based remedial goals for the residential scenario.

Toluene, ethylbenzene and xylene are generally considered as non-carcinogenic toxic chemicals and individual target hazard quotient and cumulative target hazard index is calculated. To characterize the overall potential

for non-carcinogenic effects associated with exposure to multiple chemicals, USEPA uses a Hazard Index (HI) approach. This approach assumes that simultaneous subthreshold chronic exposures to multiple chemicals that affect the same target organ are additive and could result in an adverse health effect. The target heath limits for non-carcinogenic toxic chemicals are 1. The media available for human contact are groundwater on-site and potential future receptors are on-site workers. Risks associated with off-site residential exposures to groundwater were evaluated relative to off-site migration of the plume to residential areas.

Table 1 shows the calculated baseline risk and proposed remedial goals based on site-specific contamination levels. Using the calculated levels, main risk of ground water is due to toluene in contaminated ground water and leaching soil. The risk of ground water is over target limits, so remediation is essentially needed. The goals of ground water remediation of areas A, B and C are 10 mg/L, 10 mg/L and 20 mg/L as toluene concentration, respectively, which are determined in consideration of soil remediation goals and soil leaching to groundwater.

Concentration reduction factor (CRF = contaminant concentration divided by remediation concentration) means degree of remediation works. Increasing a CRF value for a constituent will lower the target concentration of contaminant and reduce the associated baseline risk. Remediation of groundwater has higher CRF value than that of soil. Therefore groundwater cleanup is relatively hard and difficult. As cumulative risk level of on-site is summation of soil risk and groundwater risk, optimal resultant cleanup goal is relatively lower soil cleanup criteria than legal level and a little increase of CRF of groundwater. Therefore risk based soil cleanup levels of the zones A, B and C are proposed to 35 mg/kg, 50 mg/kg and 80 mg/kg as toluene concentration, respectively.

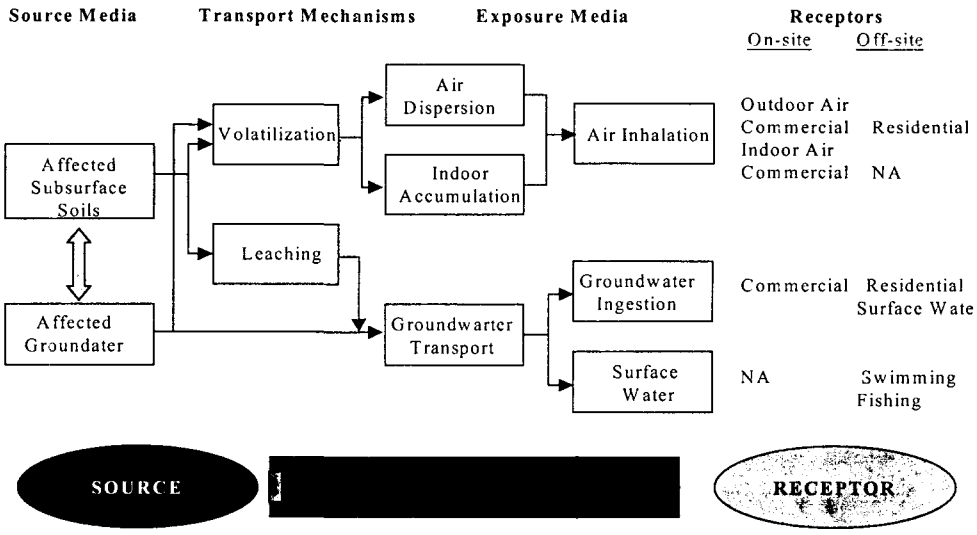

Figure 1. Exposure pathway flowchart

TABLE 1. Baseline risk and proposed remedial goals

a) A zone

COC	Risk		Cleanup criteria		CRF	
	on-site	residential	ground water[b]	soil[c]	ground water	soil
Toluene	15[a]	2.4[a]	10	35	25	15
Ethylbenzene	2[a]	<1	0.7	2	25	15
Xylene	<1	<1	0.7	2	25	15

b) B zone

COC	Risk		Cleanup criteria		CRF	
	on-site	residential	ground water	soil	ground water	soil
Toluene	24[a]	6.7[a]	10	50	35	6
Ethylbenzene	1	<1	-	2	35	6
Xylene	<1	<1	-	2	35	6

c) C zone

COC	Risk		Cleanup criteria		CRF	
	on-site	residential	ground water	soil	ground water	soil
Toluene	9.8[a]	6.8[a]	20	80	10	2.5
Ethylbenzene	<1	<1	0.5	4	10	2.5
Xylene	<1	<1	0.5	4	10	2.5

[a] above baseline risk (HI = 1)

[b] unit = mg/L