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Ecological Risk Assessment of Arsenic in Soil Environment: Screening Level Approach

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ABSTRACT

Arsenic (As) is of concern in soil environment. High levels of arsenic are present in some agricultural areas because arsenic compound have been used extensively as pesticides, herbicides, and fungicides. The concentration of arsenic in abandoned mines and industrial areas are also significant. The inorganic forms of arsenic are most found as arsenite (As III) or arsenate (As V). Arsenate is the dominant species under oxidizing conditions. In this study, soil toxicity data of arsenic were obtained by plant assay. The effect of arsenite and arsenate on the seed germination and seedling growth were also investigated in order to compare the sensitivity of plant species to arsenic. Ecological risk of arsenic was characterized by comparing predicted no-effect concentration (PNEC) with predicted exposure concentration (PEC). PNEC of arsenic was estimated based on the plant toxicity data, and PEC was obtained from the monitoring data of Korean Environmental Protection Agency.

Arsenic species were obtained as sodium arsenate dibasic heptahydrate, Na_2HAsO_4 $7H_2O$ (98%, Yakuri, Japan) and sodium (meta)arsenite, $NaAsO_2$ (>99%, Fluka). The natural field soil used was a sandy loam soil (pH 7.1, 2.64 percent organic matter) collected from the campus of Konkuk University (Seoul, Korea). Test plants were mung bean, wheat, barely, cucumber, sorghum, chinese cabbage, broccoli, kale, mustard, and pea. Ten test species were exposed to different concentrations of arsenic for five days. Each test unit contained 0.1kg or 0.05kg soil as dry weight depending on seed size. Moisture content was adjusted to 40 %. Distilled water without arsenic was used as the control. Toxic levels of arsenic were determined by measuring the median lethal concentration (LC50), the median effective concentration (EC50), the no-observed-effective concentration (NOEC), and lowest-observed-effective concentration (LOEC)

endpoints for seed germination and early seedling growth. The EC50 values for the test plants were in the range of 11 to 279 mg As/kg soil dry weight. The most sensitive and resistant plants tested were mung bean and sorghum, respectively. PNEC was derived from the EC50 values divided by assessment factor of 1000, which is the proposed value by OECD guidelines.

To determine the PEC of arsenic in soil environment, arsenic data were obtained from the ministry of environment in Korea. Arsenic levels of 16 districts in Year 2004 were available. The concentrations of As in total monitoring data range from 0.000 to 128.000 with an average of 0.517 mg/kg. Mean concentrations of As in each areas were selected for the risk characterization. PEC was compared with the PNEC to determine the risk values, as shown in Figure and Table.

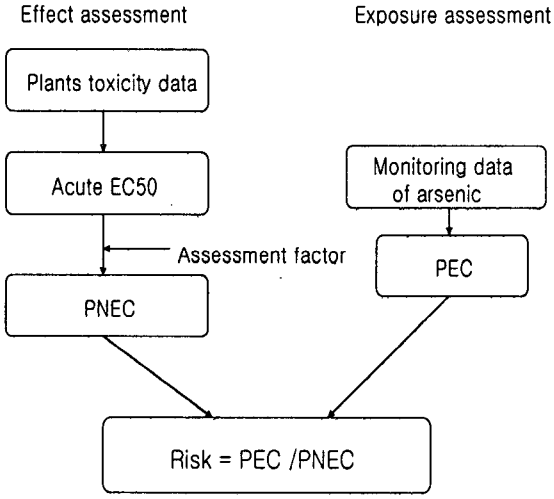

Fig. Scheme of the ecological risk assessment

Table. Ecological risk values of arsenic

district	mean As	When PNEC is 0.340 risk	0.356 risk	0.371 risk
total	0.517	1.521	1.453	1.394
Seoul	0.272	0.799	0.764	0.733
Busan	0.659	1.939	1.852	1.777
Deagu	0.486	1.431	1.367	1.311
Incheon	0.075	0.219	0.209	0.201
Gwangju	0.631	1.856	1.772	1.701
Deajeon	0.167	0.493	0.470	0.451
Ulsan	1.461	4.298	4.105	3.939
Gyeonggi	1.233	3.627	3.464	3.324
Kangwon	0.173	0.507	0.485	0.465
Chungbuk	0.539	1.586	1.514	1.453
Chungnam	0.621	1.827	1.745	1.675
Jeonbuk	0.054	0.159	0.152	0.146
Jeonnam	0.162	0.475	0.454	0.435
Kyeongbuk	1.204	3.541	3.382	3.245
Kyeongnam	0.140	0.411	0.393	0.377
Jeju	0.034	0.101	0.097	0.093

When the risk quotient (PEC/PNEC) is equal or greater than 1, it is considered that there could be a higher or perhaps unacceptable environment risk. Among areas evaluated, Ulsan showed the highest risk to arsenic, probably because Ulsan is the major industrial city in Korea, and arsenic may discharged from the many factories. This is a screening level of ecological risk assessment of arsenic in soil environment. The uncertainty of risk values estimated will be reduced when more data of arsenic toxicity are accumulated.

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