Environmental Geochemistry and Health

Spatial distribution and health risk assessment of soil petroleum hydrocarbons at an oil refinery in northwest China

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Appendix A

Cancer risk assessment

The calculation formulas of carcinogenic risk of single pollutant in the soil：

Pathway of the oral intake

$$CR_{ois} = OISER_{ca} \times C_{sur} \times SF_o \quad \text{Eq.(A.1)}$$

C_{sur}—Concentration of pollutants in the surface soil，mg/kg

Pathway of the skin contact

$$CR_{dcs} = DCSER_{ca} \times C_{sur} \times SF_d \quad \text{Eq.(A.2)}$$

Inhalation pathway of the soil particles

$$CR_{pis} = PISER_{ca} \times C_{sur} \times SF_i \quad \text{Eq.(A.3)}$$

Inhalation of gaseous pollutants from surface soil in the outdoor air

$$CR_{iov1} = IOVER_{ca1} \times C_{sur} \times SF_i \quad \text{Eq.(A.4)}$$

Pathways of inhaling gaseous pollutants from lower soil into the outdoor air

$$CR_{iov2} = IOVER_{ca2} \times C_{sub} \times SF_i \quad \text{Eq.(A.5)}$$

C_{sub}—The concentration of pollutants in the lower soil，mg/kg

Inhalation of gaseous pollutants from lower soil in the indoor air

$$CR_{iiv1} = IIVER_{ca1} \times C_{sub} \times SF_i \quad \text{Eq.(A.6)}$$

Risk calculation formula for all exposure pathways of single pollutant in the soil :

$$CR_n = CR_{ois} + CR_{dcs} + CR_{pis} + CR_{iov1} + CR_{iov2} + CR_{iiv1} \quad \text{Eq.(A.7)}$$

Hazard quotient assessment

The hazard quotient calculation formulas of single pollutant in the soil：

Pathway of the oral intake

$$HQ_{ois} = \frac{OISER_{nc} \times C_{sur}}{RfD_O \times SAF} \quad \text{Eq.(A.8)}$$

C_{sur}—Concentration of pollutants in the surface soil，mg/kg；

Pathway of the skin contact

$$HQ_{dcs} = \frac{DCSER_{nc} \times C_{sur}}{RfD_d \times SAF} \quad \text{Eq.(A.9)}$$

Inhalation pathway of the soil particles

$$HQ_{gis} = \frac{OISER_{nc} \times C_{sur}}{RfD_i \times SAF} \quad \text{Eq.(A.10)}$$

Inhalation of gaseous pollutants from surface soil in the outdoor air

$$HQ_{iov1} = \frac{OISER_{nc1} \times C_{sur}}{RfD_i \times SAF} \quad \text{Eq.(A.11)}$$

Pathways of inhaling gaseous pollutants from lower soil into the outdoor air

$$HQ_{iov2} = \frac{OISER_{nc2} \times C_{sub}}{RfD_i \times SAF} \quad \text{Eq.(A.12)}$$

Csub —The concentration of pollutants in the lower soil，mg/kg

Inhalation of gaseous pollutants from lower soil in the indoor air

$$HQ_{iiv1} = \frac{IIVER_{nc1} \times C_{sub}}{RfD_i \times SAF} \quad \text{Eq.(A.13)}$$

Non-carcinogenic risk of all exposure pathways of single pollutant in the soil :

$$HI_n = HQ_{ois} + HQ_{dcs} + HQ_{gis} + HQ_{iov1} + HQ_{iov2} + HQ_{iiv1} \quad \text{Eq.(A.14)}$$

Screning values

Soil

$$HCVS_n = \frac{AHQ \times SAF}{\frac{OISER_{nc}}{RfD_o} + \frac{DCSER_{nc}}{RfD_d} + \frac{PISER_{nc} + IOVER_{nc1} + IOVER_{nc2} + IIVER_{nc1}}{RfD_i}} \quad \text{Eq.(A.15)}$$

Groundwater

$$HCVG_n = \frac{AHQ \times WAF}{\frac{IOVER_{nc3} + IIVER_{nc2}}{RfD_i} + \frac{CGWER_{nc}}{RfD_o}} \quad \text{Eq.(A.16)}$$

Detection rate

$$\text{Detection rate} = \frac{\text{Detection samples number}}{\text{all samples number}} \quad \text{Eq.(A.17)}$$

Exceeding rate

$$\text{Exceeding rate} = \frac{\text{Exceeding samples number}}{\text{all samples number}} \quad \text{Eq.(A.18)}$$

Appendix B

Table S1 The non-carcinogenic risk of TPH(C10-C40) and its components in soil

Depth	Contaminants	Concentration (mg/kg)	HQois	HQdcs	HQpis	HQiov1	HQiov2	HQiiv1	HIn
0-6.5m	TPH（C10-C40）	30000.0	1.66E+00	5.03E+00	-	-	-	-	6.69E+00
	Aliphatic hydrocarbon（C10-C12）	8790.0	1.95E-01	2.36E-01	8.90E-04	6.34E+00	4.76E-01	5.04E-01	7.75E+00
	Aliphatic hydrocarbon（C13-C16）	3840.0	8.51E-02	1.03E-01	3.89E-04	1.29E+00	4.53E-02	4.80E-02	1.58E+00
	Aliphatic hydrocarbon（C17-C21）	3780.0	4.19E-03	5.07E-03	-	-	-	-	9.25E-03
	Aliphatic hydrocarbon（C22-C40）	2430.0	2.69E-03	3.26E-03	-	-	-	-	5.95E-03
	Aromatic hydrocarbon（C10-C12）	5100.0	2.83E-01	3.42E-01	1.29E-03	3.15E+00	8.07E-02	8.52E-02	3.94E+00
	Aromatic hydrocarbon（C13-C16）	3090.0	1.71E-01	2.07E-01	7.83E-04	8.35E-01	9.38E-03	9.83E-03	1.23E+00
	Aromatic hydrocarbon（C17-C21）	2790.0	2.06E-01	2.49E-01	-	-	-	-	4.55E-01
	Aromatic hydrocarbon（C22-C40）	180.0	1.33E-02	1.61E-02	-	-	-	-	2.94E-02
6.5-14m	TPH（C10-C40）	10400.0	-	-	-	-	-	-	-
	Aliphatic hydrocarbon（C10-C12）	3047.2	-	-	-	-	4.76E-01	5.04E-01	9.80E-01
	Aliphatic hydrocarbon（C13-C16）	1331.2	-	-	-	-	4.53E-02	4.80E-02	9.33E-02
	Aliphatic hydrocarbon（C17-C21）	1310.4					-	-	-
	Aliphatic hydrocarbon（C22-C40）	842.4					-	-	-
	Aromatic hydrocarbon（C10-C12）	1768.0					8.07E-02	8.52E-02	1.66E-01
	Aromatic hydrocarbon（C13-C16）	1071.2					9.38E-03	9.83E-03	1.92E-02
	Aromatic hydrocarbon（C17-C21）	967.2					-	-	-
	Aromatic hydrocarbon（C22-C40）	62.4	-	-	-	-	-	-	-

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Contaminants	Concentration (mg/L)	HQois	HQdcs	HIn
TPH（C10-C40）	30.10	-	-	-
Aliphatic hydrocarbon（C10-C12）	8.82	1.70E+00	3.08E+00	4.78E+00
Aliphatic hydrocarbon（C13-C16）	0.04	3.13E-02	5.67E-02	8.80E-02
Aliphatic hydrocarbon（C17-C21）	0.02	-	-	-
Aliphatic hydrocarbon（C22-C40）	0.01	-	-	-
Aromatic hydrocarbon（C10-C12）	0.01	9.33E-06	1.43E-05	2.36E-05
Aromatic hydrocarbon（C13-C16）	0.02	4.94E-06	6.95E-06	1.19E-05
Aromatic hydrocarbon（C17-C21）	0.01	-	-	-
Aromatic hydrocarbon（C22-C40）	0.00	-	-	-