**Integrated risk assessment of potentially toxic elements and particle pollution in urban road dust of mega city of Pakistan**

**For submission**

**Human and Ecological Risk Assessment: An International Journal**

**SUPPLEMENTARY INFORMATION**

**Table S1:** Classification ofgeoaccumulation (Igeo), contamination factor (CF), ecological risk (Ei) and pollution index values.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Geoaccumulation Index value( Igeo)  | Pollution level | Contamination factor (CF) values | Contamination range | Ecological risk (Ei) range | Risk level | Pollution index(PI) values | Pollution level |
| Igeo < 0 | unpolluted  | CF< 1 | Low contamination factor | Ei < 40 | Low |  |  |
| 0 < Igeo ≤ 1 | unpolluted to moderately polluted | 1 ≤CF<3 | Moderate contamination factor | 40 ≤ Ei < 80 | Moderate | PI≤ 1 | Low |
| 1 < Igeo ≤ 2 | Moderately polluted | 3=CF<6 | Considerable contamination factor | 80 ≤ Ei< 160 | Higher | 1<PI≤ 3 | Middle |
| 2 < Igeo ≤3 | Moderately to heavily polluted | CF=6 | Very high contamination factor | 160 ≤ Ei< 320 | High | PI>3 | High |
| 3 < Igeo ≤ 4 | Heavily polluted |   |   | 320 ≤ Ei | Serious |  |  |
| 4 < Igeo ≤ 5  | Heavily to extremely polluted |   |   |   |   |  |  |
| Igeo > 5 | Extremely polluted |   |   |   |   |  |  |

Martin and Meybeck (1979); Chen et al., (2015); Muller (1969); Harikumar et al. ([2009](https://link.springer.com/article/10.1007/s10653-018-0091-2#CR24)); Hussain et al. ([2015](https://link.springer.com/article/10.1007/s10653-018-0091-2#CR27))

**Table S2.** Parameters along with symbols and values used to estimate the health risk in urbanized city.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | Symbol | Units | Values | References |
| Average time cancer | ATc | Days | 70 × 365 | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |
| Average daily dose |  | (mg/kg)/day |   |   |
| Average time non-cancer | ATnc | Days | 30 × 365 | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |
| Body weight | BW | Kg | 70a, 6b | USEPA (2002), Askarova and Mussagaliyeva, (2014 |
| Carcinogenicity slope factor | SF | Per (mg/kg)/day | Inhalation SF: 6.3(Cd), 0.84 (Ni), Pb (0.008) | Ferreira-Baptista and De Miguel, (2005) Lu *et al.* (2014), USDOE (2011) |
| Ingestion SF: 0.0085(Pb) |
| Chronic reference dose | RfD | Per (mg/kg)/day | Oral RfD: 0.001 (Cu), 0.0003 (Mn), 0.003 (Pb), 0.024 (Cd), 0.0035 (Ni), 0.3 (Zn) | (Askarova and Mussagaliyeva, 2014), Ferreira-Baptista and De Miguel (2005) |
| Dermal RfD: 0.012 (Cu), 0.046 (Mn), 0.00005 (Pb), 0.046 (Mn), 0.00001 (Cd), 0.005 (Ni) |
| Inhalation RfD:0.04(Cu), 0.00005(Mn), 0.0035 (Pb), 0.00001(Cd), 0.00005 (Ni) |
| Concentration of soil heavy metals | C | mg kg-1 |   |   |
| Dermal absorption factor | ABS | Unit less | 0.1 (Cd), 0.04 (Cr), 0.006 (Pb), 0.02 (Zn), 0.001 (Mn, Co) | HC (2004), Chen *et al.* (2015) and Kelepertzis (2014) |
| Exposed skin exposed surface area | SA | m2 | 5700a, 2800b | [(Askarova and Mussagaliyeva 2014)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR16) |
| Exposure duration | ED | Year | 30a, 6b | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |
| Exposure frequency | EF | Day year−1 | 350 | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |
| Ingestion rate | IngR | mg d−1 | 100a, 200b | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |
| Inhalation rate | InhR | m3day−1 | 20a, 7.6b | USEPA, (2002), Zheng *et al.* (2010) |
| Particular emission factor | PEF | m3kg−1 | 1.36E−09 | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |
| Skin adherence factor | SAF | mg/cm2 | 0.07a, 0.2b | [USEPA (2002)](file:///D%3A%5CNew%20project%5CTable1.xlsx#RANGE!CR72) |

aAdult and bChildern

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| Table S3: AQI criteria associated with PM concentration ranges |
| AQI | Concentration breakpoints of PM (µg m-3) | AQI Category |
| PM 2.5 | PM 10 | TSP |
| 0-50 | 0.0 – 12 | 0.0 – 54 | 0 – 104 | Good |
| 51-100 | 12.1 – 35.4 | 55 – 154 | 105 – 264 | Marginal (moderate) |
| 101-150 | 35.5 – 55.4 | 155 – 254 | 265 – 364 | Unhealthy for sensitive |
| 151-200 | 55.5 – 150.4 | 255 – 354 | 365 – 464 | Poor (unhealthy) |
| 201-300 | 150.5 – 250.4 | 355 – 424 | 465 – 524 | Very poor (very unhealthy) |
| 301-400 | 250.5 – 350.4 | 425 – 504 | 525 – 604 | Hazardous |
| 401-500 | 350.5 – 500 | 505 – 604 | 605 – 704 | Very Hazardous |
| >500 | >500 | >604 | > 704 | Very Critical |
| US-EPA Standard | 35 | 150 | 260 |  |

US EPA (2012) ; Gurjur *et al.* (2008)

**References**

Askarova MA and Mussagaliyeva AN. 2014. The ecological situation in contaminated areas of oil and gas exploration in Atyrau Region. Procedia Soc and Behav Sci 120: 455–459.

Chen H, Teng Y, Lu S, Wang Y, Wang J. 2015. Contamination features and health risk of soil heavy metals in China. Sci Tota Environ 512:143–153.

Ferreira-Baptista L, De-Miguel E. 2005. Geochemistry and risk assessment of street dust in Luanda, Angola: a tropical urban environment. Atmos Environ. 39: 4501–4512

Gurjar BR, Butler TM, Lawrence MJ, Lelieveld J. 2008. Evaluation of emissions and air quality in megacities. Atmos J 42:1593–1606.

Harikumar P, Nasir U and Rahman MM. 2009. Distribution of heavy metals in the core sediments of a tropical wetland system. Int J Environ Sci Technol 6(2): 225–232.

HC. 2004. Federal contaminated site risk assessment in Canada-Part II: Health Canada toxicological reference values (TRVs) and chemical-specific factors. Ottawa, Canada: HC Hussain R, Khattak SA, Shah MT, Ali L. 2015. Multistatistical approaches for environmental geochemical assessment of pollutants in soils of gadoonamazai industrial estate, Pakistan. J Soils Sedi 15(5): 1119-1129.

Kelepertzis E. 2014. Investigating the sources and potential health risks of environmental contaminants in the soils and drinking waters from the rural clusters in Thiva area (Greece). Ecotox Environ Safe 100: 258–265.

Lu X, Zhang X, Li LY & Chen H. 2014. Assessment of metals pollution and health risk in dust from nursery schools in Xi’an, China. Environ Res, 128: 27–34.

Martin J, and Meybeck M. 1979. Elemental Mass-Balance of Material Carried by Major World Rivers. Marine Chem 7(3):178-206. doi:10.1016/0304-4203(79)90039-2

Muller G, 1969. Index of geo-accumulation in sediments of the Rhine River. J Geochem Exp 2:108–118

US EPA. 2012. Revised air quality standards for particle pollution and updates to the air quality index (AQI). Office of air quality planning and standards, EPA 454/R99-010 USDOE .2011. The risk assessment information system (RAIS). U.S. Oak: Department of Energy’s Oak Ridge Operations Office (ORO).

USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington

Zheng N, Liu J, Wang Q, Liang Z. 2010. Health risk assessment of heavy metal exposure to street dust in the zinc smelting district, Northeast of China. Sci Tota Environ 408(4): 726–733.