# SUPPORTING INFORMATION

# Assessment of potentially toxic elements contamination in the soil of Greater Cairo, Egypt using geochemical and magnetic attributes

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**Table S1.** Summary of the formulae used to calculate the single and integrated indices.

| S/N | Pollution Index | Criteria/Categories | Reference |
|---|---|---|---|
| 1 | Enrichment Factor (EF) $$EF = (E/Al)_{Sample} / (E/Al)_{Crust}$$ | 1. EF < 2: no enrichment<br>2. EF = 2–5: moderate enrichment<br>3. EF = 5–20: significant enrichment<br>4. EF = 20-40: very high enrichment<br>5. EF > 40: extremely high enrichment | Loska et al. (2004)<br>Saha et al. (2017) |
| 2 | Geo-accumulation index ($I_{geo}$) $$I_{geo} = \log_2 (C_n/1.5 B_n)$$ | 1. $I_{geo}$ < 0: practically uncontaminated<br>2. $I_{geo}$ = 0-1: uncontaminated to moderately contaminated<br>3. $I_{geo}$ = 1-2: moderately contaminated<br>4. $I_{geo}$ = 2-3: moderately to heavily contaminated<br>5. $I_{geo}$ = 3-4: heavily contaminated<br>6. $I_{geo}$ = 4-5: heavily to extremely contaminated<br>7. $I_{geo}$ > 5: extremely contaminated | Müller (1969)<br>Förstner (1990) |
| 3 | Improved Nemerow's Pollution Index ($P_n$) $$P_n = \sqrt{(I^2_{geomax} + I^2_{geoave})/2}$$ | 1. $P_n$ = 0-0.5: practically uncontaminated<br>2. $P_n$ = 0.5-1: uncontaminated to moderately contaminated<br>3. $P_n$ = 1-2: moderately contaminated<br>4. $P_n$ = 2-3: moderately to heavily contaminated<br>5. $P_n$ = 3-4: heavily contaminated<br>6. $P_n$ = 4-5: heavily to extremely contaminated<br>7. $P_n$ > 5: extremely contaminated | Guan et al. (2014) |
| 4 | Pollution Load Index (PLI) $$PLI = (C_f^1 * C_f^2 * C_f^3 * \ldots * C_f^n)^{\frac{1}{n}}$$ $$C_f = C_{sample} / C_{background}$$ | 1. PLI < 1: unpolluted<br>2. PLI = 1-2: moderately polluted<br>3. PLI = 2-10: strongly polluted<br>4. PLI > 10: extremely polluted | Tomlinson et al. (1980)<br>Hakanson (1980)<br>Chon et al. (1996) |
| 5 | Potential Ecological Risk Index (PERI) $$PERI = \sum_i^n E_r^i$$ $$E_r^i = T_r^i * C_f^i$$ | 1. Class 1 (PERI ≤ 50: low risk)<br>2. Class 2 (50 < PERI ≤ 100: moderate risk)<br>3. Class 3 (100 < PERI ≤ 150: high risk)<br>4. Class 4 (150 < PERI ≤ 200: very high risk)<br>5. Class 5 (PERI > 200: extreme risk) | Hakanson (1980)<br>Guan et al. (2014) |

where $(M/Al)_{Sample}$ and $(M/Al)_{Crust}$ refer, respectively to the ration of the concentration of the target element E and Al in the soil samples and the upper continental crust. $C_n$ denotes the measured concentration of PTE n in a soil sample and $B_n$ denotes the concentration of PTE n in the upper continental crust. $I_{geomax}$ is the maximum $I_{geo}$ value and $I_{geoave}$ is the arithmetic mean value of $I_{geo}$. n is the number of elements studied and $C_f^n$ is contamination factor for $n^{th}$ element. $C_{metal}$ refer to element concentration in a soil sample, $C_{background}$ refer to concentration of that element in the upper continental crust. $E_r^I$ is potential ecological risk for $i^{th}$ PTE, $T_r^I$ is toxic response factor of $i^{th}$ PTE, $C_f^I$ is the contamination factor. Toxic response factor for Co, Cr, Cu, Hg, Ni, Pb, V, and Zn is 5, 2, 5, 40, 6, 5, 2, and 1, respectively (Hakanson, 1980; Guan et al., 2014; Chai et al., 2017; Khalifa and Gad, 2018).

# References

1. Chai, L.; Li, H.; Yang, Z.; Min, X.; Liao, Q.; Liu, Y.; Men, S.; Yan, Y.; Xu, J. Heavy metals and metalloids in the surface sediments of the Xiangjiang River, Hunan, China: distribution, contamination, and ecological risk assessment. *Environ. Sci. Pollut. Res.* **2017**, *24*, 874-885. https://doi.org/10.1007/s11356-016-7872-x.

2. Chon, H.T.; Cho, C.H.; Kim, K.W.; Moon, H.S. The occurrence and dispersion of potentially toxic elements in areas covered with black shale's and slates in Korea. *Appl. Geochem.* **1996**, 11, 69-76. https://doi.org/10.1016/0883-2927(95)00061-5.

3. Förstner, U*Contaminated Sediments*; Lecture Notes in Earth Science, 21; Springer: Berlin, Germany, 1990.

4. Guan, Y.; Shao, C.; Ju, M. Heavy metal contamination assessment and partition for industrial and mining gathering areas. *Int. J. Environ. Res. Public Health* **2014**, *11*, 7286–7303. https://doi.org/10.3390/ijerph110707286.

5. Hakanson, L. An ecological risk index for aquatic pollution control: A sedimentological approach. *Water Res.* **1980**, *14*, 975–1001. https://doi.org/10.1016/0043-1354(80)90143-8.

6. Khalifa, M.; Gad, A. Assessment of heavy metals contamination in agricultural soil of southwestern Nile Delta, Egypt. *Soil. Sediment. Contam.* **2018**, *27*, 619–642. https://doi.org/10.1080/15320383.2018.1498445.

7. Loska, K.; Wiechula, D.; Korus, I. Metal contamination of farming soils affected by industry. *Environ. Int.* **2004**, *30*, 159–165. https://doi.org/10.1016/S0160-4120(03)00157-0.

8. Müller, G. Index of geoaccumulation in sediments of the Rhine River. *Geo. J.* **1969**, *2*, 108–118.

9. Saha, J.K.; Selladurai, R.; Coumar, M.V.; Dotaniya, M.L.; Kundu, S.; Patra, A.K. *Soil Pollution—An Emerging Threat to Agriculture*; Springer Nature: Singapore, 2017.

10. Tomlinson, D.C.; Wilson, D.J.; Harris, C.R.; Jeffrey, D.W. Problem in heavy metals in estuaries and the formation of pollution index. *Helgol. Meeresunters* **1980**, *33*, 566–575. https://doi.org/10.1007/BF02414780.