Electronic Supplementary Material (ESI) for Environmental Science: Processes & Impacts.

Table S1: Mathematical equations with the importance of Geo-environmental and ecological indices.

	Indices	Mathematical equations	Classifications	Contamination degree	References
Geo-environmental indices	Geo-accumulation index (I_{geo})	$I_{geo} = log_2\left(\frac{C_n}{1.5 \times B_n}\right)$ Where, C_n is the measured elemental concentration in sediment and B_n is the background heavy metal concentrations	$I_{geo}<0$ $0 \le I_{geo}<1$ $1 \le I_{geo}<2$ $2 \le I_{geo}<3$ $3 \le I_{geo}<4$ $4 \le I_{geo}<5$ $I_{geo} \ge 5$	Practically uncontaminated Uncontaminated to moderately contaminated Moderately contaminated Moderately to heavily contaminated Heavily contaminated Heavily to extremely contaminated Extremely contaminated	Müller (1979); Kumar et al. (2022); Kumar et al. (2021)
	Contamination factor (CF)	$CF_{metals} = \frac{C_n}{B_n}$ Where, C_n and B_n are the measured and background elemental concentrations in sediment respectively	$CF<1$ $1 \le CF<3$ $3 \le CF<6$ $CF \ge 6$	Low contamination Moderate contamination Considerable contamination Very high contamination	Hakanson (1980); Kumar et al. (2022); Kumar et al. (2021)
	Degree of contamination (C_d)	$C_d = \sum_{i=1}^{n} CF_i$ where, CF is the contamination factor	$C_d<8$ $8 \le C_d<16$ $16 \le C_d<32$ $C_d \ge 32$	Low contamination Moderate contamination Considerable contamination Very high contamination	Kumar et al. (2022); Hakanson (1980)
	Modified degree of contamination (mC_d)	$mC_d = \frac{1}{n}\sum_{i=1}^{n} CF_i$ where, CF is the contamination factor	$mC_d<1.5$ $1.5 \le mC_d<2$ $2 \le mC_d<4$ $4 \le mC_d<8$ $8 \le mC_d<16$ $16 \le mC_d<32$ $mC_d>32$	Nil to very low contamination Low contamination Moderate contamination High contamination Very high contamination Extremely high contamination Ultra high contamination	Abrahim and Parker (2008); Kumar et al. (2021); Kumar et al. (2022)
	Enrichment factor (EF)	$EF = \frac{\left(C_n/Al\right)sample}{\left(B_n/Al\right)background}$ Where, C_n is the measured elemental concentration in sediment and B_n is the background heavy metal concentrations	$EF = 1$ $1 \le EF < 1.5$ $1.5 \le EF < 3$ $3 \le EF < 5$ $5 \le EF < 10$ $EF > 10$	Baseline data Possible anthropogenic origin Minor enrichment Moderate enrichment Severe modification Very severe modification	Tamim et al. (2016); Kumar et al. (2022); Islam et al. (2017)
	Pollution load index (PLI)	$PLI = \sqrt[n]{(CF_1 \times CF_2 \times \ldots CF_n)}$ where, CF is the contamination factor	$PLI = 0$ $PLI < 1$ $PLI > 1$	Perfection Baseline level Contaminated	Kumar et al. (2022); Kumar et al. (2021)

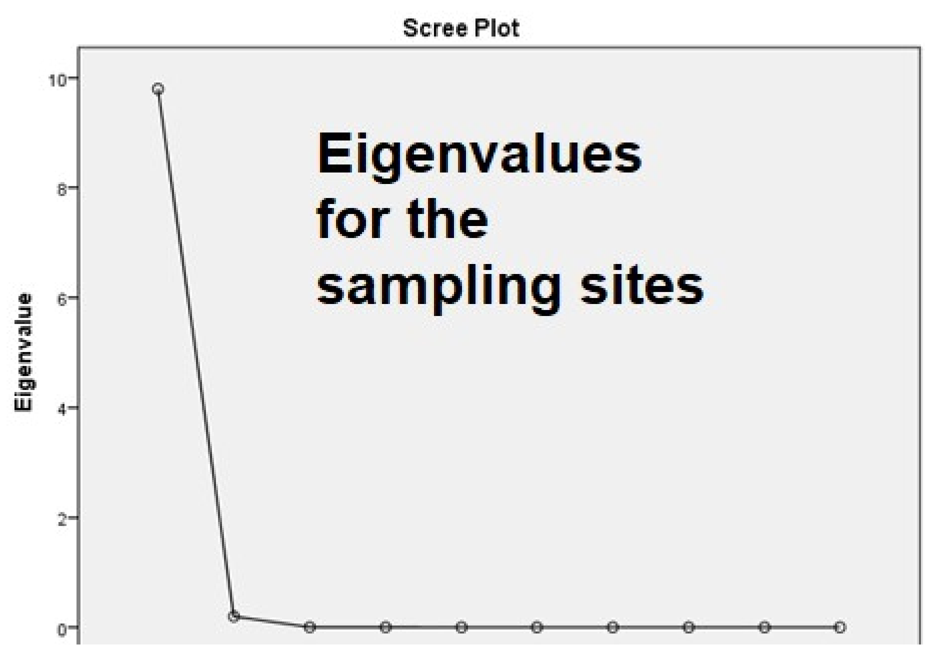
Sediment quality guideline based indices	Mean ERM Quotient (*M-ERM-Q*)	M-ERM-Q = $\frac{\sum_{i=1}^{n}\frac{C_i}{ERM_i}}{n}$ where, C_i is the concentration of element i, ERM_i is the ERM values for the element i and n is the number of element	M-ERM-Q < 0.1 0.11 ≤ M-ERM-Q < 0.5 0.51 ≤ M-ERM-Q < 1.5 M-ERM-Q > 1.5	9% probability of toxicity 21% probability of toxicity 49% probability of toxicity 76% probability of toxicity	Long et al. (2000); Islam et al. (2017)
	Toxic Unit analysis (*TU*)	$TU = \frac{C_M}{PEL}$ where, C_M is the concentration of heavy metal and *PEL* is the probable effect level. $\sum TUs = TU_{metal1} + TU_{metal2} + TU_{metal3} \ldots\ldots\ldots + TU_{metaln}$ where, ΣTUs is the sum of toxic units for metals in sediments	ΣTUs < 4 4 ≤ ΣTUs ≤ 6 ΣTUs > 6	Low toxicity level Moderate toxicity level Heavy toxicity level	Islam et al. (2020); Kumar et al. (2021)
	Environmental Toxicity Quotient (ETQ)	ETQ = $\frac{\sum_{i=1}^{n} TS_i \times {C_i}/{TS_{As}}}{n}$ where, C_i is the concentration of element i,and n is the number of analyzed elements. TS_i is the total score of each element and TS_{As} is the total score of arsenic published by Agency for Toxic Substances and Disease Registry (ASTDR). The ASTDR provided scores for each element are As = 1674, Pb = 1531, Cd = 1320, Co = 1013, Ni = 996, Zn = 915, Cr = 895, Cu = 807	ETQ < 10 10 ≤ ETQ ≤ 50 50 ≤ ETQ ≤ 100 100 ≤ ETQ ≤ 300 ETQ >300	Low toxicity level Moderate toxicity level High toxicity level Very High toxicity level Extremely High toxicity level	Maftei et al. (2019); Ali et al. (2018); ASTDR (2017)
Ecological indices	Potential ecological risk factor (Er^i)	$Er^i = Tr^i \times CF^i$ where, Tr^i is the biological toxic metal response factor (Cr=2, Mn=1, Zn=1, As= 10, and Sb= 10; Islam et al. 2017) and CF is the contamination factor	$Er^i < 40$ $40 \le Er^i < 80$ $80 \le Er^i < 160$ $160 \le Er^i < 320$ $Er^i > 320$	Low risk Moderate risk Considerable risk High risk Very high risk	Islam et al. (2017); Khan et al. (2020); Hakanson (1980)
	Potential ecological risk index (*RI*)	RI= $\sum_{i=1}^{n} Er^i$ where, Er^i is the potential ecological risk factor	RI < 150 150 ≤ RI < 300 300 ≤ RI < 600 RI ≥ 600	Low risk Moderate risk Considerable risk High risk	Islam et al. (2020); Khan et al. (2020)

Table S2: Health risk assessment factors including reference values.

	Unit	Value	Metal(oid)s	R_fD_{dermal} (mg.kg^{-1}.day^{-1})	SF_{dermal} (mg.kg^{-1}.day^{-1})	References
Exposure frequency (EF)	d/yr	350	Cr	3.00E-03	5.00E-01	Maftei et al. (2019)
Exposure duration (ED)	yr	30	Mn	1.84E-03		Kusin et al. (2018)
Body average weight (BW)	kg	70	Co	2.00E-02		Ferreira-Baptista & De Miguel, (2005)
Average day (AT)	days	10950	Zn	3.00E-01		Kusin et al. (2018)
Skin surface area (SA)	cm^2	5700	As	3.00E-04	1.50E+00	Kusin et al. (2018)
Adherence factor (AF)	mg/cm^2	0.07	Sb	8.00E-06		Kusin et al. (2018)
Dermal absorption factor (ABS)	n/a	0.001	Ba	4.90E-03		Ferreira-Baptista & De Miguel, (2005)
Conversion factor (CF)	kg/mg	1.00E-06	U	5.10E-04		Ferreira-Baptista & De Miguel, (2005)

Table S3: Varimax rotated principal component analysis of elemental variables in Teesta River, Bangladesh. Significant values are in bold face.

Elements	Principal Components			Sampling site	PC1
	PC1	PC2	PC3		
Na	.155	.088	**.926**	T1	**.975**
Al	.677	-.006	-.046	T2	**.982**
K	**.941**	-.044	.271	T3	**.999**
Ti	.617	.378	-.322	T4	**.999**
Cr	**.901**	.350	.103	T5	**.998**
Mn	-.185	.728	-.220	T6	**.997**
Co	**.964**	.131	.154	T7	**.959**
Zn	**.884**	.210	.037	T8	**.993**
As	**.881**	.069	-.081	T9	**.998**
Rb	**.961**	.026	.222	T10	**.999**
Sb	.723	-.167	-.314		
Cs	**.961**	.018	.180		
Ba	**.948**	.077	.223		
Th	.064	**.930**	.223		
U	.404	**.828**	.182		

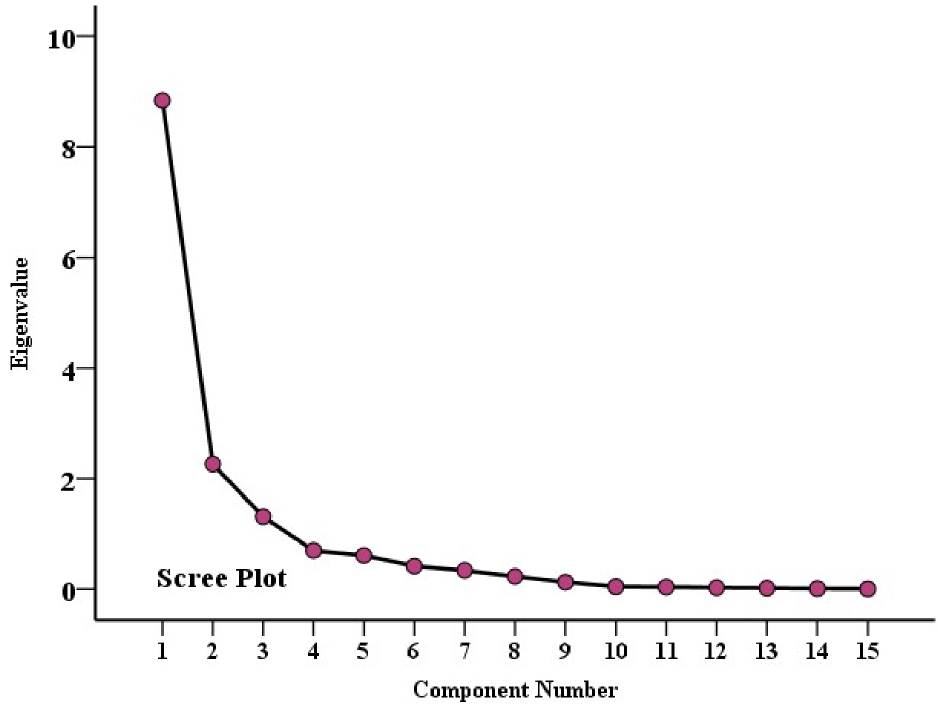


Eigenvalues	8.52	2.456	1.44		9.80
% of Variance	56.801	16.372	9.597		98.01
Cumulative %	56.801	73.173	82.770		98.01

Table S4: Correlations among the analyzed parameters for Teesta River sediment, Bangladesh.

	Na	Al	K	Ti	Cr	Mn	Co	Zn	As	Rb	Sb	Cs	Ba	Th	U
Na	1														
Al	.109	1													
K	.395*	.630**	1												
Ti	-.063	.501**	.451*	1											
Cr	.230	.580**	.862**	.621**	1										
Mn	-.113	-.099	-.180	.076	.072	1									
Co	.290	.615**	.946**	.551**	.936**	-.093	1								
Zn	.166	.469**	.804**	.565**	.902**	-.004	.906**	1							
As	.068	.522**	.810**	.550**	.793**	-.042	.847**	.773**	1						
Rb	.356	.641**	.984**	.534**	.895**	-.173	.959**	.831**	.833**	1					
Sb	-.128	.391*	.589**	.405*	.511**	-.202	.635**	.566**	.581**	.608**	1				
Cs	.282	.568**	.964**	.496**	.901**	-.186	.961**	.868**	.837**	.976**	.629**	1			
Ba	.321	.597**	.950**	.508**	.915**	-.169	.960**	.891**	.801**	.961**	.579**	.961**	1		
Th	.270	.010	.048	.330	.397*	.477**	.218	.245	.075	.122	-.118	.114	.185	1	
U	.267	.264	.370*	.472**	.654**	.354	.515**	.499**	.384*	.439*	.176	.439*	.484**	.886**	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed)



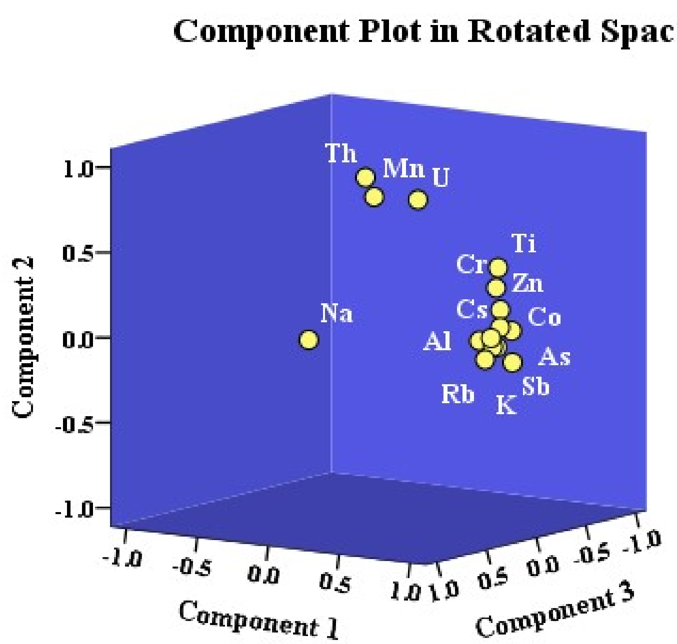


Fig. S1: Principal component analysis of the analyzed trace metal(oid)s by scree plot of the characteristic roots (eigenvalues) and component plot in rotated space.

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