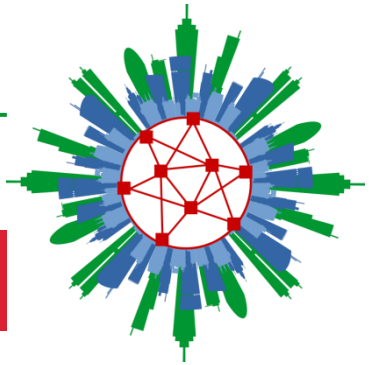
SuMoCoS

Sustainability and Mobility in the Context of Smart Cities

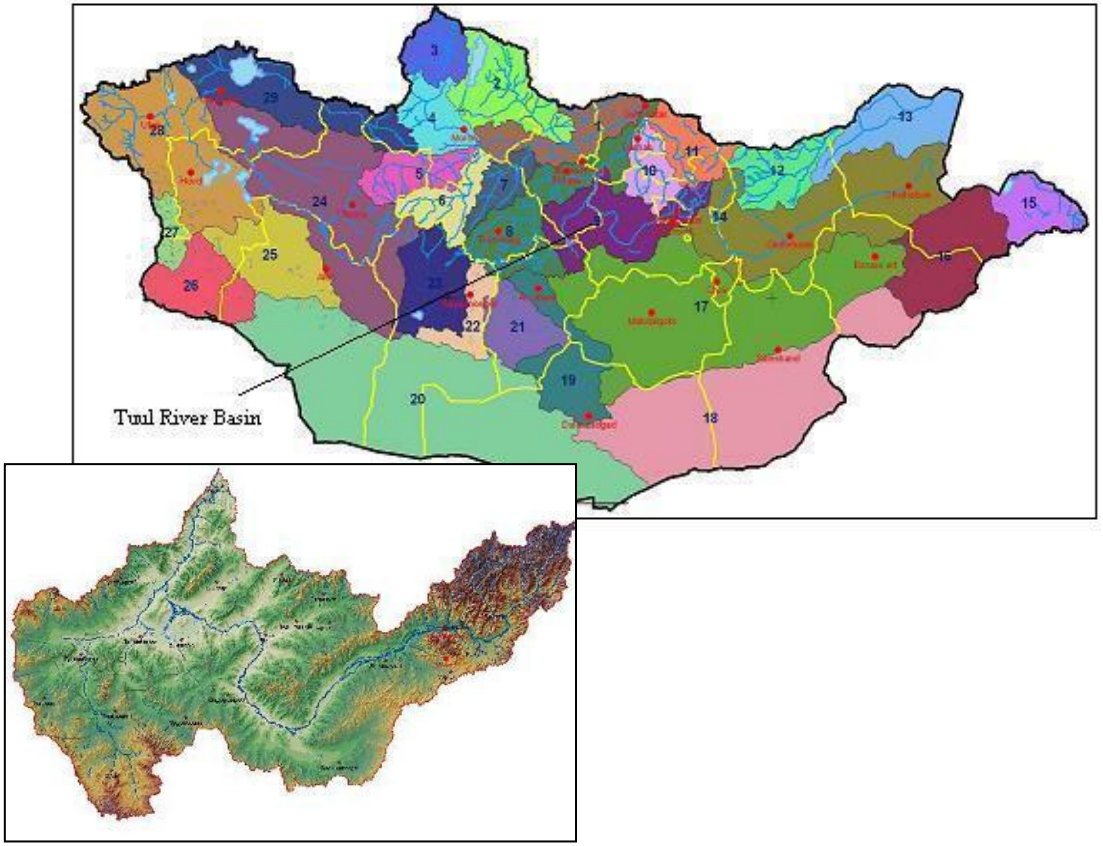


Spatial and Temporal Variations of Sediment Metals in the Tuul River, Mongolia

T.-O. Soyol-Erdene, S. Lin, E. Tuuguu, Dorj Daichaa, K-M. Huang, U. Bilguun, E-A. Tseveendorj

soyolerdene@seas.num.edu.mn

Tuul River and its pollution

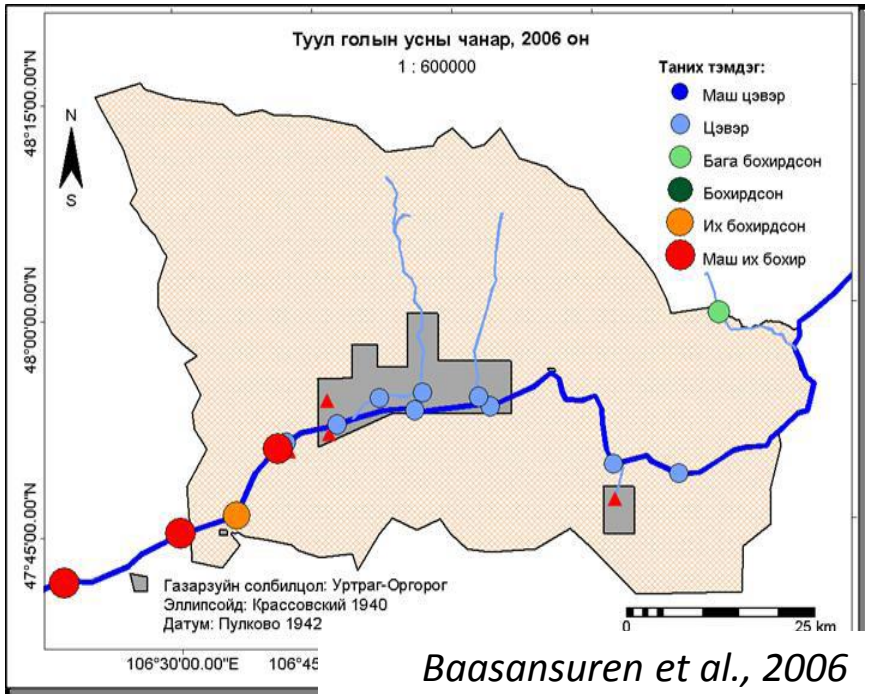


- **Flows across the Ulaanbaatar city**
- **Basin area equals to only 3.19% of whole country's area**
- **Lives more than half of the population.**
- **Main water resource of the Ulaanbaatar city and downstream area**

Tuul River pollution

- Polluted at downstream of the city
  - Impacted by maltreated sewage water discharge from the WWTP
  - Pollutants concentration reached up to 30 times higher than permissible level

Photo by Soyol-Erdene



Baasansuren et al., 2006

- Routinely monitor main several water quality parameters (major ions, BOD, COD etc)
- No data for toxic metals in water and sediments

Objectives

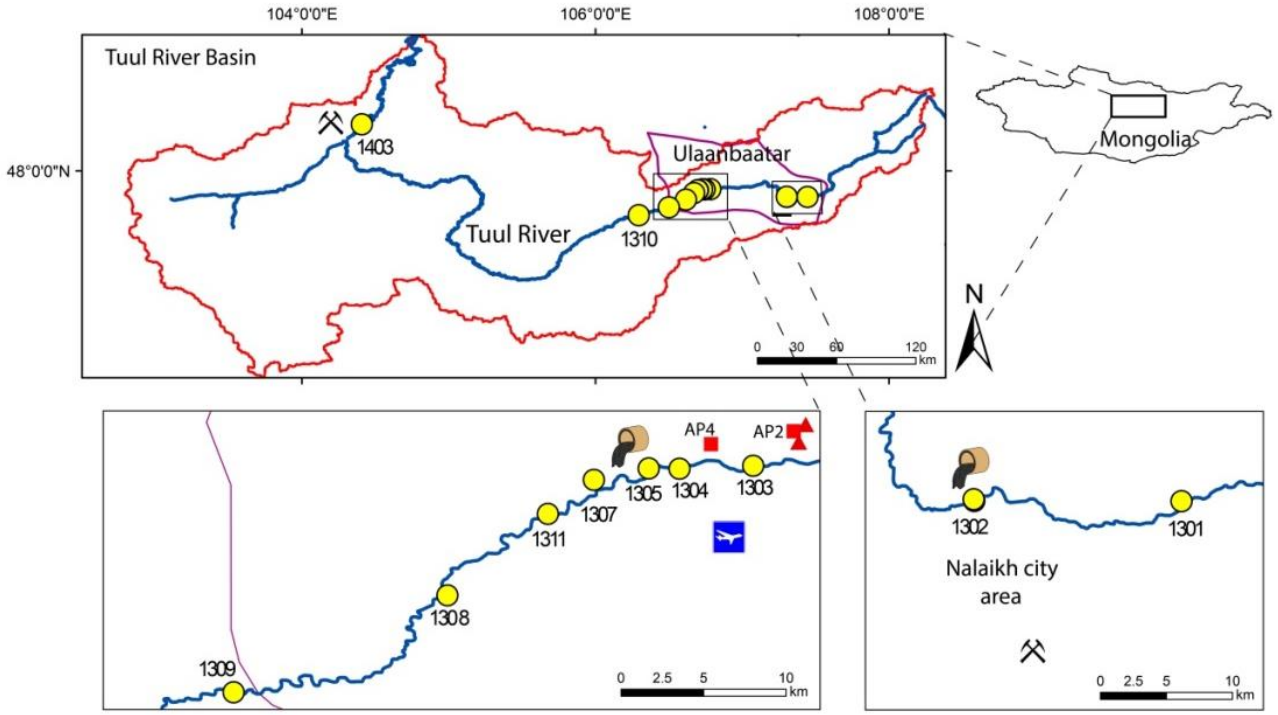
Part 1 (Tuul River basin)

- to identify spatial distribution of sediment metals
- to evaluate anthropogenic contribution
- to establish metals vertical profiles and historical variations
  - Source evaluation
- to asses ecological risk by SQG

Part 2 (Near CWWTP)

- To investigate pollution degree at downstream of UB city
- to evaluate anthropogenic contribution
- to assess ecological risk by RAC

Study area and sampling



Rough investigation for 500 km stretch

- 2013-2014
- 12 sites
  - Upper
  - Urban
  - Municipal sewage drainage
  - Gold mine
- Up to 50 cm core samples
  - Sliced by 1 cm

Materials and Methods

- Sample preparation for metal analyses
  - Acid digestion : Aquaregia & four acid mix

- Al, Fe, Cu, Zn, Pb, Ni, Cd, Hg, Cr, As, and U analyses
  - By AAS at National Taiwan University
  - By ICP-OES at Minho University, Portugal
  - By ICP-MS at SGS international Laboratory, Ulaanbaatar, Mongolia

- Age dating by Pb210 method
  - Alpha counting of Po210, National Taiwan University

Results and Discussion – Part 1

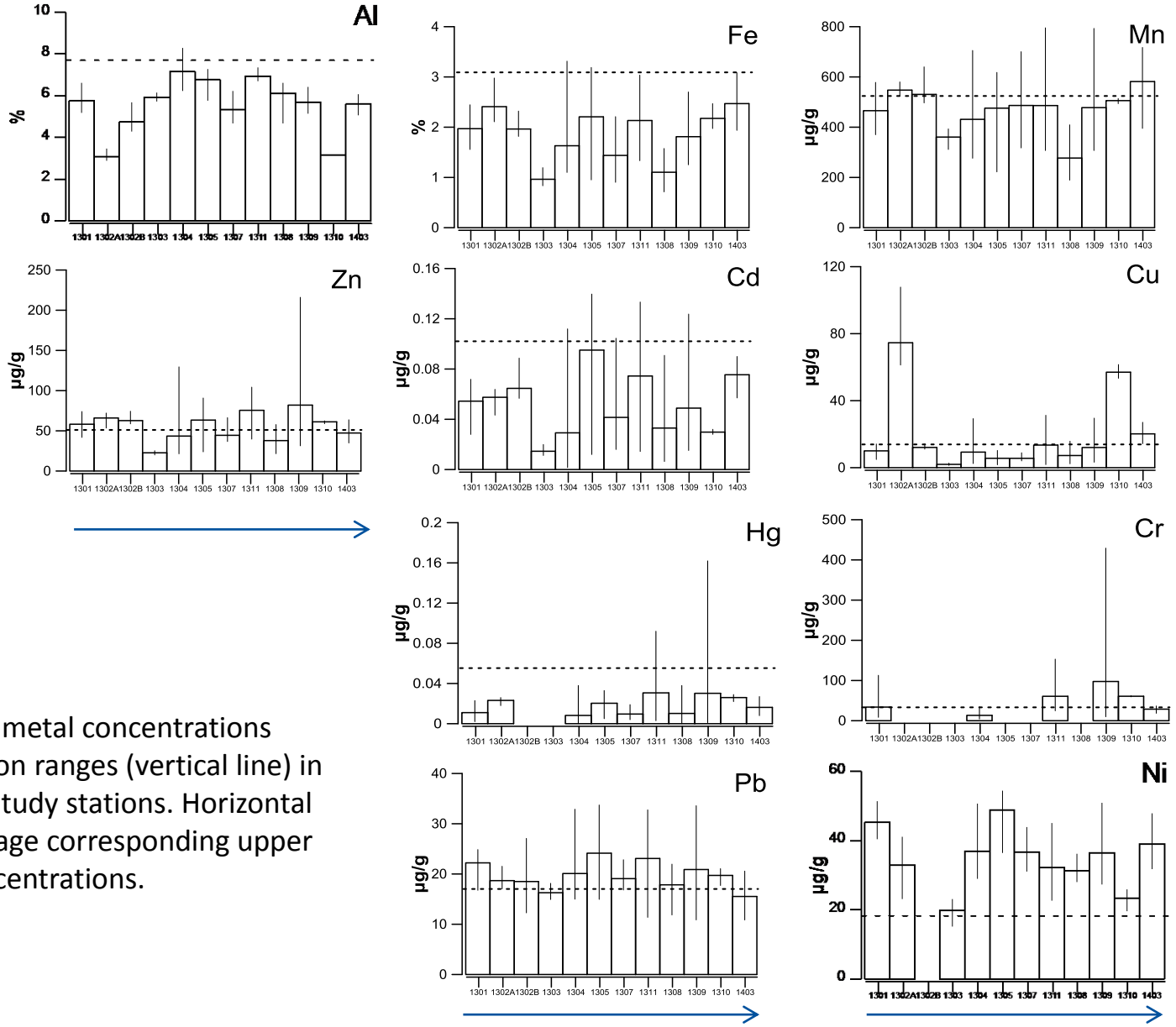
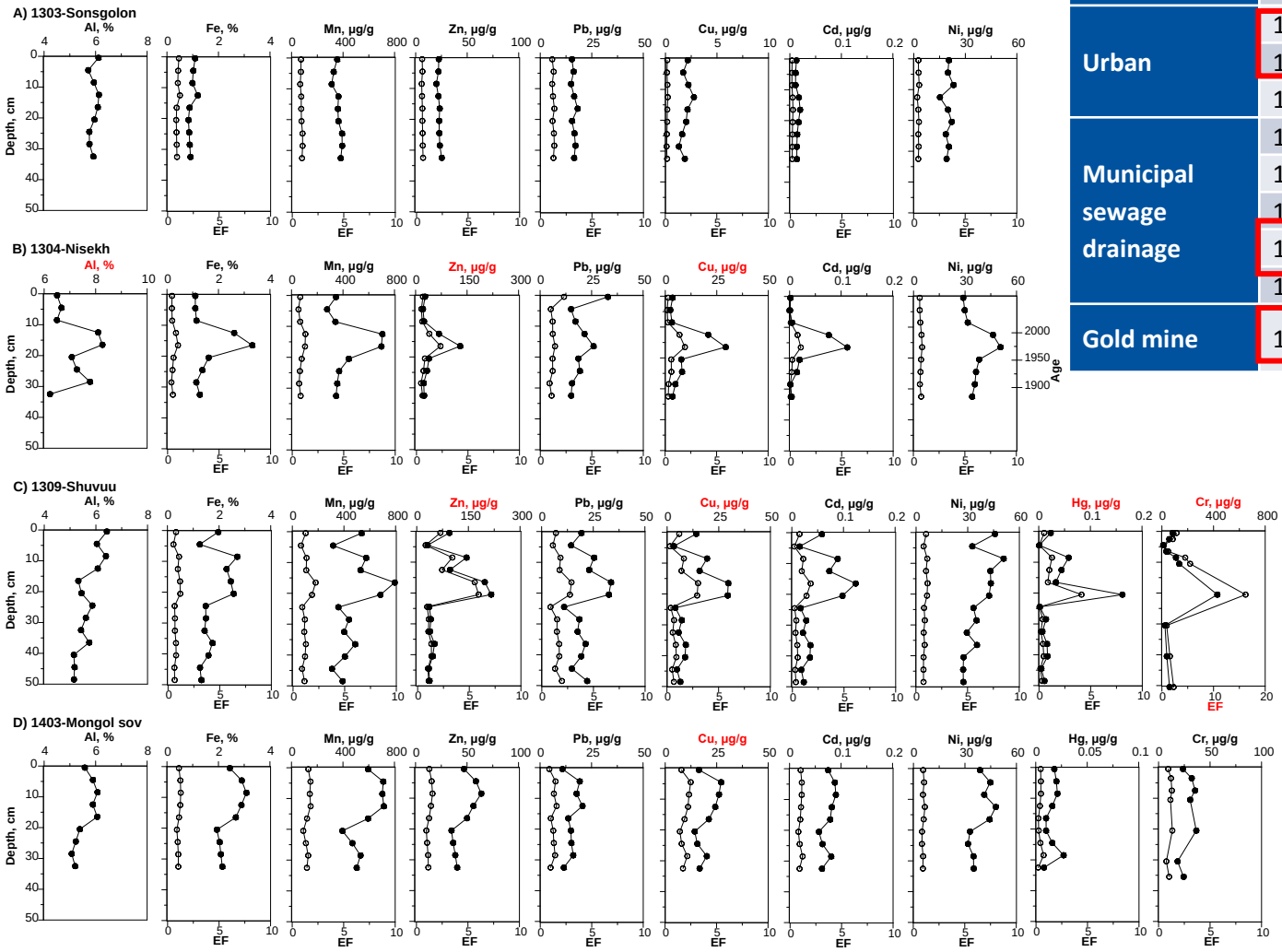


Fig. 2. Average heavy metal concentrations (bar) and concentration ranges (vertical line) in sediments at twelve study stations. Horizontal dashed lines are average corresponding upper continental crust concentrations.

Vertical profile & Historical variation

Region	ID	Location	Core length (cm)
Upstream	1301	Terelj	22
	1302A	Nalaikh1	30
	1302B	Nalaikh2	27
Urban	1303	Songolon	32
	1304	Nisekh2	34
	1305	Morin davaa	36
Municipal sewage drainage	1307	Songino	20
	1311	Songino guur	46
	1308	Bio guur	20
	1309	Shuvuu	48
	1310	Altanbulag	4
Gold mine	1403	Mongol sov	36



EFc	Pollution degree
EFc<1	No enrichment
1-3	Ялимгүй нэмэгдэлтэй
3-5	Бага зэрэг нэмэгдэлтэй
5-10	Дунд зэрэг нэмэгдэлтэй
10-25	Нэлээн баяжилттай
25-50	Их нэмэгдэлтэй
EFc>50	Маш их нэмэгдэлтэй

Fig. 3. Vertical profiles of heavy metals in Tuul River sediment. (● concentration; ○ crustal enrichment factor). Different scale X axis for some higher value were labeled by red.

Age dating of polluted 1304 core

- Main pollution source of sedimentary metals is power plant ash pond

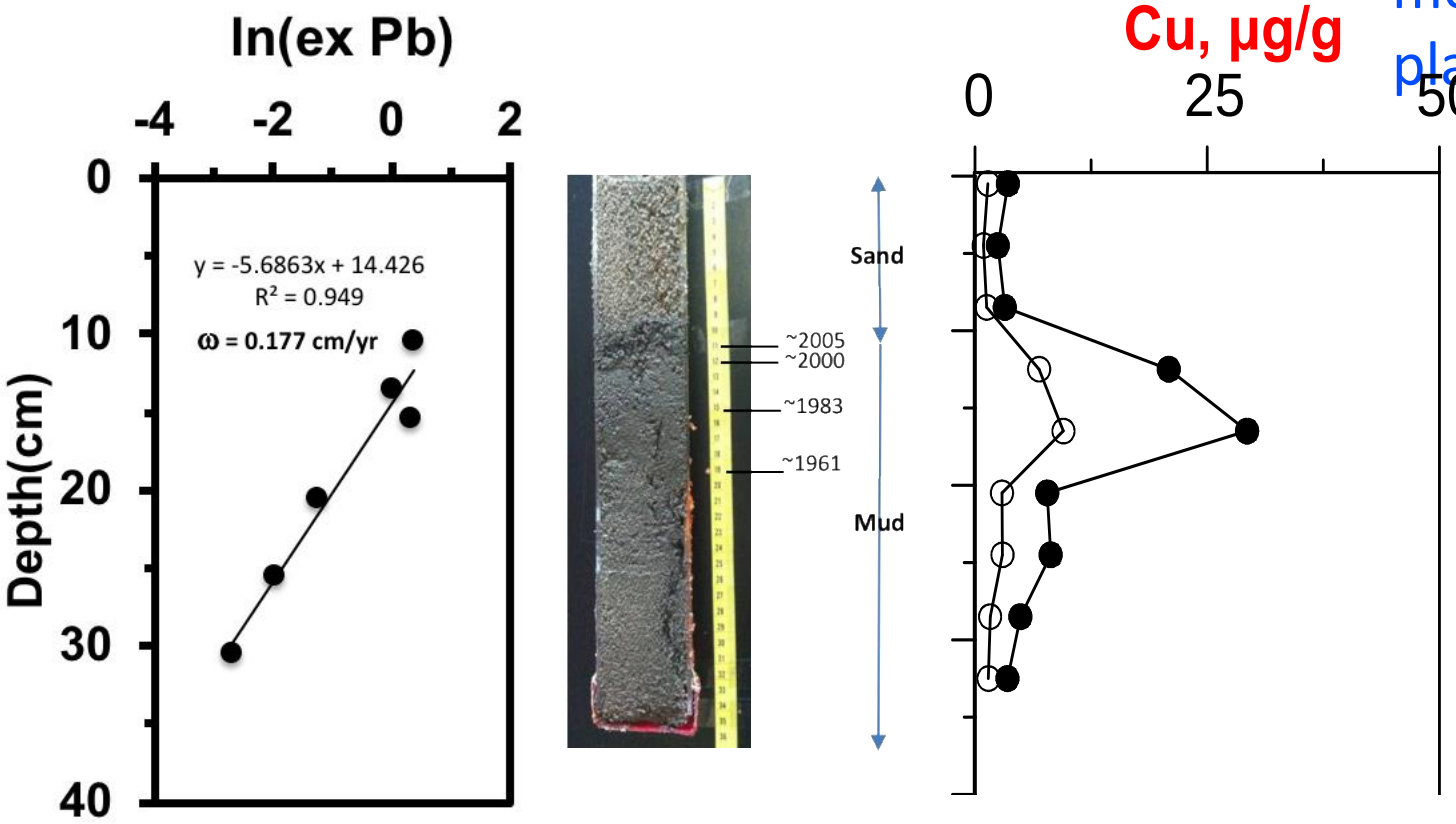
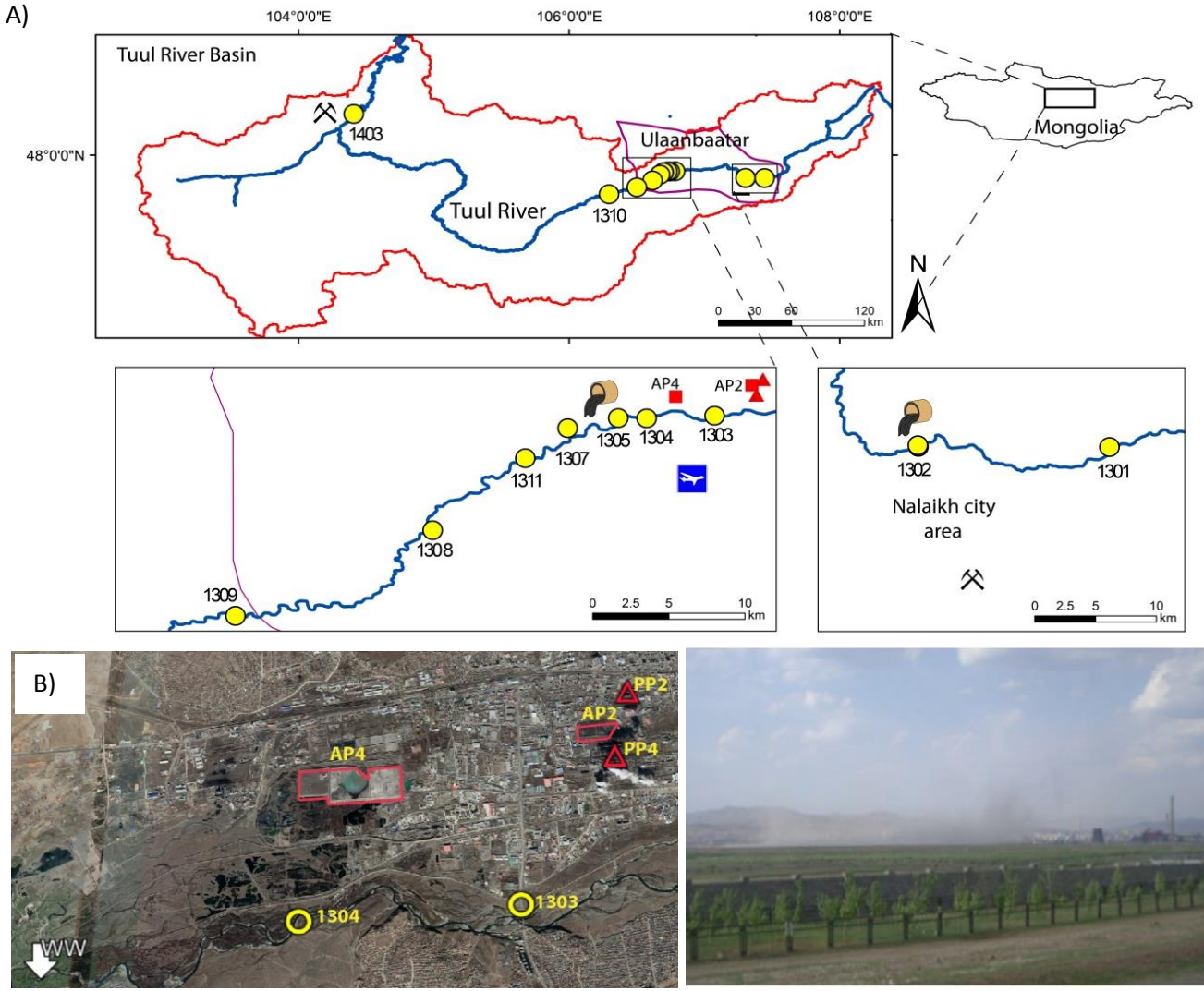


Fig. 4. Age model for 1304 core based on excess Pb-210. Note sediment grain size changes from top sand layer to lower muddy sediments.

Possible sources at 1304 site



- Main pollution source of sedimentary metals is power plant ash pond

Ecological Risk Assessment with SQG

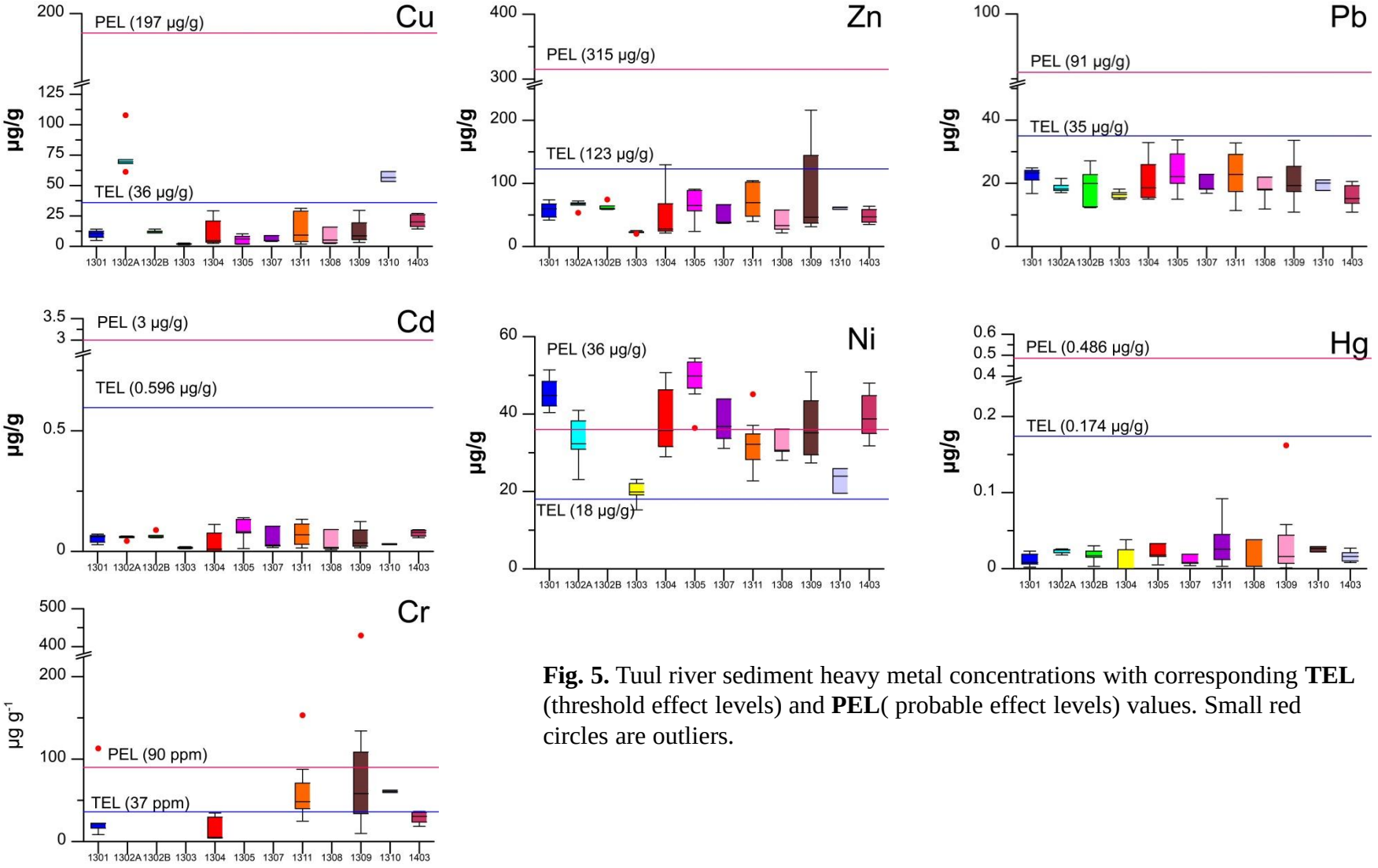


Fig. 5. Tuul river sediment heavy metal concentrations with corresponding **TEL** (threshold effect levels) and **PEL**(probable effect levels) values. Small red circles are outliers.

Pollution assessment

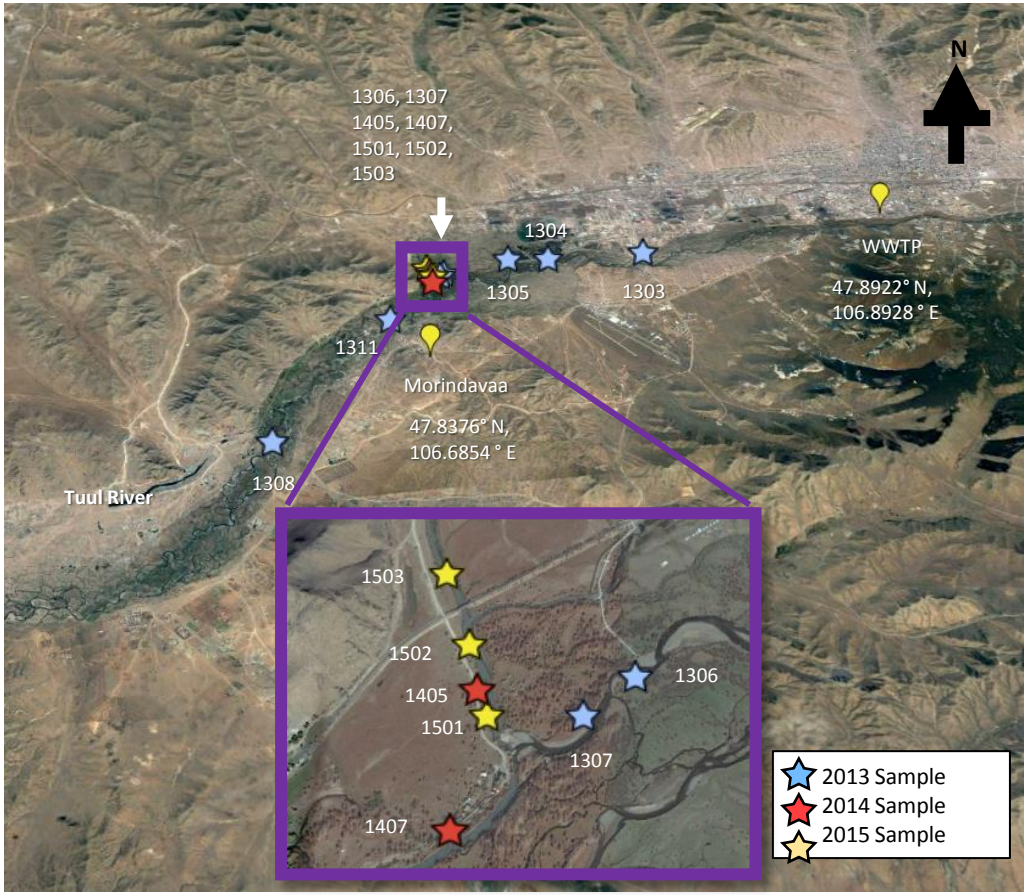
Enrichment factor

$$EFc = \frac{(X/Al)_{sediment}}{(X/Al)_{crust}}$$

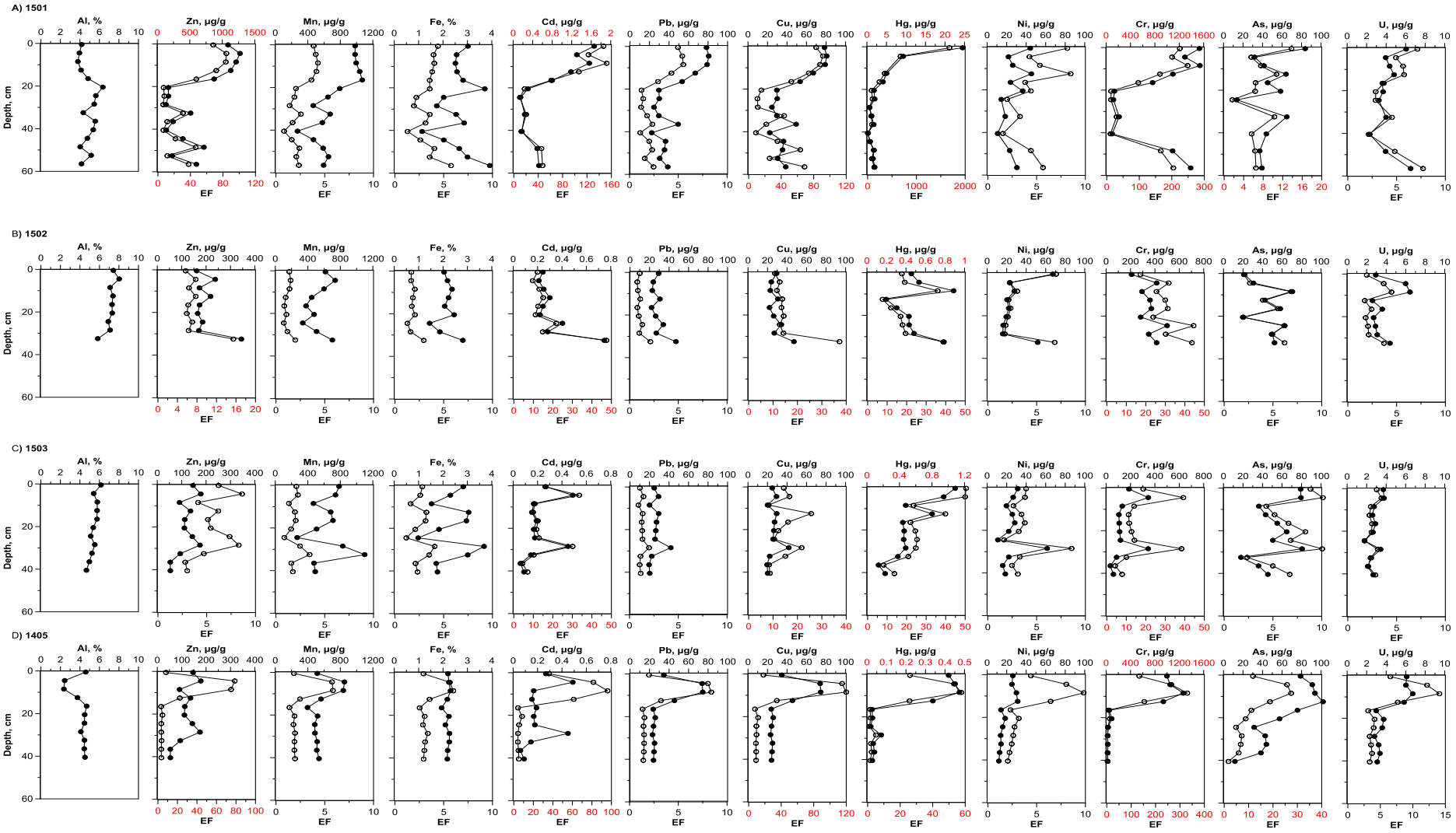
	Zn	Pb	Cu	Cd	Ni	Hg	Cr	Pollution characters
Upstream	1.1–3.6	1.0–3.3	0.47–18	0.37–1.6	1.0–1.9	0.049–1.2	0.47–6.4	Moderate pollution, Relatively high EF.
Urban	0.45–2.3	0.91–2.3	0.12–1.9	0.02–1.8	0.34–1.3	0.06–0.64	0.13–0.93	Background level, low EF.
Municipal Sewage Drainage	0.52–5.9	0.71–3.0	0.14–11	0.08–1.8	0.46–1.1	0.02–4.1	0.32–26	**Moderate to severe pollution, high EF**
Zaamar gold mine	1.0–1.6	0.89–1.6	1.4–2.5	0.80–1.2	0.84–1.1	0.21–0.74	0.84–1.2	Background level, low EF

Specific investigation near the MSWTP

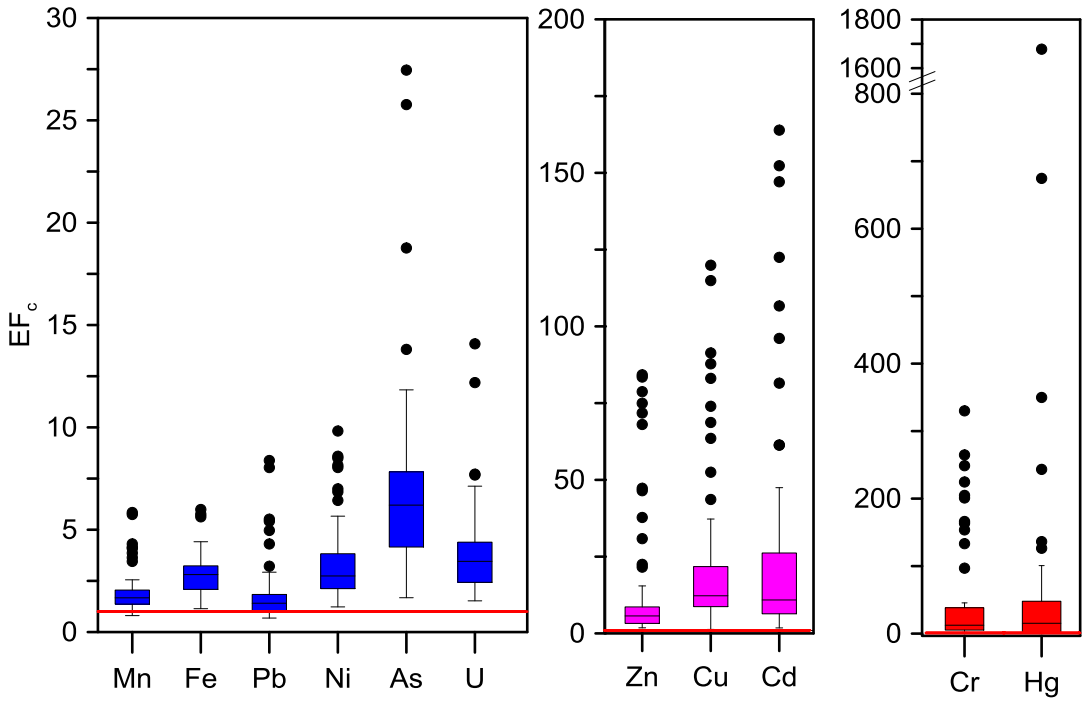
- Seven short core sampling near the MWTP outlet in 2013-2015



Vertical profiles of metals



Enrichment factor



EFc	Pollution degree
EFc<1	No enrichment
1-3	Ялимгүй нэмэгдэлтэй
3-5	Бага зэрэг нэмэгдэлтэй
5-10	Дунд зэрэг нэмэгдэлтэй
10-25	Нэлээн баяжилттай
25-50	Их нэмэгдэлтэй
EFc<50	Маш их нэмэгдэлтэй

Fig. 5. Crustal enrichment factors (EFc) of heavy metals in the Tuul River sediments. Small dots are outliers. Note that different Y axis scales for each part.

For crustal values Wedepohl, 1995

Source assessment by PCA

	PC1	PC2	PC3	PC4
	Crustal	Sewage	Industrial	Ash
Zn/Al		0.455	0.833	
Mn/Al	0.743			
Fe/Al	0.879			
Cd/Al			0.605	0.442
Pb/Al			0.859	
Cu/Al			0.862	
Hg/Al				0.786
Ni/Al	0.690			
Cr/Al		0.619	0.523	
As/Al				0.786
U/Al		0.424		0.796
TC		0.898		
TS	-0.472	0.657		
TOC		0.936		
TON		0.964		
C/N		-0.421		
Carbonate				
Clay	0.955			
Silt	0.720			0.481
Sand	-0.921			
% of variance	24	22	16	14
Cumulative %	24	46	62	76

Rotation Method: Varimax with Kaiser Normalization. Blank fields: R < 0.4, considered not important.

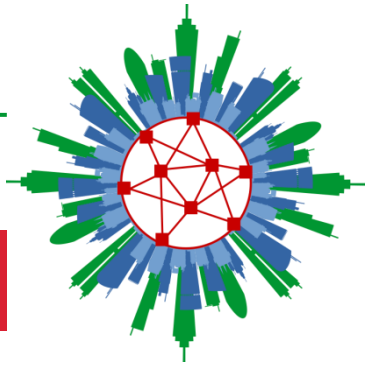
Possible sources	Corresponded metals
Crustal	Mn, Fe, Ni
Sewage	Zn, Cr, U
Industrial	Zn, Cd, Pb, Cu, Cr
Ash	Cd, Hg, As, U

Conclusion

- The distribution, enrichment, and accumulation of heavy metals (Al, Fe, Cu, Zn, Pb, Ni, Cd, Hg, Cr, U and As) in sediments of Tuul River, Mongolia, were investigated.
- Results show that sings of pollution existed in the study environment, with large spatial variations of copper, mercury, zinc, and lead concentrations in the Tuul River sediments, and, in particular, in area near the Ulaanbaatar city vicinity.
- Natural variations were superimposed by anthropogenic-derived heavy metals for both at the upper river near the UB city and even to some part of downstream location.
- High levels of heavy metals were found in surface sediments near the sewage treatment plants. Some metal concentrations exceeded the level that could be categorized as toxic to the aquatic biota health.
- Vertical heavy metal concentration profiles show unusual accumulation of metal pollution traced back to 1960s', reaching the highest level when coal-fired power plants were used to power the UB city.
- Open ash ponds of the nearby power plants are most likely the continuous source of heavy metals entering the river sediment and airborne particles.
- Inefficient sewage treatment plants and ash ponds are major sources of heavy metals leaking into this study Tuul River environment.
- The finding of ash pond as a source of polluted airborne particles as well as sediments also indicates this pollutant could further propagate to wider distance with higher degree of widespread to other area of the Asia.
- This finding indicates that new and alternative measures have to be enforced to prevent further pollution entering the Tuul River drainage basin and to other parts of the Asia and ocean.

SuMoCoS

Sustainability and Mobility in the Context of Smart Cities



Thank you for your attention

For more information:

T.O. Soyol-Erdene, S. Lin, E. Tuuguu, D. Daichaa, K. Huang, U.Bilguun, E.A. Tseveendorj (2019). Spatial and temporal variations of metals in sediments of Tuul River, Mongolia, *Environmental Science and Pollution Research (accepted, in press.)*

T.O. Soyol-Erdene, S. Lin, E. Tuuguu, D. Daichaa, N. Dashnyam, U. Bilguun, K.-M. Huang, E.A. Tseveendorj. Severe pollution in the Tuul River drainage basin, a source area of Asian dust *(in prep.)*