Possible sources and controlling factors of toxic metals in the Florida Everglades and their potential risk of exposure

Yong Cai
cai@fiu.edu

Department of Chemistry & Biochemistry
and Southeast Environmental Research Center
Florida International University, Miami, Florida, USA

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- **USEPA Region 4**
  - **Peter Kalla**
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  - **EPA entire field team**
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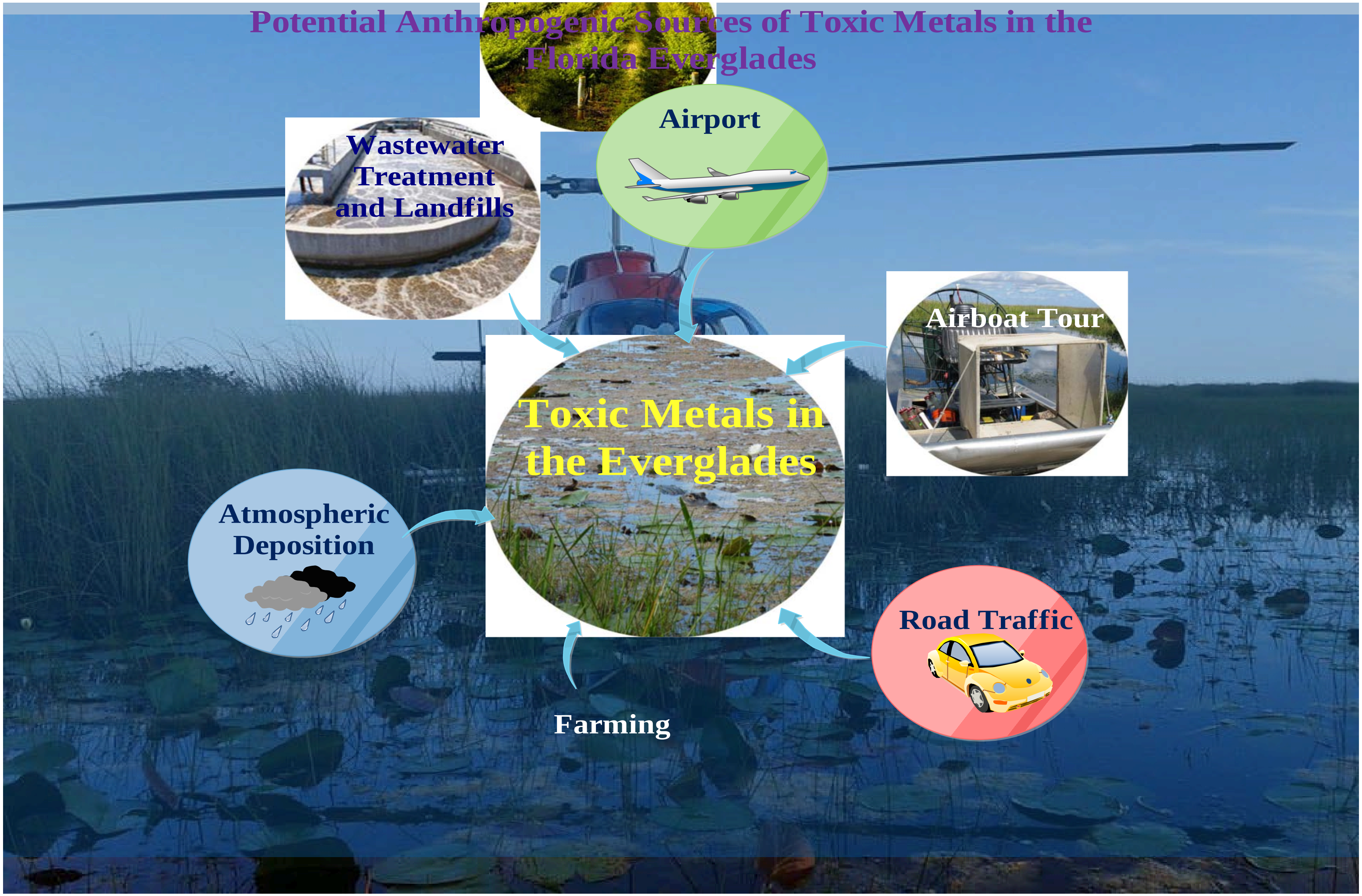
Motivation

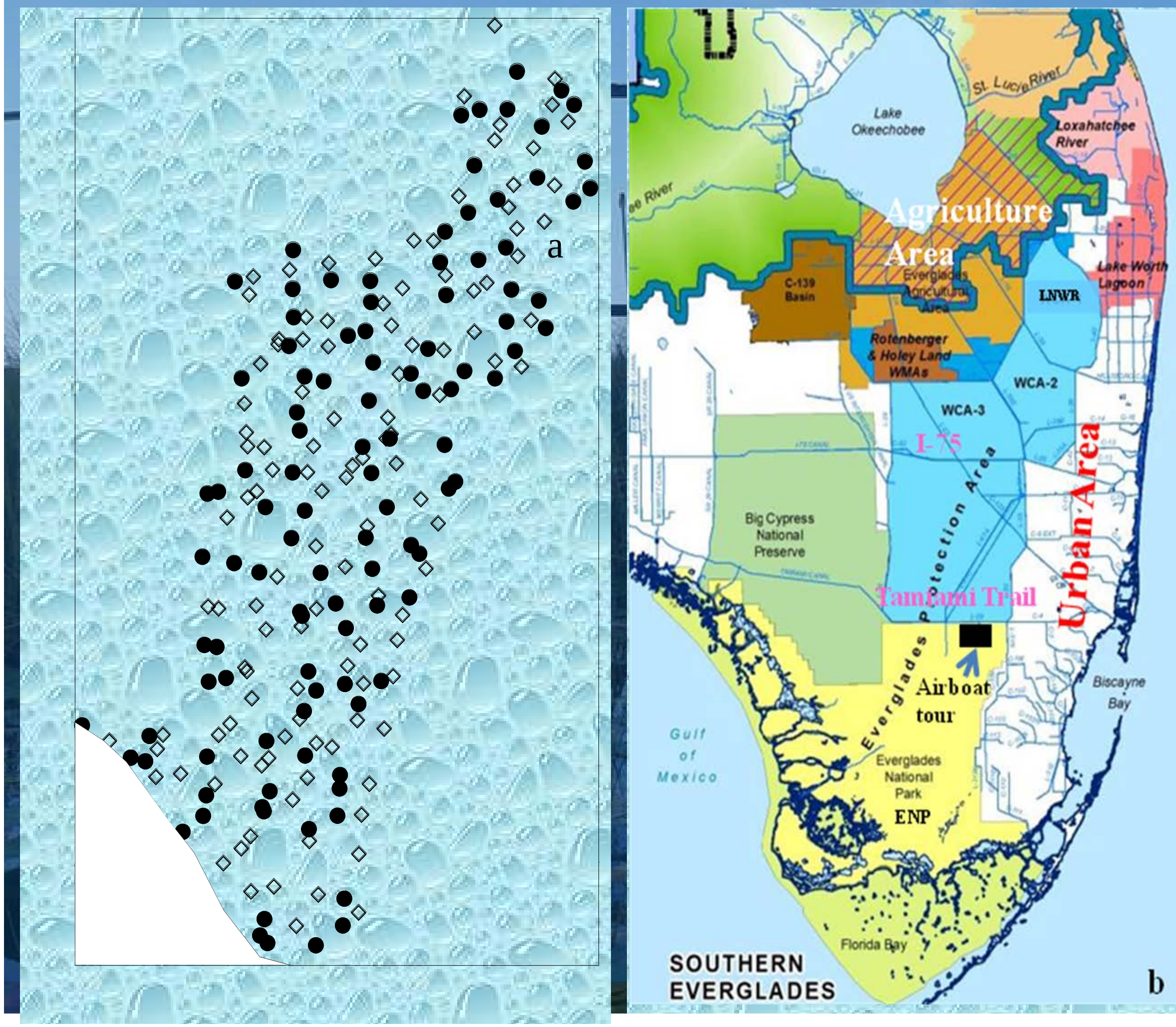


Potential Anthropogenic Sources of Toxic Metals in the Florida Everglades
Wastewater Treatment and Landfills
Airport
Airboat Tour
Toxic Metals in the Everglades
Atmospheric Deposition
Road Traffic
Farming

Justification

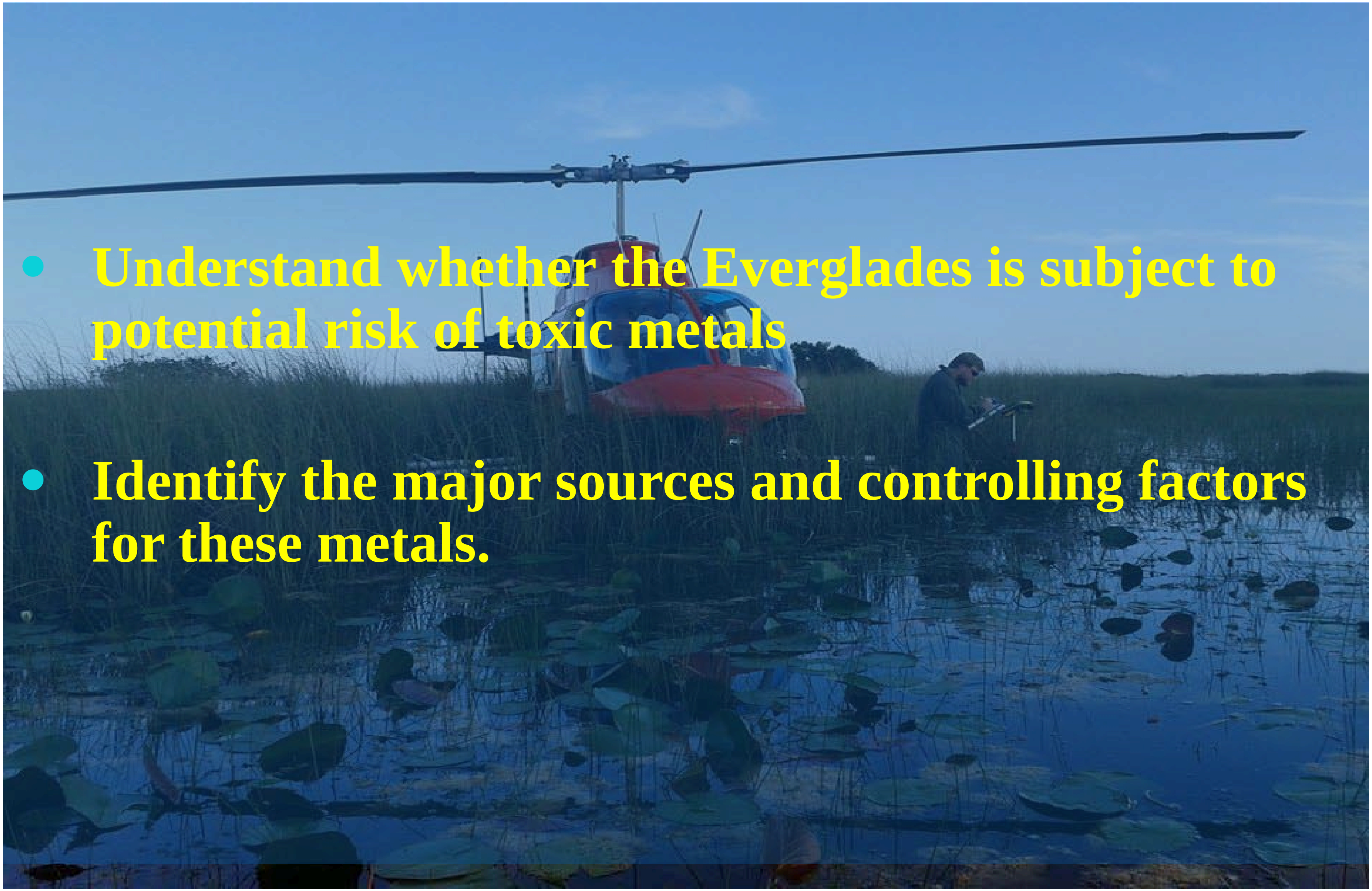
- **Very limited research on toxic metals/metalloids in the Everglades**
- **The possibility of metal pollution**
- **A missing piece of information in the Comprehensive Everglades Restoration Plan (CERP)**
- **Regional Environmental Monitoring and Assessment Program Project (REMAP) offers a great opportunity**

- Maps showing sampling sites in the Florida Everglades (a)



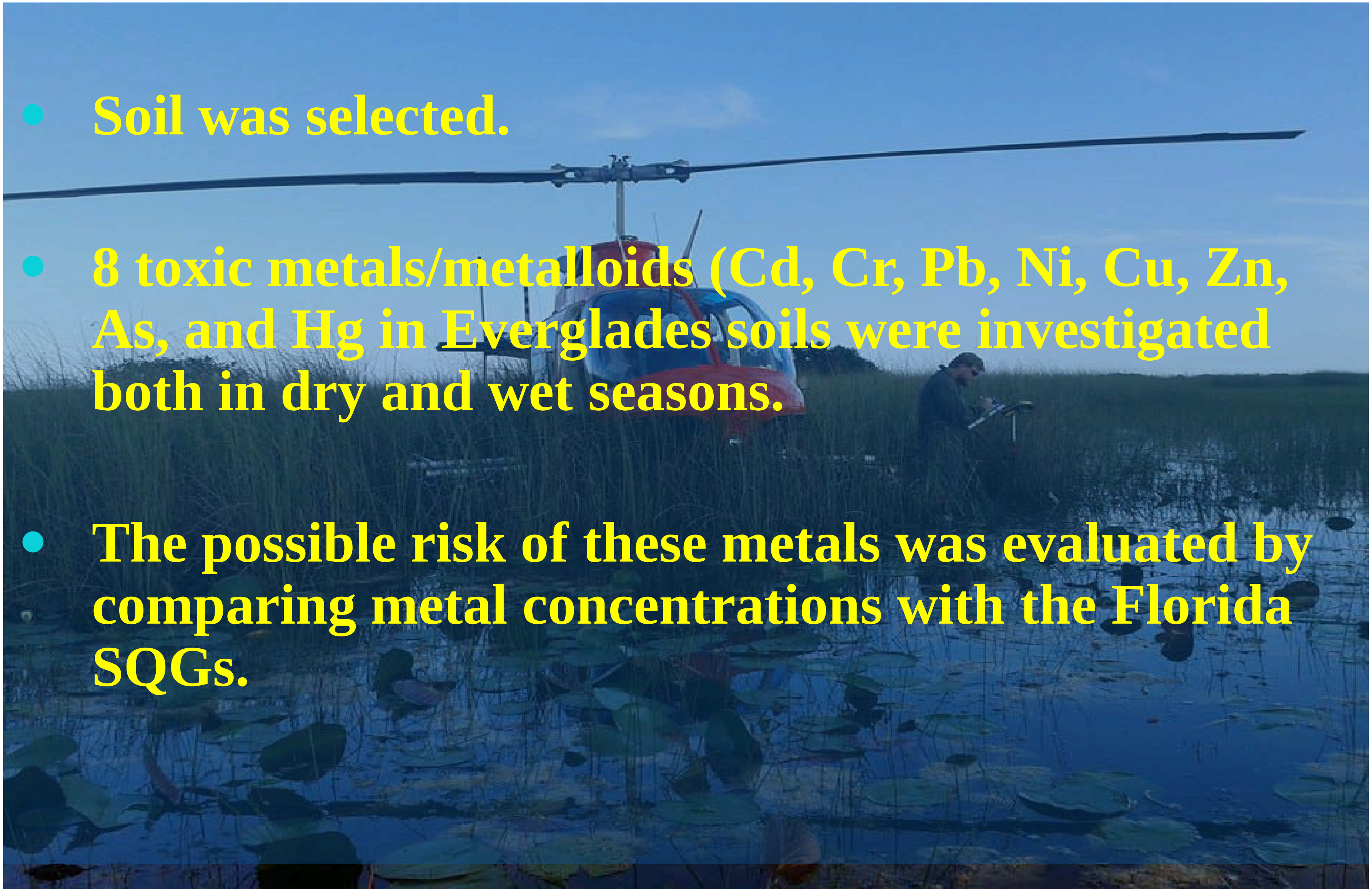
- The potential sources of metals (the figure was modified from Figure 1-1 of 2015 South Florida Environmental Report (South Florida Water Management District)) (b).

Objectives



- **Understand whether the Everglades is subject to potential risk of toxic metals**
- **Identify the major sources and controlling factors for these metals.**

Methodology



- **Soil was selected.**
- **8 toxic metals/metalloids (Cd, Cr, Pb, Ni, Cu, Zn, As, and Hg in Everglades soils were investigated both in dry and wet seasons.**
- **The possible risk of these metals was evaluated by comparing metal concentrations with the Florida SQGs.**

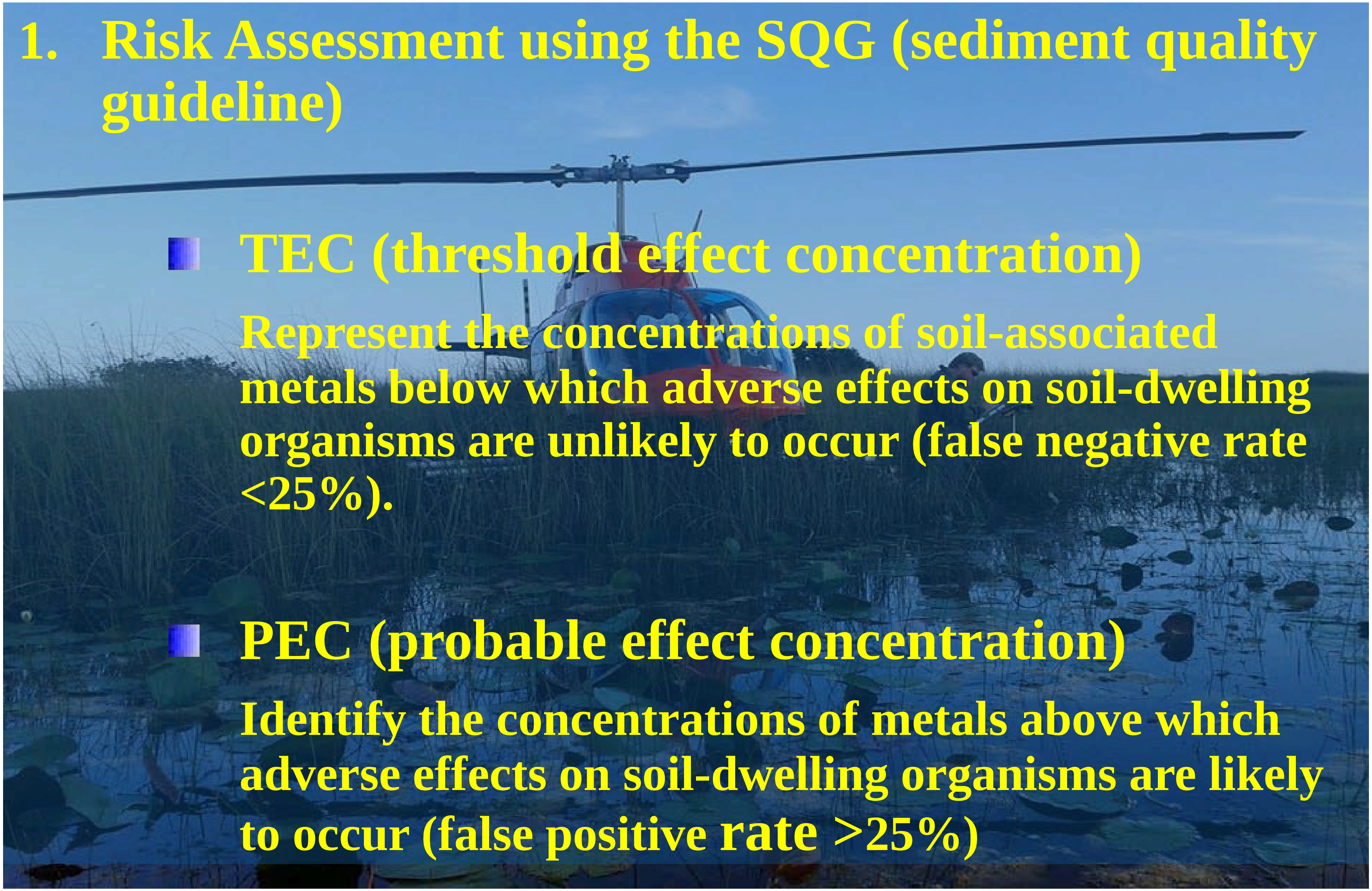
Methodology

- **A new method developed to quantitatively evaluate contributions of anthropogenic loading and environmental factors to toxic metal distributions**
  - **Including an index, i.e. enrichment factor, in multiple regressions of metals against possible controlling factors**
  - **Enrichment factor**

$$EF = (C_i / C_{Al})/(B_i / B_{Al})$$

  - **EF value of <1: originate mainly from natural sources**
  - **Higher EF: contribution of anthropogenic > natural**

Major Findings



1. **Risk Assessment using the SQG (sediment quality guideline)**

   - **TEC (threshold effect concentration)**

     Represent the concentrations of soil-associated metals below which adverse effects on soil-dwelling organisms are unlikely to occur (false negative rate <25%).

   - **PEC (probable effect concentration)**

     Identify the concentrations of metals above which adverse effects on soil-dwelling organisms are likely to occur (false positive rate >25%)

Major Findings

2. Risk Assessment

Table 2 Florida sediment quality guidelines (SQGs, mg kg^{-1}) and percentage of toxic metals over the SQGs in Everglades soil samples. TEC, threshold effect concentration; PEC, probable effect concentration.

	Metal							
	As	Cd	Cr	Ni	Pb	Cu	Zn	Hg
SQGs (mg kg^{-1})								
FL TEC	9.8	1.0	43	23	36	32	120	0.18
FL PEC	33	5.0	110	49	130	150	460	1.1
Percentage of metals over the SQGs (%)								
FL TEC	3.2	1.2	4.4	1.1	10.2	2.7	0.0	23.4
FL PEC	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0

Major Findings

3. Source Identification and Controlling Factors

Table 3 Toxic metal EFs in Everglades soils

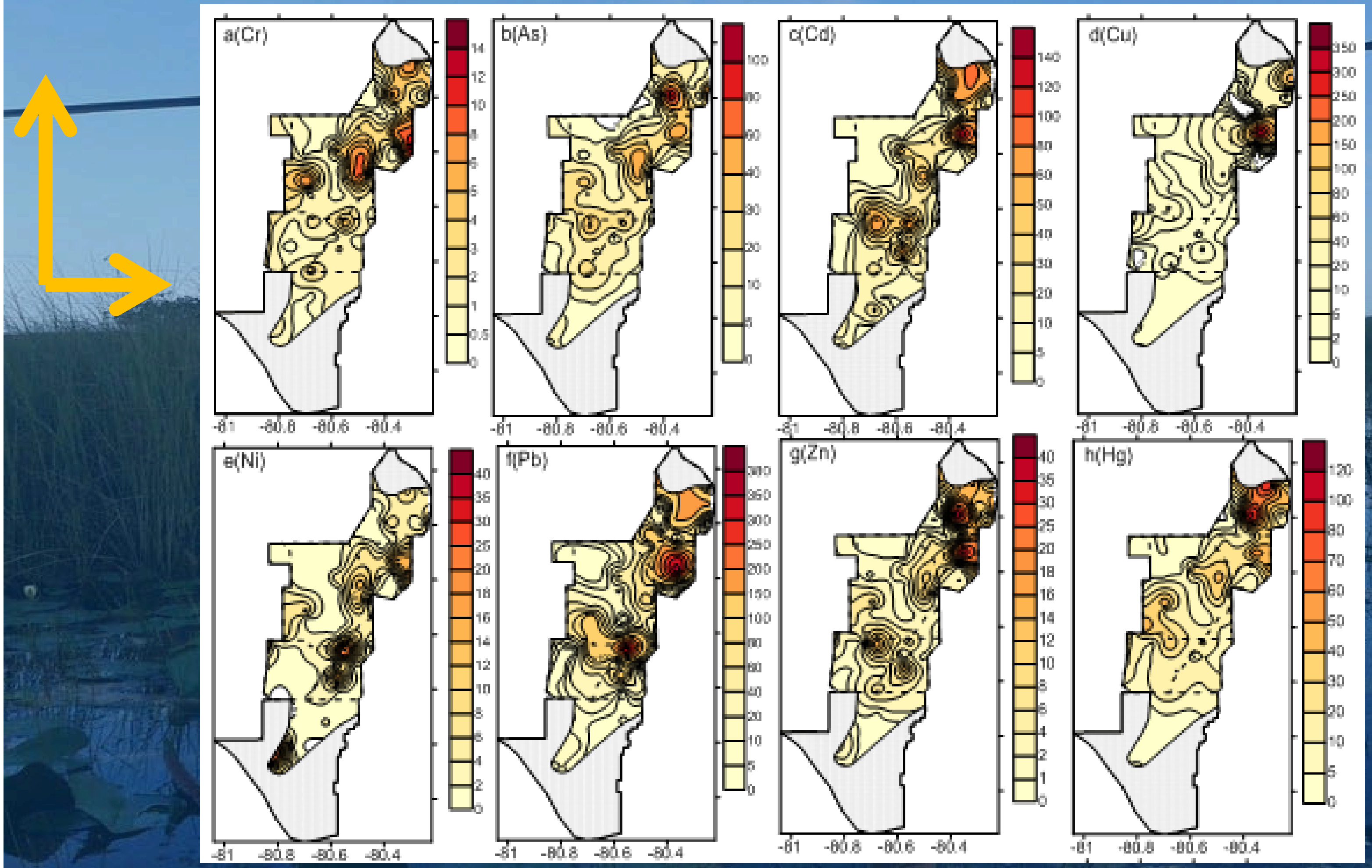
Metal	Range	Median	Mean
Cd	0.02-409.8	11.0	35.0
Cr	0.07-201.6	1.4	11.3
Pb	0.17-933.5	19.5	82.4
Ni	0.05-56.9	1.9	5.4
Cu	0.04-385.1	2.1	11.5
Zn	0.001-60.6	2.7	6.8
As	0.14-236.0	7.8	19.4
Hg	0.37-511.6	9.1	28.2

$10 \le EF < 25$ Severely affected (Cd, Pb)

$5 \le EF < 10$ moderately affected (As, Hg)

Major Findings

Spatial variations of toxic metal EFs- dry season



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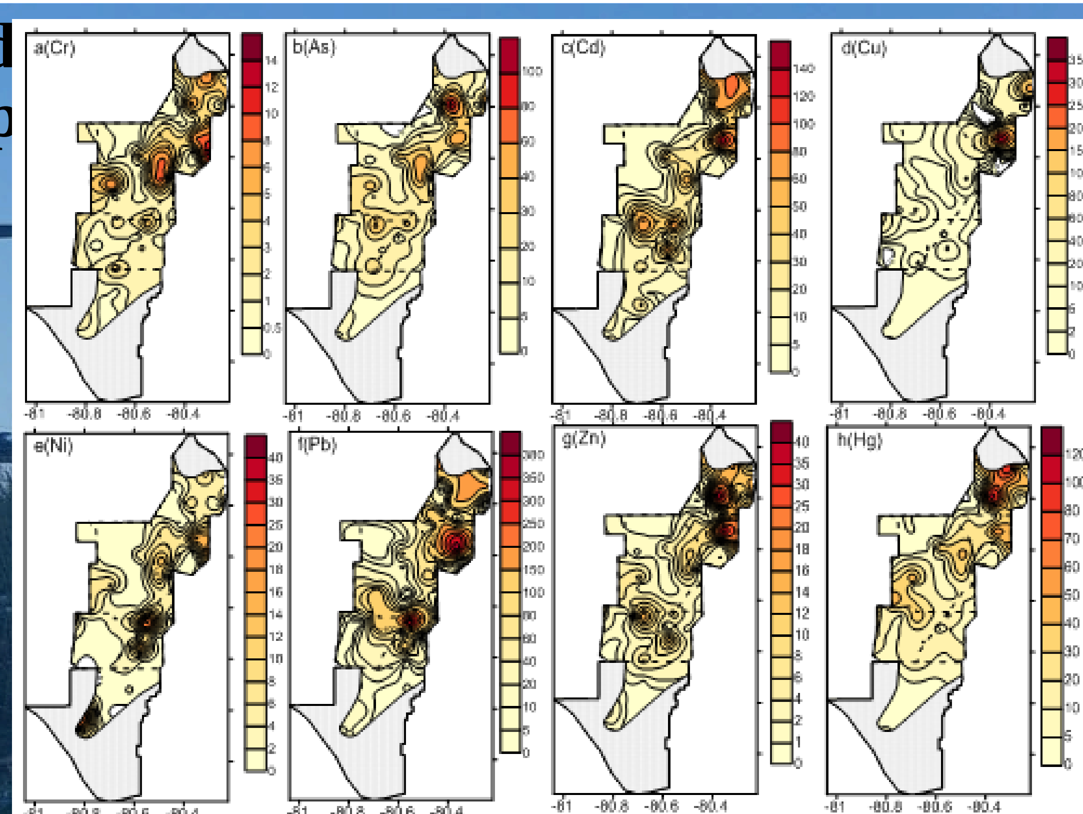
Major Findings

Map modified from Figure 1-1 of 2015 South Florida Environmental Report (SFWMD)



- ✓ *EFs of Pb, Cr, Zn, Cu in LNWR and WCA 2, connecting to the EAA, were higher than that in WCA 3 and ENP.*
- ✓ *EFs of Pb, Cd, Zn, Ni exhibited several "hot spots" in the areas nearby the I-75 and Tamiami Trail.*
- ✓ *Most "hot spots" of Pb, Cd and Cu were located on the eastern part of the Everglades, nearby the urban areas.*

Major Findings

Correlation analysis - similarity of toxic metals in the distribution pattern of EFs

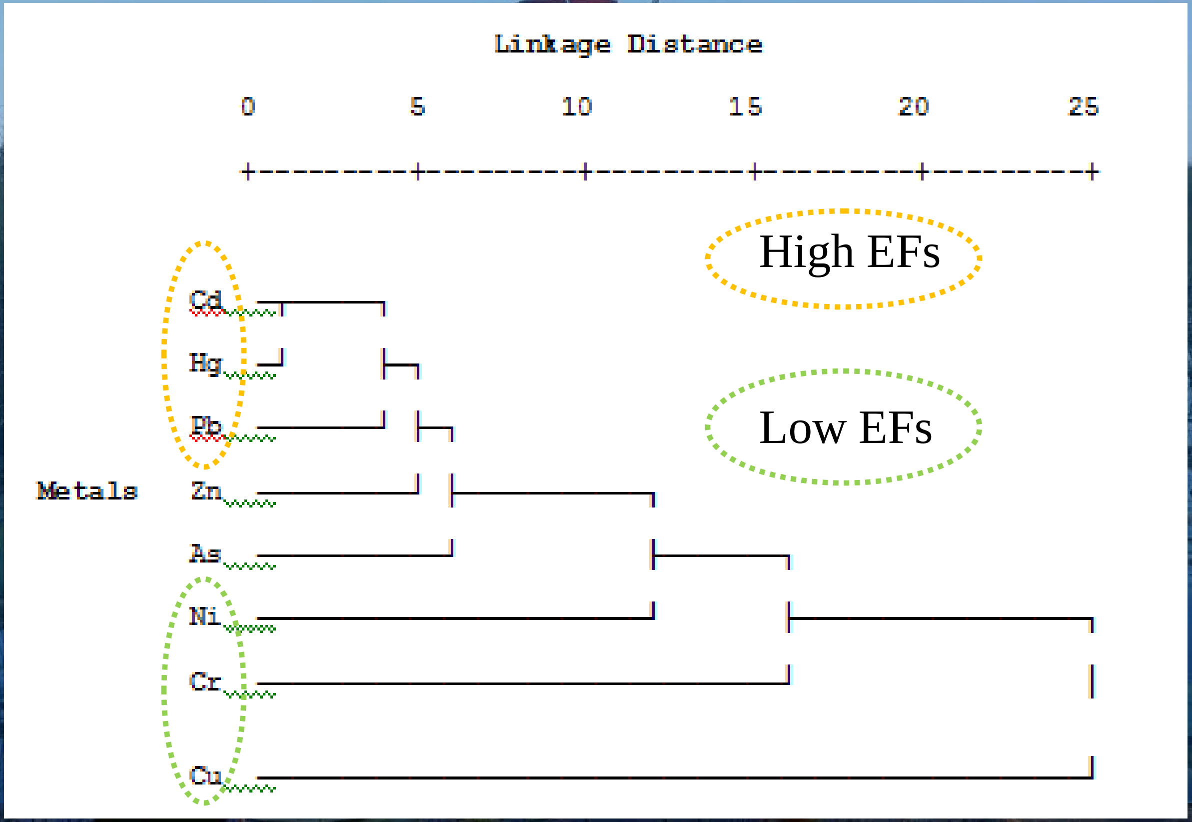
Table 4 Correlations of toxic metal EFs in Everglades soil. '**' represents that correlation is significant at the 0.01 level (2-tailed). '*' represents that correlation is significant at the 0.05 level (2-tailed).

r^2	Cr	Ni	Cu	As	Cd	Zn	Pb	Hg
Cr	1							
Ni	0.51**	1						
Cu	0.13	0.34**	1					
As	0.43**	0.58**	0.33**	1				
Cd	0.46**	0.64**	0.51**	0.77**	1			
Zn	0.56**	0.63**	0.50**	0.76**	0.79**	1		
Pb	0.72**	0.67**	0.45**	0.59**	0.83**	0.77**	1	
Hg	0.49**	0.49**	0.33**	0.80**	0.82**	0.74**	0.72**	1

Major Findings

Cluster analysis - similarity of toxic metals in the distribution pattern of EFs

Dendrogram derived from the hierarchical cluster analysis of toxic metal EFs in Everglades soils.



Major Findings

Multiple regressions of metals against their EFs and environ. factors - Identify the primary controlling factors

	Cr	Ni	Cu	As	Cd	Zn	Pb	Hg
Mn	-0.08	-0.01	-0.06	0.04	0.00	-0.09	-0.05	0.02
EF	**0.80**	**0.52**	**0.63**	**0.28**	**0.32**	**0.37**	**0.52**	**0.18**
Eh	-0.02	0.06	0.09	-0.11	0.00	0.00	-0.14	-0.10
PO_4^{3-}	-0.01	-0.16	-0.10	0.01	-0.08	-0.02	0.00	-0.01
DOC	0.00	0.01	0.03	-0.05	-0.06	-0.09	0.10	-0.06
Cl^-	-0.06	0.04	**0.20**	0.01	0.13	0.10	-0.04	0.01
SO_4^{2-}	-0.02	-0.04	**-0.27**	-0.09	-0.08	-0.05	-0.09	-0.08
pH	0.11	**0.26**	**0.12**	**0.33**	0.05	0.09	0.09	**-0.14**
TOC	-0.05	-0.00	**0.42**	**0.59**	**0.49**	**0.48**	**0.19**	**0.56**
R	0.79	0.57	0.72	0.64	0.64	0.63	0.58	0.70
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Summary

✓ **A new method was developed for source identification and controlling factors elucidation**

- **Identify the possible sources of toxic metals by the distribution of their EFs**

- **Estimate the relative importance of anthropogenic loads and various environmental parameters by conducting the multiple regressions with EFs as one of the parameters representing the anthropogenic source.**

Summary

- ✓ **In addition to Hg, other metals, particularly Pb, warrant further study.**
- ✓ **Some of these metals were controlled by anthropogenic discharge, while the others were mainly controlled by environmental parameters (NOM, pH, etc.).**


Thank You
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