

Original Article

# Assessment of Heavy Metals Concentration in Khartoum City After Overflow Season Beside and Inside the Revivers

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**Abstract** - The study aimed to assess concentrations of heavy metals in soil samples on both sides along the three Niles (Blue, White, and Nile Rivers) and Almogran area (Tuti Island) in Khartoum city (the capital of Sudan country) after the overflow season. Concentrations of heavy metals Br, Cu, Ni, Pb, Co, Rb, Cr, Zn, Zr, Sr, Mn, Ti, K, Ca, and Fe were determined using X-ray fluorescence (XRF) techniques compatible with direct analysis of soils. The results showed that the element's concentration along the Blue Nile is higher than White Nile, Nile river, and Almogran area. In addition, Enrichment Factor (EF) and Geo-accumulation index (GI) factor was calculated, and both are in recommended ranges except EF for Ni high at Blue Nile 2.58, which is more than recommended value (2).

**Keywords** - Heavy Metal, Soil, Flow, X-RF, Nile, Concentration.

## 1. Introduction

X-ray fluorescence (XRF) is a spectroanalytical technique compatible with direct soil analysis, which can be applied with minimal or no sample preparation [1]. The recent technological advancements in the optical and electronic components allowed the development and miniaturization of this technology, and it has become attractive for use in hybrid laboratories and situ analyses. Some studies have already pointed out the potential of using XRF sensors in proximal soil sensing (PSS) approaches [2]. Despite that, XRF has been poorly explored for assessments of the physical and chemical attributes of tropical soils.

To use XRF sensors as a practical analytical method in hybrid laboratories—to ensure a massive increase in the number of samples analyzed—it should be compatible with a simple soil sample preparation (e.g., just air-dried and sieved rapidly). Recent studies involving XRF sensors for practical analysis of soil attributes have used dried samples with particle sizes smaller than 2 mm [3][5][6]. It is a consensus that pellet preparation after grinding the soil allows one to explore the potential of the XRF technique in soil analysis [7]. The preparation of a pellet is recommended for analyses with the XRF technique because it improves the material's homogeneity and allows one to control the density, porosity, and surface roughness characteristics, reducing the physical matrix effects [17]. Although it is known that the preparation of pellets

guarantees better precision in the measurements performed with the XRF [9-10], recent studies have assumed that when analyzing soil samples with particle sizes smaller than 2 mm, their heterogeneity and physical matrix effects can be neglected.

## 2. Material and Methods

To verify the quantity of heavy metal pollution levels in the sediment samples, two indices have been applied, including the following:

### 2.1. Enrichment Factor (EF)

Enrichment factors are a means of quantifying the enrichment of a potentially contaminant-derived element in an environmental sample relative to a user-defined background composition. The enrichment factor is calculated by equation (1). [11-13]:

$$EF = \frac{[C_x / C_{ref}]_{sample}}{[C_x / C_{ref}]_{background}} \quad (1)$$

where the concentration of the element of interest is  $C_x$ , and the concentration of a reference element for normalization is  $C_{ref}$ .

### 2.2. Pollution index (PI)

The use of a reference element makes the EF superior to other indices, such as the pollution index (PI), which is



just the ratio of the concentration of the element of interest in the sample relative to the background. [14-16][21]

$$PI = \left[ \frac{[C_x]_{Sample}}{[C_x]_{Background}} \right] \quad (2)$$

**2.3. Geo-accumulation index (GI)**

The *GI* is, therefore, essentially a logarithm of the *PI*. As both metrics are based upon simple ratios of concentrations of a single element, they are vulnerable to distortion by particle size sorting effects, associations of particular trace elements with particular mineral types, and the closed nature of elemental datasets, which contain only relative information because if all components are analyzed, they will sum to 100%. The Geo-Accumulation Index was proposed by Müller [18] to assess the pollution levels of each heavy metal in surface sediments, taking their background value into account [18,19]. According to Litenithy and Laszlo (1999), Woitke et al. (2003), and Ilie et al. (2017) [19-21], the Igeo was determined using the following equation Equation [22-24]:

$$GI = \log_2 \frac{[C_x]_{Sample}}{[C_x]_{Background} \times 1.5}$$

**3. Sample Preparation**

A set of soil samples were selected for the comparison of their exchangeable content. These samples were collected from about 0.2 m soil depth with a clayey texture and high variability. The soil samples were air-dried and sieved (<2 mm). For pelletizing, the samples (particles < 2 mm) were initially dried at 105 °C for 24 h and, after that, ground in a planetary ball mill (Retsch model PM 200 mill, Germany) by using two grinding tungsten carbide jars (50 mL; Retsch, Germany) with 10 tungsten carbide balls (10 mm diameter). Grinding was performed at 400 rpm for 5 min clockwise/5 min counterclockwise with a 10-s stop before changing the rotation direction.

**4. Results and Discussion**

Two indices were applied to describe the pollution levels of heavy metals in the study area, including enrichment factor (EF) and geo-accumulation index (GI). Recently, it has been reported that the EF is an appropriate measure of geochemical trends and can be applied for contemplating the lithogenic or anthropogenic origin of heavy metals (Ye et al., 2011). Depending on the category and the obtained values of EF, all investigated metals were found to be within their minimum limits with EF < 2, except for Ni at the Blue Nile area was obtained to be 2.58 Fig.6, indicating that the heavy metals may be precipitated after the flow. It has been demonstrated that the geo-accumulation index (GI) can effectively explain soil contents. Based on its category and the obtained values of GI, all sediment samples at all sites were unpolluted Fig.5.

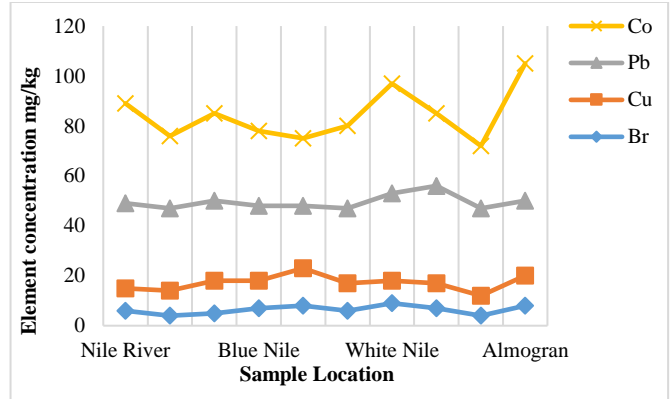


Fig. 1

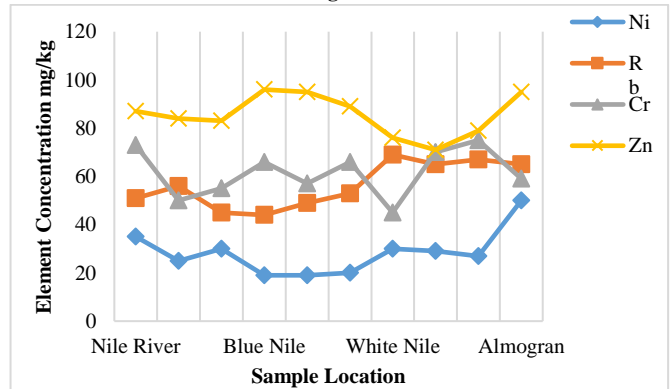


Fig. 2

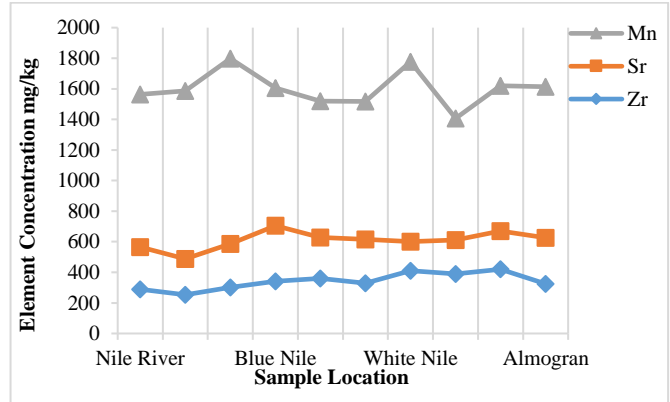


Fig. 3

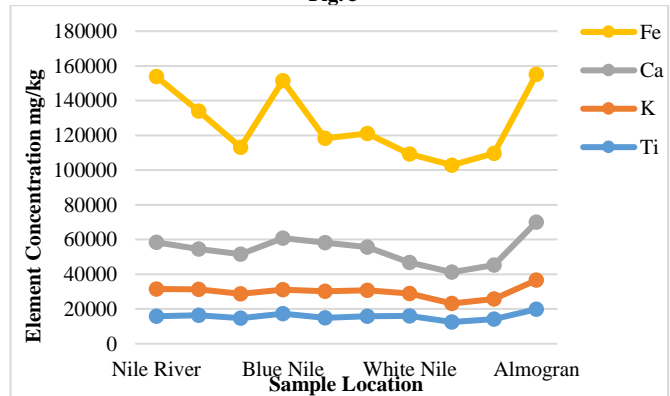


Fig. 4

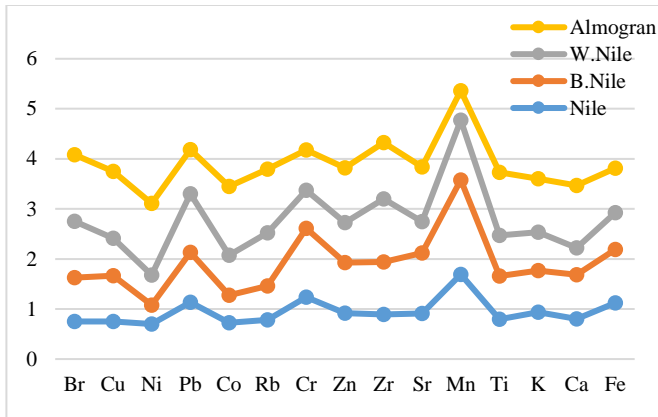


Fig. 5 Pollution index (PI)

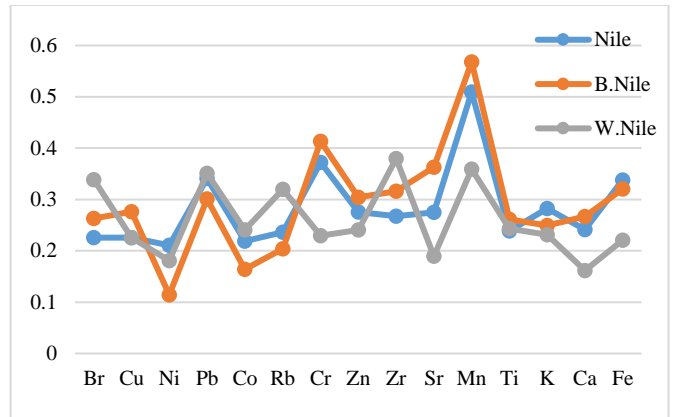


Fig. 6 Geo-accumulation index (GI)

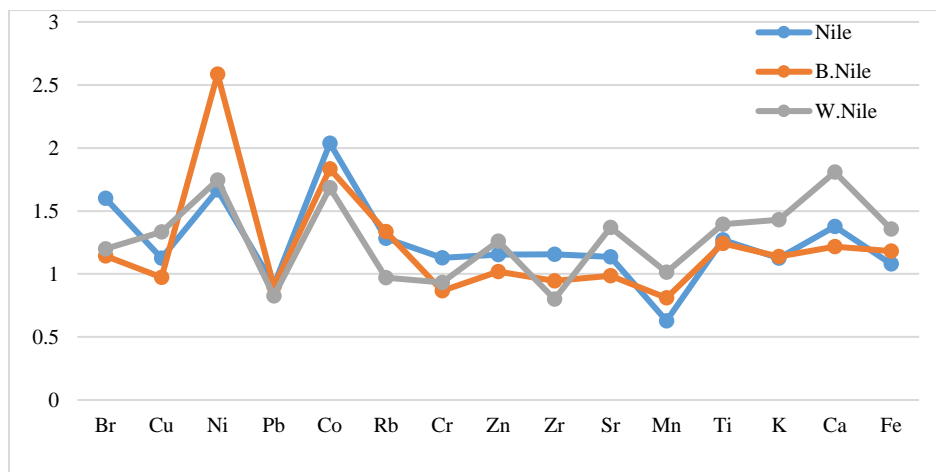


Fig. 7 Enrichment Factor (EF)

## 5. Conclusion

This result indicated that the metal concentrations were within the common range of soil, according to Murthy (2008). The concentrations of Ti, K, Ca, Fe, and Mn were in recommended range in soil according to the previous reference. Their concentrations ranged between 12517 to 19880 mg/kg, 10654 to 16754 mg/kg, and 17968 to 33463 mg/kg, 61513 to 95576 mg/kg, and 796 to 1863 mg/kg, respectively, Fig. 3. According to Lindsay 1979, the concentrations of Zn, Rb, Ni, Pb, and Br were in the range of 71 to 96 mg/kg, 44 to 69 mg/kg, 19 to 50 mg/kg, 30 to 40 mg/kg, and 4 to 9 mg/kg respectively, Fig.1 which in common range. Moreover, they are lower than the value listed in Dutch standards. Furthermore, the concentration of

Zr and Sr was found in a range of 253 to 420 mg/kg and 222 to 364 mg/kg, respectively. The concentrations of Co, Cr, and Cu ranged from 12 to 55 mg/kg, 41 to 81 mg/kg, and 42.3 to 4.7 mg/kg, respectively, Fig.2.

The Investigation of the metals found that they are in minimum limits with  $EF < 2$ , except for Ni at the Blue Nile area was obtained to be 2.58, and that may be because of precipitated heavy metals after the flow season and for the geo-accumulation index (GI), it has been demonstrated that it can be used effectively in explaining soil contents. Based on its category and the obtained values of GI, all sediment samples at all sites were unpolluted.[25].

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## Appendix

Table 1. Heavy metal concentrations in the sediment samples of the studied sites.

Location		Heavy metals concentrations (mg/kg)														
		Br	Cu	Ni	Pb	Co	Rb	Cr	Zn	Zr	Sr	Mn	Ti	K	Ca	Fe
Nile	Loct. 1	6	9	35	34	40	51	73	87	289	276	1670	15786	15723	26839	95576
	Loct. 2	4	10	25	33	29	56	43	84	253	235	1832	16432	14973	23054	79505
	Loct. 3	5	13	30	32	12	45	41	76	301	286	1211	14765	13952	22953	61513
	Avg.	5	10.66	30	33	27	50.66	52.33	82.33	281	265.66	1571	15661	14882	24282	78864
	EF	1.6	1.125	1.66	0.90	2.037	1.28	1.127	1.15	1.156	1.13	0.62	1.26	1.12	1.37	1.079
	PI	0.75	0.75	0.7	1.13	0.72	0.78	1.23	0.91	0.88	0.91	1.69	0.79	0.93	0.80	1.12
	GI	0.22	0.22	0.210	0.34	0.21	0.23	0.37	0.27	0.26	0.27	0.50	0.23	0.28	0.24	0.33
Blue Nile	Loct. 1	7	11	19	30	30	44	81	96	341	364	1863	17242	13873	29637	90647
	Loct. 2	8	15	19	40	27	49	57	95	361	268	891	14917	15362	27915	60029
	Loct. 3	6	11	20	30	33	53	66	89	329	287	901	15826	14936	24936	65367
	Avg.	7	12.33	19.33	33.33	30	48.66	68	93.33	343.66	306.33	1218.33	15995	14723	27496	72014
	EF	1.14	0.97	2.58	0.9	1.833	1.33	0.86	1.01	0.94	0.98	0.81	1.24	1.13	1.21	1.18
	PI	0.87	0.91	0.38	1	0.54	0.67	1.37	1.01	1.04	1.20	1.88	0.86	0.82	0.88	1.06
	GI	0.26	0.27	0.11	0.30	0.16	0.20	0.41	0.30	0.31	0.36	0.56	0.26	0.24	0.26	0.32
White Nile	Loct. 1	9	9	30	35	44	69	45	76	410	190	1178	16043	12865	17968	62453
	Loct. 2	7	10	29	39	29	65	70	71	389	222	796	12517	10654	18036	61657
	Loct. 3	4	8	27	35	25	67	75	79	420	250	950	14211	11643	19526	64234
	Avg.	6.66	9	28.66	36.33	32.66	67	63.33	75.33	406.33	220.66	974.66	14257	11720	18510	62781
	EF	1.2	1.33	1.74	0.82	1.68	0.97	0.93	1.26	0.79	1.36	1.01	1.39	1.42	1.80	1.35
	PI	1.12	0.75	0.6	1.16	0.8	1.06	0.76	0.8	1.26	0.62	1.19	0.80	0.76	0.53	0.73
	GI	0.33	0.22	0.18	0.35	0.24	0.31	0.22	0.24	0.37	0.18	0.35	0.24	0.23	0.16	0.22
Almogran	Loct.	8	12	50	30	55	65	59	95	325	302	987	19880	16754	33463	85101
	PI	1.33	1.33	1.42	0.88	1.37	1.27	0.80	1.09	1.12	1.09	0.59	1.25	1.06	1.24	0.89
	GI	0.40	0.40	0.43	0.26	0.41	0.38	0.24	0.32	0.33	0.32	0.17	0.37	0.32	0.37	0.26

\*Location 1: sediment sample.

\*Location 2: soil sample from the east side of the river.

\*Location 3: soil sample from the west side of the river.