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ECOLOGICAL RISK ASSESSMENT OF CRUDE OIL IMPACTED FARMLAND SOILS: A CASE STUDY OF OHAJI/EGBEMA IN NIGER DELTA, NIGERIA

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ABSTRACT: *The study assessed the impact of crude oil on farmland soils in Ohaji Egbema. Farmlands used for this study are farms that were indirectly impacted through overland flow and acid rain. A total of 42 farmland soil samples were used for this study. The farmland soil samples were collected at a depth range of 0 - 10 cm using a hand trowel through random sampling. The samples were air dried for 72 hours before laboratory analysis for arsenic (As), nickel (Ni), chromium (Cr), cadmium (Cd) and lead (Pb). The results obtained show that heavy metals in farmland soils at different locations in Ohaji/Egbema varied in both concentration and trend. The observed trends at different locations are: Cd>As>Ni>Cr>Pb for Mmahu, Abaezi, Abacheke and Awarra while for Assa and Obitti, it is Cd>Ni>As>Cr>Pb. To establish the extent the farmland soils were polluted, contamination factor (CF), degree of contamination (C_d) and geoaccumulation index (Igeo) were applied. Results of the Cf showed that Ni, Cr and Pb had low contamination, As had moderate contamination while Cd had high contamination in the farmland soils with a range of 155.15 - 206.87 and C_d of 1242.72. The Igeo for Cd ranged from 31.13 to 41.52, an indication of extreme contamination. The associated potential ecological risks were assessed using potential contamination index (PCI), ecological risk factor (Er^i) and ecological risk index (RI). It was found that Cd had PCI ranging from 155.22 - 198.51, Er^i range of 4654.44 - 6206.11 and RI of 37311.56. This indicates that the farmland soils of Ohaji/Egbema are highly contaminated with Cd and exposed to severe ecological risk.*

KEYWORDS: Farmland soils, Oil pollution, Heavy metal, Risk assessment, Ecotoxicology.

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INTRODUCTION

Nigeria runs a petroleum-driven economy. However, the approach to crude oil production and distribution in Nigeria is fraught with pollution and thus unsustainable (Kadafa, 2012). Just like in many other crude oil producing areas in Niger Delta, Ohaji/Egbema has experienced varying scales of environmental degradation due to activities relating to exploitation, processing and transportation of crude oil.

The exploration, discovery and exploitation of abundant petroleum resources in Niger Delta, which Ohaji/Egbema is part of, began in the 1950s. This, in turn, resulted in the exposure of the Niger Delta region to various scales of crude oil related pollution (Okoye et al., 2021; Orisakwe, 2021). Interestingly, Niger Delta is one of the world's ten most important wetland and marine ecosystems (Imoobe & Iroro, 2009). Unfortunately, Niger Delta ranks among the five most severely damaged ecosystems globally due to an unsustainable approach to crude oil production and related activities (Kadafa, 2012).

According to United Nations Development Programme UNDP (2006), between 1976 to 2001, a total of 6,817 oil spills were recorded, with a loss of approximately three million barrels of oil out of which about 70% of the spilled oil was not recovered. For instance, the Funiwa Well No. 5 in 1980 blew up and spilled an estimated 421,000 barrels of oil into the surrounding environment. This caused the destruction of not less than 836 acres of mangrove forest within six miles offshore (Ukoli, 2001). Also, a spill at Shell's Bonga Oil Field in 2011 released up to 40,000 barrels and affected over 350 farming communities (Alozie, 2020). According to Ihiegbulem (2011), crude oil spillage at Umuogwa, Umuodebi and Awarra communities in Ohaji/Egbema on June 18, 2004, degraded both terrestrial and aquatic lives. Similarly, oil spillage devastated farmlands in Abacheke, Ugada and Etwkuru communities in Ohaji/Egbema (Amobi, 2017). On April 22, 2022, there was an explosion at an illegal oil refinery at Abaezi in Ohaji/Egbema which led to loss of lives, properties and environmental degradation. Though most of the farmland soils may not have been impacted directly by oil spillages, gas flaring or explosions, however it is likely that many farmlands have been indirectly impacted through redistribution by overland flow and acid rain. Hence, as much as 60% of the people in Ohaji/Egbema who depend on land resources in the area for their livelihood have been directly or indirectly exposed to varying degrees of oil related pollution (Kadafa, 2012; Njoku et all., 2014).

Heavy metals are known pollutants which are toxic and persist in the environment (Pekey, 2006; Nemati et al., 2011; Enegide & Chukwuma, 2008; Nwawuike & Ishiga, 2018) and a source of poor ecological quality (Defew et al., 2005). Several heavy metals such as cadmium (Cd), lead (Pb), arsenic (As), chromium (Cr), zinc (Zn), copper (Cu), mercury (Hg) and nickel (Ni) are among the most hazardous and environmentally relevant heavy metals associated with crude oil pollution (Bamgbose et al., 2012). These metals are not easily degraded (Yan et al., 2020; Guijarro, 2021; Raffa et al., 2021), transferred through trophic processes in both terrestrial and aquatic environments and thus possess substantial ecotoxicological risks (Proshad et al., 2018; Ali et al., 2019; Proshad et al., 2019). These heavy metals not only distort ecological balance in agricultural soils but also pose danger to living organisms (Lu et al., 2012; Du et al., 2015). To ensure the safety of agricultural produce, the understanding of concentration variations of heavy metals in farmland soils is critical (Okoye et al., 2022). More so, in farmland soils that are within the vicinity of crude oil production and related activities. However, there exists dearth of studies of this nature in Ohaji/Egbema.

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It is against this backdrop that this study was carried out to examine the ecological risks associated with crude oil impacted farmland soils in Ohaji/Egbema. Thus, this study sought to deepen insight into: (a) heavy metal concentration in farmland soils in Ohaji/Egbema, (b) evaluation of heavy metal contamination in farmland soils and (c) determination of the ecological risk of metal contamination in farmland soils.

MATERIALS AND METHOD

Site Description

Ohaji/Egbema is one of the 27 local government areas in Imo State, Nigeria. It is a major food production hub in the state and also rich in petroleum and gas resources. Ohaji/Egbema shares boundary with Owerri West and Ngor-Okpala, to the east while to the north, it has boundary with Oguta on the Imo State side. On the south-west, Ohaji/Egbema shares boundary with Ogba/Egbema/Ndoni in Rivers State.

The study area falls within the tropical rainforest zone. Dry season lasts between November and March while the rainy season lasts between April and October. On average, the annual precipitation exceeds 2,500 mm while temperature ranges between 26°C to 30°C (Nigerian Meteorological Agency NIMET, 2014). Topographically, Ohaji/Egbema is low-lying with no part exceeding 80 meters above sea level. Geologically, the soils of Ohaji/Egbema are derived from the Benin Formation (Ahukaemere et al., 2016). Seven communities (Assa, Awarra, Obitti, Abacheke, Mmahu, Abaezi and Umuagwo) with links to crude oil production and related activities all in Ohaji/Egbema were used for this study.

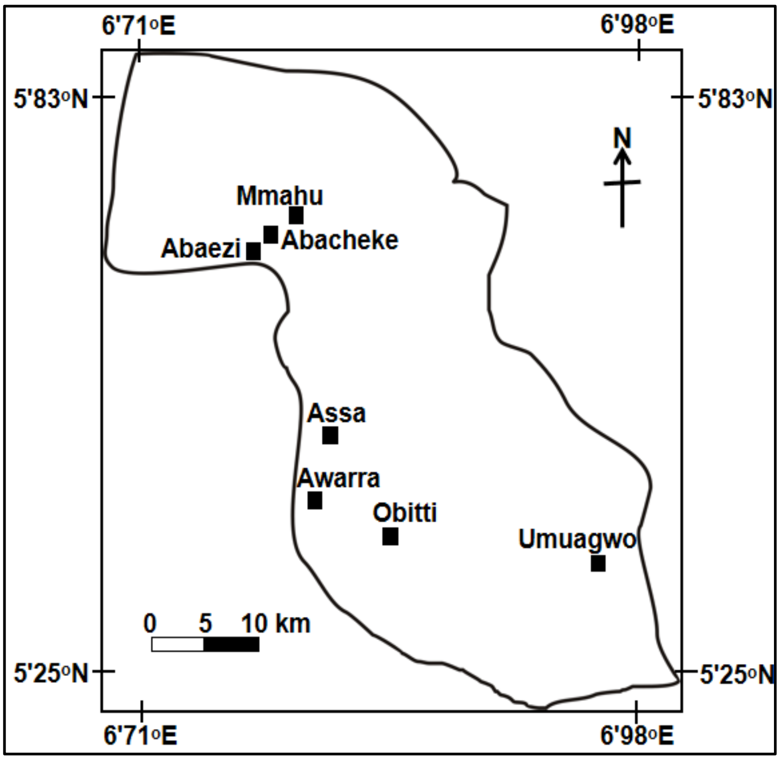

Figure 1: Map of study area showing sampling locations (Credit: This study).

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Sampling and Sample Preparation

Two farmland soil samples were randomly obtained from 3 cassava farms in each of the 7 communities in Ohaji/Egbema. This gave 6 farmland soil samples from each community and a total of 42 farmland soil samples used for this study. The farmland soil samples were collected at a depth range of 0 - 10 cm using a hand trowel. The obtained farmland soil samples were packaged in plastic bags and labeled in the field. The samples were air dried for 72 hours and repackaged in zip-lock bags, labeled and carefully packed in plastic boxes prior to laboratory analysis.

Laboratory Analysis

Farmland soils were analyzed for heavy metal concentrations. The heavy metals analyzed for are arsenic, nickel, chromium, cadmium and lead. These metals were chosen because they are associated with petroleum pollution. The heavy metals were extracted using wet acid digestion method and the filtrate were analyzed using standard Atomic Absorption Spectrophotometer (AAS) procedures.

Data Analysis

The descriptive analysis of As, Ni, Cr, Cd and Pb concentrations in the farmland soil samples were computed using Microsoft Excel 2010. KaleidaGraph 4.0 was used to plot farmland soil-upper continental crust (UCC) normalized concentration graph.

Farmland Soil Contamination Assessment

The analyzed heavy metal data from farmland soils were used to assess the extent of contamination in farmland soils using:

Contamination Factor (CF)

The extent to which the farmland soils were contaminated by the selected heavy metals were determined using contamination factors. Tomlinson et al. (1980) posit that contamination factor is expressed thus:

$$CF = \frac{C_{metal}}{C_{background}} \qquad (1)$$

Where:

C_{metal} is metal concentration in the sampled farmland soils.

$C_{background}$ is the background metal concentration.

The background metal concentration used for this study was obtained from the upper continental crust proposed by Rudnick and Gao (2003). The CF is interpreted as follows: CF < 1: signifies low contamination; 1 ≤ CF < 3: signifies moderate contamination; 3 = CF ≤ 6: signifies considerable contamination and CF ≥ 6: implies very high contamination.

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Degree of Contamination (C_d)

To further probe the extent to which the farmland soils were contaminated, the degree of contamination put forth by Hakanson (1980) was employed. The formula is mathematically given as:

$$C_d = \sum CF \quad (2)$$

It is the sum of all the CF of heavy metals obtained in a sample location. The interpretation of C_d is as follows: $C_d < 6$ shows low C_d; $6 < C_d < 12$ means moderate C_d; $12 < C_d < 24$ is considerable C_d while $C_d > 24$ is high C_d and indicates strong anthropogenic pollution.

Geoaccumulation Index (*Igeo*)

To evaluate the geoaccumulation in farmland soils of Ohaji/Egbema, the geoaccumulation index developed by Muller (1979) was applied. It is given as:

$$Igeo = Log_2\left(\frac{C_s}{1.5 \times C_b}\right) \quad (3)$$

Where:

Cs is the metal concentration obtained from the farmland soil, Cb is the background metal concentration. 1.5 is a moderating constant value. Geoaccumulation index as shown on Table 1, has seven classes of contamination according to Muller (1980).

Table 1: Classes of Geoaccumulation Index

Class	Value	Sediment quality
0	Igeo≤0	Uncontaminated
1	0< Igeo <1	Uncontaminated to moderately contaminated
2	1< Igeo <2	Moderately contaminated
3	2< Igeo <3	Moderately to heavily contaminated
4	3< Igeo <4	Heavily contaminated
5	4< Igeo <5	Heavily to extremely contaminated
6	Igeo≥5	Extremely contaminated

Potential Ecological Risk Assessment of Farmland Soils

Potential Contamination Index (PCI)

To determine the extent of ecological risk posed by the selected heavy metals in farmland soils, the potential contamination index by Davaulter and Rognerud (2001) was employed. It can be calculated thus:

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$$PCI = \frac{Metal_{sample\ \max}}{Metal_{background}} \tag{4}$$

Where:

Metal $_{sample\ maximum}$ is the maximum metal concentration in farmland soil while metal $_{background\ i}$s the corresponding metal background value.. The background values were sourced from the upper continental crust by Rudnicj and Gao (2003). It is thus interpreted: PCI < 1 is low contamination, 1 < PCI < 3 is moderate contamination and PCI > 3 is severe or very severe contamination.

Potential Ecological Risk Factor (Er^i)

To further assess the potential ecological risk of selected metals in farmland soils, the potential ecological risk factor postulated by Hakanson (1980) was used. It is given thus:

$$Er^i = Tr^i \times C^i{}_f \tag{5}$$

Where:

Er^i is the potential ecological risk factor of metal (i) while Tr^i is the toxic response factor of metal (i). C^i_f is the contamination factor of metal (i). The toxic response factor values are; As (10), Cr (2), Pb (5), Cd (30) and Ni (5) (Hakanson, 1980). The interpretation of Er^i values are as follows: $Er^i < 40$ implies low potential ecological risk, $40 \leq Er^i < 80$ means moderate potential ecological risk, $80 \leq Er^i < 160$ is considerable potential ecological risk, $160 \leq Er^i < 320$ implies high potential ecological risk and $Er^i \geq 320$ means very high potential ecological risk.

Potential Ecological Risk Index (RI)

Hakanson (1980) puts forth an ecological risk assessment called the potential ecological index. It is used to estimate the ecological risk posed by metals in soils. It is computed by summing up the Er^i and is interpreted thus: RI < 150 implies low ecological risk, 150 ≤ RI < 300 is moderate ecological risk, 300 ≤ RI < 600 implies considerable ecological risk and RI ≥ 600 is very high ecological risk. The RI formula is thus given:

$$RI = \sum Er^i \tag{6}$$

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RESULTS AND DISCUSSION

Heavy Metal Concentrations in Ohaji/Egbema Farmland Soils

The minimum, maximum, mean and standard deviations of selected heavy metal concentrations of heavy metals in Ohaji/Egbema farmland soils are displayed on Table 2. The table also presented a spatial comparison between concentrations on the farmland soils and different locations in Ohaji/Egbema and the UCC values of Rudnick and Gao (2003). The heavy metals in farmland soils at different locations in Ohaji/Egbema showed variations in both concentration and trend. The observed trends at different locations are: Cd>As>Ni>Cr>Pb for Mmahu, Abaezi, Abacheke and Awarra while for Assa and Obitti, it is Cd>Ni>As>Cr>Pb. However, the trend in UCC concentration is Cr>Ni>Pb>As>Cd. Relative to the UCC values of Rudnick and Gao (2003), Cd in farmland soils was higher while Ni, Cr and Pb in farmland soils were lower in all locations sampled. In all locations, As was higher in farmland soils except in Obitti as shown in Figure 2. The observed high concentration of Cd in the farmland soils could also be due to excessive use of inorganic fertilizer.

Table 2: Heavy Metal Distribution in Farmland Soils of Ohaji/Egbema

Locations	As	Ni	Cr	Cd	Pb	GPS Coordinates	
	mgkg^{-1}					Latitude	Longitude
Mmahu 1	11.07	7.22	2.86	14.35	2.00	5.525794	6.752313
Mmahu 2	10.97	7.21	2.86	14.35	2.01	5.525985	6.752164
Mmahu 3	11.01	6.91	2.73	14.38	2.00	5.525724	6.751645
Mmahu 4	11.09	7.01	2.57	13.80	1.99	5.525936	6.752132
Mmahu 5	10.88	7.30	3.00	14.36	2.12	5.525895	6.751998
Mmahu 6	11.07	6.91	2.87	14.28	2.01	5.524895	6.751819
Mean±SD	**11.01±0.08**	**7.09±0.17**	**2.82±0.14**	**14.25±0.23**	**2.02±0.05**		
Abaezi 1	7.38	5.87	4.68	16.68	1.26	5.493503	6.729360
Abaezi 2	7.23	5.87	4.67	16.70	1.24	5.493268	6.729082
Abaezi 3	7.35	5.79	4.73	16.68	1.25	5.493374	6.729610
Abaezi 4	7.40	5.94	4.67	16.60	1.26	5.493202	6.729008
Abaezi 5	7.38	5.87	4.80	16.56	1.25	5.493816	6.729896
Abaezi 6	7.30	5.87	4.69	16.73	1.26	5.493426	6.729362
Mean±SD	**7.34±0.07**	**5.87±0.04**	**4.71±0.05**	**16.66±0.07**	**1.25±0.01**		
Abacheke 1	7.38	3.99	3.38	15.52	0.53	5.505275	6.735436
Abacheke 2	7.38	4.00	3.37	15.45	0.45	5.505256	6.735037
Abacheke 3	7.29	3.99	3.30	15.50	0.55	5.505117	6.735105
Abacheke 4	7.42	3.98	3.37	15.56	0.59	5.304889	6.733984
Abacheke 5	7.39	3.91	3.40	15.51	0.52	5.304902	6.733589
Abacheke 6	7.40	4.00	3.40	15.52	0.53	5.504501	6.733526

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Mean±SD	**7.38±0.04**	**3.98±0.04**	**3.37±0.04**	**15.51±0.03**	**0.53±0.05**		
Assa 1	5.54	6.52	3.64	17.84	1.02	5.385704	6.781822
Assa 2	5.38	6.52	3.64	17.81	1.02	5.385594	6.781994
Assa 3	5.52	6.50	3.63	17.87	1.02	5.384794	6.779597
Assa 4	5.48	6.52	3.63	17.80	0.99	5.384868	6.779605
Assa 5	5.60	6.50	3.61	17.85	1.02	5.384868	6.779602
Assa 6	5.54	6.52	3.66	17.84	0.99	5.384390	6.778806
Mean±SD	**5.51±0.08**	**6.51±0.01**	**3.63±0.02**	**17.83±0.03**	**1.01±0.02**		
Awarra 1	12.91	4.99	3.12	15.13	1.87	5.359635	6.773193
Awarra 2	12.91	4.81	3.13	15.12	1.86	5.359451	6.772931
Awarra 3	12.88	4.98	3.02	15.14	1.87	5.359086	6.772704
Awarra 4	12.73	4.98	3.13	14.97	1.86	5.359126	6.772682
Awarra 5	12.93	4.96	2.99	15.13	1.86	5.359324	6.772981
Awarra 6	12.91	4.88	3.13	15.13	1.86	5.359186	6.772924
Mean±SD	**12.88±0.07**	**4.93±0.07**	**3.09±0.06**	**15.10±0.07**	**1.86±0.01**		
UCC	4.8	47	92	0.09	17		

Table 2 continues

Locations	**As**	**Ni**	**Cr**	**Cd**	**Pb**	**GPS Coordinates**	
			mgkg^{-1}			**Latitude**	**Longitude**
Obitti 1	3.69	5.28	2.08	13.96	0.69	5.332886	6.818628
Obitti 2	3.68	5.27	2.08	13.97	0.69	5.332707	6.818761
Obitti 3	3.70	5.29	2.09	13.96	0.70	5.332789	6.818790
Obitti 4	3.69	5.29	2.08	13.97	0.67	5.332808	6.818523
Obitti 5	3.70	5.29	2.08	13.96	0.69	5.334608	6.818371
Obitti 6	3.69	5.27	2.08	13.96	0.70	5.335450	6.818092
Mean±SD	**3.69±0.01**	**5.28±0.01**	**2.08±0.01**	**13.96±0.00**	**0.69±0.01**		
Umuagwo 1	9.23	7.04	5.20	18.62	0.80	5.331614	6.953625
Umuagwo 2	9.23	7.04	5.21	18.62	0.79	5.329050	6.950605
Umuagwo 3	9.22	7.05	5.20	18.61	0.81	5.331481	6.959332
Umuagwo 4	9.23	7.04	5.21	18.62	0.81	5.331493	6.959540
Umuagwo 5	9.22	7.04	5.19	18.62	0.80	5.329171	6.954206
Umuagwo 6	9.22	7.05	5.20	18.62	0.80	5.331005	6.954382
Mean±SD	**9.22±0.00**	**7.04±0.00**	**5.20±0.01**	**18.62±0.00**	**0.80±0.01**		
UCC	4.8	47	92	0.09	17		

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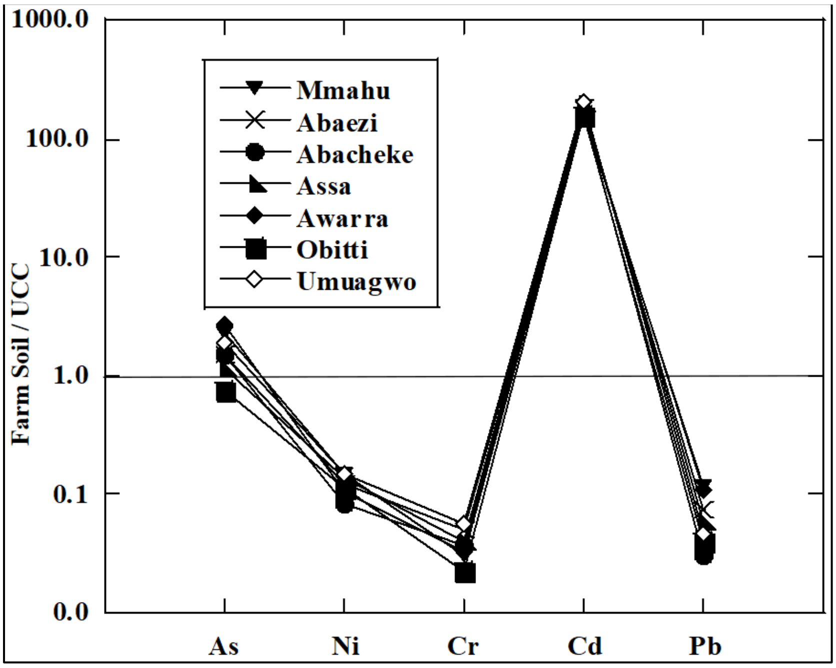

Figure 2: Comparison of concentrations of heavy metals in farmland soils of Ohaji/Egbema. All values were normalized to the UCC values of Rudnick and Gao (2003).

Farmland Soil Pollution Assessment

Contamination Factor (CF) and Degree of Contamination (C_d)

The contamination factor, degree of contamination and pollution load index of selected heavy metals are presented in Table 3. Contamination factors for As, Ni, Cr, Cd and Pb ranged from (0.77 - 2.68), (0.08 - 0.15), (0.02 - 0.06), (155.15 - 206.87) and (0.03 - 0.12) respectively. Based on the interpretation of contamination factor by Tomilinson et al. (1980), the contamination of Ni, Cr and Pb in the farmland soils are low while As has a low to moderate contamination. However, Cd has a very high contamination in farmland soils. To determine the degree of contamination in the farmland soils, the degree of contamination was used. As, Ni, Cr, Cd and Pb in farmland soils of Ohaji/Egbema had C_d of 11.88, 0.87, 0.27, 1,242.72 and 0.48 respectively. According to Hakanson (1980), the specified interpretation of C_d implies that Ni, Cr and Pb have low degree of contamination; As has moderate degree of contamination while Cd has high degree of contamination. Thus, the high degree of contamination of Cd in the farmland soils is an indication of a very strong anthropogenic input. Interestingly, related previous studies in Niger Delta obtained lower Cf values compared to this study. All the parameters used by Iwegbue et al. (2006), Simeon and Friday (2017), Ebong et al. (2020) had values of <1 while Nsikak et al. (2016) obtained average Cf values of 2.53 (Cd), 0.08 (Cr), 0.03 (Ni) and (0.001) Pb. Besides Cd that was moderately contaminated, the other parameters were not contaminated.

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Table 3: Contamination Factor and Degree of Contamination of Farmland Soils in Ohaji/Egbema

Locations	CF_{As}	CF_{Ni}	CF_{Cr}	CF_{Cd}	CF_{Pb}
Mmahu	2.29	0.15	0.03	158.36	0.12
Abaezi	1.53	0.12	0.05	185.09	0.07
Abacheke	1.54	0.08	0.04	172.30	0.03
Assa	1.15	0.14	0.04	198.15	0.06
Awarra	2.68	0.10	0.03	167.80	0.11
Obitti	0.77	0.11	0.02	155.15	0.04
Umuagwo	1.92	0.15	0.06	206.87	0.05
C_d	**11.88**	**0.87**	**0.27**	**1,243.72**	**0.48**

Geoaccumulation Index (*Igeo*)

The determination of the extent to which heavy metals geoaccumulate in the farmland soils was done using Geoaccumulation Index and the output shown in Table 4. Generally, the Igeo of most of the heavy metals were <1 and thus, according to Muller (1981), are in the class of uncontaminated to moderately contaminated. However, the Igeo of Cd ranged from 31.13 - 41.52 which is an indication of extreme contamination. The results of geoaccumulation index in previous studies carried out within Niger Delta by Nsikak et al. (2016), Aigberua et al. (2017), Okoye et al. (2021), Aigberua (2021), and Tubotu and Agbaire (2022) indicate that Ni, Pb, Cr and As had values <1. This implies that the sites studied were uncontaminated by these heavy metals. However, Aniekan et al. (2014), Nsikak et al. (2016), Nwankwoala and Ememu (2018), and Tubotu and Agbaire (2022) found in their separate studies that Cd had Igeo values ranging between 1.69 and 5.07. This implies a range of moderate to extreme contamination.

Table 4: Geoaccumulation Index of Farmland Soils in Ohaji/Egbema

Locations	$Igeo_{As}$	$Igeo_{Ni}$	$Igeo_{Cr}$	$Igeo_{Cd}$	$Igeo_{Pb}$
Mmahu	0.46	0.03	0.01	31.78	0.02
Abaezi	0.31	0.03	0.01	37.15	0.01
Abacheke	0.31	0.02	0.01	34.59	0.01
Assa	0.23	0.03	0.01	39.76	0.01
Awarra	0.54	0.02	0.01	33.67	0.02
Obitti	0.15	0.02	0.00	31.13	0.01
Umuagwo	0.39	0.30	0.01	41.52	0.01

Potential Ecological Risk Assessment of Farmland Soil

Potential Contamination Index (PCI)

The potential contamination index was used to probe the ecological risk assessment of these heavy metals in the farmland soils as presented on Table 5. Differences in PCI were observed across metals and locations within the study area. Specifically, it was found that As has a PCI range of 0.77 - 2.69, Ni (0.09 - 0.94), Cr (0.02 - 1.50), Cd (155.22 - 198.51) and Pb (0.04 -

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0.12). However, according to Davaulter and Rognerud (2001), contamination of As ranged from low to moderate, Ni, Cr and Pb have low contamination while Cd has very severe contamination. Nwawuike and Ishiga (2022) reported PCI values of 12.27, 14.03, 4.67 and 2.21 for (As), (Cr), (Pb) and (Ni) respectively.

Table 5: Potential Contamination Index of Farmland Soils in Ohaji/Egbema

Locations	PCI_{As}	PCI_{Ni}	PCI_{Cr}	PCI_{Cd}	PCI_{Pb}
Mmahu	2.31	0.16	0.03	159.74	0.12
Abaezi	1.54	0.13	0.05	185.91	0.07
Abacheke	1.55	0.09	0.04	172.79	0.03
Assa	1.17	0.14	0.04	198.51	0.06
Awarra	2.69	0.11	0.03	168.18	0.11
Obitti	0.77	0.11	0.02	155.22	0.04
Umuagwo	1.92	0.15	0.06	206.93	0.05

Potential Ecological Risk Factor (Er^i) and Potential Ecological Risk Index (RI)

The potential ecological risk factor and potential ecological risk index of selected heavy metals are presented on Table 6. The potential ecological risk factors for As, Ni, Cr, Cd and Pb ranged from (7.69 - 22.94), (0.42 - 0.75), (0.05 - 0.11), (4654.44 - 6206.11) and (0.16 - 0.59) respectively. Based on the interpretation of Er^i given by Hakanson (1980), As, Ni, Cr and Pb contamination in the farmland soils have low potential ecological risk while Cd contamination in farmland soils has a very high potential ecological risk. Previous studies by Adebiyi and Ayeni (2021) had Er^i values of 2.85 (Pb), 1.75 (Ni), 67.87 (Cd) and 0.70 (Cr) while Chris and Anyanwu (2022) reported Eri of 87.6 (Cd), 44.56 (Pb), 0.14 (As) and an RI of 3499.12.

Table 6: Potential Ecological Risk Factor of Farmland Soils in Ohaji/Egbema

Locations	Er^i_{As}	Er^i_{Ni}	Er^i_{Cr}	Er^i_{Cd}	Er^i_{Pb}
Mmahu	22.94	0.75	0.06	4,750.78	0.59
Abaezi	15.29	0.62	0.10	5,552.61	0.37
Abacheke	15.37	0.42	0.07	5,169.06	0.16
Assa	11.48	0.69	0.08	5,944.61	0.30
Awarra	26.83	0.52	0.07	5,033.94	0.55
Obitti	7.69	0.56	0.05	4,654.44	0.20
Umuagwo	19.22	0.75	0.11	6,206.11	0.24
RI	**118.82**	**4.33**	**0.54**	**37,311.56**	**2.40**

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CONCLUSION

The assessment of heavy metal contamination (As, Ni, Cr, Cd and Pb) in the farmland soils of Ohaji/Egbema with samples obtained from Mmahu, Abaezi, Abacheke, Assa, Awarra, Obitti and Umuagwo was made in comparison with the upper continental crust. The concentration of the heavy metals followed the sequence Cd>As>Ni>Cr>Pb. Trends in heavy metal burdens in the farmland soils disclosed significant differences in metal distribution among sampled locations in the study area. The CF, C_d, PLI, Igeo, PCI, Er^i and RI values of Ni, Cr and Pb indicated low contamination and ecological risk; As had moderate ecological risk while Cd had very high contamination and posed severe ecological risk. High cadmium contamination in soils poses great ecological risk. Thus, remediation of cadmium and arsenic in farmland soils of Ohaji/Egbema is recommended.

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