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Pollution Status, Proximate Composition and Ecological Risk Index of *Amaranthus hybridus* and *Vernonia colorata* Leaves Harvested from Roadside and Farms within Zaria Metropolis, Kaduna State, North-West Nigeria

Udofia I. M.[1]*, Ufot I. N.[1], Danzarami D. A.[2]., John G.O.[1],**

[1]*Chemistry Department, University of Uyo, Uyo, Akwa Ibom State, Nigeria*
[2]*Nigerian Institute of Leather and Science Technology (NILEST), Zaria, Kaduna State, Nigeria*
**Corresponding author, Email address: ifrekemfonudofia@gmail.com,*
***Corresponding author, Email address: danzaramidanlami@gmail.com*

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Abstract: This study investigated the pollution status, proximate composition and ecological health risk of *Amaranthus hybridus* and *Vernonia colorata* harvested from roadside and farm within Zaria, Kaduna State, North-west Nigeria. The harvested vegetables were prepared using appropriate standard methods and concentrations of metals were determined using AAS. The concentrations of Cd, Cu, Fe, Zn and Ni were below the permissible limit of FAO/WHO. Conversely, concentrations of Pb and Mn were above permissible limit. The result for proximate composition of moisture, ash, fat, crude protein, fibre and carbohydrate contents was 3.34-3.44%, 2.00-4.50%, 12.00-16.40%, 17.50-18.81%, 6.56-12.20% and 59.39-62.58% for the harvested vegetables respectively. The pollution status of the vegetables was evaluated and the contamination factor ranged from low to very high contamination. The degree of contamination showed a sequence of *V. colorata* (RS) > *V. colorata* (FL) > *A. hybridus* (RS) > *A. hybridus* (FL). Ecological risk factor showed a low ecological risk except Pb with an appreciable ecological risk factor.

Keywords: *Pollution; Contamination; Leaves; Toxic Metals; Proximate Analysis,*

1. Introduction

The emission of pollutants by vehicles into the atmosphere as a result of traffic density emanating from high fleet growth, increased population, increased urbanization and economic improvement have caused serious damage to the environment. The primary pollutants from vehicular emission includes carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), sulphur oxides (SOx), hydrocarbons (HCs) and, particulate matter (PM). Reports have revealed that, apart from the greenhouse gases emanated from road transport, other harmful substances have also been released into the human environment (Ekwumemgbo *et al.*, 2016, 2023; Nwagbara and Iyama, 2019; Okon *et al.*, 2021, 2024; Ebong *et al.*, 2023). These harmful substances are heavy metals which include; lead (Pb), zinc (Zn), iron (Fe), copper (Cu), chromium (Cr), and cadmium (Cd), and can have serious health and environmental impacts (Turer and Maynard, 2003; Okon *et al.*, 2022; Ebong *et al.*, 2022 Etuk *et al.*, 2023 a & b). Heavy metals are a group of metallic elements defined by their high density, atomic mass, and potential toxicity (Nwokem *et al.*, 2023; Okon *et al.*, 2023a & b; Anweting *et al.*, 2024a & b). Exposure to high levels of toxic metals can have devastating effects on human health, causing a wide range of problems, including: bone, lung, and kidney damage, gastrointestinal issues like diarrhea and stomach irritation, neurological problems like mental retardation, psychosis, and autism, cancer, birth defects, and developmental issues, skin, brain, and kidney problems, respiratory, cardiovascular, and gastrointestinal diseases, headaches, hypertension, edema, and loss of appetite, neurological symptoms like vertigo, sleeplessness, hallucinations, and paralysis, musculoskeletal issues like arthritis and muscle weakness, in extreme cases, even death (AbdElnabi *et al*., 2023; Obasi and Akudinobi, 2020; Ohiagu *et al*., 2022). Offiong *et al.* (2021) established that metals can bio-accumulate in biological cells, and remain throughout the food chain with deleterious effect on biological systems. Plants can act as indicators of environmental health, showing the presence of pollutants in their leaves, roots, and stems, which reveals the quality of the surrounding water, soil, and air (Ozyigit *et al*., 2022; El Hammari *et al*., 2022). Bio-monitoring is a more effective way to study aquatic and terrestrial environments than traditional methods, as it is more sensitive, comprehensive, and widely applicable (Zhou *et al*., 2008). Bio-indicators, such as various plant and animal species, are used to detect and record changes in these environments. Many different species, including fish (Authman *et al*., 2015; Łuczyńska *et al*., 2018), plants (Tashekova and Toropov, 2017; Molnár *et al*., 2020), diatoms (Kireta *et al*., 2012; Costa and Schneck, 2022), and birds (Maznikova *et al*., 2024), have been used as bio-indicators to monitor and understand the health of aquatic and terrestrial ecosystems. Plants have the ability to absorb and accumulate heavy metals through their root and leave surfaces, allowing them to take up and store these substances from their environment (Ad *et al*., 2015). Although the absorption and accumulation ability of plants (leaves) can be useful as a means of heavy metal remediation, it can be consequently harmful to potential consumers.

Among the various edible parts of plants, leaves have been the most utilized by humans, providing value such as food, medicine, economic benefits, and their aesthetic appeal (Ojiego *et al*., 2022). Worldwide, human beings depend on leafy vegetable as a good source of vitamins, essential metals, nutrients and antioxidants (Ali *et al*., 2020; Dada *et al*., 2021), such vegetables include *Amaranthus hybridus* and *Vernonia colorata*. *Amaranthus hybridus* is commonly known as green amaranth, smooth pigweed and smooth amaranth. In Nigeria, it is generally and commonly called spinach although not of the same species with the real spinach plant (*Spinaciaoleracea*). It is also known as green in southern Nigeria, *alefo* in the north and efo in the west. It is probably the most widely occurring leafy vegetable in Africa (Mordi, 2007). Apart from being used as vegetable, it also serves as herbs for the treatment of intestinal bleeding, diarrhea and excessive menstruation (Foster and Duke, 2000). *Vernonia colorata* is a shrub that grows throughout Africa and South-Asia and belongs to the family Asteraceace (Duarte and Silva, 2013). It is commonly called bitter leaves because of its bitter taste and is used as vegetables in soups. The bitter taste of *V. colorata* has been attributed to its antinutritional components such as alkaloids, saponins, glycosides and tannins (Bonsi *et al*., 1995). In Nigeria, bitter leaf is known as Ewuro in Yoruba, Onugbu in Igbo, Chusar-doki in Hausa (Egedigwe, 2010) and Etidot among the Efik, Ibibio and Annang.

Due to sparsity of data with regards to the nutritive value and health risk associated with vegetable consumption within the study area, there is need for further research to complement the existing data, bearing in mind that any negative impact on vegetables may have direct influence on the nutritional need of man who depends on these vegetables. This can also serve as a bio-indicator for the air and soil quality within the study area. This research assessed the proximate composition and total concentrations of seven (7) toxic metals (Cd, Cu, Fe, Pb, Zn, Ni and Mn) in two plant leaves along road with high traffic density within Zaria metropolis, Kaduna state, North-west, Nigeria. The study also examined the pollution status and ecological risk associated to prolonged exposure to these toxic metals via the leave sample harvested within the study area. The structures of *Amaranthus hybridus and Vernonia colorata are* shown in Fig. 1a and Fig. 1b respectively.


Figure 1a: *Amaranthus hybridus*


Figure 1b: *Vernonia colorata*

2. Methodology

2.1. *Study area*

Zaria formally known as Zazzau town is a highly populated and busy town in Kaduna, North-west Nigeria with coordinates 11° 5' 7.9476" N and 7° 43' 11.8020" E. Zaria has a population of 766,007 (Zaria population, n.d) and home to the largest university in Nigeria and also a center for textile industries. The major source of livelihood within this area is farming. Zaria has a tropical savanna climate with warm weather year-round, a wet season lasting from April to September, and a drier season from October to March.

2.2. Sample collection and preparation

A. hybridus and V. colorata were collected from the roadside (round about Kano junction) and a farmland (NARICT farm) both within Zaria metropolis, Kaduna state. The collected vegetables were packed in a well-labelled Kraft paper and taken to the laboratory for identification, preparation and analysis. The samples were identified by a plant taxonomist in Botany Department, Ahmadu Bello University, Zaria. The harvested samples were washed with tap water and then rinsed with distilled water severally. The samples were air dried at room temperature to remove residual moisture and then further oven dried at 60°C. Samples were milled into fine powder and sieved through a 2.0 mm sieve to obtain a dried powdered sample.

2.3. Digestion of samples

2g of the finely milled sample was measured into a 100ml beaker, aqua regia (3:1) was added and placed on a hot plate. The filtrate was obtained into a sampling bottle and stored for analysis. Concentration of Cd, Cu, Fe, Pb, Zn, Ni and Mn was determined using an atomic absorption spectrophotometer.

2.4. *Proximate composition analysis*

The A.O.A.C 1980 standard method of analysis was implemented to determine the proximate composition of the studied samples. The proximate composition analyzed include; moisture, ash, fat, crude fibre, crude protein and carbohydrate content.

2.4.1. Moisture content

Aluminum dishes were washed and dried to constant weight in an oven at 100°C, cooled in a desiccator and weighed (W_1). 2g of the sample was placed in the dish and weighed (W_2). The sample was placed in an oven for 3 hours, removed into a desiccator to cool and weighed W_3:

The % of moisture content = $\frac{W2-W3}{W2-W1}x100$ **Eqn. 1**

2.4.2. Ash content

An oven dried crucible was weighed (W_1). 2g of the sample was placed in the crucible and weighed (W_2). The samples were incinerated in a muffle furnace at 550°C for 4 hours, removed and cooled in a desiccator and weighed (W_3) until a constant weight was obtained as highlighted by Mikore and Mulugeta (2017):

The % of ash = $\frac{W3-W1}{W2-W1}x100$ **Eqn. 2**

2.4.3. Fat content

250ml boiling flask was dried in an oven and placed in a desiccator to cool. An empty filter paper was weighed W_1. 2g of the sample was placed in the filter paper and weighed as W_2. The boiling flask was filled with petroleum ether. The Soxhlet apparatus was assembled and refluxing was allowed for 8 hours. The filter paper was transferred to an oven, and then to a desiccator and allowed to cool until a constant weighed W_3 was obtained:

The % of fat = $\frac{W2-W3}{W2-W1}x100$ **Eqn. 3**

2.4.4. Crude fibre

2g(W) of the sample was placed in a beaker containing 1.2ml of H_2SO_4 per 100ml of solution and boiled for 30minutes, the residue was filtered and washed with hot water, the residue was transferred to a beaker containing 1.2g of NaOH per 100ml of solution and boiled for 30minutes, the residue was washed with hot water, dried in an oven and weighed (C_2), the weighed sample was incinerated in a furnace at 550°C, removed and allowed to cool, and weighed (C_3):

The % of fibre = $\frac{C2-C3}{W}x100$ **Eqn. 4**

2.4.5. Crude protein (Kjeldahl Method)

2g of the sample was weighed into 100cm^3 of Kjeldahl digestion flask and about 1g of the catalyst mixture (K_2SO_4 + anhydrous $CuSO_4$) was added. 25cm^3 of concentrated sulphuric acid was added into the flask. The content was heated slowly until frothing subsided and then more vigorously with occasional rotation of the flask to ensure even digestion and to avoid over heating of the content. The heating continued until a clear solution was obtained. On cooling, the solution was transferred into 100cm^3 volumetric flask and distilled water was added up to mark. 10cm^3 aliquot of the digest was pipetted into Markham semi macro flask and 10cm^3 of 40% sodium hydroxide solution was added. The solution was distilled and the liberated ammonia was trapped in a 100cm^3 conical flask containing 10cm^3 of 4% boric acid and two drops of methyl red indicator. Distillation was continued until the pink colour of the indicator turned greenish, the content of the conical flask was titrated with 0.1M HCl. The end point was indicated by a change from greenish to pink colour. The volumes of the acid used for each distillate as well as the blank were noted:

The % of crude protein = $\frac{\text{Final}-\text{Initial}(0.2)\text{ x Stand. No. of Nitrogen}(1.4)}{\text{Initial Wt}(0.5)\text{ x Standard No. of protein}(6.25)}$ **Eqn. 5**

2.4.6. Carbohydrate (nitrogen free extract, NFE)

The carbohydrate content was obtained via estimation by difference, where the summation of the percentages of moisture, ash, fat, crude and fibre content was subtracted from 100%:

% of carbohydrate = 100 - (%protein + %fat + %ash + %fibre + %moisture) **Eqn. 6**

2.5. Pollution assessment of leave samples

Pollution indices serve as a primary method for evaluation of the pollution status of a given sample. The contamination factor (CF), degree of contamination (Cdeg), and ecological risk factor (ERF) was utilized in this study.

2.5.1. Contamination factor (CF)

The contamination factor was applied to determine the level of contamination of each of the studied sample. The equation of Anweting *et al.*, (2024b) proposed by Hakanson (1980) was used in the calculation:

$$CF = \frac{Cm}{Bm} \quad \textbf{Eqn. 7}$$

where CF is the contamination factor, Cm is the concentration of the metal in the leave sample, and Bm is the background concentration of metal. Hakanson (1980) classified the contamination factor as follows; (i) CF < 1 - Low contamination (ii) 1 < CF < 3 - Moderate contamination (iii) 3 < CF < 6 - High contamination (iv) 6 > CF - Very high contamination.

2.5.2. *Degree of contamination (Cdeg)*

The degree of contamination is the sum of the contamination factor of metals for a particular sample and it was applied to assess the environmental hazard associated with the leave samples.

$$C_{deg} = \sum CF \quad \textbf{Eqn. 8}$$

The four classes of C_{deg} proposed by Hakanson (1980) and adopted by Kowalska *et al.* (2016) are as follows; (i) C_{deg} < 8 = low degree of contamination (ii) 8 < C_{deg} < 16 = moderate degree of contamination (iii) 16 < C_{deg} < 32 = considerable degree of contamination (iv) 32 < C_{deg} = very high degree of contamination.

2.5.3. *Ecological risk factor (ERF)*

Ecological risk factor was utilized to evaluate the threat associated with the bioaccumulation of metals in the studied leaves using the formula of Zhang and Liu, (2014) and Hamid *et al.*, (2022);

$$ERF = Tr\ x\ CF \quad \textbf{Eqn. 9}$$

Where ERF is the ecological risk factor, Tr represent the toxic response factor and CF denotes the contamination factor of metals. Toxic response factors of Cd, Cu, Fe, Pb, Zn, Ni and Mn are 30, 5, 1, 5, 1, 5 and 1, respectively (Tisha *et al.*, 2020; Zhang and Liu, 2014; Ebong *et al.*, 2024). Ebong *et al.* (2024) highlighted that the ERF is classified as follows; (i) ERF < 40 = Low ecological risk (ii) 40 < ERF≤ 80 is Moderate ecological risk (iii) 80 < ERF ≤ 160 = Appreciable ecological risk (iv) 160 < ERF ≤ 320 = High ecological risk (v) ERF > 320 = Severe ecological risk.

3. Results and discussion

3.1. Metal composition of the studied samples

Results for the concentration of toxic metals in the studied samples are presented in Table 1. In this study, Cd was not detected in all analyzed sample. This result may imply that consumers of this vegetables may not be exposed to Cd toxicity since it was not detected in the vegetables. Although the possibility of these samples being totally free from Cd is very slim, bioaccumulation of the minute quantity present can still be hazardous, as Cd even in very trace amount is still very toxic (Anweting *et al.*, 2024b). Levels of Fe detected in *A. hybridus* was 2.06mg/kg and 2.75mg/kg for road side and farm respectively, and 2.49mg/kg and 4.89mg/kg in *V. colorata* for roadside and farm respectively.

Table 1: Concentrations of metals in *A. hybridus* and *V. colorata* leaf samples.

Key: RS= Roadside, FL= Farm land, SD= Standard deviation, RL, Recommended limit.

Heavy Metals	**Cd**		**Cu**		**Fe**		**Pb**		**Zn**		**Ni**		**Mn**	
	RS	**FL**	**RS**	**FL**	**RS**	**FL**	**RS**	**FL**	**RS**	**FL**	**RS**	**FL**	**RS**	**FL**
A. hybridus (mg/kg)	-	-	0.31	0.25	2.06	2.75	3.06	2.06	32.94	17.94	2.50	38.75	0.75	0.25
V. colorata (mg/kg)	-	-	4.97	4.52	2.49	4.89	11.74	2.84	11.00	58.50	10.00	48.75	5.00	2.44
SD	-	-	3.30	3.02	0.30	1.51	6.14	0.55	15.51	28.68	5.30	7.07	3.01	1.55
RL	**0.20**		**40.00**		**10.11**		**0.30**		**100.00**		**40.00**		**0.14**	

According to the data, samples from farm had higher values than road side. This can be attributed to the heavy application of Fe rich organic fertilizers which consequently elevate the concentration of Fe in plants within the farm. Values obtained were below 57.03±0.21-200.13±1.03mg/kg of Akanbi *et al.* (2024). 3.06mg/kg and 2.06mg/kg of Pb was obtained in *A. hybridus* for road side and farm respectively. 11.74mg/kg and 2.84mg/kg was also obtained in *V. colorata* for roadside and farm respectively. Pb concentration was observed to be significantly higher in roadside than farm land. These results are in agreement with 4.91-7.24 mg/kg obtained by Agbi (2021) but below the 12.41±4.14-48.50±16.2mg/kg of Ahmad *et al.* (2022). The result also revealed Zn concentration of 32.94mg/kg and 17.94mg/kg for *A. hybridus* in roadside and farm respectively, 11.00mg/kg and 58.50mg/kg for *V. colorata* in roadside and farm respectively. The values obtained were above 0.10-1.30mg/kg of Akomolafe and Nkemdy (2020). For Ni, the concentrations obtained for *A. hybridus* in roadside and farm were 2.50mg/kg, 38.75mg/kg and 10.00mg/kg, 48.75mg/kg for *V. colorata* respectively. These values were above 2.09-7.01mg/kg of Yasmeen *et al.* (2023). Results from the farm land were significantly higher than those from the road side. This study exposed that concentration of Ni in the studied samples were below permissible limit of FAO/WHO except *V. colorata* in the farm land. The study revealed Cu concentrations of 0.31mg/kg and 0.25mg/kg in *A. hybridus* for road side and farm respectively, and 4.97mg/kg and 4.52mg/kg in *V. colorata* for road side and farm respectively. The values obtained were below the 5.03-62.18mg/kg obtained by Upahi *et al.* (2021) but higher than 0.10-0.40mg/kg of Akomolafe and Nkemdy (2020). Mn had concentrations of 0.75mg/kg and 0.25mg/kg for *A. hybridus* in roadside and farm respectively, 5.00mg/kg and 2.44mg/kg for *V. colorata* in roadside and farm respectively. The concentration of *V. colorata* were within the range obtained by Ibrahim *et al.*, (2023). Generally, the concentrations of Cd, Cu, Fe, Zn and Ni were below the FAO/WHO permissible limit. Conversely, Pb and Mn had values above the permissible limit. Also, *V. colorata* showed higher concentrations in both locations, suggesting a greater ability to absorb and accumulate metals in its leaves.

3.2. Proximate composition

The proximate composition of leaves samples is summarized in Table 2. The moisture content obtained for both leave samples in roadside and farm land ranged between 3.34-3.44%. This was relatively lower than 3.50-4.32% obtained in the control plots. The low moisture content obtained is in agreement with 3.92±0.17% of Ayo (2013), but significantly lower than 29.41-30.15% obtained by Ekwumemgbo *et al.* (2015). High moisture content of vegetables aids in digestion of food, however, high moisture.

Content also reduces the shelf life of vegetables because they facilitate bacterial and fungal action resulting in spoilage. Ash content obtained in *A. hybridus* was 4.45%, 4.50% and 5.02% for roadside, farm and control respectively. 2.00%, 2.90% and 3.52% was obtained in *V. colorata* in roadside, farm and control respectively. These values were within the range of Otache and Agbajor (2017) and Daben *et al.* (2017). The values of this results depict that *A. hybridus* irrespective of the location contains more minerals than *V. colorata*. Fat content obtained from both leave samples in roadside, farm and control ranged between 12.00-16.40%.

Table 2: Results for proximate analysis of *A. hybridus* and *V. colorata*

Proximate Composition (%)	*Amaranthus hybridus*			*Vernonia colorata*		
	RS	**FL**	**CS**	**RS**	**FL**	**CS**
Moisture	3.44	3.42	3.50	3.40	3.34	4.32
Ash	4.45	4.50	5.02	2.00	2.90	3.52
Fat	13.12	12.00	12.05	16.40	15.70	15.50
Crude protein	18.59	17.50	20.15	18.81	18.15	20.50
Fibre	6.56	6.97	8.71	9.00	12.20	13.07
Carbohydrate	60.32	62.58	75.78	59.39	59.91	60.12

Key: RS= Roadside, FL= Farm land, CS= Control sample

Results obtained from roadside were slightly higher than those of farm in both plant leaves. The high fat content obtained aligns with the findings of Runde *et al.* (2020) and Daben *et al.* (2017), but in contrast with the low value of Ekwumemgbo *et al.* (2015). This study revealed crude protein values ranging 17.50-20.50% in roadside, farm and control. Results of the control were higher than the roadside and farm. These values were higher than the values obtained by Daben *et al.* (2017) and Ekwumemgbo *et al.* (2015) but lower than the result of Asaolu *et al.* (2012). Fibre content obtained ranged from 6.56-13.07% for both plant samples in roadside, farm and control. This value is in consonant with Asaolu *et al.* (2012) but contrary to the higher value of Ayo (2013). Although the values at the roadside are lower than farmland and control which could signal anthropogenic effects, the values of *V. colorata* were generally higher than values of *A. hybridus*, this shows that *V. colorata* contains more fibre than *A. hybridus*. Carbohydrate content of both plant samples in roadside, farm and control ranged between 59.39-75.78%. It is observed that the control had higher values than the roadside and farm land. This study agrees with the findings of Runde *et al.* (2020) but significantly higher than Asaolu *et al.* (2012).

3.3. Pollution assessment of leave samples

3.3.1. Contamination factor and degree of contamination

Eqn 7 was applied in the calculations to determine the contamination factor, and the results are shown in Table 3. The contamination factor of Cu, Fe, Pb, Zn, Ni and Mn are 0.01-0.12, 0.20-0.48, 6.87-39.13, 0.11-0.59, 0.06-1.22 and 1.79-35.71 respectively. In accordance with the classification criteria defined by Anweting *et al.* (2024b), all values of Cu, Fe and Zn had a low contamination, Ni varied between low to moderate contamination, Mn between moderate to Very high contamination. Pb showed a very high contamination, this is consistent with the result obtained by Ayobami (2022). The contamination sequence observed was Pb > Mn > Ni > Fe > Zn > Cu. The high concentration of Pb can be attributed to the high traffic density which results in high vehicular emissions. Emissions such as smoke contains high amount of Pb (Arif *et al.*, 2024). The degree of contamination measures the amount of harmful substances in the sample at a given location, it was calculated using eqn. 8. The values obtained ranged between 10.08-75.58.

Table 3: Contamination factor and degree of contamination of *A. hybridus* and *V. colorata*

Sample	Location	Cd	Cu	Fe	Pb	Zn	Ni	Mn	Cdeg
A. hybridus	RS	-	0.01	0.20	10.20	0.33	0.06	5.36	**16.16**
	FL	-	0.01	0.27	6.87	0.18	0.97	1.79	**10.08**
V. colorata	RS	-	0.12	0.25	39.13	0.11	0.25	35.71	**75.58**
	FL	-	0.11	0.48	9.47	0.59	1.22	17.43	**29.30**

Key: RS= Roadside, FL= Farm land

Based on the classification of Hakanson (1980), *A. hybridus* in farm land showed moderate degree of contamination, *A. hybridus* in roadside and *V. colorata* in farmland had a considerable degree of contamination and, *V. colorata* in roadside showed a very high degree of contamination. The major contributors to the high values obtained is Pb(50.08%) and Mn(45.97%). The contamination sequence observed was *V. colorata*(RS) > *V. colorata*(FL) > *A. hybridus*(RS) > *A. hybridus*(FL). The trend depicts that *V. colorata* exhibit high concentrations due to their efficiency to accumulate toxic metals in their tissues.

3.3.2. Ecological risk factor

The outcomes for ERF are presented in Table 4. Eqn 9 was utilized for the calculation. The mean values of Cu, Fe, Pb, Zn, Ni and Mn obtained from the table is 0.31, 0.30, 82.08, 0.30, 3.13 and 15.07 respectively. Based on the classification of Ebong *et al.*, (2024), Cu, Fe, Zn, Ni and Mn belongs to the low ecological risk class, whereas, Pb belongs to the appreciable ecological risk class. The major contributor for the high value is Pb in *V. colorata* of roadside. Pb contributed (81.11%) which was higher than ¾ of the total risk factor. Consequently, long term consumption of these vegetables could lead to serious ecological risk. High factor for Pb in this study is in harmony with the findings of Adewumi *et al.* (2023).

Table 4: Ecological risk factor of *A. hybridus* and *V. colorata*

Sample	Location	Cd	Cu	Fe	Pb	Zn	Ni	Mn
A. hybridus	RS	-	0.04	0.20	51.00	0.33	0.31	5.36
	FL	-	0.03	0.27	34.33	0.18	4.84	1.79
V. colorata	RS	-	0.62	0.25	195.67	0.11	1.25	35.71
	FL	-	0.57	0.48	47.33	0.59	6.09	17.43

Key: RS= Roadside, FL= Farm land

Conclusion

This study revealed that concentrations of Cd, Cu, Fe, Zn and Ni were below permissible limit, whereas, Pb and Mn had concentrations above the recommended values proposed by FAO/WHO. The concentrations obtained for leaves from roadside were relatively higher than leaves from farmland except Fe and Ni. Proximate assessment showed that the leaves could serve as a source of protein and fibre. Pollution indices indicated a low to very high degree of contamination. These indices reveal Pb as the most significant toxic metal, originating from vehicular emissions, which can lead to lead poisoning if these contaminated vegetables are consumed. This study exposed that the high volume of traffic in the area has harmful effects on plants due to vehicular emissions, which in turn reflect the poor air and soil quality in the study area.

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