Research in Health Science
ISSN 2470-6205 (Print) ISSN 2470-6213 (Online)
Vol. 8, No. 1, 2023
www.scholink.org/ojs/index.php/rhs

Original Paper

Effect of Topography on the Heavy Metal Levels of Raphia Palm Tree and Oil Palm Tree Wine Produced within Awka South and North Local Government Areas in Anambra State

Aniobi C.C.[1], Okeke H.C.[2], Okeke O.[3], Akagha I.C.[4], Osueze C.N.[5] & Ezeagwu P.C.[6]

[1] Department of Community Medicine, University of Nigeria, Enugu Campus, Enugu State, Nigeria

[2] Department of Geological Sciences, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

[3] Plastic Production Unit, Scientific Equipment Development Institute, Akwuke, Enugu State, Nigeria

[4] Chemistry Department, Federal University of Technology, Owerri, Imo State, Nigeria

[5] Plastic Recycling Unit, Scientific Equipment Development Institute, Akwuke, Enugu State, Nigeria

[6] Department of Pure and Applied Sciences, Federal College of Dental Technology and Therapy, Enugu, Enugu State, Nigeria

Received: January 13, 2023 Accepted: February 1, 2023 Online Published: February 6, 2023

doi:10.22158/rhs.v8n1p1 URL: http://dx.doi.org/10.22158/rhs.v8n1p1

Abstract

Studies were carried out to evaluate the effect of topography on the heavy metal levels of raphia palm tree and oil palm tree wine produced within Awka South and North local government areas using standard analytical procedures and instrumentation. Soil and palm (oil palm tree and raphia palm tree) wine samples produced in the studied upland and lowland areas were wet digested and analyzed for the presence of Pb, Cu, Cd and Zn using atomic absorption spectrophotometer.

The lowland soil samples had 0.38±0.08, 6.27±0.40, 0.18±0.05 and 9.55±0.80µg/g as mean levels for Pb, Cu, Cd and Zn respectively. The upland soil samples had 0.70±0.04, 4.89±0.15, 0.06±0.02 and 7.07±0.22 µg/g as the mean levels for Pb, Cu, Cd and Zn respectively. The studied heavy metals were present in the soil sample areas in the following decreasing order; Zn > Cu >Pb >Cd.

The mean range of Pb, Cu, Cd and Zn levels in the palm (oil palm tree and raphia palm tree) wine samples produced in the upland areas were 0.04- 0.06, 1.06- 1.91, 0.03- 0.05 and 2.86- 4.04 µg/g respectively. Pb was at toxic level in the oil palm tree wine samples produced in the upland areas.

The mean range of Pb, Cu, Cd and Zn levels in the palm (oil palm tree and raphia palm tree) wine samples produced in the lowland areas were 0.05- 0.09, 1.95- 3.23, 0.04- 0.07 and 4.66- 6.51µg/g respectively.

Pb, Cu and Cd were at toxic levels in the oil palm tree wine samples produced in the lowland areas. The palm wine samples produced in both the lowland and upland areas contained the investigated heavy metals at statistically significant levels. Because of the near daily consumption of palm wine produced from the oil palm and raphia trees as a drink of leisure by all categories of the people in the society, especially with high volume of production taking place in the lowland areas, it is important that human activities that supports the contamination of the soil with heavy metals, where these wines are produced are checkmated by government and host communities so as to limit the exposure to the heavy metals by palm wine consumers.

Keywords

Lowland areas, Upland areas, Heavy metals, Oil palm tree wine, Raphia palm tree wine

1. Introduction

Palm wine is a common and very prominent traditional alcoholic beverage drank by many people of all ages, classes and gender within and outside Nigeria. According to FAO, (2018), more than 70% of Nigerian population consumes palm wine made from either oil palm tree or raphia palm tree. Palm wine is a pleasantly tasty effervescence alcoholic beverage gotten from the fermented sap of an oil palm tree (*Elaeis guineense*) and raphia palm tree (*Raphia hookeri*). According to Ezeagu and Fafunso (2013). palm wine has a rich nutrient composition of sugar, protein, amino acids, alcohol, a dense population of yeast and mineral elements. Ape et al. (2015) stated that palm wine naturally contains 85-89% of water and 10-14% of alcohol. Its taste and smell is derived from many factors, which include the maturity of the sap, specie of the palm wine tree and the geographical area the trees are grown. According to Lucky et al. (2017), in many African countries, including Nigeria, palm wine serves both domestic and commercial needs of the people, which include use in naming and marriage ceremonies, child dedications, burial ceremonies, alternative medical therapy in case of low sperm count and poor sight, energy production and traditional worship. It has equally found use amongst lactating mothers in boosting breast milk production.

Both oil palm tree and raphia palm tree grows best in lowlands, especially swampy areas but also in upland areas, usually in an awkward growth pattern.

The estimation of metal levels in consumable food materials from the soil has generated significant reviews due to their biochemical importance as well as toxicities at very high levels (Mihaela et al., 2019). According to Okeke et al. (2020), the major cause of heavy metal pollution of any environment is the indiscriminate discharge of solid waste materials into the natural environment, which consequently alters its natural composition.

Jack and Nwachoko (2015) stated that the level of metals in palm wine can be traced to natural sources, atmospheric deposition of air-borne metal particulates on the palm trees and sorption from the soil to its roots. The soil area where the trees grew provides the primary and natural sources of metals in wines while secondary sources of metals in wines are mainly from anthropogenic activities such as industrial discharge of untreated wastes, inorganic fertilizer application, indiscriminate hazardous waste disposal, mineral exploration and emissions from vehicles. Ukhun et al. (2005) observed that the metallic composition of palm wine depends on several factors which include soil chemistry, topography, climate and anthropogenic activities going on in the areas where the palm trees are grown. Ezeh et al. (2019) stated that heavy metals bind to protein sites, which are not made for them, by kicking metals off their binding points, causing cell malfunctioning and eventually exert toxicity effects. According to Okeke et al. (2020), food chain contamination with heavy metals has attracted a lot of reviews due to the potentiality of the metals to bio accumulate and bio-magnify in the biological system. Heavy metals are the most hazardous materials in the environment due to their high level of durability, non-biodegradability and toxicity to the biota (Okeke et al., 2020). According to Woyessa et al. (2015), heavy metals could accumulate in different body parts such as liver, kidney, heart, spleen and muscle, where they trigger disease conditions. Amongst the heavy metals, lead, cadmium, mercury and arsenic are severely toxic either at minute or high dose exposure. Considering the fact that some heavy metals have the ability to trigger an irreplaceable health damage to humans and animals, their levels in food substances are always of interest to environmentalists and health regulatory authorities.

Palm wine sourced from oil palm tree and raphia palm tree is a very popular alcoholic beverage drank for leisure by the Nigerian population, virtually on daily basis. To many people, it is an important component of their everyday relaxation. Palm wine is produced and sold in many communities within Awka North and South local government areas. The palm trees grows in both the lowland and upland areas within the studied environment but more rapid and favourable growth occurs in the lowland areas. The difference in topographies of the lowland and upland areas could significantly impart on the nutrient and anti-nutrient composition of the produce from the soil areas.

The levels of heavy metal concentration of palm wine produced in the upland and lowland areas within Awka South and North local government areas could be a function of the anthropogenic activities within the area, which could be accelerated by the mobility and transport of the metals within the area.

Palm wine from oil palm tree and raphia palm tree is an alcoholic beverage that is on the top list of almost all ceremonies within the studied environments, apart from its daily consumption for leisure at eatery centres, therefore, evaluation of the heavy metal levels in this alcoholic beverage that has become an ideal food drink for many people within the studied environments became imperative. Therefore to ascertain the suitability of the palm wine produced from the upland and lowland areas within the studied environments for continued consumption, especially as it concerns contamination with heavy metals, this study was carried out.

2. Materials and Methods

Sample Collection

Soil samples of the upland and lowland areas where the palm wine are produced within the studied environments were collected at soil depth 0- 20cm and stored in well labeled clean plastic containers.

Palm wine samples produced from oil palm tree (*Elaeis guineense*) and raphia palm tree (*Raphia hookeri*) were obtained (from five communities which include Nibo. Umuawulu, Ebenebe, Nise and Mbaukwu) and stored separately in well labeled and sterilized plastic containers. The soil and palm wine samples were immediately transported to the laboratory for heavy metal determination.

Heavy metal determination in the soil and palm wine samples

The soil samples from the upland and lowland areas were ground, sieved and digested using aqua regia (HCl / HNO_3, 3:1). The digest was analyzed for Pb, Cu, Cd and Zn using Perkin-Elmer, 2008 model atomic absorption spectrophotometer. Quality control was assured by the use of triplicates standard reference materials and procedural blanks.

Also, for the palm wine samples, wet digestion was carried out using concentrated HNO_3 and digest was assayed for Pb, Cu, Cd and Zn using atomic absorption spectrophotometer (Perkin-Elmer, 2008 model).

Statistical Analysis

The data obtained were expressed in mean ± standard deviation and subjected to one way analysis of variance (ANOVA) at 5% confidence level using IBM SPSS 22.0.

3. Results and Discussion

Lead:

Result of Table 1 shows that the mean Pb levels in the lowland and upland soil samples, where the wines were produced were 0.38±0.08 and 0.30 ±0.04 µg/g respectively.

Table 1. Mean Heavy Metal Levels in the Upland and Lowland Soil Samples

Sample / Heavy metal (µg/g)	Lowland	Upland	F test P value	WHO limits(µg/g)
Pb	0.38±0.08	0.30±0.04	0.02	0.5
Cu	6.27±0.44	4.89±0.15	0.02	10
Cd	0.18±0.05	0.06±0.02	0.01	0.5
Zn	9.55±0.80	7.07±0.22	0.02	30

The mean Pb level in the lowland soil samples was statistically higher than it was in the upland soil samples, however, the mean Pb values in both soil areas were within the permissible limits of the metal in the soil as established by WHO (2005). The observed higher mean Pb value in the lowland soil samples compared to the upland soil samples could have stemmed from the varying rate of transport and mobility of contaminants such as lead in the two studied soil areas. Although anthropogenic activities appears more intense in the upland areas compared to the lowland areas, however, appreciable levels of environmental pollutants such as heavy metals once deposited on the soil are transported quickly towards the lowland soil areas under certain climatic conditions, where the mobility of pollutants are usually and generally slow and thus retained. Hence, the varying rate of mobility, transport and retention of heavy metals such as Pb could have contributed to the statistically significant levels of the metal in the upland and lowland soil sample areas. The observation of this study was corroborated by Richard et al. (2021), who stated that the mobility and transport of trace elements have significant implications on its concentrations in different soil environments and topography.

Copper:

Result of Table 1 shows that the mean Cu levels in the lowland and upland soil samples were 6.27±0.44 and 4.89±0.15 µg/g respectively. The mean Cu level in the lowland areas was statistically higher than it was in the upland soil samples as shown in Figure 1.

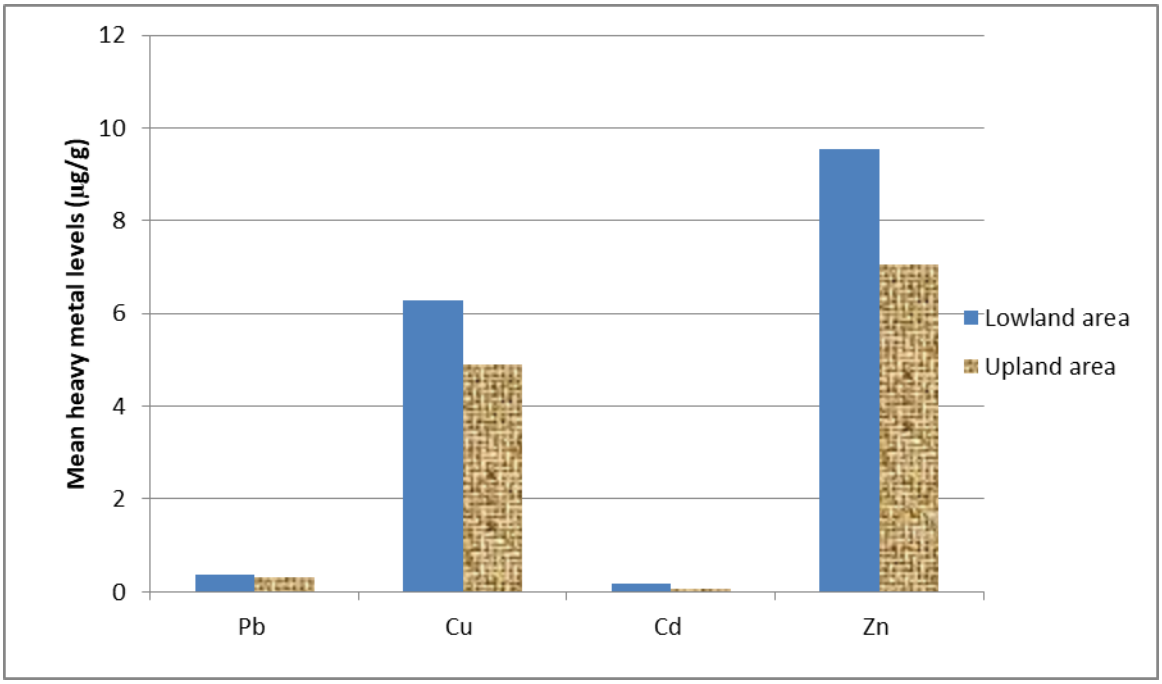

Figure 1. Bar Chart Representation of the Mean Heavy Metal Levels in Both the Upland and Lowland Soil Sample Areas, where the Palm Tree Samples are Grown

The mean Cu levels in the two studied soil sample areas were within the recommended limits set for the metal in a soil meant for agricultural purposes. Varying levels of heavy and trace elements retention, mobility and transport within the two studied environments could have significantly imparted on their varying Cu levels as has been observed. Okeke et al. (2020) reported a higher mean value of 18.64±0.37 µg/g for Cu in upland soil samples in Nnobi, Anambra State, than what was obtained for the metal in the environments this research was studied. Varying anthropogenic activities in the compared places could have contributed to the wide dissimilarities of results for Cu.

Cadmium:

From Table 1, it was observed that the mean Cd level in the upland soil samples, with a value of 0.06±0.02 µg/g was significantly lower than 0.18 ± 0.05 µg/g reported for the metal in the lowland soil samples. The mean Cd levels in both the upland and lowland soil samples were within its permissible limits.

Zinc:

9.55±0.80 and 7.07 ± 0.22 µg/g were the respective mean Zn levels in the studied lowland and upland soil samples as shown in Table 1. Although at non toxic levels, the lowland soil samples contained higher mean Zn level than the upland soil samples as shown in Figure 1. The mean Zn levels in the studied soil sample areas differed significantly at $p<0.05$.

Table 2. Mean Heavy Metal Levels in the Oil Palm Tree and Raphia Palm Tree Wine Samples Produced in the Upland Areas

Sample / Heavy metal (µg/g)	Oil palm tree wine	Raphia palm tree wine	F test P value	WHO limits(µg/g)
Pb	0.06±0.01	0.04±0.01	0.02	0.05
Cu	1.91±0.33	1.06±0.09	0.01	2
Cd	0.05±0.02	0.03±0.01	0.02	0.05
Zn	4.04±0.16	2.86±0.22	0.01	10

Table 3. Mean Heavy Metal Levels in the Oil Palm Tree and Raphia Palm Tree Wine Samples Produced in the Lowland Areas

Sample / Heavy metal (µg/g)	Oil palm tree wine	Raphia palm tree wine	F test P value	WHO limits(µg/g)
Pb	0.09±0.02	0.05±0.02	0.02	0.05
Cu	3.23±0.42	1.95±0.13	0.01	2
Cd	0.07±0.02	0.04±0.01	0.02	0.05
Zn	6.51±0.73	4.66±0.26	0.01	10

Lead:

Result of Table 2 indicates that the mean Pb levels in the oil palm tree and raphia palm tree wine samples produced in the upland areas were 0.06 ± 0.01 and 0.04 ± 0.01 µg/g respectively. The mean Pb levels of the palm wine samples produced in the upland areas were statistically significant, however, the oil palm tree wine samples had mean Pb level above the threshold limits set for it in consumable liquid foods such as wine. The wine samples produced in the upland areas contained mean Pb levels in following order; oil palm tree wine > raphia palm tree wine as shown in Figure 2.

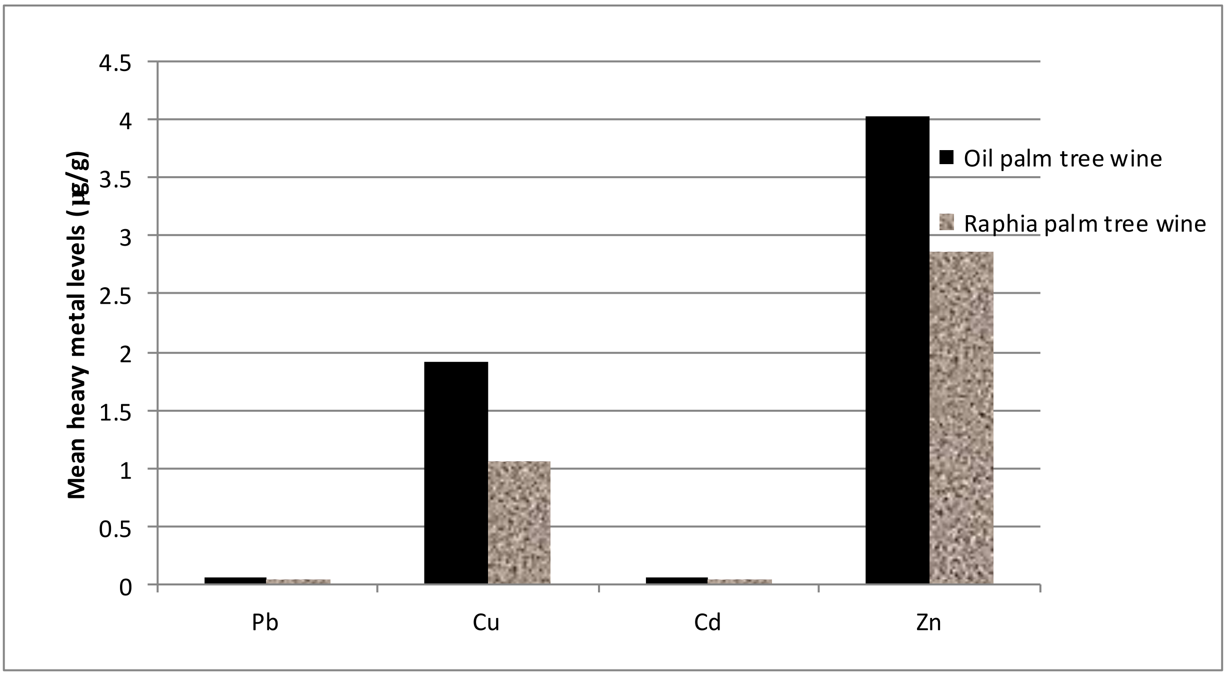

Figure 2. Bar Chart Representation of the Mean Heavy Metal Levels in the Palm Wine Samples Produced in the Upland Areas

Considering the toxicities associated with this metal to man, its consistent exposure to palm wine consumers especially at the observed level is therefore of a health concern. The higher mean Pb value obtained for the oil palm tree wine samples compared to the raphia palm tree wine samples produced in the upland areas could be ascribed to the age palm trees, sorption variation of the metal by the trees and other interplaying environmental variables.

Also, the result of Table 3 shows that the mean Pb levels in the oil palm tree and raphia tree wine samples produced in the lowland areas were 0.09 ± 0.02 and 0.05 ± 0.02 µg/g respectively. The mean Pb levels in the wine samples were statistically significant. Equally, the wine samples produced in the lowland areas contained mean Pb levels in following order; oil palm tree wine > raphia palm tree wine as shown in Figure 3.

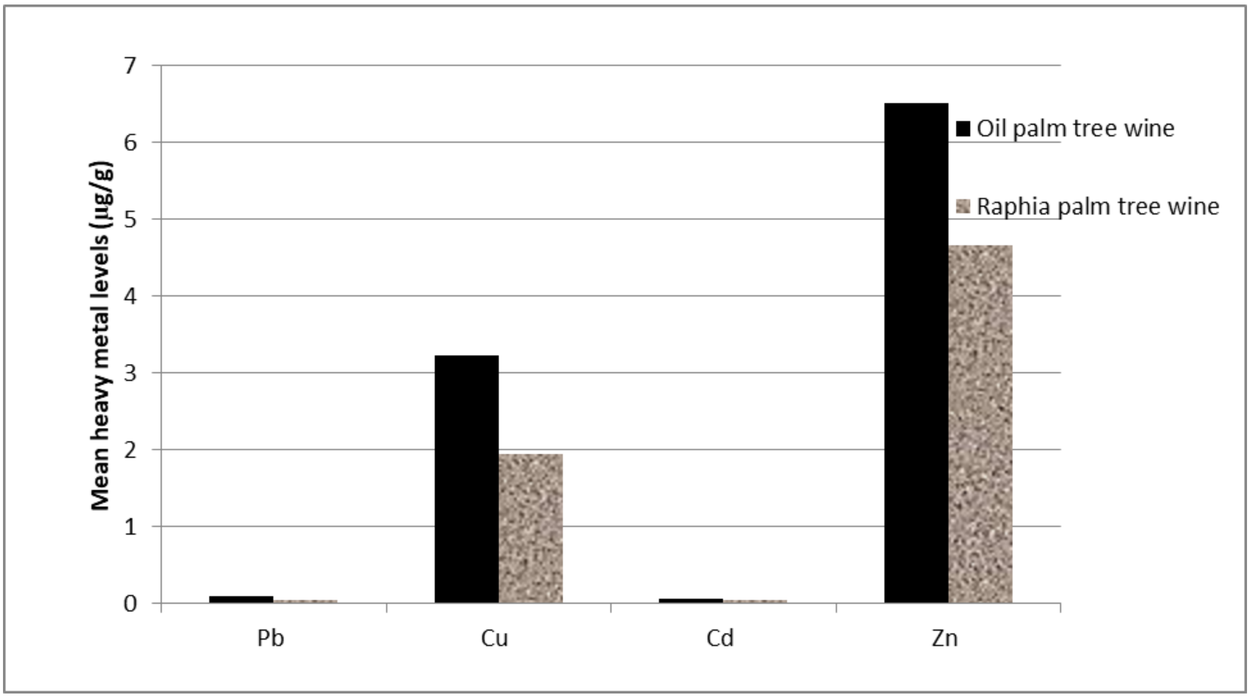

Figure 3. Bar Chart Representation of the Mean Heavy Metal Levels in the Palm Wine Samples Produced in the Lowland Areas

The oil palm tree wine samples produced in the lowland areas had mean Pb level above the recommended threshold limits. From the result of Tables 2 and 3, it was observed that the mean Pb levels in the oil palm tree and raphia palm tree wine samples produced in the lowland areas were higher than the palm wine samples in the upland areas. Slow transport, mobility and consequently high retention of persistent pollutants such as Pb in the lowland soil areas may have accounted for the observed high Pb values in the palm wine samples produced from those areas. The stronger and deeper roots of the oil palm trees could have helped to accelerate the smooth translocation of pollutants such as Pb to its tree parts than it would be in the raphia palm tree, and this indication may thus further explain the observed higher mean Pb level in the oil palm tree wine samples. Jack and Nwachoko (2015) reported a higher mean value of 0.135 mg/kg for Pb in palm wine samples produced in some oil producing communities in Rivers state than what this study got for the metal in palm wine samples produced in both the upland and lowland areas.

Anthropogenic activities within the referenced area especially oil exploitation could have accounted for the higher mean value obtained for the metal in the palm wine produced in the referenced area than what was gotten in the studied palm wine samples.

Copper:

The result of Table 2 shows that the mean Cu levels in the oil palm tree and raphia tree wine samples produced in the upland environment were 1.91 ± 0.33 and 1.06 ± 0.09 µg/g respectively. The mean Cu levels in the palm wine samples were statistically significant and within the recommended threshold limits of the metal in consumable liquid food substances. 3.23 ± 0.42 and 1.95 ± 0.13 µg/g were the respective mean Cu levels in the oil palm tree and raphia palm tree wine samples produced in the lowland areas. The oil palm tree samples had a statistically higher mean Cu level than the raphia palm tree wine samples. The mean Cu level in the oil palm tree wine samples produced in the lowland areas was above the recommended threshold limits. Although copper is a trace element required by the body in trace amounts for enzyme and biochemical functions, excessive levels in the body increases its storage in the liver, which could cause damage to that vital part of the body. Just as observed with Pb values, the mean Cu values in the palm wine (oil palm tree and raphia tree wine) samples produced in the lowland areas were higher than what was obtained as mean values for the metal in the palm wine samples produced in the upland areas, as equally shown in Figures 2 and 3.

Ape et al. (2015) reported a lower mean value of 0.13 µg/g for Cu in the palm wine samples produced in the non- industrial areas in Enugu State than what this study reported for the metal in the palm wine samples produced in both upland and lowland areas.

Cadmium:

The result of Table 2 shows that 0.05 ± 0.02 and 0.03 ± 0.01 µg/g were the respective mean Cd levels in the oil palm tree wine and raphia palm tree wine samples produced in the studied upland areas. The mean Cd levels in the palm wine samples were statistically significant. The mean Cd levels were within permissible limits in the palm wine samples produced in the upland areas. In addition, result of Table 3 shows that the oil palm tree wine samples produced in lowland areas had a statistically higher mean value of 0.07 ± 0.02 µg/g for Cd than 0.04 ± 0.01 µg/g obtained for the metal in the raphia palm wine samples.

The mean Cd level in the oil palm tree samples produced in the lowland areas was above the recommended threshold limits of the metal as stated in Tables 2 and 3. Considering the toxicities associated with this metal, it is of a serious health concern for palm wine consumers to be exposed to it especially at consistent high levels. According to Okeke et al. (2019), organs such as kidney, liver, lung and placenta are seriously impaired by undue exposure to cadmium.

Jack and Nwachoko (2015) reported that a mean Cd value of 0.034 mg/kg in the palm wine samples in some oil producing communities in Rivers State, which compares agreeably with what this study reported for the metal in the palm wine samples produced in the upland areas.

Zinc:

The result of Table 2 shows that the mean Zn levels in the oil palm tree and raphia palm tree wine samples produced in the upland areas were 4.04 ± 0.16 and 2.86 ± 0.23 µg/g respectively. The mean Zn levels in the studied palm wine samples were statistically significant and equally within its permissible limits Additionally, the result of Table 3 shows that raphia palm tree wine samples had a statistically lower mean value of 4,66 ± 0.26 µg/g for Zn than 6.51 ± 0.73 µg/g gotten for than in the oil palm tree wine samples. The palm wine samples from the lowland areas had mean Zn levels within the acceptable limits. Although zinc is a trace element required in trace amounts in the body for optimal enzyme function it can be harmful to the body at a consistently high level of exposure.

4. Conclusion

The four studied heavy metals (Pb, Cu, Cd and Zn) were all detected in the soil, oil palm tree and raphia palm tree wine samples in the studied upland and lowland areas. The studied heavy metals were within their permissible limits in the upland and lowland soil areas, where the palm trees are grown.. Although more anthropogenic activities may have occurred in the upland soil areas compared to the lowland soil areas, the studied heavy metals were all more present in the lowland soil areas, possibly because of its low and undulating topography and the consequent slower mobility of the metals, which may have given rise to their higher retention in the soil. This observation may have accounted for the higher presence of the studied metals in both the raphia palm tree and oil palm tree wine samples produced in the lowland areas when compared to the palm wine samples produced in the upland soil areas.

With the exception of Pb level in the oil palm tree wine samples, the mean levels of the other three studied heavy metal were within their respective permissible limits in the palm wine samples produced in the upland areas.

Cu, Pb and Cd were within toxic levels in the oil palm tree wine samples produced in the lowland areas.

More importantly, most palm wine produced for wholesale consumption are produced in the lowland areas, hence anthropogenic activities that moves pollutants down to the lowland areas, where they are highly retained, could adversely increase the levels of heavy metals in food materials such as palm wine harvested from such an environment and consequently increase the metals' exposure level and risk of toxicity to the palm wine consumers.

Agricultural practices such as fertilizer application among other anthropogenic activities that proliferates the environment with heavy metals, yes, may not be completely stopped but their minimization is essential to controlling the undue exposure to heavy metals by the people especially through consumption of daily food leisures' such as palm wine.

References

Ape, D., John, N. S., Nwafor, E. C., & Ekpe, I. O. (2015). Determination of trace and major elements in palm wine from industrial and non-industrial areas of Enugu State, Nigeria. *International Journal of Multidisciplinary Sciences and Engineering*, *6*(2), 18-29.

Ezeagu, I. E., & Fafunso, M. A. (2013). Biochemical constituents of palm wine. *Ecology and Food Nutrition*, *42*, 213-222. https://doi.org/10.1080/03670240390226222

Ezeh, E., Okeke, O., Ezegwu, T. C., & Okeke, M. U. (2019). Comparative assessment of the physicochemical and heavy metal contents of borehole and sachet water consumed in Aba metropolis, Abia state. *Academia Journal of Environmental Sciences*, *7*(9), 126-131.

https://doi.org/10.24214/jcbps.A.9.3.18189

Food and Agricultural Organization. (2018). Fermented fruits and vegetables. A global perspective. Agricultural Sciences, Bulletin of Food and Agricultural Organization. 134-138.

Jack, I. R., & Nwachoko, N. (2015). Assessment of some heavy metal levels in palm wine from some oil producing communities in Rivers State of Nigeria. *International Journal of Appled Chemistry Research*, *2*(1), 1-5.

Lucky, G. B., Cookey, G. A., & Ideriah, J. K. G. (2017). Physicochemical and nutrient parameters in palm wine from oil palm tree (*Elaeis guineense*) and raphia (*Raphia hookeri*) in South –South Nigeria. *Chemistry Research Journal*, *2*(6), 146-152.

Mihaela, A., Dunitroscu, V., A., Lanase, G. A., & Maria, P. C. (2019). The optimization of the methods for Cu, Zn and Pb content determination in Romanian wines by AAS after dry or microwave mineralization. *Journal of Food Composition and Analysis*, *12*, 17-25.

Okeke, M. U., Okeke, O. R., Ezeh, E., Aniobi, C. C., Ochuba, C. O., & Offor, C. R. (2020). Effect of ash application on the heavy metal levels in the rice grains grown in paddy farmlands in Ishiagu, Ivo Local Government Area of Ebonyi State. *Journal of Environmental Science, Computer Science and Engineering and Technology*, *9*(1), 68-81. https://doi.org/10.24214/jecet.A.9.1.06881

Okeke, O., Ndubuisi, J. O., Ozuah, A. C., Aniobi, C. C., & Okeke, M. U. (2020). Physicochemical characteristics, heavy metal levels and pollution index status in soil samples around Nnobi abattoir in Anambra State. *Journal of Environmental Science, Computer Science and Engineering and Technology*, *9*(3), 471-480. https://doi.org/10.24214/jecet.A.9.3.47180

Richard, G., Youkparigha, Y. O., Aigberu, A. O., Izah, S. C., & Braide, B. (2021). Public health implications of some heavy metals contained in palm wines of Wilberforce Island area, Nigeria. *Journal of Biotechnology Research*, *7*(3), 34-38. https://doi.org/10.32861/jbr.73.34.38

Ukhun, M. E., Okolie, N. P., & Oyerinde, A. O. (2005). Some mineral profiles of fresh and bottled palm wine- a comparative study. *African Journal of Biotechnology*, *4*(8), 829-832.

World Health Organization. (2005). Guidelines in water, soiland food quality and trace elements in human nutrition. Geneva- Switzerland. 193-210.

Woyessa, G. W., Kassa, S. B., Demissie, E. G., & Srivastava, B. B. (2015). Determination of the level of trace and heavy metals in some soft drinks of Ethiopia. *International Journal of Current Research in Chemical and Pharmaceutical Sciences*, *2*, 84-88.