

Heavy Metal Determination and Health Risk Assessment of Oyster Mushroom *Pleurotus tuberregium* (Fr.) Singer, Collected from Selected Markets in Imo State. NIGERIA

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Abstract Oyster mushroom *Pleurotus tuberregium* (Fr.)(Sing), Qsu, is a common mushroom which is used as food or medicine, more commonly as a soup thickener. This study investigated the presence of heavy metals (Zn, Pb, Ni, Cu) in wild samples of *Pleurotus tuberregium* sclerotia consumed within Imo state. The oyster mushrooms purchased from different markets from Imo State were mineralized with H₂SO₄ and HNO₃ and analyzed using flame Atomic Absorption Spectrophotometer (AAS) Thermo Scientific model. The mean concentrations of Pb: 0.13 mg/kg (ranged 0.04±0.005mg/kg to 0.35±0.005mg/kg), Zn: 1.26mg/kg (ranged from 0.03 ± 0.007 mg/kg to 3.25 ± 0.01 mg/kg) and Ni and Cu were 0.0001mg/kg, 0.164mg/kg, respectively. These results were compared with the data from literature and levels set by regulatory authorities, with the conclusion that the consumption of oyster mushroom sclerotium does not pose a toxicological risk. The Zn, Pb, Ni and Cu content of the studied products would contribute to only about 7.4%, 30.3%, 0.001% and 1.91%, respectively of the provisional tolerable weekly intake of Zn, Pb, Ni and Cu. The Cu and Zn contents would contribute to nutritional intake of the metal in the general population. It is recommended that the outer layers of the sclerotia be properly scrapped and washed before use to reduce air-borne metal contamination.

Keywords: oyster mushroom, trace metal, contamination, target hazard quotient, consumption

Cite This Article: Uloma A. Ihugba, Chris O. Nwoko, Feechi R. Tony-Njoku, Adaeze A. Ojiaku, and Lucy Izunobi, "Heavy Metal Determination and Health Risk Assessment of Oyster Mushroom *Pleurotus tuberregium* (Fr.) Singer, Collected from Selected Markets in Imo State. NIGERIA." *American Journal of Environmental Protection*, vol. 6, no. 1 (2018): 22-27. doi: 10.12691/env-6-1-4.

1. Introduction

Edible Oyster Mushrooms (*Pleurotus tuber-regium*) from the family of Pleurotaceae, contains high concentrations of nutritional trace elements and mineral constituents in human diets, helps in growth and tissue repair in the body of humans [1]. It represents part of natural forest ecosystems and plays an important role in the cyclic pathways of elements and organic matter [2]. Oyster Mushroom is characterized to have low energy value and high concentration of essential biologically valuable elements, specific β-glucans and antioxidant substances [3,4]. Moreover, they provide a valuable source of fiber, vitamins and minerals such as thiamin, riboflavin, vitamin D, potassium, phosphorus, iron and calcium [5,6]. It has been known for long that mushrooms are able to accumulate large amounts of heavy metals [7] what makes them ideal for biomonitoring of environmental pollution- particularly contamination of forest ecosystems [8]. There are many factors that influence the presence of metals in mushrooms, for example climate, environmental conditions and concentration of macromolecules in the cell wall of each specific species [9]. Under natural conditions,

the concentration of heavy metals in certain species of Oyster mushrooms can be higher even if the soil contamination level is low [1]. The highest concentrations of trace elements are mostly found in the hemosphere, lower values are in the spores and the lowest values are in the stem [10,11].

Edible Mushrooms are valued for their unique taste, aroma, nutritional value and medicinal potentials [12]. Mushrooms of the genus *Pleurotus tuberregium* are among the very popular edible varieties not only due to their properties but also to their rapid growth and ease of cultivation [13]. Consumers of delicacies such as Mushrooms, which may not have been extensively investigated for toxic metal contents, could be exposed via the diet. Information about heavy metal concentrations in foods and their consumers dietary intake is very important for assessing their health risks to humans. In Imo state, southeastern Nigeria, oyster mushroom is a predominant delicacy, mainly used as soup thickener and /or prepared into local cake. There is urgent need to continuously monitor heavy metal load in this fungi species so as to reduce risk of human heavy metal poisoning. The aim of this research work therefore was to assess heavy metal concentration of oyster mushroom and its risk to human health.

2. Materials and Methods

2.1. Study Area

The study was carried out in Imo State, Southeastern Nigeria. It falls within the geographical coordinates of longitude 7°2'15" – 7°3'00"E and latitude 5°27'80" – 5°28'00"N. Imo State is underlain by the Benin Formation. This formation which is Pliocene to Miocene in age consists of coastal plain sands, which is about 0.05 – 2.0 mm in size, with minor clay beds; and this type of soil has good drainage and is well aerated, causing it to dry out quickly [14]. It contains some isolated gravels, conglomerates, and very coarse sandstone in some places. Thickness of the formation is about 800 m at its depocenter, while the mean depth to water table is about 24 m [15]. Benin Formation is overlain by alluvium deposits and underlain by Ogwashi-Asaba Formation which consists of lignite, sandstones, clays and shale

2.2. Sample Collection

Imo state formed the sample frame and was stratified into three (3) zones along the senatorial districts. Four (4) samples of *P. tuberregium* (osu) were randomly collected from each of the senatorial zones, making a total of 12 oyster mushrooms from the following markets: *Okigwe* zone: *Okigwe* market, *Anara*, *Mbano*, *Obowo*, *Owerri* Zone: *Eke-ukwu Owerri*, *Mbaise*, *Mbieri*, *Ohaji*, *Orlu* zone: *Umuaka*, *Ideato*, *Orlu market*, *Awo-idemilli*. These were all preserved until analysis.

2.3. Sample Preparation and Analysis

The samples from each zone were crushed and blended using ceramics mortar, air dried and later sieved through 2mm and labeled. One gram of the sieved samples were weighed accurately and transferred to a 250ml conical flask and thereafter digested with 10 ml of concentrated acid mixture (ratio 1:1, nitric and sulphuric acids). The digests were subsequently used to determine the concentration of Cu, Pb, Zn, Ni, using Atomic Absorption Spectrophotometer (AAS.) Thermo Scientific AA 301 version.

2.4. Quality Assurance

Appropriate quality assurance procedures and precautions were carried out to ensure the reliability of the results of the present study. Samples were generally handled carefully to avoid contamination. All chemicals used were of analytical grade: H₂SO₄ (98%, BDH Laboratory Supplies, Poole, England); HNO₃ (69%, BDH Laboratory Supplies, Poole, England). Reagent blank determinations were used to correct the instrument readings. With every set of 10 samples examined, one blank sample was run and no interference was noted. The accuracy of the analytical method was calculated by analyzing reference standards (Accu Standards, New Haven Connecticut, USA). Also, a replicate test was carried out for some of the metals. Recoveries for the reference standards varied from 99.5-100%, and for the replicate study, from 95.5 - 99.1%. Additional data on results of QC/QA protocols in the determination of heavy metal contents of

selected Nigerian foodstuff have been reported elsewhere [16].

2.5. The Pollution Index (PI) [17]

$$PI = HC_1 \times HC_2 \times HC_3 \dots \dots \dots (HC_n)^{1/n}$$

Where PI =heavy metal pollution index, HC is the concentration of *n* heavy metals in soil samples

2.6. Estimated Weekly Intake (EWI)

The estimated weekly intake (EWI, mg/kg body weight/week) of trace metals through consuming oyster mushroom was calculated using the following equation:

$$EWI = \frac{\left(\begin{array}{l} \text{Weight of mushroom consumed} \\ \times \text{metal concentration of mushroom} \end{array} \right)}{\text{Average body weight}}$$

The average weekly edible fungi intake was assumed to be 210 g/week [18] and the average body weight was assumed to be 60 kg, according to USEPA [19] guidelines. The results of the intake calculations were assessed based on the provisional tolerable weekly intake (PTWI) Joint FAO/WHO Expert Committee on Food Additives [20].

2.7. Target Hazard Quotient (THQ)

The method used for the evaluation of target hazard quotient (THQ) as described by Chien *et al.*, [21] by the equation below:

$$THQ = \frac{E_F E_D F_{IR} C}{R f D_o W_{AB} T_A} \times 10^{-3}$$

E_F is exposure frequency (365 days/year); E_D is the exposure duration (70 years), equivalent to the average lifetime [22], F_{IR} is the oyster mushroom ingestion rate (g/person/day), assuming 0.5 g for an average level consumer (ALC), and 1.0 g for a high level consumer (HLC); C is the metal concentration in Oyster mushroom (mg/kg dry weight); RfDo is the Oral Reference Dose (mg/kg/day); W_{AB} is the average body weight (70 kg), and T_A is the averaged exposure time for non-carcinogens (365 days/year × E_D).

The RfDo values in mg/kg body wt/day for Copper, Zinc, Nickel, and Lead were 0.04, 0.3, 0.02 and 0.0035 [19], respectively. An index more than 1 is considered as not safe for human health [19]. This THQ marker connects the metals concentrations in food with their toxicity, quantity and quality of food consumption and body mass of consumers. The use of this complex parameter is more extensive in evaluating the potential health risk of trace metals present in various foods [23].

2.8. Statistical Analysis

Data from three replicates were subjected to ANOVA using Minitab Statistical software version. 16 and significant (p<0.05) means were separated using Tukey pairwise comparison.

3. Results and Discussion

The results of this study showed varying trace metal concentrations across the localities where samples were purchased. In some instances, the variations were wide for some metals compared to others and this likely depends on the geological composition of the areas where the oyster mushroom was obtained (Table 1). The oyster mushroom from Imo state contained varied concentrations of heavy metals. The Zinc concentration ranged from 0.03 ± 0.007 mg/kg to 3.25 ± 0.01 mg/kg. The lowest concentration occurred at Mbieri (0.03 ± 0.007 mg/kg) while the highest was recorded in Ohaji (3.25 ± 0.01 mg/kg). Zinc concentration significantly differed among different locations in Imo state except the following locations: Okigwe market, Anara, Obowo, Eke-ukwu, Mbaise, Mbano, Mbieri, Umuaka and Awo idemili (Table 1). Lead (Pb) mushroom concentration ranged from (0.04 ± 0.01 mg/kg to 0.36 ± 0.01 mg/kg). The highest concentration of 0.36 mg/kg occurred in Mbaise and followed by Ohaji (0.35 mg/kg). Lowest Pb concentrations were recorded in Okigwe market, Anara, ideato and Awo-Idemili (0.04 mg/kg). Lead (Pb) concentration did not significantly ($p < 0.05$) differ among the following locations Okigwe market, Anara, Mbano, Ideato and Awo-Idemili. But differed among Mbaise, Ohaji and Mbieri. Nickel (Ni) concentration in oyster mushroom was negligible across the locations (0.0001 mg/kg).

Copper (Cu) concentration varied in the locations sampled. The concentration varied from 0.03 mg/kg to 0.83 mg/kg. The highest concentration occurred in Anara market followed by Okigwe market. The lowest of 0.03 mg/kg was recorded at Mbieri market followed by Ohaji, Umuaka, Ideato and Eke-ukwu Owerri market. However, Cu concentration did not differ among all the locations. The pollution index indicated varied level of heavy metal

contamination of oyster mushroom across the state. The highest pollution index of 0.046 was recorded in Ohaji market. Whereas the lowest was observed in Umuaka (0.019). With the PI < 1 in all the locations, it indicated very low level of Zn, Cu, Pb and Ni contamination of oyster mushroom.

The results of the one-way ANOVA indicated that sampling location influenced the concentration of all heavy metal determined except Ni and Cu ($P < 0.0001$) (Table 1). Tukey family error test at 5% level of significance was used to separate those mean metal concentrations impacted by the locations. For Zn, three distinct groups emerged where Ohaji differed from Ideato, Orlu market and the rest of the locations. Also for Pb, four groups emerged with Ohaji the superior group followed by Mbieri, Eke-ukwu and Obowo, Umuaka and the rest locations.

Provisional tolerable weekly intake (PTWI) is a value set by the FAO and WHO [20] and defined as the maximum quantity of contaminants that a consumer weighing 60 kg may take per week. The legislation states the following PTWI indices for individual heavy metals: Zn: 1.0 mg/kg of bodyweight (60 mg Zn.person⁻¹), Pb: 0.025 mg.kg⁻¹ of bodyweight (1.50 mg Pb.person⁻¹), Ni: 0.5 mg/kg of body weight (30 mg Ni. Person⁻¹), Cu: 0.5 mg/kg of bodyweight (30.0 mg Cu. Person⁻¹). The estimated weekly intake (EWI) of Zn, Pb, Ni, and Cu by a 60 kg adult consuming 210 g of oyster mushroom each week, and the provisional tolerable weekly intake (PTWI) for the metals investigated is presented in Table 2.

The estimated weekly intake of Zn, Pb, Ni, Cu from eating the tested fungi was lower than the PTWI. Zn (4.41 mg/kg body weight/week), Pb (0.46 mg/kg body weight/week), Ni (0.00035 mg/kg body weight/week), Cu (0.574 mg/kg body weight/week) from which the weekly intake accounted for 7.35%, 30.3%, 0.001% and 1.91% of the PTWI for Zn, Pb, Ni and Cu, respectively.

Table 1. Heavy metal concentration of Oyster mushroom (*P. tuberregium*) collected from Imo State.

Location	Zn (mg/kg)	Pb (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	PI
Okigwe market	0.99 ± 0.58^c	0.04 ± 0.004^d	0.0001 ± 0.00^a	0.35 ± 0.01^a	0.034
Anara	0.83 ± 0.1^c	0.04 ± 0.01^d	0.0001 ± 0.00^a	0.83 ± 0.97^a	0.041
Mbano	0.90 ± 0.11^c	0.04 ± 0.001^d	0.0001 ± 0.00^a	0.06 ± 0.001^a	0.021
Obowo	1.14 ± 0.11^c	0.06 ± 0.001^{cd}	0.0001 ± 0.00^a	0.06 ± 0.007^a	0.025
Eke-Ukwu	0.92 ± 0.01^c	0.25 ± 0.01^b	0.0001 ± 0.00^a	0.05 ± 0.02^a	0.035
Mbaise	1.02 ± 0.001^c	0.36 ± 0.01^a	0.0001 ± 0.00^a	0.06 ± 0.01^a	0.014
Mbieri	0.03 ± 0.007^c	0.25 ± 0.01^b	0.0001 ± 0.00^a	0.03 ± 0.01^a	0.031
Ohaji	3.25 ± 0.01^a	0.35 ± 0.005^a	0.0001 ± 0.00^a	0.04 ± 0.006^a	0.046
Umuaka	0.61 ± 0.12^c	0.05 ± 0.005^{cd}	0.0001 ± 0.00^a	0.04 ± 0.01^a	0.019
Ideato	2.4 ± 0.15^b	0.04 ± 0.003^d	0.0001 ± 0.00^a	0.05 ± 0.005^a	0.026
Orlu market	2.02 ± 0.01^b	0.04 ± 0.005^c	0.0001 ± 0.00^a	0.19 ± 0.007^a	0.040
Awo-Idemili	1.01 ± 0.16^c	0.04 ± 0.005^d	0.0001 ± 0.00^a	0.21 ± 0.02^a	0.030
Mean values	1.26	0.13	0.0001	0.164	
FAO/WHO*	0.3-1.0	0.01-0.025	0.5	0.05-0.5	
P<0.05	***	***	NS	NS	

PI=pollution index, columns bearing different alphabets are significantly different at 5% probability level. 0.1% = ***, * = 5%, NS = Not significant. Joint FAO/WHO Expert Committee on Food Additives, 2004).

Table 2. Comparison of Weekly intake of Zn, Pb, Ni and Cu by consuming Oyster mushroom (*P.tuberregium*) to provisional tolerable weekly intake (PTWI)

Parameter	Zn	Pb	Ni	Cu
EWI	4.41	0.46	0.00035	0.574
PTWI ^a	60	1.50	30	30
%EWI accounted for PTWI	7.35	30.3	0.001	1.91

PTWI^a = provisional tolerable weekly intake, ; Joint FAO/WHO Expert Committee on Food Additives [20], EWI = Estimated weekly intake of 210 g of mushroom for 60 kg body weight of an individual [19].

The THQs have been recognized as useful parameters for risk assessment of metals associated with the intake of contaminated food and foodstuff. It represents the ratio between the estimated dose of a contaminant and the reference dose below which there will be no appreciable risk.

THQ values on the consumption of meals prepared with oyster mushroom by average level consumer (ALC) who consumes a 0.5g of oyster mushroom from a meal and a high level consumer (HLC) who consumes 1.0g of oyster mushroom from a meal (using the mean of data obtained) are presented in Table 2. For the high level consumer (HLC), mean value for Zn, Pb, Cu and Ni are 0.0042, 0.025, 0.00388, 0.000005, respectively. Similarly, for

average level consumer (ALC) mean value for Zn, Pb, Cu and Ni are 0.00021, 0.018, 0.00182 and 0.0000025, respectively.

In China, [29] investigated 285 samples of 9 species of edible mushroom species collected from markets in Beijing China for levels of selected heavy metals. The values compared favourably with the present work except Zn with higher values in China. Daniel-Umeri *et al.*, [25] also observed higher Zn concentrations in *P. tuberregium* in Nigeria. Similar trends in Zn metal were also recorded in Turkey Zn: 35mg/kg, Ethiopia :51mg/kg (Table 4). In China, Cu mean value was 26.7 mg/kg as recorded by Zhu *et al.*, [30], in Ethiopia mean value of Cu was 89.7 mg/kg [28] whereas in Turkey Cu mean value was 8.0mg/kg [27].

Table 3. Target Hazard quotient (THQ) for heavy metal present in oyster mushroom (*P. tuberregium*)

Rate of consumption	Zn	Pb	Cu	Ni	location
HLC	0.0033	0.01142	0.00875	0.000005	Okigwe market
ALC	0.00165	0.00571	0.004375	0.0000025	
HLC	0.00276	0.01142	0.02075	0.000005	Anara
ALC	0.00138	0.00571	0.010375	0.0000025	
HLC	0.002983	0.01142	0.0015	0.000005	Mbano
ALC	0.001491	0.00571	0.00075	0.0000025	
HLC	0.0038	0.001714	0.0015	0.000005	Obowo
ALC	0.0019	0.00857	0.00075	0.0000025	
HLC	0.00306	0.07142	0.00125	0.000005	Eke-ukwu
ALC	0.00153	0.03571	0.000625	0.0000025	
HLC	0.000066	0.1028	0.00152	0.000005	Mbaise
ALC	0.000035	0.05142	0.00075	0.0000025	
HLC	0.00343	0.07142	0.00075	0.000005	Mbieri
ALC	0.00171	0.03571	0.000375	0.0000025	
HLC	0.01083	0.100	0.001	0.000005	Ohaji
ALC	0.00541	0.050	0.0005	0.0000025	
HLC	0.00203	0.01428	0.001	0.000005	Umuaka
ALC	0.00101	0.00714	0.0005	0.0000025	
HLC	0.008	0.01142	0.00125	0.000005	Ideato
ALC	0.004	0.00571	0.000625	0.0000025	
HLC	0.00673	0.02	0.00475	0.000005	Orlu market
ALC	0.00336	0.01	0.002375	0.0000025	
HLC	0.00335	0.01142	0.00525	0.000005	Awo-Idemili
ALC	0.00167	0.00571	0.002625	0.0000025	
mean. HLC	0.00419	0.023	0.00388	0.000005	
mean. ALC	0.000208	0.018	0.00182	0.0000025	

ALC= average level consumer, HLC=high level consumer.

Table 4. Comparison of results with data from previous studies available in the literature

Country	Zn (mg/kg)	Pb(mg/kg)	Cu(mg/kg)	Ni(mg/kg)	Reference
Ghana	NA	0.04	-	NA	[24]
Nigeria	38.2	0.524	-	0.3301	[25]
Nigeria	6.4–27.33	NA	NA	NA	[26]
Turkey	35.0	ND	8.0	-	[27]
Ethiopia	51.2	ND	89.7	-	[28]
China	86.4	3.42	-	-	[29]
China	48.4	0.67	26.7	1.50	[30]
Present study	1.26	0.13	0.164	0.0001	

4. Discussion

Oyster mushroom *Pleurotus Tuberregium* (Sing) is a common mushroom which is used as food or medicine, more commonly as a soup thickener. This study investigated the presence of heavy metals (Zn, Pb, Ni and Cu) in wild samples of *Pleurotus tuberregium* sclerotia consumed within our localities. All the metals assessed were found to be above the method detection limit. However, Ni recorded the least mean concentration of 0.0001mg/kg and this concentration is negligible. The mean Zinc concentration of 1.26 mg/kg is recommended as Zn is one of the most important minerals needed by our body systems due to the fact that it is highly associated with protein and carbohydrate rich foods. Zinc is also used in medicines to treat rashes, acne, dandruff and athlete's foot [31]. It has biological significance for living organisms and mushrooms are known as good zinc accumulators [32]. The mean value for zinc in the investigated mushroom sample is slightly above the permissible limit of 0.3-1.0 mg/kg recommended in food [20]. Zinc concentrations of edible mushroom samples in the literature have been reported to be: 38.2 mg/kg in Nigeria [25], and 6.4–27.33 mg/kg [26,33], 35 mg/kg in Turkey [27], 51.2 mg/kg in Ethiopia [28], in China 86.4mg/kg [29] and, 48.4 mg/kg [30]. This reveals that the findings of this study are in agreement with the results reported for similar studies.

Copper is essential metal, which serve as a constituent of some metalloenzymes, and is required in hemoglobin synthesis and catalysis of metabolic growth [34]. Copper was detected in the sclerotia of the oyster mushroom at varied concentrations. The mean concentration of 0.164 mg/kg is below the permissible value of 0.05-0.5 mg/kg set by FAO/WHO, (2004) in foods. Other workers presented copper contents of the mushroom samples in the literature to be in the ranges: 3.12-26.7 mg/kg [30], 2.6 – 72.4 mg/kg, 1.8 – 22.3 mg/kg [31], 5.0 – 83.0 mg/kg [35] and 13.7 – 182.4 mg/kg [36], 8.0 mg/kg [27] Table 3. The results obtained, in the current study, indicated that copper content of the investigated mushroom samples were found to be comparable with those reported in the literature.

Lead creates health disorders such as sleeplessness, tiredness, hearing, and weight loss [26]. Unfortunately, the concentrations of Pb in some locations were relatively higher than the permissible limits in food items. According to FAO/WHO [20] tolerable weekly intake of lead is 0.025 mg/kg body weight. From the study, Pb concentration of the oyster mushroom exceeded threshold limit of 0.025mg/kg in all the locations. This result may be attributed to air borne lead arising from vehicular and industrial emissions. Air borne Pb often gets deposited on the oyster mushroom while displayed openly in the market place. Nwoko and Mgbeahuruik, [37] reported higher trace metal concentration on ready-to-use herbal remedies exposed to air borne trace metal contamination than those not exposed to air borne metal contamination.

Nickel is introduced into the environment from both natural and man-made sources and is circulated throughout all environmental compartments by means of chemical and physical processes, as well as by being

biologically transported by living organisms. Mean nickel concentration of 0.0001 mg/kg in this present study is below the recommended limit of 0.5mg/kg set by FAO/WHO, [20].

The trace metal pollution index of the entire locations of less than 1 (PI <1) indicated relatively low trace metal contamination of oyster mushroom within Imo state. Trace metal contamination of food items such as mushroom is normally influenced by a number of chemical and environmental factors: geochemical and physical parameters including the type of soil, soil pH, humidity, the organic matter content of the soil, and the concentration of extractable trace metal [38,39].

The Target Hazard Quotient (THQ) for trace metal present in oyster mushroom for average and high level consumers showed mean values below reference dose (Table 3). The RfDo values in mg/kg body wt/day for Copper, Zinc, Nickel, and Lead were 0.04, 0.3, 0.02 and 0.0035 [19], respectively. An index more than 1 is considered as not safe for human health [19]. This result indicated that there is no appreciable risk in the consumption of the oyster mushroom throughout life. The THQ marker connects the metals concentrations in food with their toxicity, quantity and quality of food consumption and body mass of consumers. The use of this complex parameter is more extensive in evaluating the potential health risk of trace metals present in various foods [23]. For the metals determined in oyster mushroom the THQ were far below 1. A small value of the index (<1) shows reduced health hazard and a value between 1 and 5 represents a concern level for health hazard [23].

Comparison of the present result with data available from the literature showed that trace metal accumulation by oyster mushroom species varied across regions and ecological boundaries (Table 4). However, results for some metals from oyster mushroom species considered, in this study, were observed to differ greatly. This difference in the contents of the metals could be associated to the variation in the composition of the substrate from which the mushrooms got their nutrients, the site where the samples collected from, age of the fruiting bodies and mycelium, and distance from the source of pollution [8]. Besides, the metal concentrations in the mushroom samples could also mainly be affected by the pH or organic matter content of the substrates [40].

5. Conclusion

Oyster mushroom *Pleurotus Tuberregium* (Sing) is a common mushroom which is used as food or medicine, more commonly as a soup thickener. Oyster Mushroom trace metal contamination varied across the state, mean values of Zn and Pb only exceeded recommended threshold limits while Cu and Ni were within acceptable limits. However, estimated weekly intake (EWI) for an adult consuming 210g of mushroom, having 60kg body weight was found to be lower than PTWI for Zn, Pb, Ni and Cu. Also, target hazard quotient was found to be below the reference dose (Rfdo) and also less 1 (THQ<1).

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