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Comparative Acute Toxicity of Aqueous Extracts of *Tephrosia vogelii* and *Albizia gummifera* on *Clarias gariepinus* (African Catfish) Fingerlings

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Abstract

Fishing with *Albizia gummifera* is gaining more popularity than *Tephrosia vogelii* by local fishermen of Mangu Local Government Area, Plateau State and other parts of Nigeria, because of its productiveness and availability. Acute toxicity of aqueous extracts of leaf and bark of *T. vogelii* and *A. gummifera* were conducted on *C. gariepinus* fingerlings in static non-renewable bioassay. Dissolved Oxygen (DO) mg/L, pH and Temperature (°C) were monitored daily throughout the period by using ExStik® DO600 meter. Definitive acute concentrations of 140, 120, 100, 80, 60, 0.00 mg/L; and 600, 525, 454, 375, 225 and 0.00 g/L as control of aqueous bark and leaf extracts in mg/L for *A. gummifera* and *T. vogelii* were used respectively. The result of the water quality parameters of fishes exposed to various plant toxicant concentrations of the plants showed no variation in all the studied water parameters compared with the control treatments. The percentage mortality of fishes was observed to decrease with decrease in toxicant concentrations in both plants. The 96hrs LC_{10}; LC_{50} and LC_{99} values with confidence limits were of 61.21 (53.54 - 104.67) mg/L and 131.86 (104.67 - 166.10) mg/L; 94.58 mg/L (108.56 - 82.419) and 277.82 (220.54 - 349.98); and 208.46 (182.31 - 238.35) and 1074.73 (853.13 - 1353.82) of aqueous bark and leaf extracts of *A. gummifera* and *T. vogelii* to the exposed fishes, respectively. Lower lethal concentration values of *A. gummifera* indicated that it is more toxic than *T. vogelii.* Therefore, fishing with the *A. gummifera* should be regulated in order to preserve fish species in wild.

Keywords: 96hrs LC_{50}; Fish Poison Bean; Peacock Flower; African Catfish.

1. Introduction

Fish and fish product demand is very high compared to the quantity supplied all over the world [1]. Fish is a source of protein that is relatively cheap, available, easily processed and serves as a source of income compared to other livestock. Pollution leads to decrease in wild fisheries supplied [2]. Plant derivatives used for catching fishes are more friendly to the aquatic ecosystem and are proved economical compared to synthetic pesticides [3]. However, traditional fishing with plant substances has been shown to have negative consequences on aquatic biota, which roots to a significant ecological balance and does not encourage continuous fishing [4]. Different plant species have been used

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unsystematically to catch fish in lentic and lotic water bodies [3]. Roots, barks, leaves, fruits and seeds are toxic parts of plants employed as fish poisons [5].

Tephrosia vogelii of family Fabaceae (Leguminosae) commonly known as fish poison bean (or vogel's tephrosia), is a soft woody branch herb that is distributed in the regions of tropical and sub-tropical countries [6, 7]. *T. vogelii* is used in various applications such as insecticidal, anthelminthic, anti-bacterial and fish poison [8]. Phytochemical investigation revealed the presence of glucosides, retinoids, rotenones isoflavones, chacones, flavanones, flavanols, prenylated flavonoids, alkaloids, tannins, saponins, cardiac glycosides, steroids, balsam, phenol and volatile oil [8, 9, 10]. Retinoid is responsible for *T. vogelii* entomotoxic property [11]. Fishing with *T. vogelii* is admired by Nigerian traditional fishermen because of its effectiveness [12]. *T. vogelii* is a popular plant used to kill fish in natural waters since 30 - 40 years ago [13].

Albizia gummifera also from family Fabaceae (commonly known as peacock flower) is a fast growing tree that is widely distributed in Africa, sub-tropical and tropical [14]. *Albizia* are important forage timber and medicinal plants, and many are cultivated as ornamental for their attractive flowers [15]. These species are used in folk medicine for the treatment of rheumatism, stomachache, cough, diarrhoea, wounds and as anthelmintic [16]. The phytochemical investigation of *Albizia* species revealed the presence of saponins, terpenes, alkaloid and flavonoids [17]. *Albizia* extracts are toxic to bacteria, parasites and mosquitoes [18]. *Albizia* species also display ichthyotoxic properties [18].

Fish are ideal sentinels for detecting and documenting aquatic pollutants [19]. African catfish (*C. gariepinus*) belongs to family Clariidae. It is the most cultivated fish in Nigeria and highly demanded due to its resistant to stress, ability to tolerate a wide range of environmental conditions and relatively fast growth [20]. It is frequently and widely cultured in ponds and also occurs freely in Nigerian natural freshwater [21].

Water quality is an important integral part for fish survival and growth [22]. Aquatic organisms are stressed due to changes in water quality parameters [23]. Virtuous water quality condition is crucial for aquatic organisms' continuity [24]. Deterioration in the water quality reduces growth, makes animals vulnerable to diseases and cause heavy mortality of aquatic animals [25].

Fishing by using *A. gummifera* is gaining more popularity than other pesticides (*T. vogelii*) by local fishermen of Mangu Local Government Area, Plateau State and other parts of Nigeria, because of its productiveness and availability. This obnoxious fishing could have deleterious effects to aquatic biota, including fish. There is paucity of literature on the comparative acute toxicity effects of aqueous bark extracts of *A. gummifera* and *T. vogelii* on African catfish (*C. gariepinus*) fingerlings. As a result of that, we intended to carry out acute toxicity of the plant aqueous extracts on freshwater fish (*C. gariepinus*) to ascertain the safe level of the plants on aquatic environment.

2. Materials and Methods

2.1. Collection of Plant Materials

Bark of *A. gummifera* and leaves of *T. vogelii* were collected from Mangu and Jos South Local Government Areas of Plateau State, Nigeria. The bark and leaves of *A. gummifera* and *T. vogelii* were authenticated at Department of Plant Science and Technology, University of Jos. The plant derivatives were air dried at ambient condition. Air-dried parts were pounded and powdered using pestle and mortar and sieved by using 30 µm mesh size.

2.2. Collection, Transportation and Acclimatization of Experimental Fish

Fingerlings of *C. gariepinus* were purchased from Rayuwa Fish Farm, Karu Local Government Area, Nasarawa State, Nigeria. The fishes were transported in tanks containing water from the pond to the Laboratory Unit of Zoology Department, Nasarawa State University, Keffi. The fishes were transferred into aquaria containing dechlorinated municipal tap-water and allowed to acclimatize to the laboratory conditions for a period of two weeks. During this period, the fish was fed to satiation at 8:00 am and 6:00 pm with commercial fish feed (Vital Feed®) [26].

2.3. Preparation of Stock Solution of *A. gummifera* and *T. vogelii* Bark and Leaves

A quantity of one milligram (1.00 mg) of the powdered bark and leaves was macerated in one litre (1L) of distilled water for 24 hours [27]. The mixture was filtered through a funnel choked with non-absorbent cotton wool and the filtrate obtained was used as stock solution [28].

2.4. Preparation of Acute Toxicity Concentrations of Crude Bark and Leaf Extracts of *A. gummifera* and *T. vogelii*

Range Finding Test (RFT) was conducted to obtain definitive toxicity concentrations for the acute toxicity test for both plants [29]. Five definitive acute concentrations of 140, 120, 100, 80, 60, 0.00 mg/L; and 600, 525, 454, 375, 225 and 0.00 g/L as control of aqueous bark and leaf extracts in mg/L were prepared for *A. gummifera* and *T. vogelii* respectively.

2.5. Experimental Design for the Acute Toxicity Procedure

Randomized block design was used. A total of 12 tanks 30 litres capacity each with 15 litres of the toxicants and 0.00 mg/L as control each with replicate were maintained throughout the exposure period. Each tank contained ten (10) mixed sex fingerlings of *C. gariepinus* of average weight of 42.64 ± 0.82 g and length of 11.14 ± 0.22 cm respectively. Static non-renewable bioassay was used [29]. Fish mortality was monitored and recorded. Inability of fish to respond to external stimuli was used as index of death by probing with glass rod.

2.6. Water Quality Parameter for Acute Concentrations of Crude Bark and Leaf Extracts of *A. gummifera* Bark and *T. vogelii* Leaf

Water quality parameter for acute concentrations of aqueous extracts of plants namely: Dissolved Oxygen (DO) mg/L, pH and Temperature (°C) were monitored daily throughout the period using multi-parameter ExStik® DO600 meter.

2.7. Statistical Analysis Methods

The 96hrs lethal concentrations were computed by using Finney's Probit Analysis [30] calculator, version 1.5; One-Way Analysis of Variance (ANOVA) for significant difference between treatment means (P = 0.05) and for water parameters by Statistical Package for the Social Sciences (SPSS) version 22.0.

3. Results

3.1. Water Quality Parameters

Table 1 Mean Values of Water Quality Parameters for Acute Bioassay of Aqueous Leaf and Bark Extracts of *T. vogelii* and *A. gummifera* Exposed to *C. gariepinus* Fingerlings

Concentrations (mg/L)	pH	Temperature	DO
TV – 600	7.58 ± 0.09	24.48 ± 0.29	7.51 ± 0.07
AG - 140	7.58 ± 0.09	24.48 ± 0.29	7.51 ± 0.07
TV – 525	7.53 ± 0.09	25.43 ± 0.39	7.15 ± 0.07
AG - 120	7.56 ± 0.09	24.62 ± 0.30	7.47 ± 0.16
TV – 454	7.54 ± 0.09	25.50 ± 0.38	7.24 ± 0.12
AG - 100	7.57 ± 0.10	24.65 ± 0.23	7.63 ± 0.02
TV – 375	7.51 ± 0.09	25.45 ± 0.41	7.33 ± 0.10
AG - 80	7.56 ± 0.09	24.6 5 ± 0.23	7.55 ± 0.05
TV – 225	7.49 ± 0.07	25.5 8 ± 0.34	7.25 ± 0.12
AG – 60	7.56 ± 0.09	24.62 ± 0.30	7.47 ± 0.16
TV – 00	7.54 ± 0.07	25.58 ± 0.31	7.29 ± 0.12
AG – 00	7.50 ± 0.09	24.48 ± 0.31	7.49 ± 0.09

Key: TV = *T. vogelii*; AG = *A. gummifera;* DO = Dissolved Oxygen.

The result of the water quality parameters of fishes exposed to various plant toxicant concentrations of the plants showed no variation in all the studied water parameters compared with the control treatments. The highest and lowest temperature values were of 24.78 ± 0.31 and 24.46 ± 0.29 °C recorded in 0.00 and 140 mg/L for *A. gummifera* while for *T. vogelii* were 25.5 ± 0.34 and 25.6 ± 0.39 respectively. The pH of the experimental tanks of both plants was observed to exhibit some degree of variations, though it did differ significantly compared with the control. pH values were observed to increase with increase in toxicant concentrations, with the highest toxicant concentration of *A. gummifera* and *T. vogelii* crude bark and leaf extracts of 140mg/L and 600mg/L recorded the highest pH value of 7.58 ± 0.09 and 7.62 while the lowest pH (7.53 ± 0.03 and 7.48) was recorded from the lowest concentration tank (225 mg/L and 60 mg/L) respectively. Dissolved Oxygen (DO) values increased with increase in concentration of the plants toxicant. The least DO value of 7.47 ± 0.16 mg/L was obtained in the tank with the concentration of 120 mg/L while the highest value for DO was obtained in the tank (120mg/L) with DO value of 7.63 ± 0.02 mg/L for *A. gummifera*. For *T. vogelii,* 7.33 ± 0.10 mg/L in 375 mg/L and 7.15 ± 0.17 mg/L in 525 mg/L were obtained (Table 1).

3.2. Mortality

After 96hrs of exposure, mortality of 100% was recorded in the highest concentrations (600 and 140 mg/L) of *T. vogelii* and *A. gummifera* leaf and stem bark. While 40% and 10% mortality were recorded in the lowest concentrations. The control tanks (0.00 g/L) recorded no mortality (Table 2). The percentage mortality was observed to decrease with decrease in toxicant concentrations. Linear relationships between Log Concentration and Probit Mortality of *C. gariepinus* exposed to acute concentrations of *A. gummifera* and *T. vogelii* were illustrated in Figure 1 and 2 respectively.

Table 2 Percentage Mean Mortality and Survival of *C. gariepinus* Fingerlings Exposed to Aqueous Extracts of *T. vogelii* and *A. gummifera* Leaf and Stem Bark

Concentrations (mg/L)	Log Concentration	Number of Exposed Fishes	Mortality After 96 Hours	% Mortality	% Survival
TV - 600	3.00	10	10	100	0
AG - 140	-0.22	10	10	100	0
TV - 525	2.95	10	9	90	10
AG - 120	-0.30	10	8	80	20
TV - 454	2.90	10	8	80	20
AG - 100	-0.14	10	5	50	50
TV - 375	2.85	10	6	60	40
AG – 80	-0.52	10	3	30	70
TV - 225	2.78	10	4	40	60
AG – 60	-0.72	10	1	10	90
TV – 00	0.00	10	0	0	0.00
AG – 00	0.00	10	0	0	0.00

Key: TV = *T. vogelii*; AG = *A. gummifera;* mg = Milligram; L = Litre; % = Percentage.

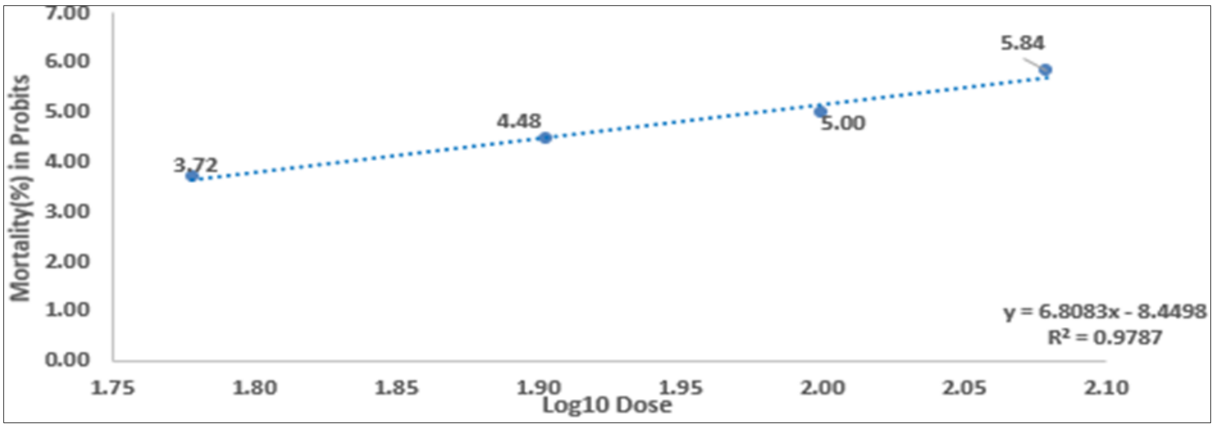

Figure 1 Linear Relationship between Log Concentration and Probit Mortality of *C. gariepinus* Exposed to Acute Concentrations of *A. gummifera*

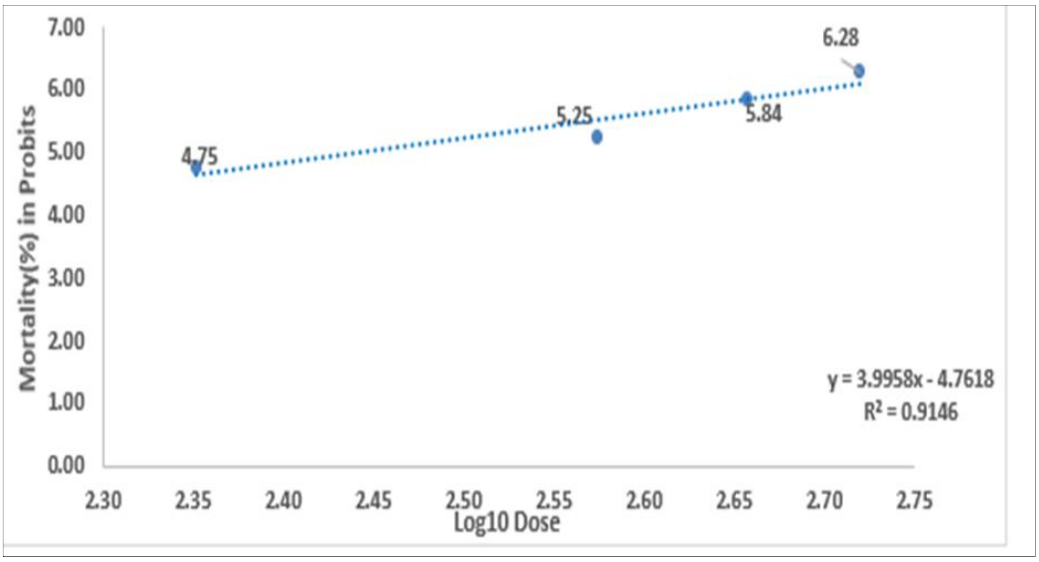

Figure 2 Linear Relationship between Log Concentration and Probit Mortality of *C. gariepinus* Exposed to Acute Concentrations of *T. vogelii*

3.3. The 96hrs Lethal Concentrations

The 96hrs LC_{10} values of 61.21 mg/L and 131.86 mg/L with confidence limits of 53.54 - 104.67 and 104.67 - 166.10 of aqueous bark and leaf extracts of *A. gummifera* and *T. vogelii* to the test fishes were obtained respectively. The 96hrs LC_{50} values of 94.58 mg/L and 277.82 mg/L with confidence limits of 108.56 - 82.419 and 220.54 - 349.98 of aqueous bark and leaf extracts of *A. gummifera* and *T. vogelii* to the test fishes were obtained respectively. While 96hrs LC_{99} values of 1074.73 (853.13 - 1353.82) and 208.46 (182.31 - 238.35) for *T. vogelii* and *A. gummifera* aqueous crude extracts to *C. gariepinus* were recorded respectively (Table 3).

Table 3 Lethal Concentrations with Lower and Upper Confidence Limits of Aqueous Crude Extracts of *T. vogelii* and *A. gummifera* Leaf and Bark

Concentrations (mg/L)	*T. vogelii*	*A. gummifera*
LC_{10} (LCL - UCL)	131.86 (104.67 - 166.10)	61.21 (53.54 - 69.99)
LC_{20} (LCL - UCL)	170.30 (135.98 - 218.96)	71.08 (62.16 - 81.27)
LC_{30} (LCL - UCL)	204.80 (162.56 - 257.99)	79.16 (69.23 - 90.51)
LC_{40} (LCL - UCL)	239.76 (190.33 - 302.03)	86.80 (75.91 - 99.24)
LC_{50} (LCL - UCL)	277.82 (220.54 - 349.98)	94.59 (82.73 - 108.16)
LC_{60} (LCL - UCL)	321.92 (255.55 - 405.53)	103.09 (90.17 - 117.88)
LC_{70} (LCL - UCL)	376.88 (299.18 - 474.76)	113.04 (98.86 - 129.24)
LC_{80} (LCL - UCL)	453.23 (359.79 - 570.94)	125.90 (110.11 - 143.95)
LC_{90} (LCL - UCL)	585.36 (464.68 - 737.39)	146.19 (127.85 - 167.15)
LC_{99} (LCL - UCL)	1074.73 (853.13 - 1353.82)	208.46 (182.31 - 238.35)

Key: LCL = Lower Confidence Limits; UCL = Upper Confidence Limits.

4. Discussion

Aqueous crude extracts of *T. vogelii* and *A. gummifera* leaf and bark have toxic effects that led to the death of exposed fishes. The mortality of *C. gariepinus* increased with increase of the toxicant concentrations of *A. gummifera* and *T. vogelii* aqueous extract on *C. gariepinus* fingerlings. These concurred with the finding of Bala *et al.* that reported an increase in mortality of *Oreochromis niloticus* fingerlings with increase of aqueous crude leaf extract of *Balanites aegyptiaca*

(Egyptian balsam) [26]. Ekpo et *al.* also reported an increase in mortality rate of early stages of *C. gariepinus* after exposure to ethanoic extract of *T. vogelii* [5]. Similar trend of mortality was also reported by Akpa *et al.* after exposing *Tilapia zillii* to leaves extract of *T. vogelii* [9]. Orji *et al.* also reported similar results after exposing juveniles of *C. gariepinus* to aqueous leaf extract of *Psychotria microphylla* [31].

The higher median LC_{50} values indicated lower toxicity because greater concentrations are required to produce 50% mortality of the exposed animals [32]. The LC_{50} of *A. gummifera* and *T. vogelii* were 94.59 mg/L and 277.82 mg/L with lower and upper confidence limits of 108.56 and 82.419; and 220.54 and 349.98 respectively, which indicated that *A. gummifera* is more toxic than *T. vogelii* since it has lower median lethal concentrations value.

Higher LC_{50} values of both studied ichthyotoxic plants with upper and lower confidence limits were reported by Bala *et al.* [26] and Syngai *et al.* [33] after exposing *O. niloticus* fingerlings to *B. aegyptiaca* aqueous crude leaf extract and aqueous garlic extract to juveniles, respectively. The 96th LC_{50} value of the fruit extract of *B. aegyptiaca* on *C. gariepinus* fingerlings was also higher than that of *A. gummifera* and *T. vogelii* [34].

The 96 hours LC_{50} of *Carica papaya* seed aqueous extract on *C. gariepinus* juveniles reported by Joseph *et al.* [20] is higher than that of *A. gummifera* and lower than that of *T. vogelii* obtained from this work.

Lower LC_{50} values for both studied ichthyotoxic plants were also reported. For example, LC_{50} for the *T. vogelii* ethanolic extract on early life stages of farmed *C. gariepinus* was reported by [5]. Akpa *et al.* reported very low value LC_{50} of leaf extracts of *T. vogelii* on *O. niloticus* [9]. Okey *et al.* reported lower LC_{50} values of clove (*Eugenia aromatica*) powder on *C. gariepinus* and *Heterobranchus bidorsalis* fingerlings [35]. Lower 96 hours LC_{50} values on *C. gariepinus* juveniles and fingerlings were reported after exposure to lyophilized aqueous leaf extract of *P. microphylla* and aqueous extract of pawpaw (*C. papaya*) seed powder [31, 36].

The studied water quality parameters values did not differ significantly with that of control, which indicated that the plant extracts have no effect on the studied water quality parameters. Aquatic fauna has bearable limits of water quality parameters in which they thrive [37]. Changes either decline or rise within these limits has unpropitious effects on the general body function of the exposed organisms [38]. The temperature values recorded in *A. gummifera* and *T. vogelii* are within the tolerable limit of 20 – 30 °C for *C. gariepinus* [37]. Temperature influences numerous key activities in fishes [24, 39]. The plant extracts have no effect on water temperature hence, they did not lead to mortality of the exposed fishes which opined with the finding of Anju *et al.* [13]; Alhou *et al.* [40]; Bala *et al.* [26]. Orji *et al.* reported the temperature which was within the tolerable range and it did differ significantly within various concentrations and the control of *P. microphylla* on *C. gariepinus* [31].

Manera and Scot [41] and Anita and Gajender [42] reported that Dissolved Oxygen (DO) levels greater than 5 mg/L is crucial for good fish production, which agreed with the finding obtained from this research. The authors reported DO values that were within the same range. Orji *et al.* reported similar values of DO after 96 hours exposure of *C. gariepinus* juveniles to aqueous extract of *P. microphylla* [31]. Ezekiel *et al.* reported similar result after exposing *C. gariepinus* fingerlings to *C. papaya* seed extract [43]. While, Alhou *et al.* reported similar lower DO value obtained from this work on *O. niloticus* exposed to acute concentrations of *B. aegyptiaca* [40].

pH affects fish health [39]. For freshwater species, ideal pH is within the range of 6.5 - 9.0 [37]. The pH values recorded in this study were within the range for fish production which opined with the finding of Alhou *et al.* who reported similar value after 96 hours exposure of *O. niloticus* fingerlings to acute concentrations of *B. aegyptiaca* [40]. Orji *et al.* also reported pH value that is within the acceptable limit after 96 hours exposure of *C. gariepinus* juveniles to aqueous extract of *P. microphylla* [31].

5. Conclusion

Lower LC_{50} (94.59 mg/L) of the bark of *A. gummifera* indicated that the plant is more toxic to *C. gariepinus* fingerlings compared to *T. vogelii* with higher LC_{50} value of 277.82 mg/L.

Recommendations

- Fishermen should be cautious on the use of these plants in catching fishes in order to preserve the fishes.
- Further studies on other aquatic organisms should be conducted.

Compliance with Ethical Standards

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Disclosure of Conflict of Interest

The authors declared that there is no conflict of interests in this study.

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	**Dr. Bala Sambo Audu** (Ph.D.) joined University of Jos, Plateau State, Nigeria as an Assistant Lecturer and rose to the Professorial cadre. He received his Bachelor of Science (B. Sc. Ed.) in Biology/Education, Masters of Science (M. Sc.) in Applied Hydrobiology and Fisheries and Doctor of Philosophy of Science (Ph.D.) in Aquatic Toxicology of the Applied Hydrobiology and Fisheries Unit, Department of Zoology, University of Jos. As an Associate Professor of Aquatic Toxicology, he teaches various courses at both undergraduate and postgraduate levels and has supervised numerous undergraduate and postgraduate projects, theses and dissertations. Audu is interested in aquatic toxicology research, incorporating molecular biology and biochemistry. He has published several articles in peer-reviewed journals across the globe and has attended conferences both at international and local levels. He is specifically interested in investigating the effects of obnoxious anthropogenic substances into the aquatic environment, their impact on general physiology, biochemistry, haematological and general physiological changes of the aquatic vertebrates particularly fish and how to mitigate or remedy the impact

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	**Mr. Audu Idi Wakawa** is a holder of B. Sc. (Hons.) Zoology and Postgraduate Diploma in Education (PGDE) obtained from University of Maiduguri, Nigeria. He obtained his M. Sc. In Applied Hydrobiology and Fisheries from the University of Jos, Nigeria. He is currently a Ph.D. student of Applied Hydrobiology and Fisheries in the same University with specialization in Aquatic Toxicology. He was a classroom teacher at Government Secondary School, Nguru, Yobe State, Nigeria and presently a Chief Lecturer at Umar Suleiman College of Education, Gashua in the same state. Besides his primary assignment as a Lecturer at the Nigeria Certificate in Education (NCE) programmes, he also facilitates at the Postgraduate and Diploma programmes of the College (affiliated to the University of Maiduguri). He is also a facilitator at the National Teachers' Institute (NTI) programmes, Kaduna. Audu Idi Wakawa has chaired many Local Organizing Committees (LOC) for the organization of national and international conferences. He has authored two textbooks and published many articles in national and international journals. He is a member of Teachers' Registration Council of Nigeria (TRCN) and Zoological Society of Nigeria (ZSN). The officer has held many administrative responsibilities notable among which include: Head of Biology Department, Dean School of Sciences, and the Deputy Provost of Umar Suleiman College of Education, Gashua, Yobe State. He has received many merit awards.
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