**Table 1: Levels of Heavy Metal Contamination in Various Fish in Southwest Nigeria (2014-2024)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Concentration (mg/kg)** | | | | | | | | | | | | **WHO limit** | **References** |
|  | **Fish type** | **As** | **Cd** | **Cr** | **Co** | **Mn** | **Pb** | **Al** | **Zn** | **Hg** | **Ni** | **Fe** | **Cu** |  |  |
| 1 | *Oreochromis niloticus* | - | 0.005 | 0.32 | - | 0.08 | 0.10 | - | 0.62 | - | - | 1.57 | 0.06 | Yes | Oladunjoye , 2022 |
| 2 | *Tilapia zilli* | - | 0.445 | 5.44 | - | - | 4.36 | - | 3.88 | - | 11.10 | - | 0.19 | Pb, Ni & Cr exceeded limit | Yahaya *et al.,* 2022 |
| *Chrysichthys nigrodigitatus* | - | 2.89 | 0.88 | - | - | 3.63 | - | 6.48 | - | 4.16 | - | 1.28 | Pb, Ni & Cu exceeded limit |
| 3 | *C. gariepinus* | BDL | 2.36 | 0.77 | - | - | 9.14 | - | - | - | 8.77 | - | - | No | Yahaya *et al.,* 2022. |
| 4 | *Sarotherodon melanotheron* | 0.55 | 0.040 | 0.004 | 0.040 | BDL | 0.045 | - | - | - | 0.047 | - | - | Yes | Adetutu *et* *al.,* 2023 |
| *Chrysichthys nigrodigitatus* | 0.13 | 0.026 | 0.016 | 0. 037 | 0.002 | 0.008 | - | - | - | 0.076 | - | - | Yes |
| *C. gariepinus* | 0.55 | 0.042 | 0.003 | 0.013 | BDL | 0.04 | - | - | - | 0.087 | - | - | Yes |  |
| *and Ethmalosa fimbriata* | BDL | 0.021 | BDL | 0.022 | 0.02 | 0.06 | - | - | - | 0.093 | - | - | Yes |  |
| 5 | *Chrysichthys nigrodigitatus* | 2.22 | 1.735 | - | 0.08 | 1.71 | - | 1.62 | 2.61 | - | 1.68 | 2.93 | 3.51 | No | Olujimi *et al.,* 2017 |
| 6 | *Clarias gariepinus* | - | 0.001 | 0.003 | - | 0.64 | 0.20 | - | 0.035 | - | 0.02 | - | - | Yes | Ogungbemi *et* *al.,* 2023 |
| 7 | *Bathygobius soporator* | - | 0.16 | - | - | - | 2.21 |  | 0.78 | - | - | 8.30 | 16.20 | No | Ndimele and Owodeinde. 2021 |
| 8 | *Chrysichthys nigrodigitatus* | - | 0.022 | - | - | - | 2.80 | - | 5.30 | - | 0.48 | - | - | No | Kanu and Idowu, 2015 |
| 9 | *Cynoglossus senegalensis* | - | 0.001 | 2.15 | - | - | 5.29 | - | 3.22 | - | - | - | 0.18 | Pb, Zn and Cr exceeded limit | Balogun *et al*.*,* 2021 |
| *Mugil cephalus* | - | 0.002 | 9.89 | - | - | 4.14 | - | 6.92 | - | - | - | 0.75 |
| *Chrysichthys nigrodigitatus* | - | 0.001 | 4.04 | - | - | 9.20 | - | 3.38 | - | - | - | 0.28 |
| *Pseudotolithus typus* | - | 0.001 | 4.62 | - | - | 3.45 | - | 2.87 | - | - | - | 1.02 |
| 10 | *T.* *zillii* | - | - | - | - | 1.02 | 4.82 | - | 9.31 | - | - | 7.10 | 3.07 | Pb, Fe and Zn exceeded limit | Taiwo *et al.,* 2017 |
| *H. fiscalis* | - | - | - | - | 1.13 | 4.41 | - | 9.50 | - | - | 7.14 | 3.20 |
| *P. humile* | - | - | - | - | 1.36 | 5.15 | - | 9.77 | - | - | 6.87 | 2.80 |
| *C.hippo* | - | - | - | - | 1.18 | 4.75 | - | 10.21 | - | - | 8.22 | 3.33 |
| *C. acaudatus* | - | - | - | - | 1.80 | 6.56 | - | 12.79 | - | - | 8.05 | 4.04 |
| *Letjanus sp.* | - | - | - | - | 1.41 | 4.60 | - | 14.03 | - | - | 8.10 | 3.43 |
| *C. nigrodigitatus* | - | - | - | - | 1.93 | 6.52 | - | 11.08 | - | - | 7.69 | 4.33 |
| *Sphyraena sp* | - | - | - | - | 1.69 | 6.39 | - | 14.11 | - | - | 7.99 | 4.22 |
| *S. maderensis* | - | - | - | - | 1.13 | 6.40 | - | 14.45 | - |  | 7.28 | 3.98 |
| 11 | *Synodontis membrane* |  | ND | - | - | 3.87 | ND | - | 35.4 | - | - | 24.5 | 3.62 | Zn and Cu, Fe exceeded limit. | Olowu *et al.,* 2015 |
| *Tilapia zilli* | -  - | ND | -  - | -  - | 7.50 | ND | - | 31.9 | -  - | -  - | 24.0 | 2.00 |
| 12 | *C.nigrodigitatus* | - | - | - | - | 1.24 | 4.62 | - | 11.35 | - | - | 8.02 | 2.94 | Pb, Fe, and Mn exceeded limit | Taiwo *et al.,* 2019 |
| *T. wesafu* | - | - | - | - | 1.23 | 5.88 | - | 13.13 | - | - | 7.75 | 3.31 |
| *Mormyrus sp.* | - | - | - | - | 1.17 | 5.83 | - | 12.39 | - | - | 8.68 | 2.94 |
| *G. niloticus* | - | - | - | - | 1.15 | 5.69 | - | 15.78 | - | - | 8.11 | 2.97 |
| *Alestes sp* | - | - | - | - | 1.05 | 4.11 | - | 9.71 | - | - | 6.80 | 2.57 |
| *T. zillii* | -  - | -  - | -  - | -  - | 1.02 | 3.84 |  | 9.71 | -  - | -  - | 7.27 | 2.08 |
| *P. quadrifilis* | - | - | - | - | 0.85 | 3.02 |  | 9.71 | - | - | 4.37 | 2.04 |
| 13 | *Clarias gariepinus* | - | - | - | - | - | 3.23 | - | ND | - | - | - | 0.055 | Pb levels exceeded limit | Olurin, 2024 |
| *Ameirus catus* | - | - | - | - | - | 3.02 | - | 0.026 | - | - | - | 0.014 |
| *Oreochromis niloticus* | - | - | - | - | - | 3.39 | - | 0.685 | - | - | - | 0.008 |
| 14 | *Callinectes danae* | - | 0.00 | 0.00 | - | - | 0.00 | - | 1.29 | - | - | 0.21 | 4.19 | Cu exceeded limit | Oladunjoye *et al.,* 2021 |
| *Cardisoma armatum* | - | 0.00 | 0.00 | - | - | 0.00 | - | 1.15 | - | - | 2.25 | 4.98 |
| *C. ornatus* | - | 0.00 | 0.00 | - | - | 0.00 | - | 19.06 | - | - | 16.85 | 23.47 |
| 15 | *Caranx hippos* | - | 0.18 | - | - | 1.88 | 0.05 | - | 1.66 | - | - | 1.65 | - | Exceeded limit | Oguguah and Ikegwu, 2017 |
| *Chrysichthys nigrodigitatus* | - | 0.04 | - | - | 0.98 | 0.03 | - | 3.91 | - | - | 1.71 | - |
| *Elops lacerta* | - | 0.05 | - | - | 0.60 | 0.07 | - | 2.42 | -- | - | 1,67 | - |
| *Galeoides decadactylus* | - | 0.06 | - | - | 0.57 | 0.05 | - | 2.02 | - | - | 5.15 | - |
| *Ilisha africana* | - | 0.13 | - | - | 0.31 | 0.04 | - | 2.07 | - | - | 1.54 | - |
| *Liza falcipinnis* | - | 0.05 | - | - | 0.23 | 0.02 | - | 0.30 | - | - | 1.26 | - |
| *Lutjanus goreensis* | - | 0.08 | - | - | 0.02 | 0.07 | - | 1.84 | - | - | 0.87 | - |
| *Mugil cephalus* | - | 0.05 | - | - | 0.10 | 0.06 | - | 1.75 | - | - | 1.14 | - |
| *Pseudotolithus senegalensis* | - | 0.13 | - | - | 0.10 | 0.14 | - | 0.57 | - | - | 1.09 | - |
| *Sarotherodon spp* | - | 0.05 | - | - | 0.37 | 0.06 | - | 3.35 | - | - | 1.51 | - |
| *Sphyraena spp* | - | 0.05 | - | - | 0.37 | 0.06 | - | 3.35 | - | - | 1.51 | - |
| *Tilapia spp* | - | 0.02 | - | - | 0.27 | 0.13 | - | 3.58 | - | - | 3.35 | - |
| 16 | *F. notalis* | - | ND | 0.56 | - | 12.8 | - | - | 8.0 | - | - | 69.12 | 1.38 | Yes | Akinjogun *et al.,* 2023 |
| 17 | *F. notalis* | - | 0.00 | 0.69 | 0.56 | - | 0.74 | - | 0.85 | - | - | - | - | Yes | Moruf and Akinjogunla, 2019 |
| 18 | *C. gariepinus* | - | 0.45 | - | - | - | 9.43 | - | 32.10 | - | - | - | 1.89 | Yes | Adewunmi *et* *al.,* 2017 |
| *P. obscura* | - | ND | - | - | - | 16.32 | - | 30.61 | - | - | - | 0.72 |
| *T. zilli* | - | 0.56 | - | - | - | 7.93 | - | 22.34 | - | - | - | 4.24 |
| 19 | *Tilapia zilli* | -  -  - | 0.190 | 0.068 | BDL | - | 0.723 | - | 0.86 | - | 0.014 | 1.484 | 0.091 | Yes | Adubiaro and Animashaun, 2022 |
| *Clarias gariepinus* |  | 0.061 | 0.047 | BDL | -  - | 1.10 | -  - | 0.206 | -  - | 0.023 | 1.988 | BDL |
| *Oreochromis niloticus* | - | 0.092 | 0.198 | 0.048 | - | 1.06 |  | 0.510 | - | 0.023 | 1.934 | 0.064 |
| 20 | Not disclosed. | - | 0.33 | 3.30 | - | - | 2.73 | - | 30.7 | - | - | - | 10.50 | Exceeded limit | Akinsorotan *et al.,* 2023 |
| 21 | Tilapia | - | BDL | BDL | BDL | 0.14 | BDL | - | 0.73 | - | BDL | 1.07 | 0.10 | Yes | Ayodele *et al.,* 2023 |
| Catfish |  | BDL | BDL | BDL | 0.07 | BDL | - | 0.71 | - | BDL | 4.13 | 0.09 |
| 22 | *Oreochromis niloticus* | - | - | 0.06 | 0.06 | - | - | - | 0.41 | - | - | - | 0.64 | All within WHO limits except Pb. | Idowu *et al.,* 2020 |
| *Hemichromis fasciatus* | - | - | 0.06 | - | - | 0.03 | - | 0.03 | - | - | - | 0.54 |
| *Sarotherodon galilaeus* | - | - | - | - | - | 0.79 | - | 0.72 | - | - | - | 0.79 |
| *Oreochromis aureus* | - | - | 0.80 | - | - | 0.80 | - | 0.80 | - | - | - | 0.31 |
| 23 | *Oreochromis niloticus,* | - | 0.0003 | - | - | 0.32 | 0.001 | - | 0.45 | - | - | 0.54 | 0.16 | Lower than WHO limits | Olagbemide *et* *al.,* 2023 |
| 24 | *Oreochromis niloticus* | 1.06 | 0.00 | 0.00 | 0.00 | 16.00 | 1.79 | - | 112.19 | - | - | 0.17 | 1.36 | Zn and Mn exceeded limits | Ajibare *et al.,* 2021 |
| 25 | *Clarias gariepinus* | - | 1.10 | - | 10.60 | - | 11.10 | - | 35.10 | 0.03 | 23.6 | 82.10 | 30.80 | Exceeded limit | Utete and Fregene, 2020 |
| 26 | Mackerel | - | - | 1.62 | - | - | 1.61 | 7.02 | - | - | 0.75 | - | 0.04 | Exceeded limit | Ojezele *et al.,* 2021 |
| Sardine | - | - | 0.325 | - | - | 1.62 | 0.40 | - | - | 0.68 | - | 0.20 |
| 27 | *Chrysichthys nigrodigitatus* | - | 0.06 | 0.44 | - | - | 0.22 | - | 0.05 | - | - | 0.38 | 0.61 | Exceeded limit | Ajayi *et al.,* 2022 |
| 28 | *Marcusenius senegalensis* | 1.00 | - | - | - | - | - | - | - | - | - | - | - | Yes | Atobatele and Olutona, 2015 |
| *Labeo senegalensis* | 2.50 | - | - | - | - | - | - | - | - | - | - | - |
| *Hepsetus odoe* | 1.25 | - | - | - | - | - | - | - | - | - | - | - |
| *Chrysichthys auratus* | 1.17 | - | - | - | - | - | - | - | - | - | - | - |
| *Chrysichthys nigrodigitatus* | 1.50 | - | - | - | - | - | - | - | - | - | - | - |
| *Channa obscura* | 2.50 | - | - | - | - | - | - | - | - | - | - | - |
| *Tilapia zillii* | 1.50 | - | - | - | - | - | - | - | - | - | - | - |
| *Sarotherodon galilaeus* | 1.50 | - | - | - | - | - | - | - | - | - | - | - |
| *Oreochromis niloticus* | 1.05 | - | - | - | - | - | - | - | - | - | - | - |
| 29 | *Tilapia zillii* | - | 0.60 | - | - | -  - | 1.80 | - | - | 0.60 | 2.60 | - | - | Exceeded limits | Olabanji and Oluyemi, 2014 |
| *Mormyrus rume* | - | 0.70 | - | - | - | 2.05 | - | - | 0.40 | 2.20 | - | - |
| 30 | *Oreochromis niloticus* | - | ND | ND | ND | - | 0.047 | - | - | - | ND | 0.006 | - | Yes | Oni and Oladele, 2016 |
| 31 | *Marcusenius senegalensis* | - | 0.003 | - | - | - | 0.003 | - | - | 0.002 | - | - | - | Yes | Atobatele and Olutona, 2015 |
| *Labeo senegalensis* | - | 0.002 | - | - | - | 0.002 | - | - | 0.001 | - | - | - |
| *Hepsetus odoe* | - | 0.003 | - | - | - | 0.003 | - | - | 0.002 | - | - | - |
| *Chrysichthys auratus* | - | 0.003 | - | - | - | 0.003 | - | - | 0.002 | - | - | - |
| *Chrysichthys nigrodigitatus* | - | 0.002 | - | - | - | 0.004 | - | - | 0.001 | - | - | - |
| *Clarias ebriensis* | - | 0.003 | - | - | - | 0.004 | - | - | 0.002 | - | - | - |
| *Clarias macromystax* | - | 0.003 | - | - | - | 0.003 | - | - | 0.002 | - | - | - |
| *Channa obscura* | - | 0.003 | - | - | - | 0.002 | - | - | 0.002 | - | - | - |
| *Tilapia zillii* | - | 0.002 | - | - | - | 0.004 | - | - | 0.001 | - | - | - |
| *Sarotherodon galilaeus* | - | 0.002 | - | - | - | 0.004 | - | - | 0.001 | - | - | - |
| *Oreochromis niloticus* | - | 0.002 | - | - | - | 0.003 | - | - | 0.001 | - | - | - |
| 32 | *Clarias gariepinus* | - | ND | -  - | -  - | 76.04 | 92.08 | - | 9.96 | - | 58.89 | - | - | Exceeded limit | Ayanda *et al.,* 2020 |
| *Astacus leptodactylus* | - | ND | - | - | 10.49 | 61.92 | - | 23.64 | - | 46.64 | - | - |
| 33 | *Scomber scombrus* | - | 1.62 | - | - | 0.39 | 2.25 | - | 2.44 | - | - | 4.59 | - | Pb, Cd and Fe Exceeded limit | Adebowale *et al.,* 2024 |
| *Clupea pallasii* | - | 0.91 | - | - | 1.08 | 4.04 | - | 3.46 | - | - | 5.56 | - |
| *Gadus chalcogrammus* | - | 1.66 | - | - | 0.53 | 6.92 | - | 1.37 | - | - | 7.0 | - |
| *Trachurus murphyi* | - | 0.60 | - | - | 0.19 | 10.38 | - | 1.86 | - | - | 5.82 | - |
| *Merluccius productus* | - | 2.18 | - | - | 0.30 | 8.37 | - | 1.76 | - | - | 4.98 | - |
| 34 | *O. niloticus* | - | 0.01 | - | - | 0.33 | - | - | 1.17 | - | - | 5.80 | 0.08 | Mn. Fe,Cu and Zn exceeded limit | Adu *et al.,* 2022 |
| *C. harengus* | - | - | - | - | 0.71 | - | - | 1.10 | - | - | 11.29 | 0.10 |
| 35 | *Nematopalaemon hastatusin* | - | 0.001 | - | - | 3.50 | 0.015 | - | 7.04 | - | - | 5.51 | 6.79 | Fe and Mn exceeded limit. | Ajibare *et al.,* 2019 |
| 36 | *H. fasciatus* | - | 0.01 | - | - | 0.10 | 0.11 | - | 1.02 | - | - | 2.70 | 0.06 | Yes | Oladunjoye *et al.,* 2016 |
| *C. nigrodigitatus* | - | 0.00 | - | - | 0.07 | 0.07 | - | 0.64 | - | - | 1.80 | 0.04 |
| *S. galilaeus* | - | 0.01 | - | - | 0.07 | 0.07 | - | 0.74 | - | - | 2.91 | 0.05 |
| 37 | *Arius latisculata* | - | 0.32 | BDL | - | - | 0.51 | - | 0.51 | - | BDL | - | BDL | Yes | Olusola *et al.,* 2015 |
| *Cynoglosus browni* | - | 0.31 | BDL | - | - | 0.05 | - | 0.51 | - | 0.01 | - | 0.01 |
| *Caranx lugubris* | - | 0.33 | BDL | - | - | 0.07 | - | 0.28 | - | BDL | - | BDL |
| *Caranx senegallus* | - | 0.34 | BDL | - | - | 0.10 | - | 0.31 | - | BDL | - | BDL |
| *Sardinella aurita* | - | 0.31 | BDL | - | - | 0.08 | - | 0.32 | - | 0.02 | - | BDL |
| 38 | *Chrysichthys filamentosus* | - | 0.002 | 0.42 | - | - | 0.56 | - | 2.45 | - | - | 6.54 | 0.18 | Yes | Mekuleyi *et al.,* 2021 |
| *Kribia nana* | - | 0.002 | 0.01 | - | - | 0.11 | - | 2.18 | - | - | 6.12 | 0.55 |
| *Pegusa lascaris* | - | 0.001 | 0.33 | - | - | 0.32 |  | 1.28 | - | - | 4.20 | 0.11 |
| 39 | *Clarias buthopogon* | - | 0.39 | 3.51 | - | 3.14 | 1.70 | - | 12.32 | BDL | 1.88 | - | 0.86 | Exceeded permissible limit | Fagbote, 2022 |
| 40 | *Cynoglossus senegalensis* | - | 0.10 | - | - | - | 0.59 | - | 61.11 | - | - | - | 7.05 | Cu and Zn exceeded limits | Wangboje and Miller, 2018. |

BDL and ND represent ‘below detection limit’ and ‘Not determined’, respectively