

Uptake of Heavy Metals by Channa Punctatus from Sewage-Fed Aquaculture Pond of Panethi, Aligarh

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Abstract

Investigations on the bioconcentration of heavy metals (Cu, Ni, Fe, Co, Mn, Cr and Zn) were observed in Channa punctatus. The results revealed that heavy metals available in water were in the order Fe > Mn > Zn > Co > Ni > Cu = Cr. The accumulation was also observed in tissues such as gills, liver, kidney, muscle and integument. Their pattern of accumulation in muscle was Fe > Zn > Mn > Cu > Cr > Ni > Co. All the heavy metals showed maximum concentration and persistence in gills with the exception of Cu and Co, which showed maximum accumulation in liver and muscle respectively. Fe was the most abundant metal in the water as well as in the fish tissues. Significant ($P < 0.01$) relations were observed among the metal accumulations in different organs of the fish. The concentration observed was far exceeding the recommended limits of FAO/WHO.

Index terms— Bioconcentration, Heavy metals, gills, Channa punctatus.

1 Introduction

Human activity has continuously disturbed the natural environment, particularly the aquatic ecosystems. The use of heavy metals in industries has led to the wide spread environmental contamination. Consequently the waste water from industries and also the sewage water from domestic sources containing heavy metals find their way into the nearby water bodies. The aquatic pollution due to heavy metals is of major concern, due to their persistence and accumulative nature. Aquatic animals live in very intimate contact with their environment thus, absorbed heavy metals from the surrounding contaminated water which ultimately affect their health. Among these animal species, fishes are the inhabitants that cannot escape from the detrimental effects of these pollutants (Olaifa et al., 2004) and are therefore very susceptible to physical and chemical changes which may be reflected in their blood components (Wilson and Taylor, 1993). The studies carried out on various fishes have shown that

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these metals alter the physiological activities and biochemical parameters both in tissues and blood (Canli, 1995; Basa and Rani, 2003). The accumulation of trace metals in a fish tissue depends mainly on the concentration of the metal in the water and exposure period. It is therefore necessary to examine their distribution in different fish tissues to understand their physiological, toxicological and hygienic effects. The metal once absorbed is transported by the blood to either a storage point, such as bone or to the liver for transportation. If transported by the liver it may be stored there, excreted in bile, or passed back into the blood for possible excretion by kidney or gills or stored in extra hepatic tissues such as fat. Keeping this in view, a study was conducted to assess the concentration accumulated in different organs of Channa punctatus exposed to potentially toxic chemicals in the wastewater. Fish is also provided as a bioindicator of the deteriorating water quality of sewage fed pond.

2 a) Description of study area

The study pond is located at Panethi (Latitude 27.88969; Longitude 78.07594), in district Aligarh (Uttar Pradesh), India. This sewage-fed pond is situated at a distance of about 1Km from Dairy products processing factory (Rama Dairy). This factory is now banned for last one year, but in the past the waste water used to reach the pond. Few cold stores are also present nearby. This factory supplied the milk and other processed products in Panethi and around the other regions of Aligarh. The waste water from this factory find its way into the study pond via small streams. This pond also received the domestic waste water of communities living in the area. Fishes thriving in this pond fulfill the need of local peoples living around.

3 Materials and Methods

4 a) Collection and analysis of water sample from sewage fed pond

Water was collected in a pre-cleaned and acidified glass bottles. The bottles were immediately brought to the laboratory and acidified with concentrated HNO₃ to pH less than 2.0. Water samples were then analyzed for the presence of heavy metals (Cu, Ni, Fe, Co, Mn, Cr and Zn) according to APHA (2005).

On spot fixation of water was done to measure the dissolved oxygen (D.O). Total solids (T.S), total dissolved solids (T.D.S) and suspended solids (T.S.S) were determined using standard techniques (APHA, 2005). The temperature and pH were recorded at the site using laboratory thermometer (Deluxe, 6) and pH strips (S.D Fine chemicals, 0 -0. f) Statistical analysis Samples were taken in triplicates. The values are given as Mean \pm S.D. The data was subjected to ANOVA. Significant differences among the means was calculated using Duncan's multiple range test (Duncan 1955).

5 III.

6 Results and Discussion

The aquatic environment of the sewage fedpond, subjected to many stressful factors, heavy metals are one of the serious pollutants that reach the aquatic habitat and also a matter of concern. For this reason, this work is projected to examine the hazardous effects of heavy metal on one of the most common fish species, *Channa punctatus* in the sewage fed-pond of Panethi.

Table 1 presents the data on physicochemical parameters of sewage-fed pond water. Table 2 and figure 2 shows the mean concentration of metals (mg L⁻¹) in water. The heavy metal content in sewage-fed pond water were in the order of Fe > Mn > Zn > Co > Ni > Cu = Cr.

Table 3 revealed concentration of different heavy metals in particular organs of *Channa punctatus*.

Table 4 and figure ?? present accumulation of particular heavy metals in different organs of *Channa punctatus*.

These results indicate that in general gill was the most affected organ where maximum accumulation of heavy metals takes place followed by muscle, kidney, liver and the integument accumulated the least, and amongst the heavy metals Fe accumulated the most in all tissues. Figure ?? : a,b,c,d,e,f,g showed mean metal (Cu, Ni, Fe, Co, Mn, Cr and Zn) concentrations (mgkg⁻¹ .dw) in gills, liver, kidney, muscle and integument of *Channa punctatus*.

Fe was the most abundant heavy metal in all tissues of *Channa punctatus*, but its highest value was observed in gills followed by liver > muscle > kidney > integument (In the pond water also the Fe concentration was maximum, therefore maximum uptake of this metal takes place by the fish tissues. Fe accumulation was followed by Zn in the present study where the values were observed to be highest in gills followed by kidney > liver > muscle > and least in integument. Other scientist also reported the highest concentration in gills of *Channa punctatus* (Vineeta ??hukla et al., 2005). These high levels in gill tissue can possibly due to the fact that they are the main sites for Zn uptake, particularly in fresh water fish and due to the large surface area that is in contact with environmental water and the very thin membrane separating the external and internal media of the animal.

The large surface area of gills in *Channa punctatus* (Karuppasamy, 2000) may be favour for metal uptake. Zn content in gills of investigated species was comparable to *Labeo dyocheilus* (Yousafzai et al., 2010). Other workers, however noticed the highest concentration in organs such as liver of *Channa punctatus* (Murugan et al., 2008) and *Clarias gariepinus* (Osman et al., 2010), testes of *Oreochromis niloticus* and *Lates niloticus* (Mohamed, 2008) and integument of *Labeo dyocheilus* and *Wallago attu* (Yousafzai et al., 2010). In this study, it was also observed that Zn content in liver was higher than muscle. The lower Zn content in muscle may be because the excessive Zn in muscle was transferred to other fish organs when exposed to Zn contaminated system (Madhusudan et al., 2003). This deloading ability of fish has been reported to be advantageous to fish consumers (Murugan et al., 2008). The permissible limits for Zn set by WHO/FAO (1989) is 40 ppm which is much less than the values observed during the study (Table 5).

In the present study, Mn accumulation was significant in tissues and showed accumulation in the order of gills > muscle > integument. It was not observed in liver and kidney. Though, in water its availability was considerably high. Studies reported in *Tinca tinca* (Selda Tekin et al., 2005), *Oreochromis mossambicus* (Robinson and Avenant-Oldewage, 2006), *Clarias gariepinus* (Osman et al., 2010) and *Labeo rohita*, also revealed the highest

100 concentration of Mn in gills (Javed and Usmani, 2011). However, other workers reported the highest concentration
101 in organs such as kidney and muscle of *Channa punctatus* and *Clarias gariepinus* respectively (Javed and Usmani,
102 2011). However in other studies the Mn content reported in different tissues was much lower than the present
103 study. Mn is an essential micronutrient (Dallas and Day, 1993) and does not occur naturally as a metal in aquatic
104 ecosystems, but is found in form of various minerals and salts. According to the Department of Water Affairs
105 and Forestry (1993), the main route of Mn adsorption occurs through the respiratory and gastrointestinal tracts.
106 The adsorption of Mn in the digestive tract is inversely related to Ca ++ levels in the diet of organism. The
107 permissible limits for Mn set by WHO(1985) is 0.01ppm which is well below the accumulation observed during
108 the study (Table 5).

109 Copper exhibited highest content in liver and lowest in integument of the investigated species and the (Uysal
110 et al., 2008).

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112 the present study the content of Cu observed in integument is similar to our earlier findings in *Clarias gariepinus*
113 and *Labeo rohita* (Javed and Usmani, 2011).

114 The amount of Cu accumulation observed during the present study is little higher than the permissible limits
115 set for Cu by WHO/FAO (1989) which is 30 ppm (Table 5).

116 In the present study the concentration of Cr and Cu in water was exactly similar (Table 2), but fish showed
117 different response to these metals (Table 3). It indicates that even in lower amounts Cu has more absorptive
118 and accumulative capacity than Cr under similar natural environment. Cr present in highest amounts in gills
119 followed by muscle and least was in integument. While liver and kidney showed insignificant accumulations.
120 Various studies conducted on Cr also noticed highest concentration in gills of *Labeo dyocheilus* and *Wallago attu*
121 (Yousafzai et al., 2010).

122 However, the highest concentration was also reported in other organs such as in kidney of *Clarias gariepinus*
123 and integument of *Labeo rohita* (Javed and Usmani, 2011), liver of *Clarias gariepinus* (Osman et al., 2010),
124 kidney of *Tilapia nilotica* (Abdel-Baki et al., 2011), liver of *Oreochromis mossambicus* (Robinson and Avenant-
125 Oldewage , 2006). The observation that was made for Cr accumulation in kidney was comparable to *Clarias*
126 *gariepinus* and *Labeo rohita* (Javed and Usmani, 2011). Concentration in integument corroborates to *Channa*
127 *punctatus* (Javed and Usmani, 2011). Duffus (1980) and Paasivirta (1991) both regard Cr in its salt form as
128 highly bioaccumulative at high concentrations, and partially dangerous.

129 Ni occupied the sixth position as far as accumulation was concerned. The order of nickel accumulation observed
130 during the study was gills > muscle > integument. It was not detected in liver and kidney. Other workers also
131 revealed the highest levels of Ni in gills of fishes *Cyprinus carpio* ??Vinodhini and Narayanan, 2007) IV.

132 8 Conclusions

133 This study was carried out to provide information on toxic heavy metal concentrations in *Channa punctatus*
134 from sewagefed aquaculture pond, India and potential health risk for local population due to their consumption.
135 The majority of heavy metal concentrations in the fish samples analyzed were exceeding the permitted limits set
136 by various authorities and will pose health risks for the local population due to high consumption of fish.

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Figure 1: Figure 1 :

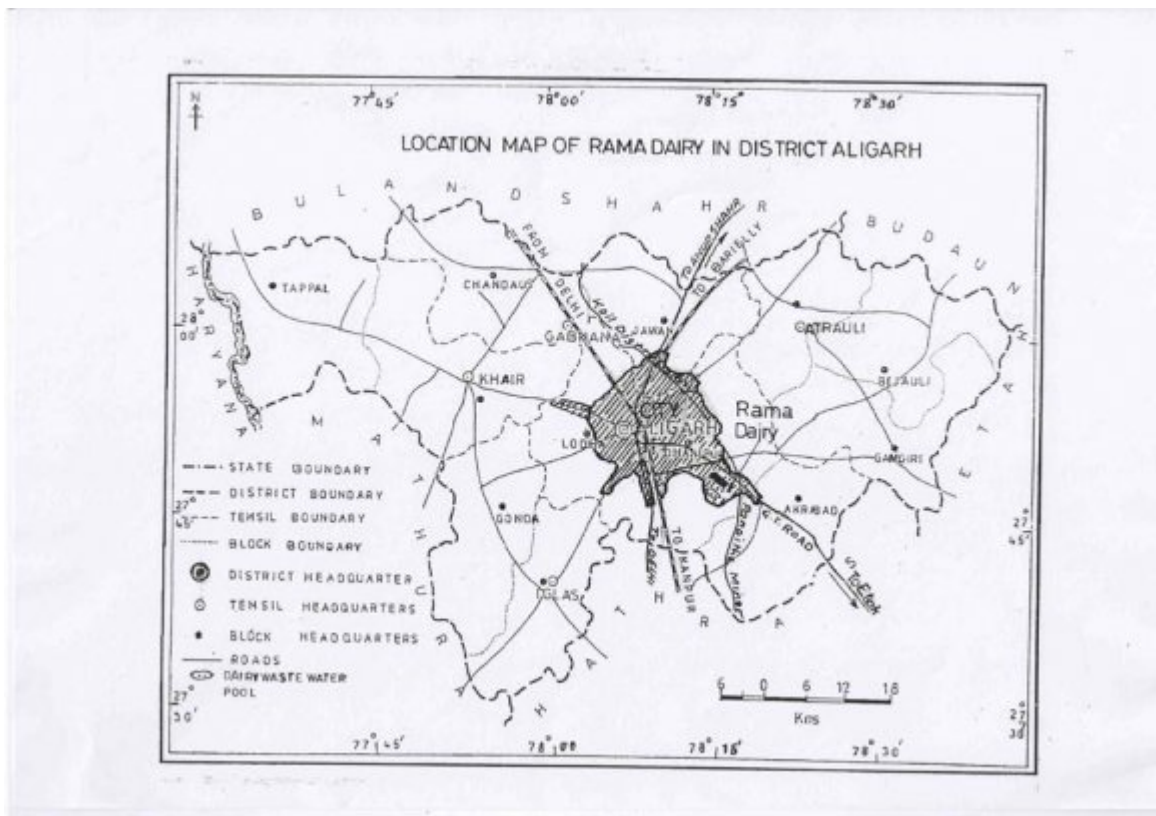
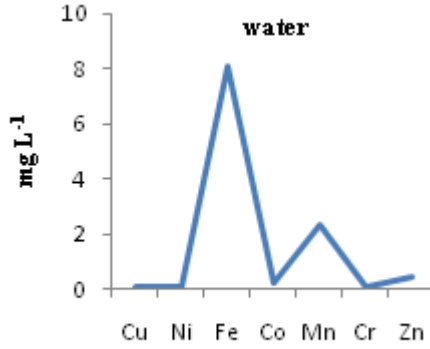


Figure 2:



2

Figure 3: Figure 2 :

1

Figure 4: Table 1 :

2

Heavy metals	Water
Cu	0.07 ± 0.01
Ni	0.08 ± 0.02
Fe	8.08 ± 2.88
Co	0.24 ± 0.02
Mn	2.32 ± 0.10
Cr	0.07 ± 0.02
Zn	0.45 ± 0.03

[Note: Values are Mean ± S.D, (n= 3) .]

Figure 5: Table 2 :

3

Heavy met-alsâ???	Gills	Liver	Kidney	Muscle	Integument
Cu	123.80 d ±4.12	153.33 ±7.29	c 143.33 ±5.77	c 45.33 d ±0.57	18.33 d ±0.57
Ni	30.95 f ±1.73	ND	ND	18.33 f ±0.09	11.33 e ±0.57
Fe	17609.38 ±4.12	a 14533.13 ±0.5	a 3543.76 ±0.68	a 5313.29 a ±0.31	875.33 a ±0.31
Co	ND	ND	ND	1.33 g ±0.06	1.33 g ±0.05
Mn	1359.51 c ±0.62	ND	ND	83.28 c ±0.06	22.31 c ±0.57
Cr	66.66 e ±2.43	13.33 ±5.76	d 10.00 ±0.00	d 29.33 e ±1.96	6.33 f ±0.02
Zn	1845.22 b ±0.57	873.31 ±6.06	b 1163.33 ±5.72	b 319.29 b ±0.18	257.11

[Note: b ±0.10]

Figure 6: Table 3 :

4

	Heavy Gills met- alsâ??”	Liver	Kidney	Muscle	Integument
Cu	123.80 c ±4.12	153.33 ±7.29	a 143.33 ±5.77	b 45.33 d ±0.57	18.33 e ±0.57
Ni	30.95 a ±1.73	ND	ND	18.33 b ±0.09	11.33 c ±0.57
Fe	17609.38 ±4.12	a 14533.13 ±0.5	b 3543.76 ±0.68	d 5313.29 c ±0.31	875.33 e ±0.31
Co	ND	ND	ND	1.33 a ±0.06	1.33 a ±0.05
Mn	1359.51 a ±0.62	ND	ND	83.28 b ±0.06	22.31 c ±0.57
Cr	66.66 a ±2.43	13.33 ±5.76	c 10.00 ±0.00	cd 29.33 b ±1.96	6.33 d ±0.02
Zn	1845.22 a ±0.57	873.31 ±6.06	c 1163.33 ±5.72	b 319.29 d ±0.18	257.11 e ±0.10

Figure 7: Table 4 :

4

[Note:) Studies reported in *Oreochromis niloticus* and *Lates niloticus*(Mohamed, 2008), *Oreochromis mossambicus* (Robinson and Avenant-Oldewage, 2006) *Liza aurata*, *Mugil cephalus*, *Liza ramada*(Uysal et al., 2008) also revealed the maximum accumulation of Fe in gills. Highest accumulation in gills indicates that these are the organs which always remain in direct contact with the surrounding water. However in other studies the highest accumulation seen in organs such as liver in the fishes *Clarias gariepinus*(Osman et al., 2010) and *Tinca tinca*(Selda Tekin et al., 2005).]

Figure 8: Table 4

(Robinson and Avenant-Oldewage, 2006). Cu content in muscle corroborates to the *Heterotis niloticus*, *Clarias gariepinus* (Anim et al., 2010), *Wallago attu* (Yousafzai et al., 2010). According to Stokes (1979) fish muscle has poor accumulative properties, with low concentration of Cu found in the muscles, even systems containing high Cu levels. Present study reports low levels of Cu in water (Table 2). However, other scientists confirmed highest levels in organs such as kidney of *Channa punctatus*, *Clarias gariepinus* and *Labeo rohita* (Javed and Usmani, 2011), gills of *Channa punctatus*(Vineeta Shukla et al., 2005) and *Lithognathus mormyrus*

[Note: pattern observed was liver > kidney > gills > muscle > integument. Other workers also reported the highest accumulation of Cu in liver of fishes *Oreochromis mykiss* and *Cyprinus carpio* (De Boeck et al., 2004), *Tilapia nilotica* (Abdel-Baki et al., 2011), *Oreochromis niloticus* (Mohamed, 2008), *Wallago attu* and *Labeo dyocheilus* (]

Figure 9:

5

Co was the least accumulated metal in tissues of *Channa punctatus*. Its accumulation was noticed only in muscle and integument while in gills, liver and kidney it was untraceable. Co was also not detected in gills and kidney samples of fishes *Clarias gariepinus*, *Cyprinus carpio* and *Oreochromis niloticus* (Adeyeye et al., 1996). Ca²⁺ competition and dissolved organic matter complexation were the most important factors preventing Co²⁺

*[Note: c © 2012 Global Journals Inc. (US) *]*

Figure 10: Table 5 :

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140 [Ecotoxicology and Environmental Safety] , *Ecotoxicology and Environmental Safety* 56 (2) p. .

141 [Edward Arnold Publishers Ltd and England] , London Edward Arnold Publishers Ltd , England . p. 164.

142 [Ibadan] , Nigeria Ibadan . *African Journal of Biomedical Research* 7 p. .

143 [Dhhs/Phs/Fda/ Cfsan/Office Of and Seafood] , Dhhs/Phs/Fda/ Cfsan/Office Of , Seafood . Washington, D.C.

144 [International Journal of Environment Science and Technology] , *International Journal of Environment Science*
145 *and Technology* 2 (5) p. .

146 [Comp. Physiol] , *Comp. Physiol* 163 p. .

147 [Vinodhini and Narayanan ()] , R Vinodhini , M Narayanan . 2008.

148 [Canli and Kargin ()] ‘A comparative study on heavy metal (Cd, Cr, Pb and Ni) accumulation in the tissue of
149 the carp *Cyprinus carpio* and Nile fish *Tilapia nilotica*. M Canli , F Kargin . *Turkish Journal of Zoology* 1995.
150 19 p. .

151 [Javed and Usmani ()] ‘Accumulation of heavy metals in fishes: A human health concern’. M Javed , N Usmani
152 . *International journal of environmental sciences* 2011. 2 (2) p. .

153 [Anim ()] ‘Accumulation Profile of Heavy Metals in Fish Samples from Nsawam, Along the Densu River’. Anim
154 . *Ghana. Research Journal of Environmental and Earth Sciences* 2010. 1 (3) p. .

155 [Begum ()] ‘Analysis of heavy metals in water, sediments and fish samples of Madivala Lakes of Bangalore’.
156 Abida Begum . *Karnataka. International Journal of Chemical Technology Research* 2009. 1 (2) p. .

157 [Shukla ()] *Bioaccumulation of*, Vineeta Shukla . 2007.

158 [Murugan ()] ‘Bioaccumulation patterns of zinc in fresh water fish *Channa punctatus* (Bloch.) after chronic
159 exposure’. Murugan . *Turkish journal of Fisheries and Aquatic Sciences* 2008. 8 p. .

160 [MohammadF ()] ‘Bioaccumulation of selected metals and histopathological alterations in tissues of *Oreochromis*
161 *niloticus* and *Lates niloticus* from lake Nasser’. MohammadF . *Egypt. Global Veterinaria* 2008. 2 (4) p. .

162 [Abdel-Baki ()] ‘Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water
163 and sediment of Wadi Hanifah, Saudi Arabia’. Abdel-Baki . *African Journal of Biotechnology* 2011. 13 (10)
164 p. .

165 [Madhusudan ()] ‘Bioaccumulation of zinc and cadmium in freshwater fishes’. Madhusudan . *Indian J. Fish* 2003.
166 50 (1) p. .

167 [Siraj and Rani ()] *Cadmium induced antioxidant defense mechanism in freshwater teleost Oreochromis mossam-*
168 *bicus (tilapia)*, Basa Siraj , Usha Rani . 2003.

169 [Paasivirta ()] *Chemical Ecotoxicology*. Lewis publishers, J Paasivirta . 1991. Inc., Chelsea, United States of
170 America. p. 210.

171 [Jenny and Avenant-Oldewage ()] ‘Chromium, Copper, Iron and Manganese bioaccumulation in some organs
172 and tissues of *Oreochromis mossambicus* from the lower Olifants River, inside the Kruger National Park’.
173 Robinson Jenny , Avenant-Oldewage . *Water Soil and Air* 2006. 4 (23) p. 387.

174 [Elda ()] ‘Comparative study on the accumulation of heavy metals in different organs of Uptake of Heavy Metals
175 by *Channa Punctatus* from Sewage-Fed Aquaculture Pond of Panethi, Aligarh tench (*Tinca tinca* L.1758)
176 and plerocercoids of its endoparasite *Ligula intestinalis*’. Elda . *Parasitology Research* 2005. 97 p. .

177 [Yousafzai ()] ‘Comparison of heavy metals burden in two freshwater fishes *Wallago attu* and *Labeo dyocheilus*
178 with regard to their feeding habits in natural ecosystem’. Yousafzai . *Pakistan Journal of Zoology* 2010. 5 (42)
179 p. .

180 [Stokes (ed.) ()] *Copper in the environment. Part 1 Ecological cycling*, P Stokes . JO Nriagu 603 (ed.) 1979. New
181 York, United States of America: John Wiley and Sons, Inc. p. . (Copper accumulations in aquatic biota)

182 [Zn] ‘Cu and Cd in *Channa punctatus*’. Zn . *Journal of Environmental Biology* 2 (28) p. .

183 [Adeyeye ()] ‘Determination of some metals in *Clarias gariepinus* (Cuvier and Valenciennes), their environ-
184 ments’. Adeyeye . *Aquaculture* 1996. 147 p. . (3-4)

185 [Domestic use (1 st edn.) Department of Water Affairs and Forestry Department of Water Affairs and Forestry ()]
186 ‘Domestic use (1 st edn.) Department of Water Affairs and Forestry’. *Department of Water Affairs and*
187 *Forestry*, (Pretoria, South Africa) 1993. 1 p. 216. (South African Water Quality Guidelines)

188 [Duffus ()] *Environmental Toxicology Resource and Environmental Sciences Series*, J H Duffus . 1980.

189 [Food and drug administration. Guidance document for arsenic in shellfish USFDA ()] ‘Food and drug adminis-
190 tration. Guidance document for arsenic in shellfish’. *USFDA* 1993b.

- 191 [Guidelines for drinking water quality (Recommendations) ()] *Guidelines for drinking water quality (Recommen-*
 192 *dations)*, 1985. (WHO Geneva)
- 193 [Olaiifa ()] *Heavy metal contamination of Clarias gariepinus from a Lake and Fish farm in, Olaiifa* . 2004.
- 194 [Duncan ()] ‘Multiple ranges and multiple Ftests’. D B Duncan . *Biometrics* 1955. 11 p. . (Fisheries Resources)
- 195 [Fao ()] *National Research Council Recommended Dietary 626 Allowances*, Who\Fao . 1989. (10th ed))
- 196 [Standard Methods for the Examination of Water and Wastewater Analysis ()] *Standard Methods for the Exam-*
 197 *ination of Water and Wastewater Analysis*, 2005. Washington D.C: American Water Works Association/Water
 198 Environment Federation. p. 289. (21 st Edition)
- 199 [Kariya ()] ‘Studies on the post-mortem identification of the pollutant in the fish killed by water pollution-VII.
 200 Detection of nickel in the fish’. Kariya . *Bulletin of the Japanese Society of Scientific Fisheries* 1968. 34 p. .
- 201 [Uysal ()] ‘The determination of heavy metal accumulation ratios in muscles, skin and gills of some migratory
 202 fish species by inductively coupled plasma-optical emission spectrometry (ICP-OES) in Beymelek Lagoon’.
 203 Uysal . *Microchemical Journal* 2008. 90 p. .
- 204 [Dallas and Day ()] *The effect of water quality variables on Riverine ecosystems: A Review. WRC Project No.*
 205 *351. Water Research Commission Pretoria South Africa*, H Dallas , J Day . 1993. p. 240.
- 206 [Wilson and Taylor ()] *The physiological responses of freshwater rainbow trout, Onchorhynchus mykiss, during*
 207 *acute exposure*, R W Wilson , E W Taylor . 1993.
- 208 [Karuppasamy ()] ‘Tissue histopathology of Channa punctatus under phenyl mercuric acetate toxicity’. R
 209 Karuppasamy . *Bulletin of Pure and Applied Sciences* 2000. 9 (2) p. .
- 210 [Boeck ()] ‘Tissue specific Cu bioaccumulation patterns and differences in sensitivity to water borne Cu in three
 211 fresh water fish: rainbow trout (Oncorhynchus mykiss), common carp (Cyprinus carpio), and gibel carp
 212 (Carassius auratus gibelio)’. De Boeck . *Aquatic Toxicology* 2004. 70 p. .
- 213 [Osman ()] ‘Water quality and Heavy metal monitoring in water, sediments, and tissues of the African Catfish
 214 Clarias gariepinus (Burchell 1822) from the River Nile’. Osman . *Egypt. Journal of Environment Protection*
 215 2010. 1 p. .