THE HEALTH STATUS AND EDIBILITY OF FISH FROM THREE HYPERTROPHIC IMPOUNDMENTS IN SOUTH AFRICA

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ZDRAVSTVENI STATUS I JESTIVOST RIBE IZ TRI HIPERTROFNE AKUMULACIJE U JUŽNOJ AFRICI

Apstrakt

Severozapadna oblast Južne Afrike je poznata po ekstenzivnim rudarskim i poljoprivrednim aktivnostima. Ove aktivnosti spiraju organska i neorganska jedinjenja iz zemljišta i za posledicu imaju pogoršanje kvaliteta vode u akumulacionim jezerima. Sledeće akumulacije iz severozapadne oblasti: Hartbeespoort Dam (HD), Klipvoor (KD) i Bospoort (BD) su poznate po visokim količinama nutrijenata i klasifikovana su kao hipertrofna jezera. Procena zdravlja riba i procena rizika po zdravlje ljudi čine važne komponente u uspostavljanju standarda kvaliteta vode i/ili dozvoljenih nivoa konzumiranja riba. Cilj ovog istraživanja bio je da se utvrdi: (1) da li su prisutni štetni efekti na jedinkama *Clarias gariepinus* i *Cyprinus carpio* iz jezera HD, KD i BD (2) da li su prisutni efekti na ljudsko zdravlje ukoliko se ovakva riba konzumira. Rezultati su poređeni sa kontrolnom lokacijom - jezerom Marico-Bosveld Dam (MD). Voda, sediment i ribe (n=20) su uzorkovani iz HD, KD i BD. Uzorci vode i sedimenta su analizirani na prisustvo neorganskih i organskih molekula. Riba je izmerena, urađena je disekcija i pregled, uzeti su uzorci krvi i određena je starost svakog primerka. Organi koji su korišćeni za histološku procenu stanja su bili: škrge, jetra, bubreg, testisi i jajnici Urađena je kvalitativna i polukvantitativna histološka procena. Mišićno tkivo svakog primerka je uzorkovano i izvršene su hemijske analize, koje su korišćene za procenu rizika po zdravlje ljudi. Makroskopskom analizom konstatovano je da je značajan broj riba iz jezera HD, KD i BD imao masnu degeneraciju i fokalnu promenu boje jetre, promene na koži i ozbiljnu infestaciju parazitima u visceralnoj šupljini. Vrednosti hematokrita su varirale od normalne do ispod i iznad normalnih vrednosti. Vrednosti leukokrita su bile u okvirima normalnih vrednosti, osim kod *C. gariepinus* iz jezera HD, koje su

pokazivale više vrednosti od normalnih. Vrednosti ukupnih proteina, factor kondicije i hepatosomatični indeks su bili u okviru normalnih vrednosti za obe vrste na svim ispitivanim lokacijama. Ribe iz jezera MD su bile starije od riba iz druga tri jezera. Histološke promene su primećene na jetri, bubregu i škrgama obe vrste, a jetra je pokazivala najviši stepen promena. pri klasifikaciji, bubreg i škrge su svrstane u grupu 1 (normalna struktura), dok je jetra svrstana u grupu 2 (struktura sa histološkim promenama). Visoki nivoi aluminijuma, silicijuma i hroma su detektovani u mišićnom tkivu. Nivo hroma je bio iznad preporučenih vrednosti. Rezultati hemijske analize mišićnog tkiva su pokazali da je u obe vrste bio detektovan *p,p,*-DDE i to na svim lokacijama, pa i na kontrolnoj. *C. gariepinus* u jezeru HD pokazivao više prosečne vrednosti *p,p*-DDD od propisanih 5µg/g/ jestivog dela ribe. Procena rizika po zdravlje ljudi je obuhvatala jestivi deo ribe (mišiće). Svi nivoi opasnih materija i rizik od izazivanja kancera su bili niski, sa izuzetkom hroma, ali ni količine ovog elementa su bile takve da se ne predviđa pojava zdravstvenih problema kod ljudi ukoliko se riba svakodnevno konzumira.

Ključne reči: histologija riba, procene rizika, zdravlje riba, eutrofikacija
Keywords: Fish histology, human health risk assessment, fish health, eutrophication

INTRODUCTION

The Hartbeespoort, (HD), Klipvoor (KD) and Bospospoort (BD) impoundments in the North West Province, South Africa are known to be polluted, being impacted from mining, industrial and agricultural activities. Excessive nutrient loads such as orthophosphates, resulted in these impoundments becoming hypertrophic and thus the quality of the water is a cause of concern. Pesticides are persistent, insoluble, are not broken down by light and maybe highly toxic to aquatic organisms and particularly those higher up the food chain such as fish, due to bioaccumulation. Fish kills have been reported in the HD, KD and BD indicating and highlighting the potential impacts of the elevated levels of eutrophication as a result of nutrient enrichment (Van Ginkel, 2007). This raised concerns, as both *C. gariepinus* and *C. carpio* from these impoundments are being used as a source of food by the local people and development of extensive commercial fisheries. The aim of this study was to determine (1) if *C. gariepinus* and *C. carpio* from the HD, KD and BD show adverse effects and (2) if consumed, pose a human health risk. The results were compared to the reference site, the Marico-Bosveld Dam (MD).

MATERIAL AND METHODS

Fish of each species *C. gariepinus* (n=20) and *C. carpio* (n=20) were sampled in the HD, KD, BD and the reference site MD using gill nets during 2009 and 2010. The fish were measured and weighed, blood collected for haematocrit, leukocrit and total protein determination. A necropsy was performed on each fish specimen to note any bodily abnormalities externally and internally. A scale from each *C.carpio* specimen and an otolith from each *C. gariepinus* specimen were removed for age determination and a piece of muscle for chemical analyses. The organs included for the histology-based fish health assessment were the gills, liver, kidney, testes and ovaries. The liver, spleen and gonads were weighed to determine the hepatosomatic (HSI), splenosomatic (SSI) and the gonadosomatic (GSI) indices respectively. Organs were processed for a qualitative

and semi-quantitative (Bernet et al., 2004; van Dyk et al., 2009) histological assessment using standard techniques.

Physical water quality parameters were recorded. Water, sediment and fish muscle were analysed for inorganic and organic chemicals by accredited laboratories. The chemicals present in the fish muscle were used in the analyses to calculate if indigested fish muscle will pose a risk to human health (US EPA) (2012).

RESULTS

Macroscopically, a number of fish from HD, KD and BD impoundments exhibited liver with fatty change and focal discoloration as well as severe parasites within the visceral cavity. The haematocrit values varied from normal to below and above the normal range. Leukocrit values were within the normal range except for *C. gariepinus* from the HD, which was above the normal range. Total protein values were within the normal range for both species for all sites. Condition factor and hepatosomatic index (HSI) values were within the accepted range. For both species the HSI was the lowest in the reference site, MD.

Microscopically histological alterations were identified in liver, kidney and gills, while no alterations were identified in the gonads. When comparing the selected target organs the liver showed the highest frequency of alterations. The mean organ index values for all study sites fell within class 1 (normal structure) with the exception of the liver index from polluted sites which were in class 2 (structure with histological alterations). The frequency of alterations was more prevalent in *C. gariepinus* than in *C. carpio*. Fish from MD recorded a higher mean age when compared to fish specimen from polluted sites.

The pH values for the hypertrophic dams (HD, KD and BD) ranged from 9.5 to 10.6 while for the reference site (MD) was less than 9.5. Aluminium (HD: 174 mg/L; KD: 1924 mg/L; BD: 1000 mg/L; MD: 1540 mg/L) and Silikon (HD: 0; KD: 4110 mg/L; BD: 1842 mg/L; MD: 3645 mg/L) were the only metals with higher concentrations in the water from all the dams. Atrazine (1.2 µL) was found in the water and it was collected from the reference site, MD. None of the phenols were detected in the water sampled from the HD and MD. None of the inorganic chemical was above the guidelines. The hormones including estrone, estriol, 17-β estradiol and ethynylestradiol were below the detection limit of 10 ng/L. In the sediment Atrazine (10 µg/kg) and Technical nonylphenol (13.2 µg/kg) were found in HD and Ametryn (2.1 µg/kg) and Technical nonylphenol (22.4 µg/kg) were found in the reference site, MD.

In the fish muscle the levels of Al, Fe, Zn Cu, Cr, Ni, Sr and Mn found in the muscle tissue and should pose no threat to fish health or human safety when consumed. Silicon concentrations in muscle were high in all the sites in the muscle tissue of both species. Chromium was found to be higher than the expected guideline values in the muscle samples. Although the muscle samples were pooled the mean concentration op *p,p,*-DDE in tissue from both species was above the limit in fish from HD and the reference site MD. *C. gariepinus* had mean *p,p*-DDD levels higher than the set limit of 5 µg/g per edible portion.

In the Human Health Risk Assessments, the main focus was on the edible parts (muscle) of the fish. From the results of the hazard indices, none of the values of the pesticides are high enough to result in a significant health hazard. The inorganic chemicals (Al and Si) were high and show that it may be a health risk for the consumers, if

inhaled. For the calculated cancer risk, the values are all below the 1-in-1 000 000 mark for the pesticides.

DISCUSSION

Evidently, on the basis of the macroscopic and histological results, the fish from polluted sites were more affected compared to fish from the reference site in terms of the parameters mentioned above. Microscopically histological alterations were identified in liver, kidney and gills (Van Dyk et al., 2009; Van Dyk et al., 2012) while no alterations were identified in the gonads (Van Dyk & Pieterse, 2008; Pieterse et al., 2010). Thus the gonads are proposed to be still in their functional state based on the parameters employed (Marchand et al., 2012; Wagenaar et al., 2012). When comparing the selected target organs the liver showed the highest frequency of alterations, which was expected as the liver is a detoxifying organ (Marchand et al., 2012, Van Dyk et al., 2012).

Chemical analysis findings showed that the detection of Atrazine levels in water samples from the MD was the main concern as this site is classified to be a near pristine site. It should be noted that there were agricultural activities next to the MD, which could explain the presence of these Atrazine in the MD. The high Al and Si concentrations in water and sediment are in line with other values reported from other South African waters (DWA, 1996). Silicon concentrations could be an issue, if inhaled. No health data is available for adverse effects, should Si be ingested.

From the results of the hazard indices, none of the values of the pesticides are high enough to result in significant health hazard. All the Hazard Quotients and risks of developing cancer are low with the exception of Cr which is an over prediction based on the VI versus III speciation, thus no predicted adverse health effects are anticipated based on consumption of fish on a daily basis.

CONCLUSIONS

Although macroscopic and microscopic alterations were identified in the selected fish species, it can be assumed that the organs are still in a functional state. The chemical analysis of *C. gariepinus* and *C. carpio* fillets indicated that the flesh of these species is adequate for human consumption, and that it complies with the minimum requirements set by relevant authorities.

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