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Conductance Of Some Heavy Metals As Affected With The Application Of Rice Straw In Earthen Fish Ponds

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Abstract

The present work was conducted over a fish culture season during the period from May to December/ 2017 to investigate the effect of rice straw, which applied in earthen fish ponds to enhance periphyton production and phytoplankton biodiversity; on some heavy metals values in pond water as well as their bio accumulation in some organs of *O. niloticus*. Six earthen ponds (1000 m^2 surface area with 1 m water depth) belongs to the World Fish, were divided into two groups, each with three replicates; the 1^{st} group was a control (C) while the 2^{nd} (T) received 45 kg dry rice straw/pond. All ponds cultured with mono six Nile tilapia fry (0.1 g) in the rate of 3 fry/ m^3. All ponds were fertilized with dry chicken manure with the rate of 15 kg/pond/week. Water samples were collected monthly from the water source (S) as well as from ponds of the two groups (C and T). Fish from all ponds were harvested and dissected to obtain muscles and gills. Some heavy metals (Fe, Zn, Cu, Cd and Pb) were detected in water and fish organs samples. Obtained results revealed that the values of all investigated metals in the examined water (except lead which was un detectable) were significantly ($P<0.05$) lower in C and T groups than in the source water. Despite that results showed that the residues of investigated metals significantly ($P<0.05$) increased in the organs of *O. niloticus* adults raised in the ponds that received rice straw, but all these residues were lower than the maximum permissible limits mentioned by international organizations (FAO/WHO, 1989; WHO, 1995) subsequently the use of rice straw didn't affect the manner of heavy metals accumulation in different organs of *O. niloticus*.

INTRODUCTION

The industrial and domestic wastewater is responsible for causing several damages to the environment and adversely affecting the health of the people (Kumar, 2006). Excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. Unlike organic pollutants, the majority of which are susceptible to biological degradation, heavy metal ions do not degrade into harmless end products (Gupta *et al.*, 2001).

Heavy metal pollution in aquatic ecosystems has been a serious global environmental problem for a long time (Tang *et al.*, 2010; Gao and Chen, 2012 and Jiang *et al.,* 2013).

Heavy metals are persistent in aquatic environments because of their resistance to decomposition under natural conditions (Huang *et al.*, 2011 and Suresh *et al.*, 2012). One of the greatest problems associated with the persistence of heavy metals is the potential for them to bio-accumulate and bio-magnify, potentially resulting in long-term implications for human and aquatic ecosystem health (Rainbow, 2007; Qui *et al.*, 2011; Chakravarty and Banerjee, 2012 and Hu *et al.*, 2013)

The periphytic organisms constitute an important food source for many other aquatic organisms (Uddin *et al.*, 2007 and Felisberto and Rodrigues, 2010).

Rice straw is relatively low cost material and has low nutritive value (Potikanond *et al.*, 1987). Farmers often burn them in the field instead of using

Wisely in the fishponds that may pollute the environment. Rice straw can be used in fishponds to develop bacterial biofilm and periphyton (Ramesh *et al.*, 1999; Mridula *et al.*, 2003 and 2005) that eventually enhance the fish production. However, excessive loading of rice straw can cause oxygen depletion and may kill fishes (Keshavanath *et al.*, 2001 and Van Dam *et al.*, 2002). Hence, prior to applying to the pond, it is prerequisite to identify the appropriate loading level of rice straw that doesn't degrade water quality.

Being non-bio degradable like many organic pollutants, metals can be concentrated along the food chain, producing their toxic effects at points often far away from the source of the pollution (Fernandez *et al.*, 2000).

Accumulation of heavy metals in the food web can occur either by accumulation from the surrounding medium, such as water or sediment, or by bioaccumulation from the food source (Tulonen *et al.*, 2006).

Many researches showed effective adsorption of heavy metals using agricultural products and by-products such as modified rice husk (Lee *et al.* 1998 and Kumar and Bandyopadhyay, 2006).

The present work was implemented to assess to what extent some heavy metals accumulation in different tissues of *O. niloticus* could be affected by the application of rice straw in earthen fishponds to enhance the growth of periphytic organisms, where these organisms have effective bioaccumulation factor toward heavy metals; constituently further bio magnification factor throw the food web.

MATERIALS AND METHODS

Study area and experimental design.

The present study was carried out in 6 earthen ponds with a surface area of 1000 m^2 and 1 m depth, belongs to the World Fish, over fish culture season which extended from May to December/2017. Ponds were divided into two groups, each with three replicates. The 1^{st} group was a control (C), while the second (T) received 45 kg dry rice straw/pond. Rice straw applied in bundles (each of 60 cm in length X 25 cm in diameter). Bundles dangled from vertical pillars which established along the pond sides. Ponds received fresh water from El-Ismailia canal and occasionally mixed with underground water. All ponds fertilized traditionally with dry chicken manure in the rate of 15 kg/pond/week.

Sampling strategy and analytical techniques.

Water samples: Monthly samples were collected by using vertical water sampler, where 1 liter representative sample from each pond was placed in a polyethylene bottle, kept refrigerated and transferred cold to the laboratory for analysis. Samples were prepared for heavy metals detection according to the method described by APHA (1995).

Fish tissues samples: Six fish from each pond were randomly taken and transported in ice box to the laboratory, where three of them were dissected for obtaining different organs, while the other three used for determining the investigated heavy metals (Fe, Zn, Cu, Cd and Pb) in the whole fish. Metals in fish tissues/organs were extracted according to the method described in AOAC (1990).

Different investigated heavy metals in water and different fish organs were detected with Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation, S. Series AA Spectrometer, UK).

Statistical analysis.

One-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) was performed to compare the different treatment means at 5% level of significance. The software SPSS, version 10 (SPSS, Richmond, USA) was used as described by Dytham (1999).

RESULTS AND DISCUSSION

Water heavy metals.

Results indicated that water iron values either in control (C) or in treated (T) groups were significantly ($P<0.05$) lower than its value in the source water (S), were the average of these values were 5.97, 7.04 and 7.69 mg/l, respectively (Fig. 1). All water iron values that recorded alongside the present study were higher than the maximum permissible limit (MPL, 1 mg/l) which recommended by USEPA (1986).

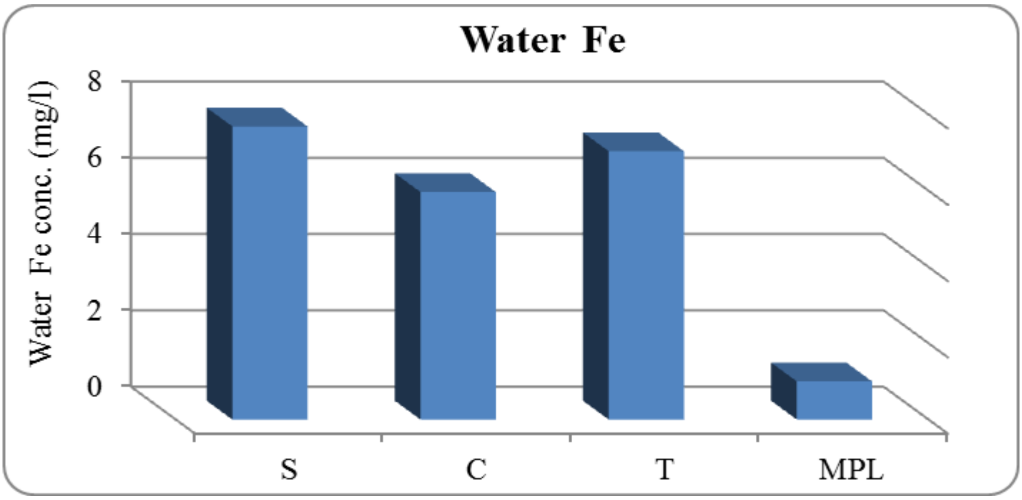

Fig. 1. Water iron in the source water and different treatments compared to maximum permissible limit (according to USEPA, 1986).

Figure 2 revealing that average water zinc values in C, T and S groups were 0.032, 0.031 and 0.044 mg/l, respectively, which lower than the MPL (1 mg/l) recommended by USEPA (1986).

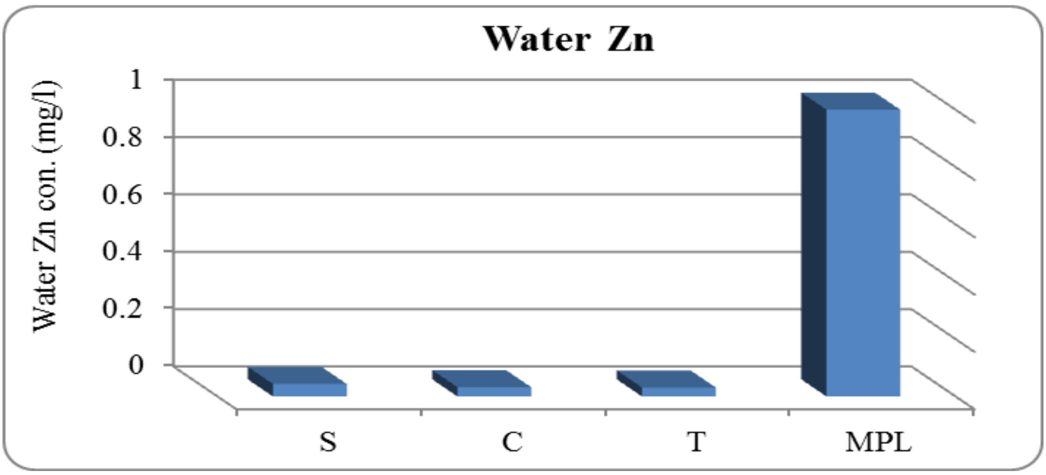

Fig. 2. Water zinc in source water and different treatments compared to maximum permissible limit (according to USEPA, 1986)

Fig. 3 showing that copper values in C and T groups were significantly (P<0.05) lower than it's value in S group (0.017, 0.018 and 0.034 mg/l, respectively). All recorded water copper were lower than the MPL (0.05 mg/l) that recommended by USEPA (1985).

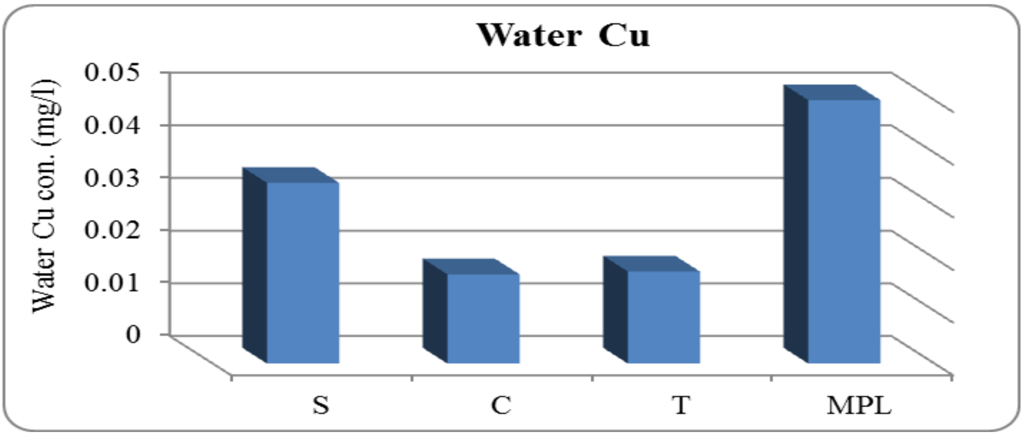

Fig. 3. Water copper in source water and different treatments compared to maximum permissible limit (according to USEPA, 1985).

Fig. 4 indicated that the average cadmium values that recorded alongside the study in C and T groups were significantly ($P<0.05$) lower than its values in source water (S), where these values were 0.0015, 0.0031 and 0.0077 mg/l, respectively. All recorded cadmium values during the study were lower than the MPL (0.01 mg/l) recommended by USEPA (1986).

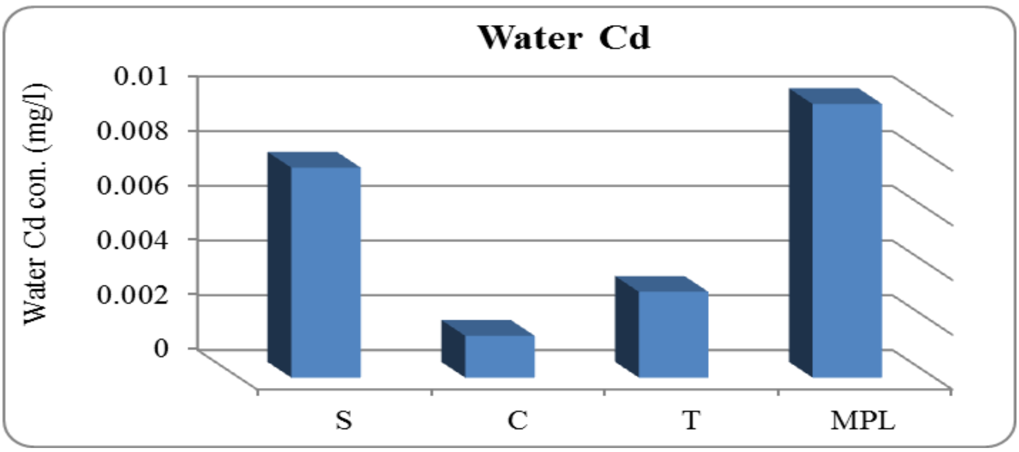

Fig. 4. Water cadmium in source water and different treatments compared to maximum permissible limit (according to USEPA, 1986).

With concern to water lead, all recorded values alongside the present study were lower than the detectable limit of the used instrument.

Investigated heavy metals residues in *O. niloticus* tissues/organs.

Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play important role in human muscles and since they play important role in human nutrition, they need to be carefully screened to ensure that unnecessary high level of some toxic trace metals are not being transferred to human through fish consumption (Adeniyi and Yusuf, 2007).

The results of the present study revealed that iron residues in the whole fish, muscles and gills of *O. niloticus* which collected from C group ponds were 130.18, 514.30 and 540.13 mg/g, respectively, while these values in fish from T group were 350.64, 290.47 and 817.7 mg/kg, respectively. It's noticeable that the lowest iron concentration was recorded in the whole fish from C group, while the highest values were recorded in the gills of all examined fish. Iron residues in the investigated tissues of fish belong to C group had the order: gills > muscles > whole fish, while this order in tissues of fish belong to T group was gills > whole fish > muscles. However, iron residues in all edible tissues that recorded alongside the present work were higher than the MPL as mentioned by **WHO (1984)**, which recommended iron residues in the edible tissues to be lower than 30 mg/kg (Fig. 5).

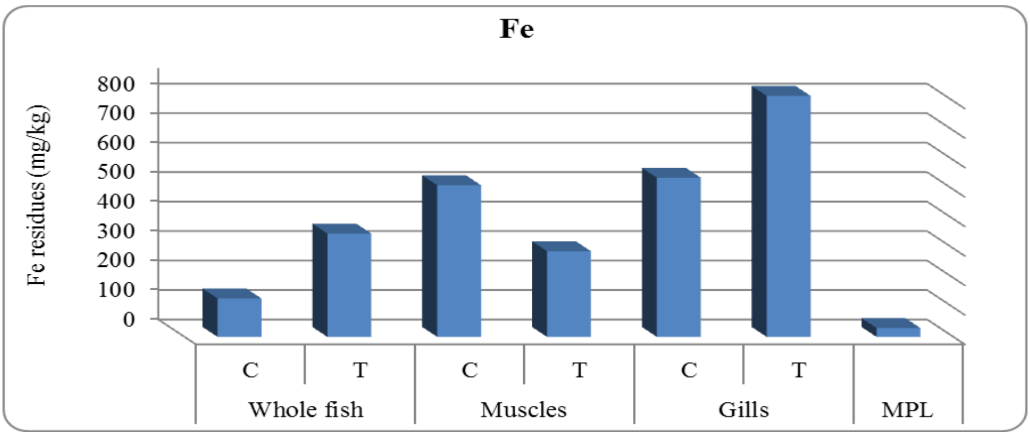

Fig. 5. Iron residues in different tissues of *O. niloticus* at the end of the study compared with the maximum permissible limit (according to WHO, 1984).

Fig. 6 showing that zinc residues in the tissues of fish raised in C and T groups had the order: gills > whole fish > muscles. These values in fish of C group were, 119.29, 64.95 and 46.34 mg/kg, respectively, while these values in tissues of fish which were raised in T group ponds were, 159.96, 60.26 and 52.94 mg/kg, respectively. Obtained results revealed that zinc residues in the edible tissues that recorded at the end of the present study are within the MPL (100 mg/kg) that recommended by WHO (1995).

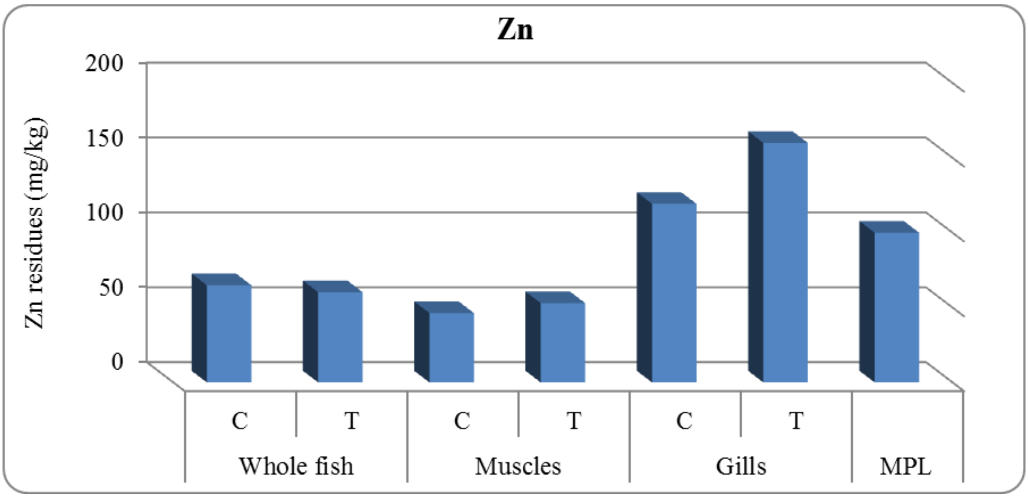

Fig. 6. Zinc residues in different tissues of *O. niloticus* at the end of the study compared with the maximum permissible limit (according to WHO, 1995).

As illustrated in Fig 7, copper residues in the gills, whole fish and muscles of fish belong to C group were 13.95, 9.18 and 8.8 mg/kg, respectively, while these values in the tissues of T group fish were, 23.29, 9.57 and 9.48 mg/kg, respectively. Cu residues in fish tissues of both groups had the order gills > whole fish > muscles. Copper residues in all investigated tissues that recorded at the end of the present study are lower than the MPL (30 mg/kg) which recommended by WHO (1995). Badr *et al.* (2014) reported that the low accumulation of Cu in gills might be due to development of some defensive mechanism such as excessive mucous secretion and clogging of gills.

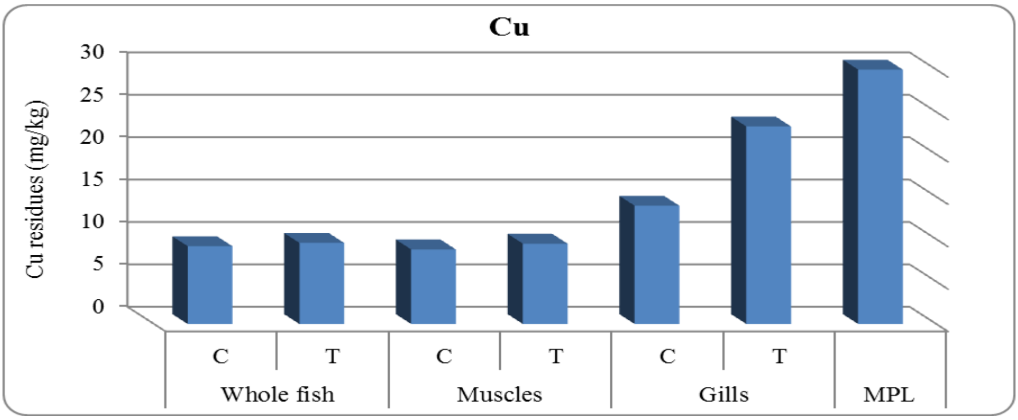

Fig. 7. Copper residues in different tissues of *O. niloticus* at the end of the study compared with the maximum permissible limit (according to WHO, 1995).

Fig. 8 showing that cadmium residues in gills, muscles and in the whole fish of C group were 0.497, 0.343 and 0.0995 mg/kg, respectively, while these residues in fish belong to T group were 0.56, 0.367 and 0.168 mg/kg, respectively. Cd residues recorded at the end of the study in all investigated fish tissues had the order gills > muscles > whole fish, however these residues in all investigated tissues were lower than 1 mg/kg, the value that recommended by WHO (1995) as MPL.

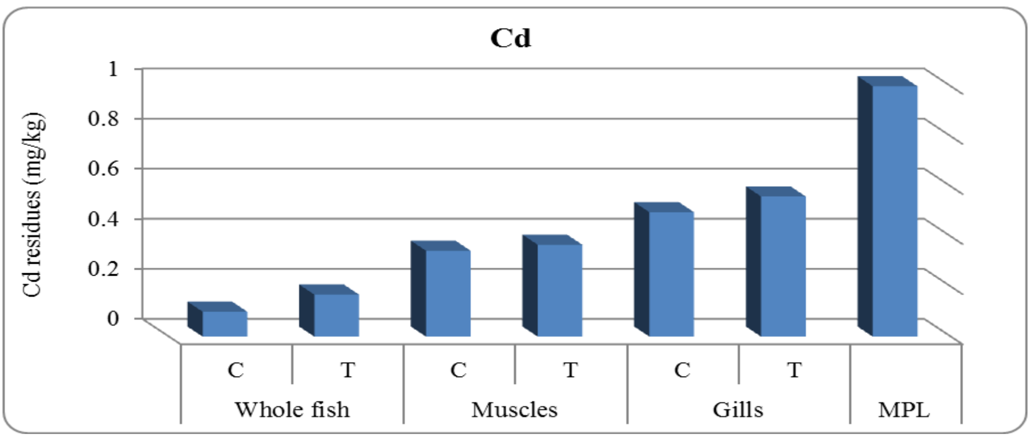

Fig. 8. Cadmium residues in different tissues of *O. niloticus* at the end of the study compared with the maximum permissible limit (according to WHO, 1995).

Fig. 9 revealing that Pb residues in fish that raised in ponds of both C and T groups had the order: gills > muscles > whole fish. These residues were 0.206, 0.187 and 0 mg/kg in fish tissues of C group, and 0.405, 0.219 and 0.041 mg/kg in fish tissues of T group, respectively.

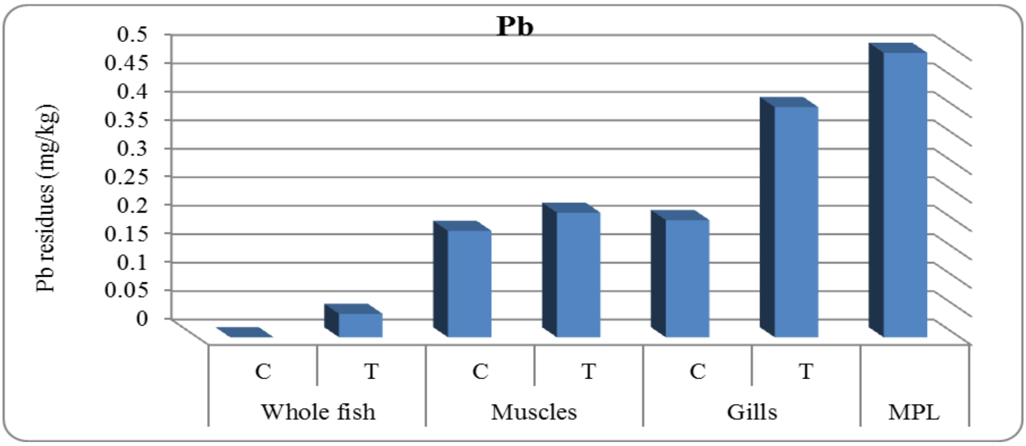

Fig. 9. Lead residues in different tissues of *O. niloticus* at the end of the study compared with the MPL (maximum permissible limit according to FAO/WHO, 1989).

However, obtained results concerning heavy metals residues in different investigated tissues of *O. niloticus* revealed that gills had the highest levels of different investigated metals. The high content of metals in gill tissues can be attributed to the fact that fish gills play a distinct role in metal uptake from the environment. Due to their respiratory function, gills are in direct contact with the contaminated medium (water), and have the thinnest epithelium of all of the organs (Kotze *et al.*, 1999). These results are in agreement with the many authors who have reported that gills have a high tendency to accumulate heavy metals than the edible muscles (Bawuro *et al.*, 2018; Hossain *et al.*, 2016; Altındağ and Yiğit, 2005 and Coetzee *et al.*, 2002). It is important to note that accumulation of metals in muscles is relatively lower than in other tissues because muscles do not directly contact with metals as they are fully covered externally by the skin. Another explanation for that is that muscles are not an active site for detoxification, and hence for transport of metals from other tissues to muscles (Uysal *et al.*, 2009). It's revealed also that the recorded residues of all investigated metals in the examined tissues of fish which were raised in T group, often higher than those of fish which were raised in C group. This result may be due to that rice straw introduced to fish ponds as a substrate to increase plankton density when compared to control which was well water (Sugumaran and Radhakrishnan, 2012). Furthermore; phyto plankton knows to accumulate increased values of heavy metals. Alnagaawy and Saeed (2012) stated that algae had much higher concentrations of Fe, Zn, Cu, Cd and Pb than those in water or tissues of *O. niloticus*. This may be related to the large surface of plankton organisms in relation to their mass unit, and their active metabolism leading to rapid adsorption of various pollutants (Ravera, 2001). He added that some algal species protect themselves by trapping and accumulating pollutants (e.g. metals) in their polysaccharide walls.

CONCLUSION

It could be concluded that the values of all investigated heavy metals decreased in water of the two groups than their values in source water. In spite of applying rice straw into earthen fish ponds increased residues of the investigated heavy metals, but their values in the edible tissue of *O. niloticus* were within the permissible limits which recommended by the international organizations, which means that fish reared in these ponds are safe for human consumption.

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سلوك بعض العناصر الثقيلة وتأثره بإستخدام قش الأرز في أحواض الأسماك الترابية

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الملخـــــــص العربـــــــي

أجريت هذه الدراسة علي مدار موسم إستزراع سمكي خلال الفترة من شهر مايو إلي شهر ديسمبر/ ٢٠١٧ لبيان تأثير قش الأرز المستخدم في أحواض إستزراع الأسماك الترابية لتحفيز نمو الهائمات الملتصقة (البيريفيتون) علي نسب بعض العناصر الثقيلة في المياة وكذلك تراكم تلك العناصر في بعض أنسجة أسماك البلطي النيلي.

تم إستخدام ستة أحواض ترابية، بالمركز الدولي للأسماك، مساحة كل منها ١٠٠٠ م^{٢} وعمق المياه بها ١ م، حيث تم تقسيم تلك الأحواض إلي مجموعتان كل منهما بثلاثة تكرارات، حيث تركت المجموعة الأولي لتعمل كمجموعة ضابطة (C) بينما إستقبلت المجموعة الثانية (T) ٤٥ كجم من قش الأرز الجاف/لكل حوض. وقد تم إستزراع كل الأحواض بأسماك البلطي النيلي وحيد الجنس بمعدل ٣ يرقات/م^{٣}. تم تسميد كل الأحواض بزرق الدواجن بمعدل ١٥ كجم/حوض أسبوعيا.

تم تجميع عينات المياه شهريا من كل من المصدر (S) وكذلك من مجموعتي الأحواض (C) و (T)، وتم كذلك إختيار ٦ سمكات عشوائيا من كل حوض عند نهاية التجربة، حيث تم تشريح ثلاث سمكات منها للحصول علي الخياشيم والعضلات المأكولة، بينما إستخدمت السمكات الباقية لقياس العناصر الثقيلة في كل السمكة. تم تجهيز عينات كل من المياة والانسجه المختلفة لأسماك البلطي النيلي (الخياشيم والعضلات وكل السمكة) لقياس بعض العناصر الثقيلة وهي: الحديد والزنك والنحاس والكادميوم والرصاص.

بينت النتائج المتحصل عليها أن قيم كل العناصر الثقيلة المختبرة في مياه أحواض المجموعتان (C) و (T) كانت أقل منها في مياه المصدر، عدا عنصر الرصاص الذي كانت قيمه أقل من الحدود المقاسة بالجهاز المستخدم سواء في مياه المصدر أو المعاملتان (C) و (T).

علي الرغم من أن قيم متبقيات العناصر المختبرة في أنسجة أسماك البلطي النيلي المرباة في الأحواض التي تلقت قش الأرز كانت أعلي من قيم متبقيات تلك العناصر في أنسجة الأسماك المرباة في أحواض المجموعة الضابطة، إلا أن قيم تلك المتبقيات لجميع العناصر المختبرة كانت أقل من الحدود المسموح بها والموصي بها من قبل الهيئات الدولية، وبناءا عليه فإن إستخدام قش الأرز في أحواض إستزراع الأسماك لم يؤثر علي إستهلاك الإنسان للأسماك المرباة في تلك الأحواض.