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Evaluation of Fresh and Ground Waters as Sources for Irrigation in Aquaculture

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ABSTRACT

Physico-chemical characteristics of fresh and ground water were demonstrated to evaluate to what extend these parameters could influenced by the nature of water source as well as the suitability of both sources for aquaculture purposes. Fe, Cu, Mn, Zn, Pb and Cd residues were followed up in water as well as in muscles, gills and livers of Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and Silver carp (*Hypophthalmichthys molitrix*) adults were recorded along side the study to evaluate the effect of different water sources on their values and the suitability of the edible tissues of different investigated fish species for human consumption. Though water quality characteristics differ between fresh and ground water but both sources considered suitable for aquaculture. Concerning heavy metals residues, there levels in water and in the edible muscles of different investigated fish species reared in either fresh or ground water are quite safe for human consumption.

Keywords:

INTRODUCTION

Fish and other organisms with aquacultural potential live in water, thus, it is no surprise that professional fish culturists state that "Water quality determines to a great extent the success or failure of a fish cultural operation" (Piper *et al*. 1982). Because water is an essential requirement for fish farming, it is only an aquaculturist that puts into consideration the quality and quantity of water available for the proposed enterprise that could be assured of success. An experienced aquaculturist should always consider physicochemical parameters of the water for the proposed enterprise (Arabi *et al*, 2011). There are two main categories of water supply for aquaculture, groundwater and fresh water. Groundwater (also called well water, or spring water) often differs substantially from fresh water in many characteristics. Groundwater is commonly considered the most desirable water source for aquaculture because, at a given site, it is usually consistent in quantity and quality, and free of toxic pollutants and contamination with predator or parasitic living organisms (Summerfelt, 1990). The term aquaculture is defined as "the art of increasing and rearing aquatic organisms and plants". It covers the activities whose main object is the production of freshwater, brackish and marine species by man under controlled or semi controlled conditions (Naeem *et al*, 2011). The production of living number from the aquatic medium is fundamental to all aquaculture activities; aquaculture is based on the manipulation of the natural or artificial aquatic environment for the production of species which are useful to man. It therefore involves all aspects of production of living matter in water (Evans, 1993). Different fish species may vary considerably in terms of specific tolerance limits for various water quality characteristics (Adeyeye and Abulude, 2004).

MATERIALS AND METHODS

Six concrete ponds with the dimensions 2.5 x 5 m and a total water volume of 10 m^3 (80 cm water depth) were randomly distributed on two groups each of them contained three ponds. The 1^{st} group received fresh water from Gadoon canal which derived from Al-Ismailia canal, while the 2^{nd} group received ground water from about 30 meters depth well. All ponds were stocked with 20 Nile tilapia (*Oreochromis niloticus*) adult with an Average initial weight of 73.83 ± 3.37 g + 10 African catfish (*Clarias gariepinus*) adult with an Average initial weight of 169.42 ± 5.68 g + 10 Silver carp (*Hypophthalmichthys molitrix*) adult with an Average initial weight of 72.5 ± 2.88 g. Dissolved oxygen maintained at the range 7-8 mg/l through artificial aeration system. Fishes were fed 6 times weekly with 25 % protein artificial feeding with a ratio of 3 % of total bio mass/day. Artificial feed amounts for each pond recalculated monthly according to total bio mass. Different water quality characteristics as well as some heavy metals residues in water and in muscles and gills were measured each 10 days through the period from 1 June 28 August and the results manipulated statistically and the monthly averages were calculated and summarized in tables.

Water analysis

Water quality characteristics were determined as the method described by standard Methods of Analysis (Boyd and Tucker, 1992).

Heavy metals residues

Water

Heavy metals in water samples were extracted with conc. HCl and preserved in a refrigerator till analysis for Fe, Zn, Mn, Cu, Cd and Pb (Parker, 1972).

Fish organs

Fish samples were transported in ice box to the laboratory, where samples of different tissue/organs taken were sorted. Metals in fish tissue/organs were extracted as described by (AOAC, 1990). Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK,) instrument was used to detect the heavy metals. The concentrations of heavy metals were expressed as mg/l for water and µg/g. dry wt. for sediment samples and fish organs.

Statistical analysis

One-way ANOVA and Duncan multiple range test were used to evaluate the significant difference in the values of different studied parameters with respect to different investigated sites. A probability at level of 0.05 or less was considered significant (Bailey, 1981). Standard errors and correlations among different investigated parameters were also estimated.

RESULTS AND DISCUSSION

Results concerning water quality characteristics summarized in Table 1.

pH

Water pH values for fresh water along the study period, ranged between 9.01 and 9.36 with an average value of 9.21. Results indicated that there was no significant difference between the average mean value of pH in fresh water and that in well water which was 9.302 and ranged between 9.06 and 9.44 along the study period. Results indicated also that there were no significant differences between pH mean value in fresh and well water

Table 1: ***Mean ± SE of different investigated physico-chemical characteristics of fresh and well waters inside the experimental ponds along the study period.***

parameter \ month	June		July		August		Average	
	F	W	F	W	F	W	F	W
pH	9.01 ± 0.13 aC	9.06 ± 0.155 aBC	9.26 ± 0.096 aABC	9.44 ± 0.117 aA	9.36 ± 0.07 aABC	9.4 ± 0.082 aAB	9.21±0.103 aABC	9.302±0.12 aABC
Total. Alkalinity (mg/l as $CaCO_3$)	278.75 ± 7.938 bB	306.667 ± 3.849 aAB	303.33 ± 14.81 aAB	313.33 ± 11.71 aAB	295.6 ± 0.97 bAB	328.578 ± 15.93 aA	292.56±7.26 bBC	316.193±6.48 aAB
Total Hardness (mg/l as $CaCO_3$)	139.5 ±0.866 aA	122.67± 5.38 bAB	127.0 ± 3 aAB	97.56 ± 4.81 bCD	116 ± 7.211 aBC	93.68 ± 13.06 aD	127.5±6.79 aAB	104.64±9.09 bBC
Electric Conductivity (ml mhos)	0.78 ±0.015 bB	1.1 ±0.0064 aA	0.73 ± 0.118 bB	1.09 ± 0.113 aA	0.818 ± 0.0058 bB	1.085 ± 0.057 aA	0.776±0.026bB	1.0917±0.0044 aA
Salinity (g/l)	0.4 ± 0.000 bB	0.514 ± 0.008 aA	0.307 ± 0.047 bB	0.533 ± 0.051 aA	0.4 ± 0.00 bB	0.544 ± 0.029 aA	0.369±0.031bB	0.5306±0.0089 aA
Total dissolved solids (g/l)	0.492 ± 0.003 bB	0.683 ± 0.13 aA	0.481 ± 0.049 bB	0.693 ± 0.059aA	0.5318 ± 0.003 bB	0.706 ± 0.036 aA	0.5016±0.0154 bB	0.694±0.0067aA
Total available phosphorous (mg/l)	0.036 ± 0.014 aA	0.036 ± 0.016 aA	0.0835 ± 0.035aA	0.0613 ± 0.023 aA	0.066 ± 0.001 aA	0.052 ± 0.001 bA	0.062±0.014aA	0.0498±0.0074aA
Ortho phosphate (mg/l)	0.074 ± 0.003 bAB	0.118 ± 0.007 aA	0.047± 0.0256 aB	0.052 ± 0.015 aB	0.043 ± 0.009 aB	0.048± 0.017 aB	0.055±0.0097 aB	0.073±0.0227 aAB
NO_2 (mg/l)	0.029 ± 0.003 aA	0.025 ± 0.0014 aA	0.018± 0.011 aA	0.019 ± 0.016 aA	0.04 ± 0.0004 aA	0.03 ± 0.0056 aA	0.029±0.006 aA	0.0247±0.003 aA
NO_3 (mg/l)	0.129 ± 0.07 aA	0.136 ± 0.06 aA	0.109 ± 0.018 bA	0.166 ± 0.011 aA	0.104 ± 0.01 bA	0.194 ± 0.014 aA	0.114±0.0076 bA	0.165±0.017 aA

Means followed by different small letters in the same row for each month and different capital letters
In the same row are significantly different ($p<0.05$). F = fresh water, W = well water

during different months. Highest pH mean value was recorded in well water during July, while the lowest was in fresh water during June. Target pH ranged between 6.5 and 9, at which most species will tolerate and reproduce successfully (South African water quality guidelines, 1996). Obtained results indicated that recorded pH values were within the mentioned optimum range for fish culture. The same range was previously indicated by Lloyd (1992), who mentioned that the favorable range of pH is 6.5-9.0 at daybreak, are most suitable for fish production.

Total alkalinity (mg/l as $CaCO_3$)

Average water alkalinity in fresh water was significantly lower than its value in well water, with average values of 292.56 and 316.193 mg/l (as $CaCO_3$), respectively. However its mean values in fresh water ranged between 278.75and 303.33, while its mean values in well water were between 306.667 and 328.578 mg/l (as $CaCO_3$) along the study period. Mean values of total alkalinity in fresh water were significantly ($p<0.05$) lower than its mean values in well water during both June and August. There were significant ($P<0.05$) differences in mean values of total alkalinity along the study period. Fresh water total alkalinity mean value recorded in June was significantly lower than mean values recorded during the other months. Concerning well water total alkalinity, its mean value recorded during August was significantly ($P<0.05$) higher than the mean values recorded during the other months. Lawson (1995) indicated that alkalinity in natural freshwater systems ranges from 5 to 500 (mg/l as $CaCO_3$). Recorded total alkalinity values during the present study consider suitable for fish culture according to Meade (1989) and Tucker and Robinson (1990) who reported that total alkalinity with a value higher than 100 or 150 (mg/l as $CaCO_3$) considered desirable, while a value ranged between 20 to 400 considered sufficient for most aquaculture purposes.

Total hardness (mg/l as $CaCO_3$)

Mean values of total hardness in fresh water ranged between 116 and 139.5 mg/l (as CaCO3), while its mean values in well water, along the study period, were between 93.68 and 122.67 mg/l (as CaCO3). Total hardness average mean value in well water (104.64 mg/l as CaCO3) was significantly ($P<0.05$) lower than its average mean value in fresh water (127.5 mg/l as CaCO3). Mean total hardness values in fresh water were significantly higher than its mean values in well water during June and July months. The highest mean value of total hardness was recorded in fresh water during June while the lowest was recorded in well water during August. Obtained hardness values recorded during the present study were most suitable for fish growth according to Rath (1993) who mentioned that pond water with hardness of 50 ppm are above satisfactory for growth of fish and don't require addition of lime but water has less than 11 ppm require limiting for higher production of fish. Most fish grow well over a wide range of hardness values (30 - 100 mg/l as $CaCO_3$) however; Fish exposed to soft water are more susceptible to other adverse water quality conditions. For example, the toxicity of heavy metals is increased in soft waters in which there are insufficient calcium and magnesium ions to compete with toxic metal ions for adsorption sites on the gills. Similarly, ammonia toxicity is increased in waters low in calcium (South African water quality guidelines, 1996).

Electric conductivity (EC [mlmhoes/cm])

Obtained results concerning electric conductivity (EC) indicated that its average mean in well water was significantly higher than its average mean in fresh water with values of 1.0917 and 0.776 mlmhoes/cm respectively. Its mean values in fresh water were between 0.73 and 0.818 while in well water EC mean values ranged between 1.085 and 1.1 mlmhoes/cm, respectively, along the study period. Mean values of electric conductivity in well water were significantly ($p<0.05$) higher than mean values in fresh water during all study months.

Salinity (ppt)

Mean fresh water salinity ranged between 0.307 and 0.4 with an average mean of 0.369 ppt. This average mean value was significantly lower than the average mean in well water (0.5306 ppt). Obtained results indicated that the mean values of well water salinity along the study period, ranged between 0.514 and 0.544 ppt. Salinity mean values in well water were significantly ($p<0.05$) higher than mean values in fresh water during all study months. The highest salinity mean value was recorded in well water during August.

Total dissolved solids (TDS [g/l])

Electric conductivity estimates the amount of total dissolved salts (TDS), or the total amount of dissolved ions in the water. This fact previously mentioned by many authors (Hem, 1985; Lloyd and Heathcote, 1985) who stated that the specific conductance of specific water is directly related to the TDS based on the assumption that TDS in the water consist mainly of ionic constituents that conduct electricity. This fact gives the explanation that obtained results of average total dissolved solids had the same trend of electric conductivity and salinity, where its average mean in well water was significantly higher than its average mean in fresh water where these values were 0.694 and 0.5016 g/l respectively. TDS mean values in fresh water were between 0.481 and 0.5318 g/l while in well water, TDS mean values, along the study period, were between 0.683 and 0.706 g/l respectively. TDS mean values in well water were significantly higher than its mean values in fresh water during all study months. A maximum of 400 mg/l of total dissolved solids is permissible for diverse fish population (Naeem *et al*., 2011). Present findings indicate high total dissolved solids which may have adversely affected the fish growth. Similar results were reported by Salam and Perveen (1996).

Nutrients

Total available phosphorous (T.Av.P [mg/l])

Obtained results indicated that there was no significant difference between average mean values of total available phosphorous (T.Av.P.) in fresh water (0.062 mg/l) and well water (0.0498 mg/l). Mean T.Av.P. values in fresh water ranged between 0.036 and 0.0835 mg/l, while its mean values in well water were between 0.036 and 0.0613 mg/l along the study period. Results indicated that there were no significant differences of T.Av.P. mean values between fresh and well water during all months except August, where its mean value in fresh water was significantly ($P<0.05$) higher than its mean value in well water.

Orthophosphates (OP [mg/l])

Average OP mean value in fresh water (0.055 mg/l) was significantly ($P<0.05$) lower than the average mean value in well water (0.073 mg/l). OP. mean values in fresh water ranged between 0.043 and 0.074 mg/l, while its mean values in well water were between 0.048 and 0.118 mg/l along the study period. Results indicated that there were no significant differences concerning OP mean values between fresh and well water during all months except during June, where its mean value in fresh water was significantly ($P<0.05$) lower than its mean value in well water. The highest OP mean value was 0.118 mg/l which recorded in well water during June. South African water quality guidelines (1996) detected values up to 0.1 mg OP as a target range which ensures the protection of all aquatic organisms.

Nitrite-nitrogen (NO_2 - N [mg/l])

There was no significant difference between average mean values of NO_2 - N in fresh water

(0.029) and well water (0.0247) mg/l. Mean NO_2 - N values in fresh water were between 0.018 and 0.04 mg/l along the study period. Its mean values in well water ranged between 0.019 and 0.03 mg/l along the study period. Obtained results indicated that there were no significant differences between NO_2 - N mean values in fresh and well waters during different months. South African water quality guidelines (1996) recommended 0 – 0.05 mg/l as a target range for NO_2 – N, while 0.06 -0.25 mg NO_2 – N /l considered a safe range for a number of warm-water fish species. Swann (1993) indicated that the optimal nitrite concentrations for freshwater fish is <0.5 mg/l. Upon these recommendations, obtained results during this study considered quite safe for different investigated fish species.

Nitrate-nitrogen (NO_3 - N [mg/l])

Obtained results indicated that the average NO_3 - N, mean value in well water was significantly ($P<0.05$) higher than its average mean value of fresh water (0.165 and 0.114 mg/l, respectively). Mean NO_3 - N values in fresh water were between 0.104 and 0.129 mg/l. Recorded NO_3 - N mean values in well water during the present study were between 0.136 and 0.194 mg/l. Nitrate nitrogen mean values in well water were significantly ($P<0.05$) higher than its mean values in fresh water during July and August months. Obtained data for nitrate nitrogen revealed that these values were below the maximum level mentioned by OATA (2008) which recommends that nitrate levels in freshwater systems do not exceed those in the tap water supply by more than 50mg/l. Obtained date also were within the target NO3 – N range recommended by the South African water quality guidelines (1996) which stated to be below 300 mg/l.

Chlorophyll-a (mg/l)

Mean values of Chlorophyll-*a* in fresh water ranged between 18.17 and 206.48 with an average value of 107.2 mg/l. In well water, Chlorophyll-*a* mean values ranged between 22.785 and 139.6 with an average value of 70.325 mg/l. Mean values of Chlorophyll-*a* in fresh water were significantly ($P<0.05$) higher than its mean values in well water during July and August months. The highest Chlorophyll-*a* mean value was recorded in fresh water during August. In spite of the fact that phosphorous value in ground water usually much lower than its value in fresh water, obtained results during this work indicated that the average mean value of orthophosphates in well water was significantly ($P<0.05$) higher than its average mean value in fresh water, while there were no significant difference concerning average mean value of total available phosphorous in fresh and well waters. This could be explained as that more phosphorous in fresh water consumed for phytoplankton growth (Bush and Austin, 2001). Concentrations of chlorophyll-*a*, the primary pigment used by algae for the capture of light energy for photosynthesis, are often used to estimate algal biomass in water (Wetzel and Likens, 1979; APHA, 1985). The increased growth of algae in fresh water reflected on the significant increase of mean values of Chlorophyll-*a* in fresh water than in well water at the end of the study.

Water heavy metals residues

Obtained results of water heavy metals residues, as showing in Table 2 , indicating that the average all mean of Fe, Cu, Mn, Zn, Pb and Cd in fresh water were 0.0123, 0.0107, 0.0812, 0.0166, 0.0023 and 0.0003 mg/l, respectively. These average mean values in well water were 0.0232, 0.0096, 0.0693, 0.0159, 0.0034 and 0.0008 mg/l, respectively.

Values of different heavy metals residues in water were as follow:

Ferric (Fe)

Mean Fe values in fresh water ranged between 0.006 and 0.0188 with an average value of 0.0123 mg/l, while its values in well water were between 0.015 and 0.0325 with an average value of 0.0232 mg/l. Fe mean residues in well water were significantly ($P<0.05$) higher than its values in fresh water during all months. The highest Fe residues were during July in both fresh and well waters.

Cupper (Cu)

Mean copper values along the study period were between 0.0068 and 0.0138 mg/l in fresh water and were between 0.007 and 0.0111 mg/l in well water. Cu average means were 0.0107 and 0.0096 mg/l in fresh and well waters, respectively. Obtained results indicated that there were no significant differences between copper residues in fresh water and its residues in well water along the study period. Mean copper residues in both fresh and well water recorded during June were significantly ($P<0.05$) lower than its mean residues during July or August.

Manganese (Mn)

Manganese mean values in fresh water ranged between 0.0608 and 0.1067 mg/l while its mean values in

Table 2: Mean ± SE of different investigated heavy metals (mg/l) in fresh and well waters inside the experimental ponds along the study period.

		June	July	August	Average	Permissible levels (mg/l) according to WHO (2011)
Fe	F	0.006± 0.0005bC	0.0188± 0.0005bA	0.0122± 0.0003bB	0.0123± 0.0037aB	No health-based guideline value has been recorded
	W	0.015± 0.0004aC	0.0325± 0.002aA	0.0221± 0.0011aB	0.0232± 0.0051aB	
Cu	F	0.0068± 0.0012aB	0.0138± 0.0011aA	0.0115± 0.0007aA	0.0107± 0.0021aA	2
	W	0.0071± 0.0001aB	0.0111± 0.0007aA	0.0106± 0.0004aA	0.0096± 0.0013aA	
Mn	F	0.1067± 0.0123aA	0.0761± 0.0063aB	0.0608± 0.004aB	0.0812± 0.0135aB	0.1
	W	0.085± 0.011aA	0.0743± 0.0017aA	0.0486± 0.0032bB	0.0693± 0.0108aA	
Zn	F	0.0176± 0.0006aA	0.0167± 0.001aA	0.0155± 0.0007bA	0.0166± 0.0006aA	No health-based guideline value has been recorded
	W	0.0131± 0.0005bB	0.0137± 0.001aB	0.021± 0.001aA	0.0159± 0.0025aB	
Pb	F	0.0024± 0.0009abA	0.0022± 0.0003aA	0.0022± 0.0003bA	0.0023± 0.00007bA	0.01
	W	0.0039± 0.0004aA	0.003± 0.0005aA	0.0032± 0.0002aA	0.0034± 0.0003aA	
Cd	F	0.0003± 0.0001aA	0.0004± 0.00004aA	0.0002± 0.00003aA	0.0003± 0.00006aA	0.003
	W	0.0003± 0.0001aAB	0.002± 0.001aA	0.0001± 0.00002bB	0.0008± 0.0006aAB	

Means followed by different small letters in the same column for each metal and different capital letters in the same row are significantly different

well water were between 0.0486 and 0.085 mg/l. Results revealed that there were no significant differences in Mn mean values between fresh and well waters during June and July months, while its mean value in fresh water during August was significantly (P<0.05) higher than its mean value in well water. Results indicated that Mn mean values significantly decreased after the 1st month in fresh water, while in well water its mean values decreased after second month.

Zinc (Zn)

Zinc mean values in fresh water ranged between 0.0155 and 0.0176 mg/l while its mean values in well water were between 0.0131 and 0.021 mg/l with. There was no constant pattern in the significance change in Zn mean values between fresh and well waters. Results revealed that there was no significant difference in Zn mean values of fresh water among different months, while concerning well water Zn mean value during August was significantly (P<0.05) higher than Zn mean values during the 1st two months.

Lead (Pb)

Lead values in fresh water were between 0.0022 and 0.0024 mg/l while in well water, Pb values were between 0.003 and 0.0039mg/l. Results indicated that Pb mean values in well water were significantly (P<0.05) higher than its mean values in fresh water during June and August months. There were no significant differences in either fresh or well waters among different months along the study period.

Cadmium (Cd)

Mean values in fresh water were between 0.0002 and 0.0004 mg/l, while in well water, cadmium values ranged between 0.0001 and 0.002 mg/l. Results indicated that there were no significant (P<0.05) differences between Cd mean values in fresh and well waters during the 1st two months. Results revealed that there were no significant differences in fresh water Cd mean values along the study period, while concerning its mean values in well water; the highest mean value was recorded during July.

Concerning the average mean values of the investigated metals residues it could be concluded that these values in fresh water followed the order: Mn > Zn > Fe > Cu > Pb > Cd, where these values were 0.0812, 0.0166, 0.0123, 0.0107, 0.0023 and 0.0003 mg/l respectively, while in well water, they had the order Mn > Fe > Zn > Cu > Pb and Cd where these values were 0.0693, 0.0232, 0.0159, 0.0096, 0.0034 and 0.0008 mg/l, respectively. It could be concluded also that the average mean values of all investigated heavy metals were below the maximum Permissible levels mentioned by WHO (2011).

Fish organs heavy metals residues

Residues of Fe, Cu, Mn, Zn, Pb and Cd in muscles, gills and livers of Nile tilapia, African catfish and Silver carp at the end of the study were detected and summarized in Table 3.

Table 3: ***Mean ± SE of different investigated heavy metals in some organs of different investigated fish species reared in either fresh or well waters.***

		Nile tilapia			African catfish		
		M	**G**	**L**	**M**	**G**	**L**
Fe	**F**	117.36± 8.291Bc	267.788± 0.123Ac	11332.5± 543.95Aa	151.084± 2Bc	222.455± 20.81Ac	3699.542± 51.46Bb
		175.544± 10.777Ac	290.584± 51.09Ac	12125.525± 1926.5Aa	204.535± 2.62Ac	46.674± 0.087Bc	6473.308± 1111.5Ab
Cu	**F**	9.06± 0.076Bd	10.176± 0.102Ad	296.05± 16.26Aa	7.783± 0.882Ad	8.233± 0.46Ad	71.747± 2.57Bc
	W	12.739± 0.78Ad	10.128± 0.074Ad	353.79± 31.21Aa	8.475± 0.342Ad	6.659± 0.318Bd	126.307± 6.02Ac
Mn	**F**	1.144± 0.21Bc	3.824± 0.93Bc	25.733± 0.77Aa	1.237± 0.036Ac	11.303± 1.7Ab	8.738± 1.976Ab
	W	3.045± 0.0865Ad	8.164± 1.681Acd	27.857± 2.61Ab	1.002± 0.211Ad	9.962± 2.0Acd	16.531± 5.22Ac
Zn	**F**	3.008± 0.31Bd	6.478± 0.1Bcd	75.266± 2.8Ab	2.943± 0.21Ad	5.891± 0.43Acd	15.98± 0.479Bcd
	W	5.496± 0.693Ac	10.55± 0.014Ac	63.179± 15.72Ab	3.942± 1.15Ac	6.656± 1.13Ac	42.95± 4.009Ab
Pb	**F**	ND	ND	ND	ND	ND	ND
	W	ND	ND	ND	ND	ND	15.849± 15.85Ab
Cd	**F**	0.343± 0.09Ad	0.211± 0.037Bd	14.97± 0.98Aa	0.265± 0.023Ad	0.806± 0.28Ad	2.356± 0.206Bc
	W	0.366± 0.023Ac	0.392± 0.0276Ac	10.437± 0.608Ba	0.335± 0.08Ac	0.462± 0.158Ac	6.709± 1.49Ab

Means followed by different Capital letters in the same column for each metal or small letters in the same row are significantly different. M = muscles, G = gills, L = livers.

Obtained results were as follow:

Ferric (Fe)

Obtained results indicated that mean values of Fe residues in different organs of different investigated fish species reared in well water were significantly (P<0.05) higher than those mean values of fishes reared in fresh water except for Fe residues in cat fish gills, while the increase in

Table 3: ***Mean ± SE of different investigated heavy metals in some organs of different investigated fish species reared in either fresh or well waters.*** **(Continued).**

		Silver carp		
		M	G	L
Fe	F	228.402± 32.97Bc	590.968± 85.3Bc	509.578± 66.26Bc
		421.715± 69.57Ac	1283.93± 174.42Ac	10561.502± 1270.35Aa
Cu	F	13.76± 1.99Ad	7.903± 1.141Bd	138.592± 18.022Ab
	W	17.423± 2.87Ad	12.325± 1.67Ad	182.394± 21.94Ab
Mn	F	1.926± 0.28Bc	9.459± 1.37Bb	27.747± 3.608Ba
	W	4.152± 0.69Ad	28.875± 3.92Ab	48.122± 5.79Aa
Zn	F	10.601± 1.53Acd	18.776± 2.71Ac	103.521± 13.46Aa
	W	9.888± 1.63Ac	9.046± 1.23Bc	117.371± 14.12Aa
Pb	F	ND	ND	3.079± 0.4Ba
	W	ND	ND	7.465± 0.898Aa
Cd	F	0.346± 0.05Ad	0.389± 0.056Ad	6.09± 0.792Bb
	W	0.512± 0.084Ac	0.552± 0.075Ac	10.094± 1.21Aa

Means followed by different Capital letters in the same column for each metal or small letters in the same row are significantly different. M = muscles, G = gills, L = livers.

tilapia gills and livers were not significant. Mean Fe values in different investigated fish species either in fresh or in well water followed the order: muscles < gills < liver except for silver carp in fresh water and catfish in well water. Fe mean values in muscles were followed the order: Nile tilapia < African cat fish < Silver carp in both fresh and well water. These values in fresh water fishes were 117.36, 151.084 and 228.402 mg/kg respectively, while these values for well water fishes were 175.544, 204.535 and 421.715 mg/kg respectively. Recommended daily intake for Fe is 50 mg/day wet weight bases as mentioned by WHO (2011). Detected Fe residues in muscles of Nile tilapia, African cat fish and Silver carp reared in fresh water as calculated on wet weight bases were 23.472, 30.217 and 45.68 mg/kg respectively, where Fe mean values in muscles of Nile tilapia, African cat fish and Silver carp reared in well water as calculated on wet weight bases were 35.109, 40.907 and 84.343 mg/kg respectively, so, based upon these calculations, a normal daily diet including this fish species poses no health risk to consumer. Lower iron concentration (10.4 and not detectable mg/kg) was previously mentioned by (Khallaf *et al*., 1994) for Nile tilapia and Catfish respectively, caught from Abbassa fish farm.

Cupper (Cu)

Results revealed that the significantly (P<0.05) highest mean values of Cu residues were in livers of different investigated fish species either in fresh or in well waters. Mean values of Cu residues in muscles were followed the order Cat fish < Nile tilapia < Silver carp in fresh water with values of 7.783, 9.06 and 13.76 mg/kg respectively, while for fishes grown in well water, muscles Cu mean values were 8.475, 12.325 and 12.739 following the order Cat fish < Silver carp < Nile tilapia**.** Results revealed that there were no significant differences between mean Cu muscles values for each Catfish and silver carp fishes reared in fresh and their mean values in well waters**,** while Cu mean value in muscles of Nile tilapia grown in fresh water was significantly (P<0.05) lower than the value in Nile tilapia muscles of well water. Cu mean values in different organs except livers in all investigated fish species either grown in fresh or well waters, were below the permissible value (20 mg/kg) recommended by FAO (1983).

Manganese (Mn)

Obtained results revealed that the recorded mean values of Mn at the end of the study in different organs (except those values recorded in Cat fish gills reared in fresh water) of all investigated fish species either grown in fresh or well waters, were had the order muscles < gills < livers. Concerning manganese mean values in muscles of fishes grown in fresh waters, they had follow the order Nile tilapia < African cat fish < Silver carp, while these values for fishes grown in well water, they had followed the order African cat fish < Nile tilapia < Silver carp. Mn mean values in muscles of Nile tilapia, African cat fish and Silver carp fishes grown in fresh water were 1.144, 1.237 and 1.926 mg/kg respectively, while these values for fishes grown in well water were 3.045, 1.002 and 4.152 mg/kg respectively. These values could be considered quite safe for consumption in case of normal diet of these fish species, according to WHO (2011) which stated 11 mg Mn/day as a recommended daily intake for an adult. The high relatively content of Mn in gill tissues of different investigated fish species 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 (Coetzee *et al*., 2002 and Altındağ and Yiğit, 2005).

Zinc (Zn)

Zinc mean values in different organs of different investigated fish species grown in either fresh or well waters were followed the order muscles < gills < livers except for Silver carp gills in well water. Similar results were previously mentioned by Velcheva (2004) who reported that Zn residues in muscles were lower than its residues in other organs. Results indicated that mean value of Zn in muscles of Nile tilapia grown in well water was significantly ($P<0.05$) higher than Zn mean value in muscles of Nile tilapia grown in fresh water, while with respect to African cat fish and Silver carp, there were no significant differences between muscles mean Zn values of fishes grown in fresh and well waters. Zn mean values in muscles were had the order African cat fish < Nile tilapia < Silver carp either in fresh or in well waters. Balasubramanian *et al*. (1995) indicated that Zn accumulation in the fish species was in the order of omnivorous feeder> phytoplankton feeder> zooplankton feeder> carnivorous feeder> macrophyte feeder. Results indicated that Zn mean values of muscles of African cat fish, Nile tilapia and Silver carp grown in fresh water were 2.943, 3.008 and 10.601 mg/kg respectively, while these values for fishes grown in well water were 3.942, 5.496 and 9.888 mg/kg respectively. according to WHO (2011) the recommended daily intake for an adult is 1 mg Zn/kg of body weight/day, so a normal consumption of the edible muscles of these fish species considered quite safe for human.

Lead (Pb)

All lead residues in different organs of different investigated fish species grown in either fresh or well waters were below the detection limit of the used instrument except livers of African cat fish grown in well water and livers of Silver carp grown in either fresh or well waters.

Cadmium (Cd)

Obtained results concerning Cd mean values in different organs in different investigated fish species grown in either fresh or well waters revealed that these values were followed the order muscles < gills < livers except for mean values in Nile tilapia fishes grown in fresh water were Cd mean value in muscles was higher than the mean value in gills, however, the difference between the two values was not significant. Similar results previously mentioned by Al – Nagaawy and Saeed (2012) who reported that cadmium values in different tissues were higher than its values in muscles with the exception of its value in Nile tilapia which was higher than its value in gills. Results indicated that the differences between mean Cd values recorded in muscles of different investigated fish species grown in fresh and those grown in well water were not significant. Mean Cd values recorded in the edible muscles were followed the order African cat fish < Nile tilapia < Silver carp either in fresh or in well waters. However there were no significant ($P<0.05$) differences among Cd mean values in different investigated fish species grown in either fresh or well waters. Cd mean values recorded in the edible muscles of Nile tilapia, African cat fish and Silver carp grown in fresh water were 0.343, 0.265 and 0.346 mg/kg, respectively, while mean Cd values in muscles of these fish species grown in well water were 0.366, 0.335 and 0.512 mg/kg, respectively. These concentrations were lower than the permissible concentration (0.5 mg/kg) mentioned by FAO (1983).

CONCLUSION

In spite of the significant differences in most water physico-chemical characteristics between ground and fresh water, these characteristics still in the adequate range which could be considered most suitable for aquaculture purposes. Concerning heavy metals residues, there levels in the edible muscles of different investigated fish species reared in either ground or fresh water are quite safe for human consumption, where these residues were below the permissible concentrations mentioned by national organizations interested in pollution and human health. According to the obtained results at the end of this work, we recommended both ground and fresh water as reliable sources for water in aquaculture fish ponds.

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تقييم كل من مياه الترع والمياه الأرضية كمصادر لمياه الري في الإستزراع السمكي

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أستخدم في هذا العمل عدد ستة أحواض أسمنتية أبعادها 5و2 × 5 م بحجم مياه كلي 10 م^3 (عمق المياه 80 سم) وقد تم توزيع هذه الأحواض بصورة عشوائية علي مجموعتين كل منهما تضم ثلاثة أحواض. كانت مياه الترعة الأرضية والتي مصدرها أحد الآبار علي عمق حوالي ثلاثون مترا هي مصدر المياه في المجموعة الثانية. تم تخزين الأسماك بمعدل 4 سمكات / م^3 علي النحو التالي: 2 سمكة بلطي نيلي / م^3 بحجم اولي83 و73 ± 37 و3 : 1 سمكة قراميط المياه العذبة / م^3 بحجم أولي 42 و169 ± 68و5 : 1 سمكة مبروك فضي / م^3 بحجم أولي 5 و72 ± 88 و2. تمت تغذية الأسماك صناعيا بإستخدام علائق الأسماك 25 % بروتين بنسبة 3 % من وزن الأسماك الكلي ستة مرات / أسبوع ويتم تعديل كمية العلائق المستخدمة شهريا تبعا لنمو الأسماك. تم إستخدام نظاما للتهوية الصناعية للحفاظ علي مستوي الأكسجين الذائب عند المعدل 7 – 8 مجم / لتر. تم قياس عدد من عوامل جودة المياه وكذلك متبقيات كل من الحديد والنحاس والمنجنيز والزنك والرصاص والكادميوم في مصدري المياه وكذلك في كل من عضلات وخياشيم وأكباد أنواع الأسماك المختبرة والمرباة في كل من مياه الترعة والمياه الأرضية بصورة دورية كل عشرة أيام في الفترة من 1 يونيو حتي 28 أغسطس 2011 . تمت معالجة البيانات إحصائيا وتم حساب المتوسطات الشهرية. وعلي الرغم من أن النتائج قد بينت وجود إختلافات ذات دلالة

إحصائية في بعض عوامل جودة المياه بين كل من مياه الترعة والمياه الأرضية، إلا أن جميع العوامل التي تم قياسها كانت في حدود المدي الملائم لتربية الأسماك. فيما يخص متبقيات العناصر المختبرة، كانت متبقياتها جميعا سواءا في مصدري المياه او في العضلات وهي الأجزاء المأكولة لكل أنواع الأسماك المختبرة أقل من الحدود القصوي المسموح بها.

من النتائج المتحصل عليها من هذا العمل نستطيع أن نوصي بإمكانية إستخدام المياه الأرضية في الإستزراع السمكي كمصدر بديل لمياه الترع وهذا المصدر يوفر مياه ذات خواص جودة مياه ملائمة لإستزراع الأسماك وتكون أنواع الأسماك المختلفة المرباة في المياه الأرضية آمنة للإستهلاك الآدمي من حيث متبقيات العناصر الثقيلة.