NVVJ., Vol. 3, Issue (1), 2023.

Original Research Article

ISSN (Print) 2786-0272 ISSN (Online) 2786-0280

Effect of the Underground Water on Health State and Growth Rate in Tilapia Fish (*Oreochromis niloticus*) in the New Valley Governorate

Sotohy A. Sotohy[1], Rasha M. Hassan[2], Ayman S. Abd-Elmaguid[3], Mahmoud M. Arafaa[4], Mahmoud H. Mohamed[2]*

** Corresponding Author*
Rasha M. Hassan, Department of fish diseases, Faculty of Veterinary Medicine, New Valley University, Alkharga, New Valley, Egypt
Email. hatmmhran967@gmail.com
Submitted 8/12/2022
Accepted 12/31/2022

[1]*Department of Animal hygiene, Faculty of Veterinary Medicine, Assiut University, Assiut, Egypt.*
[2]*Department of fish diseases, Faculty of Veterinary Medicine, New Valley University, Alkharga, New Valley, Egypt.*
[3] *Department of Agricultural economics, Faculty of Agriculture Assiut University, Assiut, Egypt.*
[4]*Department of Biochemistry and toxicology, Animal Health Research Institute, Dokki, Giza, Egypt.*

Abstract

Twenty water samples were collected from El-Dakhlah City in the New valley governorate, five from fishpond. Metal analyses were carried out in Animal Health Research Institute, Dokki, Giza, Egypt. A total of 200 unsexed 8 months Tilapia fish were used in this study. Fifty fish were collected randomly from each pond and then weighed. The results of this study showed that lead, cadmium, and iron were higher than permissible limits of WHO, on the other hand Iodine, copper and zinc were lower than permissible limits of WHO. Manganese was higher than permissible limits mostly in all examined ponds. The concentration of heavy metals and trace elements in fish tissue showed that Lead, cadmium, iron, zinc, copper, and iodine were lower than permissible limits while Manganese was higher than permissible limits. The average body weight gain of Tilapia fish was high in the filtered water ponds than other ponds.

Keywords: Tilapia, Heavy metals, permissible limits, Underground Water.

Introduction

Water quality includes all physical, chemical, and biological factors that influence the beneficial use of water. Where fish culture is concerned, any characteristic of water that affects the survival, reproduction, growth, production, or management of fish in any way is a water quality variable. Fish's physiological functions, including reproduction and development, are impacted by heavy metals. The effects of waterborne metals on fish are related to their uptake and storage by the organism, which leads to metal-induced abnormalities in the structure and function of different tissues. and organs Jezierska et al., (2001). Fish, including Tilapia (Oreochromis niloticus) and mullet (Mugil cephalus), play important roles in providing humans with a well-balanced diet. They are rich sources of essential amino acids, essential fatty acids, minerals, and vitamins such as vitamins E and D Baboli et al., (2013). Heavy metal concentrations in the environment determine how harmful they seem to be. Heavy metals seep into groundwater and soil solution because of increasing environmental concentrations and declining soil retention capabilities. Thus, these toxic heavy metals can be accumulated in living tissues and concentrate through the food chain Oreochromis niloticus (Nile tilapia), a tropical freshwater and brackish-water species, is the most eaten fish in Egypt and considered as the most important aquaculture freshwater fin fish globally Barriga et al., (2004).

Materials and Methods

A. Water Sample collection: Twenty water samples were collected from fish ponds in El-Dakhlah City, New Valley Governorate, Egypt. Five samples were taken from each fish pond once monthly. The following four farms were selected for water sampling:

Farm 1 - earthen pond (deep well without filtration) in Balat City

Farm 2 - cement (superficial well without filtration) in Mashie

Farm 3 - cement (superficial well with ordinary filter) in Moshia

Farm 4 - fiberglass (superficial well with biological filter) in Moshia Water samples were collected in plastic containers pre-washed with nitric acid and rinsed with deionized water. Water samples were acidified with concentrated HCl and kept in a deep freezer at -20°C for later analysis (Arafa et al., 2014).

B. Biochemical analysis: Biochemical analysis of water samples was performed using atomic absorption spectrophotometry for the determination of lead, cadmium, iron, zinc, copper, manganese, and iodine. The Perkin Elmer catalogue of atomic absorption model 2380, USA, 1982, was used as a reference. Biochemical analysis of water quality included pH, calcium, calcium carbonate, magnesium, magnesium carbonate, phosphate, nitrite, and chloride.

Biochemical analysis of fish tissue was carried out using a wet digesting technique with pure nitric and perchloric acids. One gram of tissue was combined with the acids, heated on a hot plate to a total colorless solution, and diluted with deionized water up to 50 ml. An atomic absorption with a single slot burner head that is capable of operating at the following wave lengths in nm: 324.8 for Cu and Cd, 248.3 for Fe and Pb, and 213.9 for Zn, was used (Arafa et al., 2014).

Fish sample A. Sample collection and preparation Two hundred fish samples were randomly taken from fish ponds. Fifty samples were taken from each pond monthly. Dorsolateral muscles were rapidly removed from each fish sample and stored in plastic containers at -20°C for heavy metals residue and trace element analysis (Klavins et al., 2009).

C. Biochemical analysis: Tissues were homogenized and ground into a powder. 0.1 g of each dry tissue was weighed out and transferred into a 100 cm3 Pyrex beaker. 5 cm3 of concentrated nitric acid was added, and the beaker with its contents was placed on a hot plate and heated at 400°C. After heating for 15 minutes, another 5 cm3 of concentrated nitric acid and 10 cm3 of concentrated sulfuric acid were added, and the temperature of the plate was gradually increased to 1000°C. The solution was set aside after 20 minutes of heating, cooled, and diluted with 10 cm3 of distilled water. The resulting solution was boiled until all the tissues were dissolved, and then set to cool. The digest was transferred into a 100 cm3 volumetric flask and made up to the mark with distilled water. The digests were kept in plastic bottles, and later, the heavy metal concentrations were determined using an Alpha 4 atomic absorption spectrophotometer (Sani, 2011).

D. Evaluation of Growth Performance Parameters: To determine the growth performance of the fish after the feeding trial, several parameters were measured, including the survival rate (SR), weight gain (WG), and specific growth rate (SGR). The following equations were used:

Survival rate = (number of live fishes / total initial number of fish) × 100

Weight Gain (WG) = final fish weight (g) – initial fish weight (g) (Zhang et al., 2012)

Specific Growth Rate (SGR) = [(ln final body weight - ln initial body weight) / feeding days] ×100

E. Statistical Analysis: Data were analyzed using MS Excel (Microsoft Corporation, Redmond, WA, USA). The normality and homogeneity of variance were tested using the Levene and Shapiro-Wilk tests, respectively (Razali and Wah, 2011). One-sample t-tests were used to compare the significant differences between the permissible limits and the means of heavy metals and trace elements in water and tissue, as well as water quality (PROC TEST; SAS, version 9, Cary, NC, USA). The significant effects of the sources were examined using one-way ANOVA (PROC ANOVA) with a significance level set at $\alpha = 0.05$. Results were expressed as means ± standard error (SE), and pairwise comparisons between means were performed using Tukey's test if a significant effect was detected. Pearson correlation coefficients between mineral contents in tissue and serum were determined using PROC CORR in the same program. Statistical significance was set at a p-value less than 0.05.

Results

During the experimental period, the water quality parameters of four fishponds were evaluated. The first pond (farm1) had non-filtered water, the second pond (farm2) had cement non-filtered water, the third pond (farm3) had cement with an ordinary filter, and the fourth pond (farm4) had a fiberglass tank with a biological filter. The concentration of lead in the water was high in all fishponds, with mean values of 0.720±0.058 (farm3), 0.545±0.041 (farm4), 0.480±0.051 (farm1), and 0.530±0.078 (farm2). The concentration of cadmium in the water was also high, with mean values of 0.224±0.022 (farm1), 0.164±0.016 (farm2), 0.285±0.024 (farm3), and 0.137±0.011 (farm4). The concentration of iron was 5.65±0.143 in farm3 and decreased to 4.39±0.213 in farm1, 4.24±0.253 in farm4, and 3.95±0.321 in farm2, as shown in Table 1. Zinc concentration was highest in farm3 (0.532±0.030) and lowest in farm4 (0.257±0.026), with values of 0.420±0.055 in farm2 and 0.296±0.061 in farm1. The concentration of copper in the water was 0.187±0.004 in farm3, 0.153±0.018 in farm1, and 0.157±0.003 in farm4, but it decreased to 0.113±0.011 in farm2, as shown in Table 1. The concentration of manganese was highest in farm2 (11.500±0.500), followed by farm3 (9.000±0.577) and farm4 (10.000±0.816), and lowest in farm1 (0.011±0.002). The concentration of iodine in the water was highest in farm3 (15.54±0.601), followed by farm2 (14.28±0.800), and then decreased in farm4 (11.10±0.952) and farm1 (12.65±0.891). This study analyzed the physical properties of water samples collected from four different farms. The pH levels in farm 3 were the highest, with a mean concentration of 8.10±0.183. The pH levels in farms 1, 2, and 4 were lower, with mean concentrations of 6.8±0.122, 7.20±0.164, and 7.00±0.141, respectively.

Table 1: heavy metals and trace elements in water (mg/l).

Parameters	Farm	Min.	Max.	Mean ± SE	Samples above the permissible limits		*p*-value*
					n	%	
Lead	Farm1	0.33	0.62	0.480 ± 0.051^{b}	5	100	0.001
	Farm2	0.36	0.70	0.530 ± 0.078^{b}	5	100	0.001
	Farm3	0.60	0.86	0.720 ± 0.058^{a}	5	100	0.001
	Farm4	0.43	0.62	0.545 ± 0.041^{ab}	5	100	0.001
Cadmium	Farm1	0.18	0.31	0.224 ± 0.022^{ab}	5	100	0.001
	Farm2	0.11	0.19	0.164 ± 0.016^{bc}	5	100	0.001
	Farm3	0.23	0.34	0.285 ± 0.024^{a}	5	100	0.001
	Farm4	0.11	0.16	0.137 ± 0.011^{c}	5	100	0.001
Iron	Farm1	3.74	5.025	4.39 ± 0.213^{b}	5	100	0.001
	Farm2	3.35	4.75	3.95 ± 0.321^{b}	5	100	0.001
	Farm3	5.36	6.03	5.65 ± 0.143^{a}	5	100	0.001
	Farm4	3.68	4.85	4.24 ± 0.253^{b}	5	100	0.001
Zinc	Farm1	0.19	0.52	0.296 ± 0.061^{bc}	0	0	0.001
	Farm2	0.26	0.52	0.420 ± 0.055^{ab}	0	0	0.001
	Farm3	0.45	0.58	0.532 ± 0.030^{a}	0	0	0.001
	Farm4	0.19	0.32	0.257 ± 0.026^{c}	0	0	0.001
Cu	Farm1	0.114	0.209	0.153 ± 0.018^{a}	1	20	0.001
	Farm2	0.095	0.140	0.113 ± 0.011^{b}	0	0	0.001
	Farm3	0.178	0.197	0.187 ± 0.004^{a}	0	0	0.001
	Farm4	0.153	0.165	0.157 ± 0.003^{a}	0	0	0.001
Mn	Farm1	0.008	0.018	0.011 ± 0.002^{c}	0	0	0.001
	Farm2	10	12	11.500 ± 0.500^{a}	5	100	0.001
	Farm3	8	10	9.000 ± 0.577^{b}	5	100	0.001
	Farm4	8	12	10.000 ± 0.816^{ab}	5	100	0.001
Iodine	Farm1	11.4	15.2	12.65 ± 0.891^{bc}	0	0	0.001
	Farm2	12.69	16.5	14.28 ± 0.800^{ab}	0	0	0.001
	Farm3	13.96	16.5	15.54 ± 0.601^{a}	0	0	0.001
	Farm4	10.15	13.96	11.10 ± 0.952^{c}	0	0	0.001

** p-value was calculated according to one sample t test; a,b Means with different superscripts in the same row are significantly different (p<0.05, Tukey HSD test).*

The mean concentration of total solids in water was highest in farms 1 and 2, with values of 3.1±0.007 and 2.9±0.005, respectively. However, there was a significant decline in farms 3 and 4, with mean concentrations of 2.1±0.004 and 1.8±0.004, respectively. The concentration of calcium in water was highest in farm 1, with a mean of 48.3±1.432. Farms 2 and 3 had lower concentrations, with means of 39.6±1.317 and 23.4±1.250, respectively. Farm 4 had the lowest concentration, with a mean of 13.9±0.633. Calcium carbonate concentration was highest in farm 1, with a mean of 120.7±2.310. Farms 2 and 3 had lower concentrations, with means of 99±2.125 and 58.5±1.81, respectively. Farm 4 had the lowest concentration, with a mean of 34.7±1.552. Magnesium concentrations were highest in farm 1, with a mean of 12.3±0.475, and lowest in farm 3, with a mean of 2.4±0.105. Farms 2 and 4 had intermediate concentrations, with means of 6.8±0.222 and 3.9±0.117, respectively. The concentration of magnesium carbonate was highest in farm 1, with a mean of 41.8±1.644. Farms 2 and 4 had lower concentrations, with means of 23.12±1.102 and 13.2±0.417, respectively. Farm 3 had the lowest concentration, with a mean of 8.16±0.385. Sulfate concentrations were highest in farm 1, with a mean of 400±4.624, and lowest in farms 3 and 4, with means of 100±2.611 and 100±2.435, respectively. Nitrite concentrations were highest in farm 1, with a mean of 0.92±0.003, and lowest in farm 4, with a mean of 0.02±0.000. Farms 2 and 3 had intermediate concentrations, with means of 0.52±0.001 and 0.3±0.001, respectively. Chloride concentrations were highest in farm 2, with a mean of 100±2.171, and lowest in farm 4, with a mean of 50±1.712. Farms 1 and 3 had intermediate concentrations, with means of 80±2.01 and 65±1.927, respectively.

Table 2: physical analysis of water (mg/l).

Parameters	Farm	Min.	Max.	Mean ± SE	Samples above the permissible limits		*p*-value*
					n	%	
PH	Farm1	6.56	7.01	6.8 ± 0.122^{b}	0	0	ND
	Farm2	7.10	7.44	7.20 ± 0.164^{ab}	0	0	ND
	Farm3	7.66	8.52	8.10 ± 0.183^{a}	0	0	ND
	Farm4	6.87	7.11	7.00 ± 0.141^{ab}	0	0	ND
Total solid	Farm1	2.89	3.31	3.1 ± 0.007^{a}	0	0	0.001
	Farm2	2.61	3.21	2.9 ± 0.005^{a}	0	0	0.001
	Farm3	1.85	2.32	2.1 ± 0.004^{b}	0	0	0.001
	Farm4	1.62	2.10	1.8 ± 0.004^{b}	0	0	0.001
Calcium	Farm1	46.85	50.22	48.3 ± 1.432^{a}	0	0	ND
	Farm2	37.96	40.63	39.6 ± 1.317^{a}	0	0	ND
	Farm3	22.10	24.63	23.4 ± 1.250^{b}	0	0	ND
	Farm4	13.25	14.62	13.9 ± 0.633^{c}	0	0	ND
CaCo3	Farm1	117.86	124.10	120.7 ± 2.310^{a}	5	100	ND
	Farm2	96.33	101.56	99 ± 2.125^{a}	5	100	ND
	Farm3	56.32	60.53	58.5 ± 1.812^{b}	5	100	ND
	Farm4	33.12	35.98	34.7 ± 1.552^{c}	5	100	ND
Mg	Farm1	11.86	12.81	12.3 ± 0.475^{a}	0	0	ND
	Farm2	6.53	7.22	6.8 ± 0.222^{b}	0	0	ND
	Farm3	2.12	2.72	2.4 ± 0.105^{d}	0	0	ND
	Farm4	3.63	4.23	3.9 ± 0.117^{c}	0	0	ND
MgCo3	Farm1	39.69	43.55	41.8 ± 1.644^{a}	5	100	ND
	Farm2	22.12	24.22	23.12 ± 1.102^{b}	5	100	ND
	Farm3	7.79	8.62	8.16 ± 0.385^{d}	0	0	ND
	Farm4	12.74	13.75	13.2 ± 0.417^{c}	0	0	ND
Sulphate	Farm1	395.01	405.27	400 ± 4.624^{a}	5	100	ND
	Farm2	246.55	254.22	250 ± 3.338^{b}	5	100	ND
	Farm3	97.89	102.81	100 ± 2.611^{c}	1	20	ND
	Farm4	97.92	102.60	100 ± 2.435^{c}	1	20	ND
Nitrite	Farm1	0.90	0.94	0.92 ± 0.003^{a}	5	100	ND
	Farm2	0.48	0.55	0.52 ± 0.001^{ab}	5	100	ND
	Farm3	0.28	0.34	0.3 ± 0.001^{b}	1	20	ND
	Farm4	0.01	0.03	0.02 ± 0.000^{c}	0	0	ND
Chloride	Farm1	77.91	82.17	80 ± 2.014^{b}	0	0	ND
	Farm2	79.57	103.62	100 ± 2.171^{a}	1	20	ND
	Farm3	63.55	67.85	$65 \pm 1.927b^{c}$	0	0	ND
	Farm4	48.36	52.04	50 ± 1.712^{c}	0	0	ND

*ND: non–determined due to the wide range of permissible limits. * p-value was calculated according to one sample t test; a,b Means with different superscripts in the same row are significantly different (p<0.05, Tukey HSD test).*

Table 3 presents the concentrations of heavy metals and trace elements in the muscles of fish from different farms. The concentration of lead in fish muscles was highest in farm 1 (0.040±0.009) and decreased in farm 4 (0.020±0.004), farm 3 (0.019±0.001), and farm 2 (0.014±0.001). The concentration of cadmium in fish muscles was highest in farm 3 (0.022±0.002), followed by farm 1 (0.020±0.004), farm 4 (0.020±0.001), and farm 2 (0.017±0.002). The concentration of iron was highest in farm 3 (0.100±0.003) and decreased in farm 4 (0.045±0.010), farm 2 (0.047±0.012), and farm 1 (0.034±0.011). The concentration of zinc was highest in farm 2 (0.012±0.002), followed by farm 3 (0.007±0.000), farm 4 (0.007±0.000), and farm 1 (0.002±0.000). The concentration of copper was highest in farm 2 (0.057±0.001) and farm 1 (0.049±0.006) and decreased in farm 3 (0.032±0.001) and farm 4 (0.022±0.001). The concentration of manganese was highest in all fish samples, with the highest concentration observed in farm 2 (2.17±0.125), followed by farm 1 (2.100±0.158), farm 3 (1.875±0.085), and farm 4 (1.830±0.028). The concentration of iodine was highest in farm 1 (0.154±0.009), followed by farm 3 (0.157±0.002) and farm 4 (0.143±0.009), and lowest in farm 2 (0.129±0.003).

Table 3: Fish muscle analysis (ug/g).

Parameters	Farm	Min.	Max.	Mean ± SE	Samples above the permissible limits		*p*-value*
					n	%	
Lead	Farm1	0.02	0.06	$0.040±0.009^a$	0	0	0.001
	Farm2	0.012	0.036	$0.014±0.001^b$	0	0	0.001
	Farm3	0.016	0.023	$0.019±0.001^b$	0	0	0.001
	Farm4	0.01	0.03	$0.020±0.004^b$	0	0	0.001
Cadmium	Farm1	0.01	0.033	0.020±0.004	0	0	0.001
	Farm2	0.011	0.022	0.017±0.002	0	0	0.001
	Farm3	0.01	0.03	0.022±0.002	0	0	0.001
	Farm4	0.019	0.022	0.020±0.001	0	0	0.001
Iron	Farm1	0.01	0.06	$0.034±0.011^b$	0	0	0.001
	Farm2	0.02	0.08	$0.047±0.012^b$	0	0	0.001
	Farm3	0.095	0.11	$0.100±0.003^a$	0	0	0.001
	Farm4	0.016	0.060	$0.045±0.010^b$	0	0	0.001
Zinc	Farm1	0.002	0.003	$0.002±0.000^c$	0	0	0.001
	Farm2	0.01	0.02	$0.012±0.002^a$	0	0	0.001
	Farm3	0.006	0.008	$0.007±0.000^b$	0	0	0.001
	Farm4	0.007	0.009	$0.007±0.000^b$	0	0	0.001
Cu	Farm1	0.03	0.06	$0.049±0.006^a$	0	0	0.001
	Farm2	0.050	0.060	$0.057±0.001^a$	0	0	0.001
	Farm3	0.029	0.036	$0.032±0.001^b$	0	0	0.001
	Farm4	0.019	0.026	$0.022±0.001^b$	0	0	0.001
Mn	Farm1	1.8	2.5	2.100±0.158	50	100	0.001
	Farm2	1.9	2.5	2.17±0.125	50	100	0.001
	Farm3	1.7	2.1	1.875±0.085	50	100	0.001
	Farm4	1.77	1.90	1.830±0.028	50	100	0.001
Iodine	farm1	0.12	0.17	$0.154±0.009^a$	0	0	0.001
	Farm2	0.12	0.14	$0.129±0.003^b$	0	0	0.001
	Farm3	0.152	0.162	$0.157±0.002^a$	0	0	0.001
	Farm4	0.133	0.162	$0.143±0.009^{ab}$	0	0	0.001

** P-value was calculated according to one sample t test; a,b Means with different superscripts in the same row are significantly different (p<0.05, Tukey HSD test).*

The growth rate of tilapia fish is presented in Table 4. At the end of the study, the mean weight of tilapia at eight months was highest in farm 4 (615.0±28.92), followed by farm 3 (567.5±18.03), farm 1 (208.50±6.95), and farm 2 (112.0±3.51). The initial weight of tilapia fish in all farms ranged from a minimum of 10 to a maximum of 16, and gradually increased, with the best growth rate observed in farm 3 and farm 4. However, in farm 1 and farm 2, the growth rate was slow due to unfiltered water.

Table 4: Growth rate of tilapia fish in 4 farms.

Parameters		Farm 1	Farm 2	Farm 3	Farm 4
		mean	mean	mean	Mean
Initial		14.00±0.58	$13.5±0.5^6$	14.00±0.56	13.2±0.73
M1		$25.60±1.11^{ab}$	$22.1±0.71^b$	$29.5±1.74^a$	$28.00±2.00^a$
M2		$47.3±2.44^a$	$29.8±1.57^b$	$48.5±2.06^a$	$53.5±2.39^a$
M3		$104.5±4.08^b$	$48.00±1.14^c$	$100.8±6.79^b$	$123.5±8.95^a$
M4		$133.5±4.5^b$	$48.1±2.51^c$	$207.50±6.92^a$	$226.5±12.25^a$
M5		$172.00±4.42^c$	$64.90±2.12^c$	$279.80±7.48^b$	$302.00±11.92^a$
M6		$189.00±3.25^b$	$63.03±2.73^c$	$417.00±13.00^a$	$437.00±11.65^a$
M7		$192.08±8.62^c$	$82.90±1.41^d$	$466.0±10.27^b$	$553.00±16.47^a$
M8		$208.50±6.95^b$	$112.0±3.51^c$	$567.5±18.03^a$	$615.0±28.92^a$
Number of fish in the pond		70000	200	200	1500
Mortality rate	N	14000	100	10	30
	%	20%	50%	5%	1 -2 %

Body weight gain is high in small age fish and decreases in large age fish. Additionally, long-term exposure of fish to water containing heavy metals affects fish health. The results of body weight gain of tilapia in Table 5 indicate that there were significant differences in gain. The body gain of farm 4 and farm 3 was significantly higher during the experimental period. However, the lowest body gain was recorded in farm 2. The weight gain of farm 2 declined in months 4 and 6, and the weight gain of farm 1 decreased in month 7. In farm 1, body weight increased at first but decreased at ages 7 and 8 months. In farm 2, the body weight gain decreased at ages 4 and 6 months. In farm 3 and farm 4, the body weight gain was good. The total gain of farm 4 was significantly the highest, but the lowest total gain was recorded in farm 2. The total body weight gain was farm 1 (1945.00±6.50), farm 2 (985.00±3.05), farm 3 (5535.00±17.64), and farm 4 (6018.00±28.3).

Table 5: Body weight gain.

Parameter	Farm1			Farm2			Farm3			Farm4		
	Min.	Max.	Mean.	Min.	Max.	Mean.	Min.	Max.	Mean.	Min.	Max.	Mean.
1M	10	14	$11.60±0.65^b$	10	10	$8.60±0.40^b$	25	10	$15.5. ±1.34^a$	10	25	$14.80±1.49^a$
2M	15	30	$21.7±1.48^b$	0	10	$7.70±1.07^c$	20	20	$19.00±0.73^b$	20	25	$25.50±1.38^a$
3M	50	65	$57.20±1.58^b$	20	17	$18.20±0.53^c$	90	40	$52.30±4.89^b$	40	105	$70.00±6.67^a$
4M	35	20	$29.00±1.80^b$	0	8	$4.30±0.94^c$	100	100	$106.70±1.56^a$	100	120	$103.00±4.90^a$
5M	45	55	$38.50±1.50^b$	15	15	$16.80±0.63^c$	50	45	$72.30±2.80^a$	70	90	$75.50±4.86^a$
6M	15	10	$17.00±1.41^b$	0	15	$2.60±0.79^b$	200	125	$137.20±8.55^a$	150	110	$135.00±6.71^a$
7M	-5	40	$12.80±3.82^c$	20	10	$19.60±1.60^c$	0	50	$49.00±6.45^b$	50	110	$109.00±7.67^a$
8M	10	0	$15.70±2.93^c$	25	140	$29.10±2.22^c$	155	100	$101.50±9.69^a$	50	200	$69.00±17.48^b$
Total.			$1945.00±6.50^b$			$985.00±3.05^c$			$5535.00±17.64^a$			$6018.00±28.3^a$

The mortality rate of tilapia fish in four different farming systems is presented in Table 4. Farm 1 was an earthen pond located in Balat city, where the water was obtained from a deep well at a depth of 1000m and was not filtered. The initial number of tilapia fish in this pond was 70,000, but the mortality rate during the experimental period was 14,000, which is approximately 20%. Farm 2 was a cement pond that used water from a superficial well at a depth of 150m without filtration. The initial number of tilapia fish was 200, but the mortality rate during the experimental period was 100, which is approximately 50%. Farm 3 was a cement pond that used water from a superficial well and was filtered using an ordinary filter made of sand and stone. The initial number of fish was 200, and the mortality rate during the experimental period was 10, which is approximately 5%. Farm 4 was a fibreglass tank with a biological filter, and the initial number of fish was 1500. The mortality rate during the experimental period was 30, which is approximately 1-2%.

Discussion

Groundwater can serve as a sustainable and alternative water resource for various human activities such as agriculture, industry, and other needs, especially during situations of water scarcity (Al-Taei, 2015). However, the availability of such resources is limited, and they can only satisfy urgent life needs (Al-Taei, 2015). Heavy metal pollution in aquatic habitats has become a serious problem, with heavy metal poisoning of aquatic habitats becoming a significant issue for humankind. This has been caused by rapid population growth, urbanization, industrialization, exploration and exploitation of natural resources, expansion of irrigation, and other modern agricultural practices, as well as a lack of environmental regulation (Idowu, 2020).

A study found significant differences in cadmium concentrations between water from farm 4 and other sources, with all concentrations exceeding permissible limits. This agrees with Sonousi (2002), Abumourade et al. (2013), Omar (2015), and Boateng et al. (2019). However, Ahmed et al. (2010) and Sharma et al. (2022) found no cadmium in water samples. Iron concentrations were also higher than permissible limits in all sources, with the highest concentration in farm 3. This agrees with Sonousi (2002), Omar (2015), Boateng et al. (2019), Hussen (2019), and Sharma et al. (2022), but differs from Ahmed et al. (2010).

Table 1 shows Zinc concentrations in water from different sources. The lowest concentration was found in farm 4 and all concentrations were below WHO (2008) permissible limits. These findings agree with Sonousi (2002), Prasad et al. (2014), Boateng et al. (2019), Hussen (2019), Tibebe et al. (2019), and Sharma et al. (2022). However, Abumourad et al. (2013) found higher concentrations and Malassa et al. (2014) reported concentrations within WHO limits. Copper concentrations in water from farm 1, farm 2, and farm 4 were similar and below WHO permissible limits. This agrees with Sonousi (2002), Prasad et al. (2014), Boateng et al. (2019), and Tibebe et al. (2019). However, Oyekul and Eludoyin (2010) and Abumourad et al. (2013) found higher concentrations. Manganese concentrations in water from farm 1 were below permissible limits while other sources were significantly higher. These results are like Prasad et al. (2014) and Sharma et al. (2022). However, Ahmed et al. (2010) and Malassa et al. (2014) found concentrations within WHO limits. Table 1 shows that Iodine concentration in water from farm 3 was higher than in other sources and all concentrations were below permissible limits. Reports of high Iodine in groundwater are rare (Wang et al., 2013). Table 2 shows no significant differences in total solids between water from farm 2 and farm 1 or between farm 3 and farm 4. All total solids values were lower than permissible limits (FAO 1992) and Araffa et al. (2014) reported normal total solids. Calcium concentrations in water from farm 1 and well differed significantly from farm 4 and farm 3 and all concentrations were within permissible limits (Snousi (2002) and Sale et al. (2019). Calcium carbonate concentrations also differed significantly between these sources and were higher than permissible limits Araffa et al. (2014). Magnesium concentrations in water from farm 2, farm 1, farm 3, and farm 4 differed significantly with the highest concentration in farm 1. All concentrations in water from farm 1 and well were within permissible limits Araffa et al. (2014). Magnesium carbonate concentrations also differed significantly between these sources with the highest concentration in farm 1. Concentrations in water from farm 1 and well were higher than permissible limits while other sources were within limits Sonousi (2002) and Araffa et al. (2014). Sulfate concentrations in water from farm 1 and farm 2 were higher than in farm 3 and farm 4. Concentrations in water from farm 1 and farm 2 were higher than permissible limits while other sources were within limits (Sale et al. (2019), Araffa et al. (2014), and Ahmad et al. (2010)). Nitrite concentrations in water from Farm 1 and well were similar and higher than permissible limits. Concentrations in water from Farm 4 differed significantly from other sources. Concentrations in water from Farm 3 were within permissible limits (Sale et al. (2019), Araffa (2014) and Ahmed et al. (2010)). Chloride concentration in well water differed significantly from other sources and all values were within permissible limits (Sonousi (2002), Sharma et al. (2022), Karthik et al. (2019) and Ahmed et al. (2010)). Lead concentration in fish tissue from Farm 1 was significantly higher than in other sources. All concentrations were lower than permissible limits (Fotedar et al. (2013), Taweel et al. (2013), Tibebe et al. (2019), Nwude (2020) and Ibemenuga et al. (2019)). However, some studies reported higher lead content in fish than WHO permissible limit (Abumourad et al. (2013), Hamada et al. (2018), Ibrahim et al. (2018), Morshdy (2019) and Abdel-Kader et al. (2020)). Cadmium concentrations in fish muscle from different water sources did not differ significantly and were lower than permissible limits Tibebe et al. (2019), Ibemenuga et al. (2019), and Nwude et al. (2020). However, some studies found higher concentrations Dural et al. (2007), Abumourad et al. (2013), Hamada et al. (2018), Ibrahim et al. (2018) and Morshdy (2019). Iron concentrations in fish muscle from farm1, well, and farm4 were similar and lower than permissible limits Nwude et al. (2020). Zinc concentrations in fish muscle from farm3 and farm4 were similar and lower than permissible limits Ibemenuga et al. (2019), Nofal et al. (2019), Tibebe et al. (2019) and Nwude et al. (2020). However, some studies found higher Zinc concentrations Aldoghachil (2006) and Abumorad et al. (2013). Copper concentrations in fish muscle from farm3 and farm4 were similar and lower than permissible limits Taweel et al. (2013), Nofal et al. (2019) and Tibebe et al. (2019). Manganese concentrations in fish muscle from all sources were not significantly different and were higher than permissible limits. Metals in skeletal tissues, otoliths, and lenses can identify environmental contamination Lall (2022).

Conclusion

It can be concluded that the fishponds in the studied area were contaminated with high levels of heavy metals, which can have negative impacts on both fish health and human health when consumed. Therefore, it is recommended that more attention should be paid to using proper filtration methods to eliminate these heavy metals from groundwater before using it in fishponds. This can help to reduce the pollution levels in the fish and ensure that they are safe for consumption.

Conflict of interest

The authors haven't conflict of interest to declare.

References

Ahmed, M. J., Ahsan, A., Haque, M. R., Siraj, S., Bhuiyan, M. H. R., Bhattacharjee, S. C., & Islam, S. (2010). Physicochemical assessment of surface and groundwater quality of the greater Chittagong region of Bangladesh. Pakistan Journal of Analytical & Environmental Chemistry, 11(2), 11

Abdel-Gawad, F. K., Khalil, W. K., Bassem, S. M., Kumar, V., Parisi, C., Inglese, S., ... & Guerriero, G. (2020). The duckweed, lemna minor modulates heavy metal-induced oxidative stress in the Nile Tilapia, Oreochromis niloticus. Water, 12(11), 2983.

Abdel-Kader, H. H., & Mourad, M. H. (2020). Trace elements exposure influences proximate body composition and antioxidant enzyme activities of the species tilapia and catfish in Burullus Lake—Egypt: human risk assessment for the consumers. Environmental Science and Pollution Research, 27(35), 43670-43681.

Abumourad, I. M., Authman, M. M., & Abbas, W. T. (2013). Heavy metal pollution and metallothionein expression: a survey on Egyptian tilapia farms. Journal of Applied Sciences Research, 9(1), 612-619.

Aldoghachi, M. A., Rahman, M. M., Yusoff, I., & Sofian-Azirun, M. (2016). Acute toxicity and bioaccumulation of heavy metals in red tilapia fish. JAPS: Journal of Animal & Plant Sciences, 26(2).

Al-Taei, S. R. (2015). Examination of Several physiochemical characteristics of underground water collected from various wells situated south Baghdad-IRAQ. Journal of Biology, Agriculture and Healthcare, 5(8), 148-155.

Atwood, H. L., Fontenot, Q. C., Tomasso, J. R., & Isely, J. J. (2001). Toxicity of nitrite to Nile tilapia: effect of fish size and environmental chloride. North American Journal of Aquaculture, 63(1), 49-51.

Baboli, M. J., Velayatzadeh, M., & Branch, A. (2013). Determination of heavy metals and trace elements in the muscles of marine shrimp, Fenneropenaeus merguiensis from Persian Gulf, Iran. Journal of animal and plant sciences, 23(3), 786-791.

Barriga-Sosa, I. D. L. A., Jiménez-Badillo, M. D. L., Ibanez, A. L., & Arredondo-Figueroa, J. L. (2004). Variability of tilapias (Oreochromis spp.) introduced in Mexico: morphometric, meristic, and genetic characters. Journal of Applied Ichthyology, 20(1), 7-14.

Boateng, T. K., Opoku, F., & Akoto, O. (2019). Heavy metal contamination assessment of groundwater quality: a case study of Oti landfill site, Kumasi. Applied water science, 9(2), 1-15.

Ciji, A., & Akhtar, M. S. (2020). Nitrite implications and its management strategies in aquaculture: A review. Reviews in Aquaculture, 12(2), 878-908.

Dang F, Wang WX (2009) Assessment of tissue-specific accumulation and effects of cadmium in a marine fish fed contaminated commercially produced diet. Aquat Toxicol 95:248–255.

Dural, M., Göksu, M. Z. L., & Özak, A. A. (2007). Investigation of heavy metal levels in economically important fish species captured from the Tuzla lagoon. Food chemistry, 102(1), 415-421.

Eid, R., Arab, N. T., & Greenwood, M. T. (2017). Iron mediated toxicity and programmed cell death: A review and a re-examination of existing paradigms. Biochimica et Biophysica Acta (BBA)-Molecular Cell Research, 1864(2), 399-430.

FAO (1985); Water Quality for Agriculture. Irrigation and Drainge Paper No .29, Rev.1. Food and Agriculture Organization of the United Nations, Rome.

FAO/WHO (1984); List of maximam level recommended for contaminats by the Jiont FAO/WHO CodexAlimentarius commission. Second Series. CAC/FAL, Rome3;1-8.

FAO/WHO (1992); Codex Alimentarius commission,standard programme codex committee on food additives and contaminates.24th session,Hague,23-28888 March ,1992.

Hamada, M. G., Elbayoumi, Z. H., Khader, R. A., & M Elbagory, A. R. (2018). Assessment of Heavy Metal Concentration in Fish Meat of Wild and Farmed Nile Tilapia (Oreochromis Niloticus), Egypt. Alexandria Journal for Veterinary Sciences, 57(1).

Hussen, M. G. (2019). Effect of ground water in New Valley province on some performance and immune parameters in broiler chickens. Master thesis in veterinary science, Assuit university.

Ibemenuga, K. N., Ezike, F. A., Nwosu, M. C., Anyaegbunam, L. C., Okoye, E. I., & Eyo, J. E. (2019). Bioaccumulation of some heavy metals in some organs of three selected fish of commercial importance from Niger river, Onitsha shelf, Anambra state, Nigeria. Journal of FisheriesSciences. com, 13(3), 0-0.

Ibrahim, D., Ibrahim, A. S., Paul, E. D., Umar, M., & Zannah, U. A. S. (2018). Determination of some heavy metal content in tilapia and catfish species in lake Njuwa, Adamawa state, Nigeria. Journal of Applied Sciences and Environmental Management, 22(8), 1159-1165.

Idowu, S. O., & Towler, B. A. (2004). A comparative study of the contents of corporate social responsibility reports of UK companies. Management of Environmental Quality: an international journal.

Jezierska, B., & Witeska, M. (2001). Metal toxicity to fish. Monografie. University of Podlasie (Poland).

Karthik, K., Mayildurai, R., Mahalakshmi, R., & Karthikeyan, S. (2019). Physicochemical Analysis of Groundwater Quality of Velliangadu Area in Coimbatore District, Tamilnadu, India. Rasayan Journal of Chemistry, 12(02), 409-414.

Klavins, M., Potapovics, O., & Rodinov, V. (2009). Heavy metals in fish from lakes in Latvia: concentrations and trends of changes. Bulletin of environmental contamination and toxicology, 82(1), 96-100.

Lall, S. P. (2022). The minerals. In Fish nutrition (pp. 469-554). Academic Press

Lall, S. P., & Milley, J. E. (2008). Trace mineral requirements of fish and crustaceans. Trace elements in animal production systems, 203.

Le KT, Fotedar R, Partridge G (2013). Selenium and vitamin E interaction in the nutrition of yellowtail kingfish (Seriola lalandi): physiological and immune responses. Aquac Nutr 20(3):303–313.

Lima, R. L. D., Braun, N., Kochhann, D., Lazzari, R., Radünz Neto, J., Moraes, B. S., ... & Baldisserotto, B. (2011). Survival, growth, and metabolic parameters of silver catfish, Rhamdia quelen, juveniles exposed to different waterborne nitrite levels. Neotropical Ichthyology, 9, 147-152.

Lv, S., Wang, Y., Xu, D., Rutherford, S., Chong, Z., Du, Y., ... & Zhao, J. (2013). Drinking water contributes to excessive iodine intake among children in Hebei, China. European journal of clinical nutrition, 67(9), 961-965.

Malassa, H., Hadidoun, M., Al-Khatib, M., Al-Rimawi, F., & Al-Qutob, M. (2014). Assessment of groundwater pollution with heavy metals in Northwest Bank/Palestine by ICP-MS.

Mason,R.G. and Simkiss,K.O.(1983);Cold-blooded vertebrate cell and tissue culture. In Jacoby, W.B; Pastan, I. H. eds. Methods of enzymatology, Vol.58. Cell culture. New York; Academic Press, 58;466-477.

Mohammed M. Hossam Abd El.Galil &Mahmoud Araffa (2014). Heavy metals levels in catfish. Alexanderia University.

Morshdy, A. E., Darwish, W. S., Daoud, J. R. M., & Sebak, M. A. M. (2019). Estimation of metal residues in Oreochromis niloticus and Mugil cephalus intended for human consumption in Egypt: a health risk assessment study with some reduction trials. Journal of consumer protection and food safety, 14(1), 81-91

NCarlsen, M. H., Andersen, L. F., Dahl, L., Norberg, N., & Hjartåker, A. (2018). New iodine food composition database and updated calculations of iodine intake among Norwegians. Nutrients, 10(7), 930.

Nofal, M. I., Zaki, V. H., Ahmed, N. A. S., Abed-Aziz, A. F., & Rashad, M. M. (2019). Effects of heavy metal pollution on Nile tilapia in Manzala farm: oxidative stress biomarkers and histopathological findings. Int J Fish Aquat Stud, 7, 315-328.

Nwude, D. O., Babayemi, J. O., & Ajibode, C. P. (2020). Heavy Metals Level in Clarias gariepinus (Catfish), Oreochromis niloticus (Tilapia) and Chrysichthys nigroditatus (Bagrid catfish) collected from Ogun River, Ogun State, Nigeria. Journal of Applied Sciences and Environmental Management, 24(8), 1433-1440.

Omar, E. A. (2015). Relationship between lead, cadmium and iron levels in cow milk and drinking wells water in the New Valley. Master thesis in veterinary science, Assiut university.

Oyeku, O. T., & Eludoyin, A. O. (2010). Heavy metal contamination of groundwater resources in a Nigerian urban settlement. African Journal of Environmental Science and Technology, 4(4).

Perkin Elemer,USA,(1982); Effect of probiotics supplementation with or without enzymes on the performance of male broiler chicks.M. V. Sc.Thesis submitted to ANGR Agricultural University,Hyderabad.

Prasad, B., Kumari, P., Bano, S., & Kumari, S. (2014). Ground water quality evaluation near mining area and development of heavy metal pollution index. Applied water science, 4(1), 11-17.

Pretto A, Loro VL, Morsch VM, Moraes BS, Menezes C, Santi A, Toni C (2014). Alterations in carbohydrate and protein metabolism in silver catfish (Rhamdia quelen) exposed to cadmium. Ecotoxicol Environ Safe 100:188–192

Razali, N.M.;Wah, Y.B. Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests. J. Stat.Modeling Anal. 2011, 2, 21–33.

Sale, J. F., Yahaya, A., Ejim, C. C., & Okpe, I. W. (2019). Physicochemical assessment of water quality in selected borehole in Anyigba Town, Kogi State, Nigeria. Journal of Applied Sciences and Environmental Management, 23(4), 711-714.

Sani, U. (2011). Determination of some heavy metals' concentration in the tissues of Tilapia and Catfishes. Biokemistri, 23(2).

SAS Institute Inc. SAS/STAT Statistics user's guide. Statistical analytical system, 5th rev ed. Cary, NC, USA: SAS Institute Inc; 2012.

Singh, S., Sharma, P., Mudhulkar, R., Chakravorty, B., & Singh, A. (2022). Assessment of hydrogeochemistry and arsenic contamination in groundwater of Bahraich District, Uttar Pradesh, India. Arabian Journal of Geosciences, 15(1), 1-18.

Song ZX, Jiang WD, Liu Y, Wu P, Jiang J, Zhou XQ, Kuang SY, Tang L, Tang WN, Zhang YA, Feng L (2017). Dietary zinc deficiency reduced growth performance, intestinal immune and physical barrier functions related to NF-κB, TOR, Nrf2, JNK and MLCK signaling pathway of young grass carp (Ctenopharyngodon idella). Fish Shellfish Immunol 66:497–523.

Sounosi., S.A.M. (2002). Survey on some Toxicological problem Hazards in "El Dakhla"-Egypt. Ph.D. in Veterinary Medical science, Forensic Medicine, Toxicology and Veterinary Regulation, Faculty of Veterinary medicine, Cairo University

Taweel, A., Shuhaimi-Othman, M., & Ahmad, A. (2013). Evaluation of copper, lead and arsenic level in tilapia fish in Cempaka Lake (Bangi, Malaysia) and human daily/weekly intake. Biologia, 68(5), 983-991.

Tibebe, D., Lemma, D., & Teshome, G. (2019). Determination of Heavy Metals in Tilapia (Oreochromis Niloticus) and Water Samples from Lake Hayq, South Wollo, Ethiopia. International Journal of Chemistry and Materials Research, 7(1), 10-19.

United states Public Health Service Drinking Water Standards (1964); Reved.PHS, Publ. No .956,U.S.Government Printing .Office .Washington ,D.C.(cited after Abd El –Kader ,M.A.1983

Vieira, M. C., Torronteras, R., Córdoba, F., & Canalejo, A. (2012). Acute toxicity of manganese in goldfish Carassius auratus is associated with oxidative stress and organ specific antioxidant responses. Ecotoxicology and environmental safety, 78, 212-217.

WHO (World Health Organization). Guidelines for drinking water quality4thedn, http://www.who.int/water_sanitation_health/publications/2011/dwq_guidelines/en/(2011)

WHO (2008); Guidelines for drinking water quality, World Health Organization, Geneva.

Wong CK and Wong MH (2000). Morphological and biochemical changes in the gills of Tilapia (Oreochromis mossambicus) to ambient cadmium exposure. Aquatic Toxicol. 48(4): 517-527.

Zhang, J., Liu, Y., Tian, L., Yang, H., Liang, G., & Xu, D. (2012). Effects of dietary mannan oligosaccharide on growth performance, gut morphology, and stress tolerance of juvenile Pacific white shrimp, Litopenaeus vannamei. Fish & shellfish immunology, 33(4), 1027-1032.