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MICROBIOLOGICAL AND PHYSICO-CHEMICAL STUDIES ON SOME FISHES GROWN IN DIFFERENT LEVELS OF TREATED SEWAGE WATER

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ABSTRACT: The effect of different levels of treated sewage water after mixing with dechlorinated tap water at concentrations 0.0, 25, 50, 75 and 100% on the microbial load, water quality and some heavy metals (Pb, Cd, Cu & Fe) in water samples and some organs (skin, muscle and gills) of Nile tilapia; *Oreochromis niloticus* and common carp; *Cyprinus carpio* for 60 days were tested. Fish weight gain, specific growth rate and survival were determined. The results showed a decrease in the total bacterial counts in tap water and different levels of treated sewage water from the 1st day towards the end of the experiment except in complete treated sewage water (100%), in which the total bacterial counts were fluctuated throughout all periods. However, the counts of some microorganisms in the fish organs tend to decrease in those reared in dechlorinated tap water and increased in all treated sewage water levels especially at 100%. The bacterial load in tilapia or carp was the highest in the gills, followed by skin and then muscles. Also, the pathogenic bacteria was recorded high numbers in the gills followed by skin and absent partially in the muscle except in the level 100% sewage water was recorded low numbers. Dissolved oxygen recorded very low concentrations in the treated sewage water (100% sewage water) while, BOD_5 reach its maximum. The same trend hold true in nitrates ammonia, total phosphate, total hardness and total alkalinity. The tested heavy metals in the treated sewage water exceed the permissible limits according to WHO.

Key words: Fish, sewage water, microbiology, pathogenic bacteria, water quality, heavy metals.

INTRODUCTION

Recycling of domestic sewage water in fish farming and agriculture is an effective form of pollution control, which contributes to cost recovery and provides cheap protein food production. Reuse of treated sewage water in fish farming has been applied in experimental systems as well as full-scale (Hejkal *et al.*, 1983; Polprasert *et al.*, 1984 and Shereif *et al.*, 1995). Use of raw domestic sewage or effluent from treatment plants in fish farming is being applied in many Asian countries. At least two-thirds of the world production of farmed fish was coming from ponds fertilized with animal and human waste (Mara and Cairncross, 1989). Although there are no proven cases of human bacterial disease being transmitted via fish culture from fish farms using animal wastes or human sewage, in some countries public health risks are the main reason for rejection of such reuse of waste. Disposal of toxic chemicals used in industries has imposed serious problems with water pollution, since these chemicals are directly discharged into sewer systems (Worobec and Hogue, 1999). Urban sewage contains toxic heavy metals, which are not removed properly during the traditional treatment of sewage (Chen *et al.*, 2005). Therefore, removal of these toxic heavy metals from primary and secondary treated sewage has drawn the attention of workers (Sinha *et al.*, 1996 and Weis & Weis, 2004). Analytical results revealed that wastewater effluent from these traditional treatment plants contains heavy metals, i.e., Cd, Cu, Fe and Pb. Edwards and Pullin (1990) gave a current knowledge on the various fish species which can be cultured in ponds fed with human waste. It would appear that considerable confusion still exists with regard to fish feeding on natural food. Bacteria, however, do not usually cause infection unless more than 10^3 infectious cells are ingested (USEPA, 1992). Isolates that were detected in numbers high enough to worry about were *Clostridium*, *Escherichia, Klebsiella, Pseudomonas, Salmonella, Shigella* and *Staphylococcus*. These pathogens may pose a risk through cross-contamination of the fish flesh or other edible parts. Diseases likely to affect the fish farmer and his family are dysentery, gastroenteritis, salmonellosis, typhoid and yersiniosis (Ampofo and Clerk, 2003).

Fish reared in treated domestic sewage must be examined to ensure that it is suitable for human

consumption. Fish found to be microbially contaminated could be used as fish meal for animal, fish, and poultry nutrition. At low concentrations, microorganisms are present on the surface of fish, gills, general viscera, and this might represent a source for cross-contamination during fish processing (Pillay, 1992). When microorganisms present in low numbers, pathogens are not likely to penetrate into the fish muscles (Mara & Cairncross, 1989 and Pillay, 1992).

With this background, the objective of this study was designed to investigate the physico-chemical characteristics of treated waste waters of Zagazig Domestic Sewage Treatment Station (ZDSTS) (generally regarded as safe) and its effect on the microbial load and some heavy metals in water samples and some fish organs of Nile tilapia and common carp were investigated for 60 days.

MATERIALS AND METHODS

This study was carried out in the Central Laboratory for Aquaculture Research, Abbassa, Abou-Hammad, Sharkia, governorate, Egypt, to determine the effect of different levels of treated sewage water from (ZDSTS) on the microbial load and some specific heavy metals in water samples and some fish organs of Nile tilapia and common carp for 60 days. Weight gain (WG g/fish), specific growth rate (SGR %) and survival rate % were determined.

The Experimental Design

The apparently healthy Nile tilapia; *Oreochromis niloticus* and common carp; *Cyprinus carpio* (3-15 g/fish) were collected from the nursery ponds of Central Laboratory for Aquaculture Research, Abbassa, Abou-Hammad, Sharkia, Egypt (CLAR). Fish were acclimated to laboratory conditions in indoor tanks for two weeks prior to the experiment. After the two weeks, sewage water was collected from (ZTSTS) in special plastic containers ($1m^3$ capacity) and taken immediately to site of the experiment. Twenty glass aquaria with 150-L capacity were filled with 100 liter then the aquaria were divided into two groups at room temperature according to the following regimes; 1) dechlorinated tap water (DTW) as control; 2) 75% DTW + 25% treated sewage water (TSW); 3) 50% DTW + 50% treated sewage water (TSW); 4) 25% DTW +75%

TSW and 5)100% TSW. Each regime had two replicates.

Each aquarium was stocked with 20 fishes (10 *Oreochromis niloticus* and 10 *Cyprinus carpio*) and supplied with compressed air via air-stones from air pumps. Dead fish once observed at any aquarium was removed and recorded. All fishes were offered 35% crude protein diet at a rate of 5% of live body weight for 6 days a week for 60 days. One quarter of aquarium's water was siphoned every 2 days along with fish excreta and replaced with an equal volume of water maintaining the same percentage of treated sewage water per each treatment group. In the 1st group, the stocked fish with average body weight 9-15 g/fish was maintained to study the bacteriological load and water quality as well as heavy metals concentrations in skin, muscle and gills. In the 2nd group, the stocked fish with average body weight 3.2-3.5 g/fish was maintained to study the weight gain, specific growth rate and survival rate % according to Barcellos *et al.* (2004) using the following equations:

WG (g/fish) = Final weight – Initial weight.

$SGR\ \% = 100\ (\ln W_2 - \ln W_1)T^{-1}$

Microbiological Analysis

Sampling of water

Water samples were taken from each treatment with sterile wide-mouthed 300-ml sterilized glass bottle disposal and taken to the laboratory in a thermo-insulated container for bacteriological analyses (APHA, 1995).

Sampling of fish

Two individuals of each fish species from each treatment of the 1st group were taken, placed in labelled sterile polypropylene bags containing water from the aquaria and transported live to the laboratory. Fish surface was swabbed (1 cm^2) with a dry cotton swab. The swab was placed in 10 ml peptone water, agitated vigorously, and squeezed dry on the inside of the media bottle. Serial dilutions were made to 10^{-5} with this resultant suspension and examined. Each fish was then killed and rinsed with de-ionized water for about 2 min, and the surface was decontaminated by dipping it in ethyl alcohol and flaming. Each fish was aseptically dissected and parts of the gills and muscle were weighed (1g for each) aseptically for analysis. Each tissue was homogenized separately in a blender in sterile peptone

water (pH 7.2) to achieve a 10% (w/v) suspension of fish. All the microbiological examinations were carried out according to the technique recommended by Thatcher and Clark (1975).

Microbial population of water and fish

The bacteriological examination for total bacterial count was estimated by using plate count agar medium (Oxoid, CM 325) at 22^{0}C and 37^{0}C for 24-48 h. Coliform and *Escherichia coli* were determined by MaConkey agar medium biotest (No.3) at 37^{0}C for coliform group and 44.5^{0}C for *E. coli* for 24 h. *Salmonella spp.* and *Shigella spp.* were estimated by *Salmonella* and *Shigella* agar medium (Oxoid C99) at 37^{0}C for 24h. All the previous examinations were performed according to Harrigan and McCance (1976). *Staphylococcus aureus* was determined on Baird-Parker's medium (Baird-Parker and Davenport, 1965) at 37^{0}C and *Streptococcus spp.* was determined on *Streptococcus* selective media (Biolife, Monza 272-p20128 Italy) at 37^{0}C for 24h. *Fecal Streptococcus* was estimated on Blood Agar media (Difco™ Azide Blood Agar Base) at 37^{0}C for 24 h. *Pseudomonas spp.* was determined on *Pseudomonas* agar media (Difco™) at 37^{0}C for 24 h, *Vibrio spp.* counts were performed on Thiosulphate Citrate Bile Sucrose Agar (TCBS. Oxoid. UK) and incubated at 37 °C for 24 h; while *Aeromonas spp.* was counted on *Aeromonas* Selective Agar (Biolife) at 37 °C for 24 h.

Physico-Chemical Analyses of Water

Water samples were analyzed at 2-week intervals. Temperature and dissolved oxygen were measured in the aquaria using YSI oxygen meter (Model 58, Yellow Spring Instrument Co., Yellow Springs, Ohio, USA). Total ammonia was measured using HACH kits (HACH Co., Loveland, Colorado, USA) according to APHA (1985). The unionized ammonia (NH_3-N) (calculated from total ammonia), total alkalinity, total hardness and nitrate-nitrogen (NO_3-N) were determined according to Boyd (1984). pH degree was measured using pH-meter (Fisher Scientific, Denver, USA). Total phosphorus was measured in water samples calorimetrically according to APHA (1985) using Spectronic 20. Biochemical oxygen demand (BOD_5) was determined following the methods described by Maria and Csaba (1999).

Metals Residues

The residues of cadmium, copper, iron and lead in water and fish tissue organs were estimated by atomic absorption spectrophotometer (Thermon Electron Corporation S series AA Spectrometer, UK) and prepared according to the method described by APHA (1985). Water samples were filtered and concentrated by evaporating a suitable quantities to a constant volume. Fish tissue samples were oven-dried at 115°C until reached constant weight. Afterwards, 1.0 g dry weight was ashed in muffle furnace (Thermolyne Corporation, Dubuque, Iowa, USA) at 500°C. Ash was digested with concentrated HNO_3 using muffle furnace then diluted to 50 ml of 2 N HCl.

Statistical Analysis of the Results

Obtained data of water quality, heavy metal residues and growth parameters were subjected to statistical analysis of variances according to Snedecor and Cochran (1982) and significant differences using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Data presented in Table 1 reflect the variations in the total bacterial counts at 22 and 37°C as well as the counts of some microorganisms in water samples in aquaria of DTW, 25%, 50%, 75% and 100% TSW. Bacterial populations from the different treatments consisted essentially of about the same bacterial genera. The bacterial genera isolated from the aquaria water included, coliform group, fecal coliform, *Salmonella spp. & Shigella spp.*, *Aeromonas spp.*, *Pseudomonas spp.*, *Staphylococcus spp.*, *Streptococcus spp.* and *Vibrio spp.* In the first day, there was no general trend, the highest value of total bacterial count was recorded in 50% TSW treatment at 22°C ($5.4x10^7$ CFU/ml) and in DTW at 37°C ($3.0x10^7$ CFU/ml) while the lowest number was recorded in 100% TSW at 22°C ($0.31x10^4$ CFU/ml). The same results were obtained by Al-Harbi and Uddin (2004) who recorded that the high bacterial abundance is not necessarily a disadvantage. However, there were no wide differences between the counts of the microorganisms in any TSW levels and DTW.

Generally, the counts decreased in dechlorinated tap water and in different levels of treated sewage water from the initial samples towards the end of the experiment except the treatment 100% TSW.

Table 1. Total viable bacterial counts (CFUx10^4/ml) in dechlorinated tap water and different levels of treated sewage water in three different periods during fish growth

Parameters	Period (day)	Dechlorenated Tap water	25% Sewage water	50% Sewage water	75% Sewage water	100% Sewage water
	1	1800	74	5400	1500	0.31
Total count 22^{0}C	30	6.4	150	1700	580	240
	60	0.6	26	1.6	1.3	2.4
	1	3000	220	380	2200	0.45
Total count 37^{0}C	30	8.1	120	500	670	170
	60	2.9	10	1.5	1.6	9.4
	1	210	0.98	1	35	0.024
Coliform	30	0.44	1.9	3	9.1	27
	60	0.1	0.4	0.72	0.6	0.64
	1	4.9	0.035	0.82	0.05	0.003
F.coliform	30	0.053	0.029	0.6	0.06	0.27
	60	0.039	0.032	0.71	0.067	0.32
	1	0.025	0.025	1.6	1.5	0.015
Salmonella & Shigella	30	0.005	0.083	7.7	2.3	8.6
	60	0.023	0.12	0.016	0.002	0.2
	1	0.49	0.23	4.5	0.22	0.02
Staphylococcus spp.	30	0.002	0.1	1.7	0.56	0.18
	60	0.004	0.002	0.004	0.004	0.2
	1	31	0.2	2.4	0.3	0.02
Streptococcus spp.	30	0.0015	0.25	0.2	1.9	1
	60	0.002	0.002	0.014	2.2	1.4
	1	0.02	0.035	0.69	0.02	0.002
F. Streptococcus	30	0.1	0.13	0.017	0.018	7.1
	60	0.21	0.33	0.31	0.29	5.1
	1	22	2.6	7	9	0.018
Pseudomonas spp.	30	0.43	0.97	15	6.5	33
	60	0.12	1	0.064	0.095	0.1
	1	16	0.063	0.38	1	0.013
Vibrio spp.	30	0.05	6.8	0.78	0.96	1.8
	60	0.028	5.4	0.81	0.76	2
	1	140	2.4	27	0.66	0.037
Aermonas spp.	30	0.033	2.4	1.3	8	9.3
	60	0.084	1	0.02	9	0.04

The total bacterial counts as well as the bacterial genera were increased from day 1 to day 06 in 100% TSW treatment, the increase of some genera (*Salmonella spp. & Shigella spp.*, *Aeromonas spp.*, *Streptococcus spp.* and *Vibrio spp.*) was in 75, 50 and then 25% TSW respectively.

The fishes from the 1st group (Nile tilapia; *Oreochromis niloticus* and Common carp; *Cyprinus carpio*) reared in these treatments were acquired the same characteristics of water and demonstrated in Tables 2 & 3. Data showed the variations in the total bacterial counts at 22 and 37°C and counts of some microorganisms in the organs (skin, gills and muscle) of Nile tilapia and Common carp reared in DTW, 25%, 50%, 75% and 100% TSW. Data present that gills have the highest counts were in fish gills treated with 50%, 75, 100% TSW at 22, 37°C, respectively in Nile tilapia and common carp compared with either skin or muscles of total bacteria among all the treatments recording 1.4 & $1.5x10^8$ CFU/g in 25% TSW group at 22 and 37°C, respectively.

Coliform counts on the skin of both fish species reared in DTW were less than the counts on those reared in the different levels of TSW. The count of fecal coliform was decreased in skin of tilapia reared in DTW ranged from 0.021 to 0.006 and increased from 0.019 to $0.031x10^4$ CFU/cm^2 in skin of tilapia and carp, respectively. These findings were disagreed with those of Easa *et al.* (1995) who found that fecal coliform counts on the skin of natural fish was higher than its count on tilapia stocked in sewage-fed ponds. It was absent in muscles of tilapia and ranged from 4.6 to 0.14 and from 54 to $0.4x10^4$ CFU/g in gills of tilapia and carp, respectively. A slightly increase in gills fecal coliform counts for the two fishes reread in different levels of TSW and the counts were still in gills >skin >muscle for the two fish species. The counts of *Salmonella spp.* and *Shigella spp.* in skin, muscle and gills of Nile tilapia and Common carp reared in DTW was lower than in those reared in different levels of TSW during different times. On the other hand, the counts of *Salmonella spp.* and *Shigella spp.* were in gills >skin and nearly absent in muscles, these results support the results obtained by Khalil and Hussein (1997).

The counts of *Staphylococcus spp.* show variations among fish

Table 2. Total viable bacterial counts (CFU) in skin, muscle and gills tissues of Nile tilapia (*Oreochromis niloticus*) reared in dechlorinated tap water and different levels of treated sewage water in three different periods during fish growth

Parameters	Period (day)	Dechlorenated Tap Water			25% Sewage water			50% Sewage water			75% Sewage water			100% Sewage water		
		Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g
Total count 22 °C	1	300	0.24	500	39	0.18	14000	0.32	0.05	390	100	0.19	430	2.3	0.82	5900
	30	201	0.28	330	3	0.092	32	45	0.36	650	670	0.62	780	14	0.26	230
	60	0.42	0.02	24	0.037	0.038	48	85	2.8	820	540	5	330	54	0.16	530
Total count 37 °C	1	470	0.32	590	25	0.12	15000	12	0.02	150	9.8	0.029	350	1.3	0.23	2800
	30	3.9	0.43	360	8.5	0.009	110	46	0.58	200	48	0.76	650	8.2	0.16	720
	60	0.52	0.02	30	0.60	0.042	67	6	0.34	400	100	6	470	1.6	0.58	22
Coliform	1	0.17	0.028	59	1.4	0.0013	15	0.29	0.0014	78	1.6	0.0015	8.2	0.03	0.001	0.33
	30	0.18	0.032	4.2	0.16	0.0015	2.1	2.5	0.0035	160	0.38	0.012	85	0.4	0.035	4.8
	60	0.016	0.015	1	0.38	0.002	11	0.012	0.08	0.20	3.1	0.46	95	0.65	0.004	0.2
F. Coliform	1	0.021	0	4.6	0.045	0.01	20	0.12	0	6.1	0.017	0	3.3	0.014	0	0.015
	30	0.007	0	0.51	0.057	0	0.48	0.34	0.0065	2.1	0.0035	0	4.2	0.032	0	1.2
	60	0.006	0	0.14	0	0	11	0.27	0	0.04	0.14	0.8	40	0.041	0	1.8
Salmonella &Shigella	1	0.028	0.012	2	0.022	0	26	0.009	0	8	0.015	0	2.5	0.032	0	14
	30	0.038	0	0.2	0.054	0	0.37	0.054	0	5.4	0.052	0	16	0.041	0.003	8.5
	60	0.04	0	0.3	0.061	0	2	0.014	0	3.4	9.4	0.001	30	0.011	0	8
Staphylococcus spp.	1	0.041	0.012	2	0.02	0.002	3.7	0.008	0	4	0.017	0	0.18	0.065	0	27
	30	0.037	0.0075	0.2	0.003	0.026	0.002	0.9	0.044	0.24	0.3	0.14	2.5	0.052	0.012	5.1
	60	0.022	0	0.4	0	0	0.02	0.4	0.016	0.16	6.1	0.012	25	0.7	0	4
Streptococcus spp.	1	0.042	0.021	1.3	0.11	0.011	1.2	0.02	0.004	0.013	0.095	0	0.19	0.018	0	2.8
	30	0.002	0	0.02	0.025	0	0.2	1.6	0.09	3.5	0.002	0	0.002	0.025	0	0.2
	60	0.04	0	0.72	0.01	0	0.06	2.7	0.062	0.19	0.76	0	0.42	0.04	0	0.2
F. *Streptococcus*	1	0	0	0	0	0	0.41	0.002	0	1.4	0.007	0	0.97	0.0015	0	0.12
	30	0	0	0.002	0.002	0	0.003	0.055	0	0.0015	3	0	0.75	0.36	0.0035	9.5
	60	0.35	0.014	8	0	0	0	3.2	0.2	40	10	0.7	40	0.42	0	0.2
Pseudomonas spp.	1	0.03	0.2	38	0.026	0.002	520	0	0	26	0.65	0.035	1.6	2.6	0.043	620
	30	0.02	0	5.5	0.04	0.002	2.5	0.047	0.23	10	0.49	0	3.7	0.34	0.027	8
	60	0.02	0	3.2	0.004	0.02	4.2	0.08	0.14	1.4	1.4	0.53	26	0.002	0.006	4.2
Vibrio spp.	1	0.0028	0	0.34	0.002	0.005	0.29	0.001	0	0.73	0.046	0	7.4	0	0	0.17
	30	0.48	0.006	0.78	0.43	0.004	11	0.0045	0	0.03	0.13	0	1.7	0.005	0	1.3
	60	0.052	0	0.18	0.55	0.0035	23	0.0005	0	0.0025	0.2	0.19	1.2	0.0042	0	1.9
Aermonas spp.	1	0.02	0	6	2	0.01	250	0.2	0	68	0.005	0	0.37	20	0.017	1600
	30	0.015	0	1.4	0.003	0	0.44	0.007	0	4.5	0.059	0	1.2	0.1	0.004	0.005
	60	0.016	0	2.4	0	0	0.62	0.02	0	0.04	12	0.012	82	0.02	0.0014	0.06

Table 3. Total viable bacterial counts (CFU) in skin, muscle and gills tissues of common carp (Cyprinus carpio) reared in dechlorinated tap water and different levels of treated sewage water in three different periods during fish growth

Parameters	Period (day)	Dechlorenated Tap Water			25% Sewage water			50% Sewage water			75% Sewage water			100% Sewage water		
		Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g	Skin x10⁴/cm²	Muscle x10⁴/g	Gills x10⁴/g
Total count	1	4.1	0.55	18000	11	0.16	720	2	2.6	550	27	1.2	950	2.9	0.76	770
22°C	30	1.4	0.87	31	9.8	0.45	150	77	2.7	1800	5.8	0.025	450	1.4	0.035	160
	60	0.50	0.004	46	0.049	0.036	140	91	3.9	3800	0.42	0.30	170	1.8	0.027	360
Total count	1	1.9	0.75	1300	6.4	0.26	870	20	2	170	20	0.26	450	2.8	0.92	480
37°C	30	1.5	1	46	14	0.43	160	120	8	2600	1.3	0.03	540	1.4	0.041	210
	60	0.06	0.006	52	0.20	0.024	150	82	0.084	4	1.3	36	360	2.4	0.28	52
Coliform	1	0.15	0.11	58	0.02	0.02	2.3	0.024	0.13	34	0.9	0.001	16	0.027	0	1.3
	30	0.42	0.17	8.4	0.052	0.051	4.6	1	0.04	12	0.02	0.0015	29	0.35	0	1.3
	60	0.27	0.14	3.9	0.034	0.034	18	0.006	0.026	0.85	0.8	0.0013	48	2	0.001	3.4
F. Coliform	1	0.019	0.022	54	0	0	0.53	0.016	0	8.6	0.009	0	1.8	0.013	0	0.025
	30	0.028	0.004	1.4	0.005	0.003	1.3	0.045	0.018	0.038	0.0035	0	0.46	0.0055	0	0.79
	60	0.031	0	0.4	0	0	18	0	0	0.002	0.24	0	30	0.0035	0	1.4
Salmonella &	1	0.009	0.016	0.44	0.002	0	2.7	0.016	0.0045	8.1	0.022	0	0	0.004	0	1
Shigella	30	0.033	0	0.022	0.038	0.045	0.63	0.27	0.013	110	0.011	0	7	0.002	0	6.5
	60	0.024	0	18	0.047	0	1	0.04	0.004	4.2	0.04	0	17	0.002	0	4.2
Staphylococcus	1	0.09	0.016	0.44	0.017	0	2	0.02	0.035	3.8	0.061	0.056	0.5	0.15	0.056	1.1
spp.	30	0.035	0.058	0.4	0.026	0	0.009	1.9	0.075	130	0.01	0.0035	0.35	0.046	0.002	0.37
	60	0.01	0.006	0.013	0	0	0	0.76	0.016	16	0.07	0.03	40	0.051	0.0013	0.6
Streptococcus	1	0.24	0.012	100	0.017	0.02	2.2	0.21	0.035	3.4	0	0	0.75	0	0	0.58
spp.	30	0.048	0	0.06	1.4	0.002	1.8	7.3	0.028	3.5	0.048	0	0.006	1.4	0.002	1.8
	60	0.02	0	11	2.1	0.0012	2.3	3.3	0.021	4.8	0.004	0.05	1.5	0.004	0	18
F. *Streptococcus*	1	0	0	0	0.002	0	0.061	60	0.015	1.4	0	0.0015	0.045	0.0021	0	0.012
	30	0	0	0.003	0.04	0	0.17	0.014	0.093	9.7	0	0	0.078	0.014	0.002	1.2
	60	0.02	0.12	24	0	0	0	3	0.24	28	1.6	0.26	24	0.037	0.0031	4.2
Pseudomonas	1	0.13	0.017	62	0.03	0	11	0	0.42	9	0.24	0.005	19	0.036	0.011	37
spp.	30	0.24	0.052	4.8	0.44	0.084	3.5	14	2.1	1900	0.003	0	37	0.07	0.023	0.7
	60	0.62	0.004	4	0.02	0.014	6	0.1	0.031	1	0.04	0.018	12	0.2	0.017	2
Vibrio spp.	1	0.021	0	0.039	0.002	0	0.039	0.028	0	0.6	0.02	0	4.7	0	0	0.3
	30	0.32	0.031	2.7	0.54	0	9.4	0.035	0	3	0.023	0	11	0.002	0	0.002
	60	0.022	0	0.32	0.63	0	9.5	0.045	0	2.7	0.0018	0	1.6	0	0	0.034
Aermonas	1	0.029	0.055	42	0.02	0.002	15	0	0.64	95	0.045	0	0.33	0.96	0.09	200
spp.	30	0.012	0.004	2.1	0.0045	0	1.4	0.007	0	9	0.049	0	1	0.028	0.034	0.3
	60	0.22	0.0035	3.8	0.0027	0	0.22	0.006	0	0.02	0.068	5.8	4.6	0.0045	0.012	0.16

reared in DTW and different levels of TSW and no variation between the two fish species. *Streptococcus spp.* showed slight variations and nonspecific trend among all treatments and gills still have the highest contaminations. Fecal *Streptococcus* was not detected in skin or muscles of fish reared in DTW or low levels of TSW at different times. High counts of Fecal *Streptococcus* were detected in gills of fish those in 75% and 100% TSW which was in 75% 40x 10^4 CFU/g in Nile tilapia and 4.2 x 10^4 CFU/g in Common carp after day 60. On the other hand, *Pseudomonas spp.* showed an increase in fish reared in different levels of TSW and those in DTW specially in gills of Nile tilapia and Common carp. As this sequence of gills skin and muscles, *Vibrio spp.* showed the same trend and the counts were higher in skin and gills of Common carp than in Nile tilapia. Muscles were nearly free from *Vibrio spp.* the two species reared in different treatments.

Aeromonas spp. was increased in organs of Nile tilapia reared in different levels of TSW than those in DTW, and muscles have the lowest values (ranged from 0 to 17x10 CFU/g). In Common carp the numbers were fluctuated and gills have the highest numbers, and muscles have the lowest ones. These results are in agreement with those reported by Sedik *et al.* (1995) and Khalil and Hussein (1997) and with in the optimum limits according to WHO (1989). However, these results indicate that there are slight differences between DTW and TSW as previously mentioned by El-Shafai *et al.* (2004). Gewaily *et al.*, (1996 & 2001) and El-Shafai *et al.* (2004) mentioned that, when the wastes were treated effectively before reusing, the expected potential health risks associated with waste water recycling will be overcome. The counts of microorganisms in the present study tend to decrease in DTW and increase in all levels of TSW especially in 100% level.

In fact, some pharmaceuticals are not totally eliminated because the conventional technology of used treatment appears insufficient to completely remove these specific compounds (Dietrich, *et al.*, 2002, Daughton and Ternes, 1999). However, the bacterial loads in either tilapia or carp were high in the gills followed in descending orders by skin then muscles. The higher contamination of gills in comparison to skin may

be attributed to the structure of gills, which have high specific surface area for bacterial attachment, and to the high water flow rate passing through them. Fatal *et al.* (1993) reported that tilapia reared in animal and human waste-contaminated ponds showed higher contamination in the digestive tract than in skin and liver, while very few colonies were detected in muscle. On the other hand, Khalil and Hussein (1997) recorded higher contamination of gills than intestine and skin of tilapia reared in primary-treated sewage. Ogbondeminu and Okoye (1992) reported that in raw sewage-fertilized ponds, fecal coliform numbers in tilapia decreased in the order, skin>gills>intestine>muscle.
Naturally, there is a wide range of bacteria present on the skin of fish, which reflects the microbial composition of pond water.

Several authors have demonstrated a correlation between fish biomass and fecal coliform concentrations in the water (Markosova & Jezek, 1994). Also, fish living in the natural environment are known to harbour Enterobacteriaceae that may be cause diseases for humans and other warm blooded animals (Pillay, 1992).

Although in the natural environment fish usually harbour bacteria only in the digestive tract (Polprasert *et al.*, 1984), *Vibrio species* have been isolated and described from normal healthy *Penaeus vannamei* juveniles (Gomez-Gil *et al.*, 1998). As well, bacteria have been isolated from 14.3% of the animals with a count in the range of $2.0x10^2$–$3.0x10^3$ CFU/ml of hemolymph. *Streptococcus spp.* was isolated from healthy and diseased tilapia, healthy common carp and diseased mullet and striped hybrid bass (Bunch & Bejerano, 1997). Isolation of *Aeromonas spp.* and *Streptococcus spp.* from a healthy population of rainbow trout has been demonstrated (Barham *et al.*, 1979). At low numbers, microorganisms will be present on the surface of fish and gut but not in muscle tissue. Above a certain threshold level, which represents the limit of the natural defense mechanisms of fish, pathogens are capable of penetrating muscle.

Polprasert *et al.* (1984) concluded that the *Escherichia coli* threshold concentration beyond which pathogens can penetrate muscle is 10^4 CFU /100 ml. Fatal *et al.* (1993) demonstrated *E. coli* at 0.2 log/g in muscles of tilapia reared in sewage-fed ponds with an *E. coli* count of 10^5 CFU/100 ml.

Pillay (1992) reported that fecal streptococci and other human disease-related bacteria were found in the gut content of Pacific salmon and rainbow trout grown in domestic sewage-fertilized ponds. No muscle contamination was detected in tilapia stocked in primary-treated sewage with fecal count of $5x10^3$ CFU/100 ml (Khalil & Hussein, 1997). On the other hand, the microbial quality of tilapia and common carp stocked in untreated sewage-fed ponds showed contamination of muscle by fecal coliform and fecal streptococci even when the count in the water was less than 10^4CFU/100 ml and there are large limitations in the published data concerning the microbial quality of fish, especially of fish reared in treated or raw waste water (Ogbondeminu & Okoye, 1992). Richards (1988) reported that the potential advantages of the purification process are the removal of pathogens, objectionable odors, and chemical contaminants of fish organs. Further, Fatal *et al.* (1993) recommended that, fish be cooked well before human consumption and stated that, the major public health concern could be the risk of *Aeromonas spp.* wound infection among the workers who handle and process the fish. For further reduction of public health risks, purification of sewage-raised fish prior to sale was recommended.

Since water quality in fish ponds is a major factor determining the fish growth, water quality of treated sewage water must be examined before reuse in fish culture. However, data in Table 4 show that no significant differences in temperature (25-29°C) and pH among all treatments. Although all aquaria were similarly supplied with compressed air via air-stones from air pumps, the dissolved oxygen recorded very low concentrations in 100% TSW (1.7±0.2 - 1.3±0.1 mg/l) and the highest concentration was in DTW (4.5±0.4 - 4.0±0.3 mg/l). For aquatic life the average concentrations of dissolved oxygen must be remain above 5 mg/l and the instantaneous minimum not fall below 4.0 mg/l Boyd (1984). Moreover, BOD_5 recorded very high levels in TSW (260.5±3.1 – 190.3±1.8 mg/l), gradually decreased towards the DTW (120.2±2.3 – 90.1±3.2 mg/l). The same trend was recorded in nitrates (NO_3), un-ionized ammonia (NH_3), total phosphate (PO_4), total hardness and total alkalinity.

Table 4. Changes in water quality and some heavy metals concentrations in dechlorinated tap water and different levels of treated sewage water during experiment period

Parameters	Period (day)	Dechlorenated Tap water	25% Sewage water	50% Sewage water	75% Sewage water	100% Sewage water
Temperature(°C)	1	28.4 ± 0.1^{A}	28.5 ± 0.5^{A}	28.6 ± 0.4^{A}	28.5 ± 0.1^{A}	28.8 ± 0.2^{A}
	30	25.8 ± 0.4^{A}	25.9 ± 0.4^{A}	26.3 ± 0.4^{A}	27.0 ± 0.2^{A}	27.1 ± 0.3^{A}
	60	25.5 ± 0.3^{A}	25.5 ± 0.3^{A}	25.8 ± 0.2^{A}	26.1 ± 0.2^{A}	26.2 ± 0.2^{A}
DO (mg/l)	1	4.5 ± 0.4^{A}	2.9 ± 0.2^{B}	2.5 ± 0.1^{C}	1.8 ± 0.1^{D}	1.7 ± 0.2^{D}
	30	4.5 ± 0.5^{A}	2.5 ± 0.1^{B}	2.2 ± 0.1^{C}	1.5 ± 0.1^{D}	1.3 ± 0.2^{E}
	60	4.0 ± 0.3^{A}	2.6 ± 0.1^{B}	1.6 ± 0.2^{C}	1.4 ± 0.1^{D}	1.3 ± 0.1^{E}
BOD_5 (mg/l)	1	120.2 ± 2.3^{E}	145.0 ± 3.2^{D}	$160.1 \pm 2.1C$	$180.3 \pm 2.4B$	$260.5 \pm 3.1A$
	30	90.1 ± 3.2^{E}	110.2 ± 2.1^{D}	$125.0 \pm 1.3C$	$145.1 \pm 1.4B$	$220.2 \pm 3.4A$
	60	105.3 ± 2.4^{E}	122.1 ± 3.4^{D}	$133.0 \pm 1.5C$	$140.1 \pm 1.2B$	$190.3 \pm 1.8A$
pH	1	7.6 ± 0.2^{A}	7.5 ± 0.3^{A}	7.5 ± 0.2^{A}	7.6 ± 0.2^{A}	7.6 ± 0.2^{A}
	30	7.5 ± 0.1^{A}	7.4 ± 0.2^{A}	7.4 ± 0.1^{A}	7.5 ± 0.1^{A}	7.8 ± 0.2^{A}
	60	7.7 ± 0.3^{A}	7.7 ± 0.2^{A}	7.7 ± 0.2^{A}	7.8 ± 0.1^{A}	7.8 ± 0.3^{A}
NO_3 (mg/l)	1	4.3 ± 0.2^{C}	4.5 ± 0.2^{C}	4.4 ± 0.1^{C}	5.5 ± 0.2^{B}	6.5 ± 0.2^{A}
	30	4.2 ± 0.1^{C}	4.4 ± 0.1^{C}	4.4 ± 0.1^{C}	5.4 ± 0.1^{B}	6.2 ± 0.1^{A}
	60	4.4 ± 0.1^{C}	4.5 ± 0.1^{C}	4.5 ± 0.1^{C}	6.5 ± 0.3^{B}	7.1 ± 0.1^{A}
NH_3 (mg/l)	1	0.006 ± 0.001^{E}	$0.022 \pm 0.001D$	$0.068 \pm 0.002C$	$0.136 \pm 0.011B$	$0.275 \pm 0.012A$
	30	0.008 ± 0.002^{E}	$0.023 \pm 0.001D$	$0.071 \pm 0.001C$	$0.122 \pm 0.003B$	$0.424 \pm 0.032A$
	60	0.010 ± 0.001^{E}	$0.074 \pm 0.002D$	$0.110 \pm 0.004C$	$0.210 \pm 0.010B$	$0.368 \pm 0.021A$
PO_4 (mg/l)	1	2.3 ± 0.2^{B}	2.4 ± 0.1^{B}	2.6 ± 0.1^{A}	2.7 ± 0.1^{A}	2.8 ± 0.2^{A}
	30	2.1 ± 0.1^{C}	2.4 ± 0.1^{C}	2.7 ± 0.4^{B}	2.7 ± 0.1^{B}	2.9 ± 0.2^{A}
	60	2.6 ± 0.2^{E}	3.0 ± 0.1^{D}	3.9 ± 0.2^{C}	5.2 ± 0.2^{B}	6.8 ± 0.4^{A}
T. Hardness (mg/l)	1	120.4 ± 2.4^{D}	130.2 ± 1.5^{C}	150.2 ± 2.1^{B}	$150.1 \pm 1.2B$	$155.6 \pm 3.4A$
	30	125.3 ± 3.5^{D}	142.2 ± 2.3^{C}	158.2 ± 2.2^{B}	$160.1 \pm 1.8B$	$165.2 \pm 2.1A$
	60	152.1 ± 5.1^{D}	164.1 ± 2.1^{C}	168.1 ± 3.1^{B}	$170.5 \pm 1.4B$	$188.3 \pm 3.0A$
T.Alkalinity (mg/l)	1	100.7 ± 1.2^{D}	120.4 ± 3.1^{C}	120.2 ± 2.3^{C}	$180.1 \pm 2.1B$	$220.3 \pm 2.4A$
	30	110.5 ± 1.1^{D}	123.3 ± 2.4^{C}	127.3 ± 1.4^{C}	$185.4 \pm 2.3B$	$225.4 \pm 2.5A$
	60	108.3 ± 3.1^{D}	125.1 ± 1.8^{C}	129.2 ± 1.2^{C}	$225.5 \pm 2.1B$	$255.4 \pm 1.7A$
Lead (ppm)	1	0.08 ± 0.01^{BC}	0.07 ± 0.02^{C}	0.09 ± 0.01^{B}	$0.10 \pm 0.02B$	$0.10 \pm 0.01A$
	30	0.05 ± 0.01^{B}	0.06 ± 0.03^{B}	0.07 ± 0.01^{A}	$0.07 \pm 0.01A$	$0.08 \pm 0.01A$
	60	0.19 ± 0.02^{D}	0.32 ± 0.05^{C}	0.36 ± 0.02^{C}	$0.40 \pm 0.01B$	$0.46 \pm 0.04A$
Cadmium (ppm)	1	$0.04 \pm 0.01E$	$0.06 \pm 0.01D$	$0.09 \pm 0.03C$	$0.19 \pm 0.01B$	$2.85 \pm 0.35A$
	30	$0.02 \pm 0.01C$	$0.03 \pm 0.01C$	$0.05 \pm 0.01B$	$0.06 \pm 0.01B$	$1.05 \pm 0.03A$
	60	$0.09 \pm 0.04D$	$0.15 \pm 0.01C$	$0.54 \pm 0.12B$	$1.40 \pm 0.12A$	$1.42 \pm 0.13A$
Copper (ppm)	1	$0.61 \pm 0.14D$	$1.16 \pm 0.21C$	$1.18 \pm 0.22C$	$1.35 \pm 0.02B$	$1.76 \pm 0.11A$
	30	$0.11 \pm 0.02D$	$0.21 \pm 0.24C$	$0.29 \pm 0.05B$	$0.31 \pm 0.03B$	$0.89 \pm 0.02A$
	60	$0.09 \pm 0.03C$	$0.08 \pm 0.01C$	$0.14 \pm 0.01B$	$0.15 \pm 0.03B$	$0.19 \pm 0.04A$
Iron (ppm)	1	$1.73 \pm 0.42D$	$2.19 \pm 0.14C$	$2.32 \pm 0.39C$	$4.47 \pm 0.35B$	$5.91 \pm 0.63A$
	30	$1.19 \pm 0.14D$	$1.56 \pm 0.10C$	$1.77 \pm 0.18B$	$1.82 \pm 0.13B$	$2.98 \pm 0.25A$
	60	$0.13 \pm 0.01E$	$0.40 \pm 0.13D$	$0.54 \pm 0.06C$	$0.78 \pm 0.20B$	$1.40 \pm 0.12A$

Means with the same letter in the same row are not significantly different Data expressed as Means ± SE. ($P \leq 0.05$)

The mean Pb and Cu level in water samples was lower than the permissible limits (0.5 & 2 ppm, respectively) according to WHO (1993), while, cadmium limits exceeded the permissible limits (0.7 ppm) in TSW. Moreover, iron levels exceeded the permissible limits (0.3 ppm) in TSW as well as in DTW but the limits were very highly significantly different between DTW and TSW. However, these findings are in agreement with those of Chukwu *et al.* (2008) who found that the waste water lowered the water quality of the receiving Tayi stream in Nigeria.

Furthermore, results in Table 5 show that Pb residues in muscle (The edible part or flesh) of the Common carp reared in TSW exceeded the permissible levels (2ppm) according to WHO (1993) while, tilapia showed fluctuations. On the other hand, gills and skin have high levels of lead. Cadmium residues in flesh of Nile tilapia were exceeded the permissible limits (0.5ppm) after 60 days in 100% TSW and common carp showed limits less than in tilapia. Copper residues showed low levels in the flesh of both tilapia and carp far from the permissible limits (20 ppm) as well as skin and gills. Iron residues in flesh of tilapia and carp were less than those in skin or gills. However, Abd El-Kader *et al.* (1993) mentioned that there are direct relationships between heavy metals residuals level in fish flesh and metals pollution level in domestic or agricultural wastes. Kock and Hofer (1998) reported that even low concentrations of heavy metal in the water may result in high concentrations in fish flesh. On the other hand, Wong *et al.* (2001) reported that despite high metal levels in the seawater and sediments, concentrations of Cd and Pb in fish flesh did not exceed permissible levels.

The health of fish depends on water quality that is the chemical, physical and microbial content. Table 6 showed that non significant changes in weight gain (WG) or specific growth rate (SGR) in Nile tilapia reared in any treatments. The survival was lowered in tilapia reared in 75% and 100% TSW than those reared in other treatments. On the other hand, Common carp showed significant decrease in WG and SGR as well as the survival in those reared in different TSW levels than those reared in DTW. The stress effect of low dissolved oxygen concentrations and poor water quality of TSW result in increased mortality of reared carp and poor WG and SGR, while

Table 5. Concentrations of some heavy metals (ppm) in skin, muscle and gills of Nile tilapia and Common carp reared in dechlorinated tap water and different levels of treated sewage water in three different periods during fish growth

Parameters	Treatments	Period (day)	Nile tilapia			Common carp		
			Skin	Muscle	Gills	Skin	Muscle	Gills
Lead (ppm)	100% DTW	1	1.06 ± 0.21B	0.32 ± 0.11A	1.37 ± 0.02C	1.15 ± 0.21B	0.95 ± 0.22C	3.49 ± 0.39C
		30	1.14 ± 0.11A	0.33 ± 0.02A	1.65 ± 0.53B	1.17 ± 0.15B	1.24 ± 0.02B	3.69 ± 0.41B
		60	1.19 ± 0.14A	0.35 ± 0.11A	1.84 ± 0.21A	1.85 ± 0.56A	1.56 ± 0.45A	3.90 ± 0.48A
	25% TSW +75 %DTW	1	1.49 ± 0.32B	0.95 ± 0.31C	1.81 ± 0.15B	1.32 ± 0.42C	1.44 ± 0.11C	3.84 ± 0.21B
		30	1.54 ± 0.12B	1.10 ± 0.14B	1.82 ± 0.12B	1.65 ± 0.11B	1.66 ± 0.22B	3.94 ± 0.51B
		60	1.97 ± 0.23A	1.26 ± 0.33A	1.99 ± 0.11A	1.93 ± 0.63A	1.70 ± 0.14A	4.63 ± 0.24A
	50% TSW +50% DTW	1	2.68 ± 0.19C	1.03 ± 0.23C	2.13 ± 0.20C	1.01 ± 0.03C	1.51 ± 0.25C	3.96 ± 0.33C
		30	3.24 ± 0.16B	1.12 ± 0.01B	3.63 ± 0.48B	1.44 ± 0.08B	1.62 ± 0.14B	4.21 ± 0.17B
		60	3.91 ± 0.22A	1.41 ± 0.11A	5.51 ± 0.33A	1.93 ± 0.55A	1.75 ± 0.26A	5.02 ± 0.56A
	75%TSW +25%DTW	1	3.15 ± 0.03C	1.73 ± 0.15C	4.89 ± 0.98C	1.97 ± 0.31C	1.56 ± 0.03B	4.10 ± 0.10B
		30	3.75 ± 0.65B	2.11 ± 0.11B	6.79 ± 1.14B	2.76 ± 0.99B	1.59 ± 0.01B	4.16 ± 0.02B
		60	7.14 ± 1.88A	2.32 ± 0.34A	8.30 ± 0.88A	5.55 ± 1.55A	2.06 ± 0.25A	5.09 ± 0.02A
	100%TSW	1	3.47 ± 0.04B	1.10 ± 0.23B	5.55 ± 0.15C	2.68 ± 0.10C	2.23 ± 0.04B	4.13 ± 0.02B
		30	3.52 ± 0.12B	1.12 ± 0.03B	6.56 ± 0.10B	3.84 ± 0.21B	2.94 ± 0.24A	4.26 ± 0.01B
		60	3.79 ± 0.22A	1.17 ± 0.20A	9.74 ± 0.33A	7.77 ± 0.22A	2.99 ± 0.15A	7.05 ± 0.22A
Cadmium (ppm)	100%DTW	1	0.28 ± 0.03C	0.01± 0.01B	0.51 ± 0.02A	0.38 ± 0.02C	0.02 ± .001C	0.03 ± 0.01C
		30	0.33 ± 0.02B	0.01 ± 0.002B	0.40 ± 0.03B	0.47 ± 0.08B	0.16 ± 0.05B	0.05 ± 0.01B
		60	0.47 ± 0.13A	0.03 ± 0.01A	0.54 ± 0.05A	1.87 ± 0.42A	0.31 ± 0.11A	0.07 ± 0.01A
	25% TSW +75 DTW	1	0.06 ± 0.32B	0.06 ± 0.01C	0.03 ± 0.01B	0.55 ± 0.22C	0.08 ± 0.01B	0.75 ± 0.32C
		30	0.07 ± 0.01B	0.09 ± 0.01B	0.04 ± 0.01B	0.61 ± 0.04B	0.10 ± 0.02A	0.96 ± 0.21B
		60	0.13 ± 0.01A	0.11 ± 0.01A	0.06 ± 0.02A	0.82 ± 0.21A	0.11 ± 0.01A	1.01 ± 0.01A
	50% TSW+ 50% DTW	1	0.08 ± 0.33C	0.04 ± 0.01B	0.08 ± 0.04C	0.51 ± 0.14C	0.02 ± 0.01C	1.29 ± 0.02C
		30	0.12 ±0.01B	0.05 ± 0.01B	0.18 ± 0.01B	0.86 ±0.11B	0.04 ± 0.01B	1.98 ± 0.24B
		60	0.23 ± 0.01A	0.19 ± 0.01A	0.35 ± 0.11A	1.56 ± 0.45A	0.06 ± 0.02A	2.49 ± 0.52A
	75%TSW+ 25%DTW	1	0.20 ± 0.02C	0.16 ± 0.02C	0.11 ± 0.01B	0.78 ± 0.11C	0.23 ± 0.04C	1.43 ± 0.11C
		30	0.43 ± 0.03B	0.22 ± 0.01B	0.13 ± 0.01B	0.88 ± 0.05B	0.42 ± 0.14B	2.44 ± 0.04B
		60	0.53 ± 0.02A	0.72 ± 0.05A	0.26 ± 0.05A	1.24 ± 0.66A	0.70 ± 0.12A	2.77 ± 0.23A
	100%TSW	1	0.71 ± 0.21C	0.02 ± 0.01B	0.05 ± 0.01C	1.25 ± 0.02C	0.22 ± 0.03B	2.15 ± 0.01B
		30	1.05 ± 0.02B	0.03 ± 0.01B	0.07 ± 0.02B	1.54 ± 0.11B	0.32 ± 0.02A	2.21 ± 0.01A
		60	1.30 ± 0.06A	0.89 ± 0.04A	1.19 ± 0.02A	1.63 ± 0.13A	0.33 ± 0.01A	2.24 ± 0.12A

Table 5. Cont.

Parameters	Treatments	Period (day)	Nile tilapia	Common carp	Parameters	Treatments	Period (day)	Nile tilapia
Copper (ppm)	100%DTW	1	1.41 ± 0.25B	0.11 ± 0.01C	1.15 ± 0.05B	2.06 ± 0.65A	0.89 ± 0.32C	2.03 ± 0.14C
		30	1.51 ± 0.08B	0.17 ± 0.06B	1.16 ± 0.07B	2.10 ± 0.22A	1.64 ± 0.65B	2.76 ± 0.35B
		60	2.40 ± 0.11A	0.24 ± 0.03A	1.54 ± 0.02A	2.17 ± 0.35A	1.82 ± 0.37A	2.83 ± 0.28A
	25% TSW	1	1.71 ± 0.22B	1.21 ± 0.18C	1.21 ± 0.16B	2.46 ± 0.14B	1.08 ± 0.32C	1.86 ± 0.26B
	+75%DTW	30	2.49 ± 0.35A	1.41 ± 0.15B	1.30 ± 0.18B	2.80 ± 0.25A	1.79 ± 0.24B	2.87 ± 0.22A
		60	2.60 ± 0.24A	1.84 ± 0.11A	1.45 ± 0.11A	2.93 ± 0.24A	2.36 ± 0.22A	2.95 ± 0.26A
	50% TSW	1	2.59 ± .16AB	1.29 ± 0.21C	1.39 ± 0.33C	2.77 ± 0.11C	1.94 ± 0.54B	3.30 ± 0.29B
	+50% DTW	30	2.65 ± 0.22B	1.46 ± 0.24B	1.94 ± 0.26B	3.12 ± 0.23B	2.01± 0.04B	4.12 ± 0.21A
		60	2.81 ± 0.14A	1.93 ± 0.27A	2.51 ± 0.44A	4.10 ± 0.75A	2.51 ± 0.25A	4.15 ± 0.34A
	75%TSW	1	3.16 ± 0.18B	2.01 ± 0.11B	3.12 ± 0.11B	2.64 ± 0.52B	1.26 ± 0.23B	3.14 ± 0.24B
	+25%DTW	30	3.37 ± 0.24A	2.37 ± 0.21A	4.24 ± 0.27A	3.42 ± 0.38A	2.27 ± 0.24A	3.33 ± 0.44A
		60	3.76 ± 0.26A	2.55 ± 0.25A	4.43 ± 0.11A	3.55 ± 0.11A	2.34 ± 0.33A	3.41 ± 0.22A
	100%TSW	1	2.99 ± 0.32B	2.27 ± 0.25B	3.55 ± 0.24B	2.84 ± 0.26B	1.56 ± 0.14C	3.38 ± 0.33C
		30	4.14 ± 0.35A	2.44 ± 0.15AB	5.22 ± 0.16A	3.53 ± 0.36A	3.05 ± 0.18B	4.08 ± 0.33B
		60	4.62 ± 0.29A	2.70 ± 0.05A	5.27 ± 0.35A	3.98 ± 0.15A	3.45 ± 0.23A	5.38 ± 0.44A
Iron (ppm)	100%DTW	1	185.60 ± .54B	49.48 ± 0.44B	157.69 ± .33B	62.11 ± 1.27B	51.79 ± 0.87C	207.90 ± 2.33B
		30	212.14 ± .34A	61.14 ± 2.14A	182.75 ± 1.22A	164.36 ± .65A	122.69 ± 3.21A	391.33 ± 3.69A
		60	60.03 ± 0.55C	8.69 ± 0.21C	101.55 ± 1.34C	65.71 ± 1.24B	83.10 ± 0.66B	65.71 ± 0.57C
	25% TSW	1	186.03 ± .15C	134.96 ± .22C	197.04 ± 4.77C	166.94 ± .58C	50.10 ± 1.33B	175.88 ± 2.44B
	+75 DTW	30	247.59 ± .12B	150.99 ± .05B	244.36 ± 2.42B	460.13 ± 4.77A	44.22 ± 2.14C	294.84 ± 2.84A
		60	286.60 ± 2.34A	253.26 ± 2.14A	294.30 ± 3.11A	229.49 ± 4.32B	89.73 ± 0.65A	295.82 ± 4.14A
	50% TSW	1	198.48 ± 2.54B	150.03 ± 1.58B	278.16 ± 3.12B	179.18 ± 3.14B	198.40 ± 1.45B	220.97 ± 5.47B
	+50%DTW	30	243.02 ± 5.66A	212.67 ± 7.25A	355.96 ± 9.21A	514.04 ± 3.12A	254.31 ± 1.42A	324.12 ± 3.41A
		60	140.91 ± 1.32C	52.16 ± 0.44C	203.41 ± 5.61C	144.43 ± 1.24C	139.77 ± 2.31C	194.08 ± 2.04C
	75%TSW	1	157.61 ± 2.31C	111.05 ± 3.11C	296.36 ± 5.63C	201.15 ± 3.47C	34.98 ± 4.22C	113.01 ± 2.78C
	+25%DTW	30	382.02 ± 2.11B	234.48 ± 1.41A	346.24 ± 2.11A	353.14 ± 0.87B	189.27 ± 1.17B	254.21 ± 2.54B
		60	401.22 ± 2.84A	195.38 ± 4.28B	340.15 ± 3.54B	434.09 ± 3.21A	232.97 ± 1.58A	270.25 ± 2.15A
	100% TSW	1	211.54 ± 3.24C	118.08 ± 5.11B	290.07 ± 5.21C	117.56 ± 3.65C	36.48 ± 2.32C	73.43 ± 1.35C
		30	242.86 ± 3.44A	98.60 ± 1.36C	314.50 ± 1.44B	621.91 ± 2.53A	336.31 ± 3.54A	751.36 ± 3.21B
		60	235.81 ± 1.41B	190.32 ± 0.75A	327.69 ± 1.85A	395.62 ± 3.44B	104.45 ± 0.33B	932.47 ± 2.40A

Means with the same letter in the same square are not significantly different
Data expressed as Means ± SE. ($P \leq 0.05$)
DTW: Dechlorinated Tap Water. TSW: Treated Sewage Water.

Table 6. Weight gain, specific growth rate and survival of both Nile tilapia and Common carp reared in dechlorinated tap water and different levels of treated sewage water after 90 days

Fish	Treatments	Initial weight (g/fish)	Final weight (g/fish)	Weight gain (g/fish)	Specific growth rate %	Survival %
Nile tilapia	Control (DTW)	3.20 ± 0.14^{A}	21.75 ± 0.07^{A}	18.55 ± 0.07^{A}	2.13 ± 0.04^{A}	95
	25% TSW +75%DTW	3.30 ± 0.00^{A}	20.85 ± 0.64^{A}	17.05 ± 0.06^{A}	2.05 ± 0.04^{A}	95
	50% TSW +50% TW	3.35 ± 0.07^{A}	20.90 ± 0.42^{A}	17.50 ± 0.42^{A}	2.04 ± 0.05^{A}	95
	75%TSW +25%DTW	3.20 ± 0.14^{A}	20.05 ± 0.07^{A}	16.85 ± 0.07^{A}	2.04 ± 0.04^{A}	90
	100%TSW	3.25 ± 0.07^{A}	19.85 ± 0.35^{A}	16.56 ± 0.21^{A}	2.01 ± 0.0^{A}	85
Common carp	Control (DTW)	3.40 ± 0.00^{A}	19.60 ± 0.14^{A}	16.20 ± 0.14^{A}	2.12 ± 0.21^{A}	95
	25% TSW +75%DTW	3.45 ± 0.05^{A}	7.65 ± 0.76^{B}	4.20 ± 0.70^{B}	1.11 ± 0.04^{B}	90
	50% TSW +50% TW	3.50 ± 0.00^{A}	6.30 ± 0.14^{B}	2.80 ± 0.14^{C}	0.83 ± 0.07^{C}	75
	75%TSW +25%DTW	3.35 ± 0.07^{A}	4.45 ± 0.24^{C}	1.10 ± 0.11^{D}	0.43 ± 0.10^{D}	60
	100%TSW	3.40 ± 0.00^{A}	4.35 ± 0.19^{C}	0.95 ± 0.05^{E}	0.38 ± 0.04^{E}	35

Means with the same letter in the same column are not significantly different. Data expressed as Means ± SE. ($P \leq 0.05$) DTP: Dechlorenated Tap Water. TSW: Treated Sewage Water.

tilapia could tolerate these changes, as previously mentioned by Bunch and Bejerano (1997) and Escher *et al.* (1999). In addition, Pickering and Pottinger (1989) revealed that poor quality of water induces stress, which is manifested in elevated cortisone levels, a hormone known to be a very potent immunosuppressant.

In conclusion, reused waste water in aquaculture should be well treated before the introduction of fish and oxidation ponds must be prepared to produce suitable water. Also, bacteriological standards should be set for the usage of the treated waste water based on local studies. We have to ensure that high standards of hygiene are maintained during fish handling and processing, health education programmers should be introduced for operators of subsistence aquaculture and well cooking of eviscerated fish should be used as an important health safeguard.

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دراسات ميكروبيولوجية وفيزيو-كيميائية على بعض الأسماك المستزرعة في مستويات مختلفة من مياه الصرف الصحي المعالج

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أجريت هذه الدراسة بأحواض زجاجية فى المعمل المركزى لبحوث الثروة السمكية بالعباسة، أبو حماد، شرقية - جمهورية مصر العربية لدراسة تأثير مستويات مختلفة من مياه الصرف الصحى المعالج بمحطة الزقازيق المضافة إلى ماء الصنبور بنسب (صفر، ٢٥%، ٥٠%، ٧٥% و ١٠٠%) على الحمل البكتيري وخواص وجودة المياه ومتبقيات بعض العناصر الثقيلة (الرصاص، الكادميوم، النحاس والحديد) في الماء وجلد وخياشيم ولحم أسماك البلطى النيلى والمبروك العادى المرباة لمدة ٦٠ يوم. تم دراسة تأثير هذه المستويات على معدل النمو النوعى والإعاشة.

أسفرت الدراسة عن النتائج الآتية:

انخفاض في الحمل البكتيري في مياه الصنبور المنزوع منه الكلورين (الكنترول) ويزيد تدريجيا فى بعض مستويات مياه الصرف المعالجة ويصل إلى المستوى العالي من مياه الصرف (١٠٠%) وكذلك الحال في الأسماك المرباة بها وذلك بدءا من العينة الأولى (أول يوم) حتى العينة النهائية (بعد ٦٠ يوما) وتذبذبت النتائج خلال فترات التجربة.

سجلت الأعداد البكتيرية انخفاضا ملحوظا في خياشيم وجلد ولحم الأسماك المرباة في المياه النقية (الكنترول) عن المرباة في مياه الصرف المعالجة وكان التأثير مرتبطا بالتركيزات، وقد سجلت الأعداد الأعلى الخياشيم ثم يليها الجلد ثم اللحم.

أوضحت تحليلات المياه أن كمية الأكسجين الذائب كانت منخفضة جدا في مياه الصرف مقارنة بمياه الصنبور المنزوعة الكلورين إلى الحد غير الكافى للتربية. بالإضافة إلى ذلك فإن متطلبات الأكسجين الحيوي (BOD_5) كان الأعلى في مياه الصرف المعالجة.

كما سجلت قياسات خواص جودة المياه (النترات والآمونيا والعسر الكلي والقلوية الكلية) تدهورا ملحوظا في مياه الصرف مقارنة بمياه الكنترول. كما أوضحت النتائج أن متبقيات الرصاص والكادميوم والنحاس والحديد ارتفاعا عن الحدود المسموح بها عالميا في مياه الصرف المعالجة مقارنة بالكنترول حسب تقديرات منظمة الصحة العالمية (WHO)

لذا توصي الدراسة بضرورة معالجة مياه الصرف الصحي جيدا قبل خلطها بمياه الاستزراع السمكي وإخضاعها للفحوصات الميكروبية والكيميائية الدقيقة والمتكررة وذلك لتجنب الخسارة في الإنتاج السمكي وضمان عدم وصول هذه الملوثات للمزارع والمستهلك.