Hygienic Quality of Water Used in Some Fresh and Marine Aquacultures and Their Implications on Fish

Samaa T. Hozien[a], Marwa A. Hassan[b], Mona M. Abdel wahab[a] zamzam H. Abdel wahed[b] and A. M. Hassan[b].

[a] Animal Health Research Institute, Ismailia, Egypt.

[b] Departement of Animal and Poultry Hygiene, Faculty of Veterinary Medicine, Suez Canal University, Ismailia, Egypt.

Abstract

This study was carried out to compare between the hygienic quality of fish and water used in different aquaculture types. A total of 56 water samples and 150 fish samples also were collected from different aquacultures in Egypt. Water samples were tested for the presence of three heavy metals as Cadmium (Cd), Lead (pb) and copper (cu). Also, it were examined for their Physicochemical characteristics. Both water and fish samples were examined bacteriologically Total bacterial count(TBC), Total coliform count (TCC) and Feacal coliform count(FCC). Also, Results revealed a significant increase in NH_3 of pond samples, TBC , FCC, Cd, pb and Cu of both water and fish samples in fresh aquacultures compared to marine aquaculture. While a significant increase in No_3, Ca^{2+}, Mg^{2+}, T.ALK , TDS, EC and Cl^- in water samples of marine aquaculture in comparsion with fresh aquacultures.

This difference between two types of fish farms may attributed to natural chemistry of water used in each farm, which in turn influence the hygienic quality of the fish produced from each farm , where marine water affect the heavy metal accumulation on fish negatively either by competitive inhibiton through ions exchange in gills or by forming un absorbable precipitate. Also, the high salinity of marine water sets up a hypertonic environment which enhance bacterial death. Also, many types of bacteria are killed by the high concentration of NaCl in marine aquaculture.

Key words: marine aquaculture, fresh aquaculture, Heavy metals, Fish bacterial load.

Introduction

Water is the external medium for fish, so water quality is an important factor for pond management because it has a great effect on fish production. Water quality include the important components of water which should be found for the optimum fish growth, Water quality consists of physical, chemical and biological factors which control the water used for fish culture purposes. These factors are: dissolved oxygen, pH, hardness, turbidity, alkalinity, nitrogenous compounds (mainly ammonia) and temperature ***(Ehiagbonare and Ogundiran , 2010).*** Untreated water and the improper way of sewage disposal system is one of the main sources for microbial water contamination which results in the accumulation of pathogenic bacteria in the commercial edible fish ***(Sujatha K. et al.,2011).*** In many countries, Increasing of the industrialization and agricultural activities lead to an increasing of discharge of chemical pollutants into the ecosystem, So increasing in metals levels in the natural waters cause a great damage of fresh and marine habitats ***(El Nemr, 2012).*** Heavy metals produce their toxic effect by producing reactive oxygen species (ROS), leading to oxidative stress. heavy metal ions are naturally toxic or carcinogenic which threat both the public health and the environment ***(Farombi et al. 2007).***

the main objectives of this study to:

1.Evaluate the physic-chemical parameters of water at some fish farms

2.Bacteriological evaluation of pond water and fish samples from different fish farms.

3.Study the possible correlation between water quality and fish.

4.Comparing the hygienic status between fresh water aquaculture and marine aquaculture.

Material and Methods

A field study was carried out during the period from November 2014 to Apirl 2015 at three localities:- farm **A** (Elhosynaya -Sharkia governorate), farm **B**(El- Mansraa -Portsaid governorate) and farm **C** (El-Tall El-kbeer -Ismailia governorate). Wherer farm **A** and **C** are fresh aquacultures depend on agriculture drainage as source of water(Nile Tilapia and Mugil are produced) while farm **B** is a marine aquaculture(where seabass and seabream are produced). A total of 56 pond water samples and 150 fish samples also were collected at different stages of the production cycle. Water samples were collected as pre method described in ***(Abd El Azeem M.H.; et al,. 2012).*** Some parameters (Temperatures using ***(CRison Oxi 45p(Barchelona),*** pH using pH meter ***(Hanna HI 9147 Oxy-Check, HANNA,USA),*** DO using digital oxygen meter (***Jenway 370pH meter (UK))*** were measured during taking water samples while others were measured as quick as possible at laboratory for **1-Chemical analysis:** immediate measuring of ECµS/cm by means of conductivity meter(***Jenway 4520 condictivity Meter(UK),*** using UV screening spectrophotometric method to determine the nitrogenous compound (NH_3 according to ***Koroleff, F. 1976*** ,NO_2 according to ***(EPA 1979),*** NO_3 according to **(*APHA,1998).*** T.Alkalinity determined using titrimetric method modified from method described by ***(APHA, 1998).*** Total, calcium and magnesium hardness were determined using Ethylene diamine tetra acetic acid (EDTA) titrimetric method according to ***(APHA, 1998).*** Cl^- was determined by Argentometric Method according to ***(APHA,1998).***

While for heavy metal detection in water samples nitric acid (0.001% v/v) was added to a portion of the filtered sample to keep the metals in suspension and the samples were kept at less than 5̊ C ***(Goan et al.,1992).*** For fish samples Tissue samples were prepared according to the method described by ***(Al-Ghais 1995).*** Lead, Cadmium, Copper were analyzed using Atomic Absorbation Spectrophotometer ***(thermo electron corporation S. series, AA spectrometer type S4 A A system, S.No.GE 711838).***

For Bacteriological examination: all water and fish intestinal samples were estimated ***using drop plate technique described by(Herigstad et al. 2001)*** onto the following media: Standard plate count agar (Difco, USA) for total bacterial count (TBC) ;EMB agar (Lab M, LAB061, UK) for *E. coli*, and total Enterobacteriacae; Total aerobic bacteria, *E. coli* and total Enterobacteriacae were cultivated at 37°C for 24–48 h. Fecal coli form cultivated at 40°C for 48-72hr.

Statistical Analysis:

Results are expressed as means ± SEM. Results were tested for differences by performing the ANOVA using MINITAB 17 computer, Correlation Coefficient were performed using IBM SPSS software computer program version 16, NY, USA (Inc.,1989-2010). Differences were considered statistically significant at $p< 0.05$.

Results:

Table (1): *Physico-chemical parameters of water (water-ponds) used in different fish farms at different localities:*

paramter	Farm A	Farm B	Farm C
	Mean±SE	Mean±SE	Mean±SE
DO (mg/l)	$5.02±0.31^{c}$	$6.47±0.07^{a}$	$5.74±0.05^{b}$
pH	$8.4±0.06^{a}$	$8.5±0.05^{a}$	$8.6± 0.12^{a}$
Temp	$19.6±0.58^{b}$	$23.8±0.83^{a}$	$21.6±0.79^{b}$
TDS	$2896±140^{b}$	$19553±752^{a}$	$450±23.2^{c}$
NH_3(mg/l)	$0.33±0.23^{ab}$	$0.04±0.01^{b}$	$1.33±0.74^{a}$
NO_2(mg/l)	$0.18±0.07^{a}$	$0.18±0.07^{a}$	$0.03±0.009^{b}$
NO_3(mg/l)	$0.12±0.06^{b}$	$0.53± 0.09^{a}$	$0.32±0.06^{ab}$
T.hardness	$958±118^{b}$	$6750±1260^{a}$	$140±8^{b}$
Ca^{+2} (mg/L)	$108±15^{b}$	$561±144^{a}$	$12.58±5.75^{b}$
Mg^{+2}(mg/L)	$206±30^{b}$	$1284±250^{a}$	$29.3±2.3^{b}$
Cl^-(mg/l)	$1384±83^{b}$	$10547±741^{a}$	$197±37.9^{b}$
T.Alkalinty ($mgCaCo_3$/L)	$132.8±29.7^{b}$	$413.3±41^{a}$	$29±2.54^{c}$

*Means with different superscripts at the same row are statistically different at P<0.05

**A=Sharkia farm , B=Portsaid farm, C= El Tall-El kabeer farm.

*** Highlighted numbers are the highest significance values while underlined numbers are the lowest significance value.

Table (2): *Bacteriological evaluation of pond water and fish samples in different fish farms at different localities:-*

paramter	Farm A	Farm B	Farm C
	Mean±SE	**Mean±SE**	**Mean±SE**
Ponds: T.B.C	5.13±0.15^{a}	4.70±0.14^{b}	4.93±0.36^{ab}
T.E.C	3.83±0.35^{a}	4.34±0.23^{a}	3.87±0.7 ^{a}
T.C.C	2.12±0.57^{ab}	1.56±0.59^{b}	3.12±0.79^{a}
F.C.C	1.26±0.54^{a}	0.59±0.40^{b}	0.59±0.40^{b}
Fish Ms: T.B.C	6.410±0.118^{a}	6.030±0.114^{b}	6.412±0.22^{ab}
T.E.C	4.916±0.243^{a}	3.704±0.271^{b}	4.969±0.388^{a}
T.C.C	3.032±0.364^{a}	2.104±0.294^{b}	4.259±0.367^{a}
F.C.C	3.873±0.291^{a}	0.909±0.235^{b}	3.481±0.324^{a}

*Means with different superscripts at the same row are statistically different at P<0.05

**A=Sharkia farm, B=Portsaid farm, C= El Tall-El kabeer farm.

T.B.C=Total Bacterial Count, T.E.C=Total Enterobacterace Count, T.C.C=Total Coliform count, F.C.C=Feacal Coliform Count.

*** Highlighted numbers are the highest significance values while underlined numbers are the lowest significance value.

Table (3): *Heavy metal Concentration (Cd, Pb, Cu) of pond water and fish samples in different fish farms at different governorates:-*

	Farm A	Farm B	Farm C
Pond: Cd (mg/l)	0.07±0.07^{a}	0.00^{a}	**0.003±0.003 ^{b}**
Pb(mg/l)	1.10±1.07^{a}	0.01±0.01^{b}	1.51±0.68^{a}
Cu(mg/l)	0.30±0.16^{a}	0.07±0.01^{b}	0.43±0.12^{a}
Fish Ms: Cd (mg/g)	**0.006±0.002^{a}**	**0.001±0.0007^{b}**	**0.003±0.0002^{ab}**
Pb(mg/g)	0.12±0.09^{a}	0.04±0.031^{b}	0.03±0.01^{b}
Cu(mg/g)	**0.033±0.003^{a}**	**0.034±0.004^{a}**	0.07±0.039^{a}

*Means with different superscripts at the same row are statistically different at P<0.05

**A=Sharkia farm, B=Portsaid farm, C=Telkbeer farm.

*** Highlighted numbers are the highest significance values while underlined numbers are the lowest significance value.

Table (4): *Correlation between different physic-chemical parameters of pond water and heavy metals concentrations in pond water samples and fish muscles:-*

	pH	TDS	chloride	Mgconc	TCa	Cadmium	lead	copper	Fish CD	fishPb	FishCU
pH	1	0.009	0.063	0.053	0.015	0.035	-.595-	-.710*	-.452*	-.072-	-.120-
TDS		1	.769**	.755**	.560**	-.369-	-.479-	-.589-	-.498*	0.003	0.094
chloride			1	.348**	0.081	-.346-	-.461-	-.580-	-.460*	0.155	0.17
Mgconc				1	.892**	-.362-	-.414-	-.498-	-.430-	0.018	0.115
TCa					1	-.251-	-.361-	-.446-	-.300-	0.244	0.193
Cadmium						1	-.249-	-.177-	0.252	-.357-	-.438-
lead							1	.971**	0.052	-.177-	-.443-
copper								1	0.176	-.303-	-.494-
FishCD									1	0.407	0.374
FishPb										1	.734**
FishCU											1

Correlation is significant at the 0.05 level (2-tail)*
** Correlation is significant at the 0.01 level (2-tailed).

Table (5): *Correlation between different physic-chemical parameters of pond water and bacteriological findings in water and fish intestinal samples:*

	pH	DO	Temp.	TDS	Amonia	Nitrite	Nitrate	WFC	WTC	WTBC	FFC	FTC	FTBC
pH	1	-.220-	0.132	0.009	-.027-	-.374**	-.207-	0.171	0.255	0.032	-.069-	-.063-	0.075
DO		1	-.843**	.324*	0.143	0.14	.486**	0.13	0.078	0.104	-.093-	-.074-	-.281*
Temp.			1	-.174-	-.101-	-.046-	-.296*	-.166-	-.048-	-.180-	-.085-	-.074-	.287*
TDS				1	-.266*	0.075	.429**	-.121-	-.319*	-.175-	-.376**	-.468**	-.087-
Ammonia					1	0.127	0.196	0.024	.353**	.389**	0.06	-.088-	-.197-
Nitrite						1	0.26	0.136	0.153	0.154	0.157	0.236	0.135
Nitrate							1	-.076-	0.067	0.206	-.276*	-.313*	-.367**
WFC								1	.542**	.496**	0.225	0.213	0.126
WTC									1	.641**	0.137	.286*	-.085-
WTBC										1	0.09	0.119	-.124-
FFC											1	.354**	.448**
FTC												1	.410**
FTBC													1

***. Correlation is significant at the 0.01 level (2-tailed).*
**.Correlation is significant at the 0.05 level (2-tailed).*

Discussion:

In accordance with results of TDS of the examined pond water samples showed in Table (1) it was high in Port said farm(B) in comparison with Sharkia farm (A) and ismailia farm (C),this agreed with a strong negative correlation showed in Table (4) between the salinity (TDS) and chloride with the heavy metal concentration in water and fish muscles, where results in Table (3) indicated that the detected heavy metals concentrations was the lowest at farm B in comparsion with other fresh aquacultures in both water and fish samples.

Concerning ammonia concentration in pond water, it detected to be the highest at farm (C) and the lowest in farm (B), this variation in ammonia mean values may attributed to areas variations and the rate of water exchange in each farm, where farms A and C is highly close to agriculture area that might be a source of pollution to water. Also, the rate of water exchange was the lowest in farm C as it was 20% weekly or each 2 weeks, in comparison with the high regular water exchange rate in other farms. Plus the high stocking density in farm C increase ammonia concentration in water.

Also results in Table (2) revealed that the means of bacteriological findings TBC, TCC, FCC was detected to be the lowest in farm (B) (marine aquaculture) in comparison with farms (A) and (C) especially in fish intestinal samples this could be related to many factors: Firstly, that the high salinity of farm B water sets up a hypertonic environment. Thus the water (solvent) in the bacteria would diffuse out of the bacterium by a process called "osmosis", Because of the loss of water, the bacteria will shrivel up and eventually die. Also , many types of bacteria are killed by the high concentration of NaCl in marine aquaculture. Secondly, the component of fish endogenous microbiota depends mainly on genetic, nutritional and environmental factors, where it is supposed that Gram-negative facultative anaerobic bacteria like Acinetobacter, Aeromonas, Flavobacterium/ Cytophaga, Micrococcus, , Pseudomonas and Vibrio constitute the main endogenous microbiota of a lot of marine fish species ***Cahill (1990); Onarheim et al. (1994) and Blanch et al. (1997).*** The opposite was found in freshwater fish species, where the endogenous microbiota of freshwater fish was predominated by members of the genera Aeromonas, Acinetobacter, Pseudomonas, Flavobacterium, some representatives of the Enterobacteriaceae family, Clostridium and Fusobacterium ***Sakata (1990); Huber et al. (2004) and Kim et al. (2007).***

The obtained bacteriological findings in water and fish samples are nearly the same due to close correlation between the bacteria present in water and in organs of fishes with E. *coli* dominating followed by P. *aeruginosa* in some tissues of cultured carps as Labeo rohita, Cirrhinus mrigala and *Cyprinus carpio* polycultured, in a freshwater pond.

Correlation between measured parameters indicated that in Table (4) a strong negative correlation showed in between the salinity (TDS) and chloride with the heavy metal concentration in water and fish muscles, this could be attributed to the fact that high salinity, high Cl-, other component of sea- water, inhibit the absorption of this pollutant through fish gills either by competitive inhibition or by combine with this pollutant lead to un absorbable precipitate. Where ***Barbara and Malgorzata (2006)*** stated that accumulation of metal in fish Muscles depends on the heavy metal concentration, time of exposure, the manner of metal uptakes and other environmental factors as; water temp, pH, hardness and salinity, also some intrinsic factors as fish age and feeding habits play an important role. It was detected that high water hardness reduces lead toxicity in fish by formation of a significant inorganic complex that reduce lead availability to fish. ***Hodson et al. (1984).*** Also in Table (4) there is a strong negative correlation between DO and water temperature. This agreed with ***Diaz and Rosemberg (1995) and Wu (1999)*** was found that in tropical aquatic environments, high temperatures lead to sever decomposition of the organic matters which cause a drastic decrease in the levels of water dissolved oxygen (DO), which called environmental hypoxia. Aquatic hypoxia may also exist from the anthropogenic inputs of nutrients and organic matter in lakes and ponds.

Table (4) revealed a negative correlation between pH and cadmium (r = -0.452), lead (r = -0.072) and copper (r = -0.120) in fish muscles which agreed with ***Raja et al. (2009)*** explained that acidic water affects heavy metal bioaccumulation in fish muscles, either indirectly by changing the heavy metal solubility or directly by damaging the gills epithelia, so become more permeable to metals. ***Part et al. (1985)*** stated that The acidic conditions of aquatic environment might increase the free divalent ions of many heavy metals that absorbed by fish gills.

Results in Table (5) showed a positive correlation between ammonia concentration and TBC and TC (r = 0.389, 0.353 at p> 0.01 respectively) in water samples where impairment water quality in fish ponds like high ammonia (either raised due to high nutrition or agriculture drainage which rich with organic matter that observed in freshwater farms), increase the risk of bacterial growth as supported by ***Markosova and Jezak (1994) and Jana and De (1990).*** And negative correlation between water pH and ammonia concentration (r = -0.27) which agreed with ***Chew et al. (2003)*** who reported that by lowering of environmental pH we can deal with the high environmental ammonia levels through reducing the concentration of NH_3 in the water, consequently reduce its level in the fish, constituting “environmental ammonia detoxification.

Conclusion:

In conclusion our results indicated that there was a strong negative correlation between the TDS, CL in water and persistence of heavy metals in water and fish muscles. Also, a strong positive correlation between ammonia concentration and TBC, FC in water samples and a negative correlation between water pH and cadmium, lead and copper in fish muscles . From the hygienic point of view, marine aquaculture supply the market with a safe fish for food in comparsion with fresh water aquacultures that mostly suffers from high ammonia concentrations, high bacteriological load, high feacal coliform content , high heavy metals residues. So exploitation our large sectors of marine water (Meditterean sea, Redwater sea, other marine lakes and canals) would be the Perfect replacement for most of fresh water aquaculture that provide bad quality product.

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الملخص العربى

لقد أجريت دراسة ميدانية لتقييم الجودة الصحية للمياه المستخدمة في المزارع السمكية مع تقدير بعض الملوثات المياه من المزارع السمكية من مناطق مختلفة بمحافظة الشرقية ومحافظة بورسعيد ومحافظة الإسماعيلية و لقد تم إجراء المسح الميداني خلال الفترة من أكتوبر 2014 إلى ابريل 2015 ذلك لكشف عن بعض العناصر الثقيلة(الكادميوم والنحاس و الرصاص) فى عينات المياه و لحوم الاسماك و ايضا قياس الخصائص الفيزيائية الكيميائية للمياه في المزارع السمكية المختلفة مع بعض الدراسات البكتريولوجيا في عينات المياه والأمعاء الأسماك.

ولقد كشفت النتائج ان اقل تلوث بالمعادن الثقيلة والمكروبات القولونيه البرازيه فى مزرعة بورسعيد (الاستزراع البحرى) بينما كانت النتائج اعلى فى مزارع المياه العذب بمزرعة الاسماعيلية و الشرقيه. و ايضا كشفت الدراسة عن علاقات ارتباط بين مختلف العناصر بالمياه و تاثير بعضهما على بعض.