

Canal Suez University
Faculty of Science
Chemistry Department



**Study on the role of water quality on the accumulation of some
heavy metals in fish farms**

Thesis Submitted By

Ibrahim Mohamed El-Sayed Mohamed Hassan Mousa

(M.Sc. Physical Chemistry 2013)

For

**The Degree of Doctor of Philosophy of Science
(Analytical and inorganic Chemistry)**

(Faculty of science)

Canal Suez University

Supervisors

Signature

Prof. Dr. Sabry A. El-Korashy

.....

Prof. of inorganic Chemistry

Faculty of Science Canal Suez University

Dr. Niema. A. Abdel -Fattah

.....

Assistant Prof. of Environmental Science

Central Laboratory for Aquaculture Research

Dr. Diao A. El-Kinawy

.....

Assistant Prof. of Environmental Science

World fish- Abbasa

(2018)

CONTENTS

	Table of Contents	I
	List of Tables	V
	List of Figures	VII
	Chapter One - Introduction -	
1.1.	Introduction.....	1
1.1	Literature Survey	5
1.1.1.	Water temperature:.....	5
1.1.2.	Dissolved oxygen:.....	6
1,1.3.	Secchi disk visibility:.....	7
1.1.4.	pH degree:	8
1.1.5.	Total Alkalinity:.....	9
1.1.6.	Total hardness:	10
1.1.7.	Nitrogenous compounds:	11
1.1.7. 1.	Ammonia (NH ₃) and Ammonium ion (NH ₄) ⁺	11
1.1.7.2.	Nitrite (NO ₂) ⁻ and Nitrate (NO ₃) ⁻	12
1.1.8.	Phosphorus:.....	12
1.1.9.	Heavy Metals:	13
1.1.9.1.	Copper:.....	14
1.1.9.2.	Zinc:	14
1.1.9.3.	Cadmium:.....	15
1.1.9.4.	Lead:	15
1.2.	Biological Characteristics:	17
1.2.1.	Phytoplankton:	17
	The aim of the study	20
	Chapter Two - Materials and Methods -	
2	Materials and Methods.....	23
2.1.	Study area.....	21
2.2.	Specimens collecting and equipment.....	21
2.2.1.	Water	21
2.2.2.	Fish.....	22
2.2.3.	Phytoplankton:	22

2.2.4.	Statistical analysis	22
2.2.5.	Water analysis.....	23
2.2.6.	Fish analysis.....	24
2.2.7.	Heavy metals	24
2.2.8.	Growth parameters.....	25
2.2.8.1.	Condition factor (K).....	25
2.2.8.2.	Hepato-somatic index (HSI)	25
	Chapter Three - Results and Discussion -	
3	RESULTS	26
3.1.1.	Physical Parameters	26
3.1.1.1.	Water temperature.....	27
3.1.1.2.	Water Transparency	27
3.1.2	Chemical Parameters:	31
3.1.2.1	Hydrogen ion concentration (pH)	31
3.1.2.2	Electric Conductivity (EC; $\mu\text{S}/\text{cm}$):.....	32
3.1.2.3	Dissolved oxygen (DO)	32
3.1.2.4.	Total alkalinity (T.alk).....	33
3.1.2.5.	Total Hardness (T.H)	34
3.1.2.6.	Calcium Hardness (Ca.H):.....	35
3.1.2.7.	unionized Ammonia:.....	36
3.1.2.8.	Nitrite Concentration (mg/L):.....	36
3.1.2.9.	Nitrate (NO_3^-)	37
3.1.2.10.	Orthophosphate (O.P):	38
3.1.2.11.	Total dissolved Solids (TDS):.....	39
3.1.2.12.	Heavy metals in water.....	40
3.1.2.12.2.	Copper (Cu).....	41
3.1.2.12.3.	Iron (Fe)	42
3.1.2.12.4.	Manganese (Mn):	43
3.1.2.12.5.	Lead (Pb).....	44
3.1.2.12.6.	Zinc (Zn)	45
3.1.3.	Correlation between water parameters	46
3.2.	Fish analysis.....	51

3.2.1.	Heavy metals in fish.....	51
3.2.1.1.	Cadmium (Cd)	51
3.2.1.2.	Copper (Cu)	53
3.2.1.3.	Iron (Fe)	54
3.2.1.4.	Manganese (Mn)	57
3.2.1.5.	Lead (Pb).....	59
3.2.1.6.	Zinc (Zn)	61
3.2.2.	Correlation between water and fish parameter:	66
3.2.3	Correlation between the concentrations of heavy metals in fish with each other's:.....	73
3.2.4.	Growth parameters	75
3.2.4.1.	Condition factor (K).....	75
3.2.4.2.	Hepato- somatic index (HSI).	75
3.3.	Biological studies.....	78
3.3.1.	Phytoplankton	78
3.3.2.	Distribution and monthly variations of total phytoplankton	80
3.3.3.	Distribution and variations of common groups	
3.3.3.1.	Chlorophyceae (green algae)	80
3.3.3.2.	Cyanophyceae (blue green algae)	81
3.3.3.3.	Bacillariophyceae(diatoms).....	81
3.3.3.4.	Euglenophyceae (Euglena)	82
	Chapter Four - DISCUSSION	
	4- DISCUSSION	84
4.1.	Physical and chemical parameters	84
4.1.1.	Hydrogen ion concentration (pH).....	84
4.1.2.	Water temperature.....	85
4.1.3.	Transparency	86
4.1.4.	Dissolved oxygen (DO)	86
4.1.5.	Total alkalinity.	87
4.1.6.	Total Hardness and Calcium Hardness	88
4.1.7.	Nitrite (NO ₂)	89
4.1.8.	Nitrate (NO ₃)	90
4.1.9.	Ammonia	91
4.1.10.	Orthophosphate	92

4.1.11.	Electric conductivity ($\mu\text{S}/\text{cm}$)	93
4.1.12.	Total Dissolved Solids	94
4.2.	Heavy metals	95
4.2.1.	Cadmium	95
4.2.2.	Copper	97
4.2.3	Iron	98
4.2.4.	Manganese (Mn)	100
4.2.5.	Lead	101
4.2.6.	Zinc	102
4.3.	The correlation coefficient matrix	106
4.3.1.	The correlation coefficient matrix	106
4.4.	Growth parameters	107
4.4.1.	Condition factor (K)	107
4.4.2.	Hepato- somatic index (HSI)	108
4.5.	Biological studies	109
4.5.1.	Phytoplankton	109
5	Summary and Conclusion	113
6	REFERENCES	117

LIST OF TABLES

<i>Table No.</i>	<i>Title</i>	<i>Page</i>
<i>Table (1)</i>	<i>Monthly and farms variation (means+ standard deviations) of some physical and chemical parameters of water samples collected from the three studied fish farms.....</i>	29
<i>Table (2)</i>	<i>Monthly variations (means \pm standard deviations) of heavy metals concentrations (ppm) in water of the three studied fish farms.</i>	46
<i>Table (3)</i>	<i>Pearson correlation coefficient (r = value) between water parameters in the three studied fish farms.</i>	47
<i>Table (4)</i>	<i>Farms variations (means \pm standard deviations) of heavy metals concentrations ($\mu\text{g/g}$ dry wt) in Musculature of Oreochromis Niloticus in the different three studied fish farms.</i>	63
<i>Table (5)</i>	<i>Farms variations (means \pm standard deviations) of heavy metals concentrations ($\mu\text{g/g}$ dry wt) in gills of Oreochromis Niloticus in the different three studied fish farms.....</i>	64
<i>Table (6)</i>	<i>Farms variations (means \pm standard deviations) of heavy metals concentrations ($\mu\text{g/g}$ dry wt) in liver of Oreochromis Niloticus in the different three studied fish farms.....</i>	65
<i>Table (7)</i>	<i>Farms variations mean of heavy metals concentrations (ppm) in muscles, gills and liver of Oreochromis Niloticus in the different three studied fish farms.</i>	66
<i>Table (8)</i>	<i>Pearson correlation coefficient (r = value) between water parameters and heavy metal concentration in musculature in fish in the different three studied fish farms.</i>	69
<i>Table (9)</i>	<i>Pearson correlation coefficient (r = value) between water parameters and heavy metal concentration in gills in fish in the different three studied fish farms.</i>	71
<i>Table (10)</i>	<i>Pearson correlation coefficient (r = value) between water parameters and heavy metal concentration in liver in fish the different three studied fish farms.</i>	73
<i>Table (11)</i>	<i>Pearson correlation coefficient (r = value) between the concentration of heavy metal in fish musculature with each other's in the different three studied fish farms.</i>	75

<i>Table No.</i>	<i>Title</i>	<i>Page</i>
<i>Table (12)</i>	<i>Pearson correlation coefficient ($r = \text{value}$) between the concentration of heavy metal in fish gills with each other's in the different three studied fish farms.</i>	<i>75</i>
<i>Table (13)</i>	<i>Pearson correlation coefficient ($r = \text{value}$) between the concentration of heavy metal in fish liver with each other's in the different three studied fish farms.</i>	<i>76</i>
<i>Table (14)</i>	<i>Monthly variations (means + standard deviations) of condition factor (K) and hepato – somatic index (HIS) of Oreochromis Niloticus collected from the three studied fish farms.</i>	<i>77</i>
<i>Table (15);</i>	<i>Farms variations (means \pm standard deviations) of condition factor (K) and Heapto-Somatic Index (HSI) of Oreochromis Niloticus collected from the three studied fish farms.</i>	<i>77</i>
<i>Table (16)</i>	<i>Monthly total number of phytoblankton standing groups (org/l x103) in water samples collected from fish farm (1), from fish farm (2) and from fish farm (3).</i>	<i>81</i>
<i>Table (17)</i>	<i>Monthly average of phyto groups (org/L x103) in water samples collected from fish farm (1).</i>	<i>83</i>
<i>Table (18)</i>	<i>Monthly average of phyto groups (org/L x103) in water samples collected from fish farm (2).</i>	<i>84</i>
<i>Table (19)</i>	<i>Monthly average of phyto groups (org/L x103) in water samples collected from fish farm (3).</i>	<i>84</i>
<i>Table (20)</i>	<i>Community composition of total phytoplankton in the three studied fish farms.</i>	<i>84</i>

LIST OF FIGURES

<i>Fig. No.</i>	<i>Title</i>	<i>Page</i>
<i>Fig (1)</i>	<i>Monthly and farms variations in water in the three studied fish farms.</i>	<i>27</i>
<i>Fig (2)</i>	<i>Monthly and farms variations in water Transparency in the three studied fish farms.</i>	<i>28</i>
<i>Fig (3)</i>	<i>Monthly and farms variations in water pH in the three studied fish farms.</i>	<i>31</i>
<i>Fig (4)</i>	<i>Monthly and farms variations in the electrical conductivity water in the three studied fish farms.</i>	<i>32</i>
<i>Fig (5)</i>	<i>Monthly and farms variations in dissolved oxygen in water in the three studied fish farms.</i>	<i>33</i>
<i>Fig (6)</i>	<i>Monthly and farms variations of total alkalinity of water in the three studied fish farms.</i>	<i>34</i>
<i>Fig (7)</i>	<i>Monthly and farms variations of total Hardness of water in the three studied fish farms.</i>	<i>35</i>
<i>Fig (8)</i>	<i>Monthly and farms variations of Ca-Hardness in water in the three studied fish farms.</i>	<i>35</i>
<i>Fig (9)</i>	<i>Monthly and farms variations of total unionized ammonia in water in the three studied fish farms.</i>	<i>36</i>
<i>Fig (10)</i>	<i>Monthly and farms variations of nitrite in water in the three studied fish farms.</i>	<i>37</i>
<i>Fig (11)</i>	<i>Monthly and farms variations of nitrate in water in the three studied fish farms.</i>	<i>38</i>
<i>Fig (12)</i>	<i>Monthly and farms variations of ortho phosphate in water in the three studied fish farms.</i>	<i>39</i>
<i>Fig (13)</i>	<i>Monthly and farms variations of total alkalinity of water in the three studied fish farms.</i>	<i>40</i>
<i>Fig (14)</i>	<i>Monthly and farms variations of Cadmium concentration (ppm) in water of the three studied fish farms.</i>	<i>41</i>
<i>Fig (15)</i>	<i>Monthly and farms variations of Cupper concentration (ppm) in water of the three studied fish farms.</i>	<i>42</i>
<i>Fig (16)</i>	<i>Monthly and farms variations of Iron concentration (ppm) in water of the three studied fish farms.</i>	<i>43</i>
<i>Fig (17)</i>	<i>Monthly and farms variations of Manganese concentration (ppm) in water of the three studied fish farms.</i>	<i>44</i>

<i>Fig. No.</i>	<i>Title</i>	<i>Page</i>
<i>Fig (18)</i>	<i>Monthly and farms variations of Lead concentration (ppm) in water of the three studied fish farms.</i>	<i>44</i>
<i>Fig (19)</i>	<i>Monthly and farms variations of Zinc concentration (ppm) in water of in the three studied fish farms.</i>	<i>45</i>
<i>Fig (20)</i>	<i>Monthly and farms variations of cadmium concentration ($\mu\text{g/g}$ dry wt) in musculature (a), gills (b) and liver (c) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>52</i>
<i>Fig (21)</i>	<i>Monthly and farms variations of Cupper concentration ($\mu\text{g/g}$ dry wt) in musculature (a), gills (b) and liver (c) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>54</i>
<i>Fig (22)</i>	<i>Monthly and farms variations of Iron concentration ($\mu\text{g/g}$ dry wt) in musculature (a), gills (b) and liver (c) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>56</i>
<i>Fig (23)</i>	<i>Monthly and farms variations of Mangnese concentration (ppm) in musculature (a), gills (b) and liver (c) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>58</i>
<i>Fig (24)</i>	<i>Monthly and farms variations of Lead concentration ($\mu\text{g/g}$ dry wt) in musculature (a), gills (b) and liver (c) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>60</i>
<i>Fig (25)</i>	<i>Monthly and farms variations of Zinc concentration ($\mu\text{g/g}$ dry wt) in musculature (a), gills (b) and liver (c) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>62</i>
<i>Fig (26)</i>	<i>Monthly variations in condition factor (K) of <i>Oreochromis niloticus</i> in the three studied fish farms.</i>	<i>77</i>
<i>Fig (27)</i>	<i>Monthly variations in hepato- somatic index (HSI) of <i>Oreochromis Niloticus</i> in the three studied fish farms.</i>	<i>77</i>
<i>Fig (28)</i>	<i>Community composition of total phytoplankton in fish farm (1).</i>	<i>79</i>
<i>Fig (29)</i>	<i>Community composition of total phytoplankton in fish farm (2)</i>	<i>79</i>
<i>Fig (30)</i>	<i>Community composition of total phytoplankton in fish farm (3)</i>	<i>79</i>

ABSTRACT

Monitoring of water quality is very important, where it is the main factor impacts the cultured fish. So, the present study investigates factors affecting fish culture in some fish farms that use different sources of water (fresh water, agriculture drainage and sewage wastewater). In three different farms at Abbassa and Hessania, Sheikh governorate, Egypt. Water and fish samples were taken monthly during 2016 fish farming season, to evaluate the physical and chemical and biological characteristics and heavy metals distribution in water and fish organs (muscles ,gills and liver).

Results obtained from this study indicated significant difference between the water of the three farms, particularly in their physical and chemical characteristic (water temperature, pH, electrical conductivity, TDS, total and calcium hardness, total Alkalinity, phosphate, NH_3 , NO_2 , NO_3 , DO and transparency). Heavy metals varied depending upon the organ, location and the month of sampling. Also, the order of occurrence of heavy metals in water ranked at the following order,

$\text{Fe} > \text{Zn} > \text{Mn} > \text{Cu} > \text{pb} > \text{Cd}$ at fish farm (1), but at fish farm (2) it was $\text{Fe} > \text{Mn} > \text{Zn} > \text{Cu} > \text{Pb} > \text{Cd}$, while it was $\text{Fe} > \text{Mn} > \text{Zn} > \text{Pb} > \text{Cu} > \text{Cd}$ in fish farm (3). the level of concerned heavy metals in musculature and liver tissues in the three studied fish farms recorded in the order of $\text{Fe} > \text{Zn} > \text{Cu} > \text{Mn} > \text{Cd} > \text{Pb}$, except its order in liver in farm (1) had the order $\text{Fe} > \text{Zn} > \text{Mn} > \text{Cu} > \text{Pb} > \text{Cd}$, also gills in farm (3) had the same order while the gills in farm (1) had the order $\text{Fe} > \text{Zn} > \text{Cu} > \text{Mn} > \text{Pb} > \text{Cd}$, but in farm (2) had the order $\text{Fe} > \text{Zn} > \text{Mn} > \text{Cu} > \text{Cd} > \text{Pb}$. The levels of heavy metals exceeded the permissible limits according WHO (1989), in gills and liver, but in muscles did not exceed the permissible limits, except Fe. Comparison of the values of

condition factor (K) and hepato-somatic index (HSI) of the three studied fish farms indicated that fish of farm (1) was the best condition. In the present study phytoplankton was represented by four groups namely Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae, where Chlorophyceae dominated over other groups of phytoplankton in farm (2) while Cyanophyceae dominates in farm 1 and Bacillariophyceae in farm 3. Potential adverse health effects in such applications could be avoided if the wastewater is sufficiently treated before use.