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Hematological and Histopathological Studies on Tilapia Fish (*Oreochromis niloticus*) Living in the Water of Rosetta Branch, River Nile, Egypt

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Abstract: Tilapia fish (*Oreochromis niloticus*) samples were collected from three selected stations (Kafr El-Zyat and Tamalay on Rosetta branch of the River Nile and Shanawan drainage canal at Shanawan village, Egypt). The alteration in some blood parameters (red blood cells count and white blood cells count, hemoglobin, packed cell volume, glucose, protein, albumin and globulin and albumin/globulin ratio, A/G) and histology of liver and ovary were studied in relation to different types of pollution. Results showed increased number of white blood cells, protein, albumin and globulin and A/G ratio especially at Kafr El-Zyat station, which received industrial wastes. On the other hand, it is noticed an increase in red blood cells, hemoglobin and packed cell volume at Tamalay station, which received agricultural wastes. However, there is an increase in glucose at Shanawan station, which received agricultural and sewage wastes. Histopathological alternations of liver include degeneration, necrosis, fibrosis, hemorrhage, hemolysis, edema, dilation, thickness, congestion, stagnant blood and branching. While, the histopathological alternations of ovary include hyperplasia in granulose, separation of yolk from granulose, separation of theca, Atresia, hemorrhage, hemolysis, degeneration and necrosis. It was concluded that the wastes including industrial agricultural and sewage has a negative impact on *O. niloticus* fish health.

Key words: Hematology · Histopathology · Tilapia Fish (*Oreochromis niloticus*) · Rosetta Branch · Egypt

INTRODUCTION

The River Nile is mainly divided into two branches, the Damietta and Rosetta branches. It receives heavy load of wastes and effluents particularly from developing industries and agriculture besides the domestic wastes [1].

Fish and other aquatic organism are exposed to great varieties of pollution that have found their way into water in the form of sewage, industrial and agricultural wastes. Many authors had studied the effect of different types of pollutants on fish in relation to their hematology and histopathology [1-12].

Blood serves as the most convenient indicator of the general status of the animal body. Because fish are in direct contact with the environment, only a thin epithelial membrane separates the blood of a fish from water in which it swims. Therefore, any unfavorable change in the water reflects on the haemopoietic system. So, hematological studies are used for evaluating the environmental pollution [3, 11, 13].

The histological studies are considered as direct evidence referring to any adverse effect on fish. Generally, the liver is considered as the principal organ of detoxification in vertebrates and particularly in fish. It is also, the potential site for lipid deposition in these animals [14]. Meanwhile, fish liver is a good indicator of aquatic environmental pollution, where one of the important functions of the liver is to clean off any poison, or pollutants from the blood coming from the intestine [15]. Ovary suffers from various histological differences due to different types of water pollutants. These histological changes appear in the form of atretic oocytes [16]. These diseases affect the reproduction and maintenance of the fish species [3].

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Oreochromis niloticus, is so far one of the most important economic fish species in our country. During the last few years and with the development of industries and modern civilization, large amount of pollutants were discharged in the Nile River. These pollutants not only affect the growth, health and nutritional value of *O. niloticus* but also the survival and reproduction of this economic fish [1, 2].

Due to *O. niloticus* is highly esteemed fish in Egypt, so, the present study aimed to evaluate the pollution status of some areas along Rosetta branch of the River Nile and a drainage canal using *O. niloticus* hematology and histology (liver and ovary) as biomarkers of the effect of the wastes discharge.

MATERIALS AND METHODS

Samples Collection: Water and Tilapia fish (*O. niloticus*) samples were collected from three stations as follows:

- Shanawan drainage canal, at Shanawan village, which receives sewage wastes from many cities and villages, in addition to agricultural wastes from adjacent fields [17, 18].
- Rosetta branch of the River Nile, at Tamalay village, which receives agricultural wastes from adjacent fields [19].
- Rosetta branch of the River Nile, at Kafr El-Zyat city, which receives industrial wastes, i.e. Kafr El-Zyat industrial area including Soda, Soap and Pesticides factories [20, 21].

These three studied stations located in Al-Menoufeya (Shanawan and Tamalay) and Al-Gharbia (Kafr El-Zyat) provinces (Fig.1). The fish of the control group was collected from a fish farm in El-Kanater El-Khayria, Egypt.

Water Samples: In situ, air and water temperature (°C) was determined by dry mercury thermometer, pH value by Orion Research Ion Analyzer 399 A pH meter, transparency (cm) was determined by using Secchi-disc and electric conductivity (µmohs/cm) by using conductivity meter model (YSI SCT-33, USA).

Water samples were kept into a one liter polyethylene bottle in ice box and analyzed in the laboratory. The dissolved oxygen content, total dissolved solids, chloride, ammonia, nitrite, nitrate, carbonate and bi-carbonate alkalinity were determined by methods specified in APHA [22].

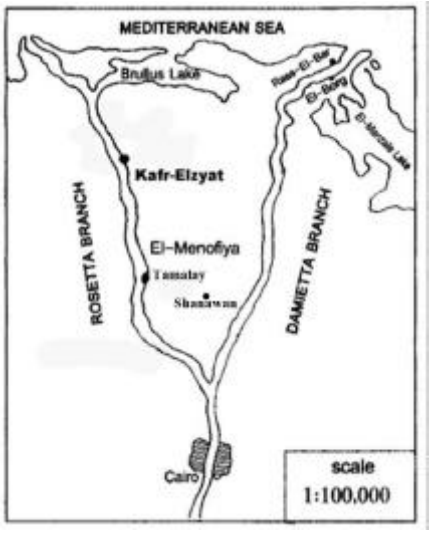


Fig. 1: A map showing Shanawan, Tamalay and Kafr El-Zyat Stations.

Blood Samples: Blood samples were taken from fish by severance of the caudal peduncle into two groups of small sterilized vials. The first group was contained anticoagulant (heparin) to prevent the formation of clot. Then the red blood cells and white blood cells counts were determined by a double hemocytometer using the method of Wintrobe [23]. Hemoglobin content was estimated in blood by using cyanomethemoglobin method (Boehringer Mannheim, Kit) described by Van Kampan and Zijlstra [24].

The packed cell volume was carried in small hematocrit graduated tubes, using hematocrit centrifuge at 3000 rpm for 10 min.

The second group was left to clot and then centrifuged at 3000 rpm for 10 min to obtain serum. Supernatant serum was obtained using micropipette model (Labsystems K 33071) to determine the concentration of protein colorimetrically by using the Boehringer Mannheim kits according to Gornall *et al.* [25]. Albumin content was determined colorimetrically according to Doumas [26]. Globulin content was obtained by subtraction of protein with albumin as follow: Globulin = Protein-Albumin.

Albumin/globulin (A/G) Ratio Is Obtained as Follows:

A/G ratio = Albumin / Globulin

The concentration of glucose was measured using enzymatic colorimetric method (GOD-period-method) described by Trinder [27].

Histological Method: Liver and ovary samples from each fish were carefully removed and fixed in 10% formalin, dehydrated in ascending grades of alcohol and cleared in xylene. The fixed tissues were embedded in paraffin wax and sectioned into five micrometers thick, then stained with haematoxylin and eosin (H&E). Then the sections were examined on light microscope and photographed by using a microscopic camera.

Statistical Analysis: The means and standard deviations of the measured parameters were estimated using the Microsoft Excel 2010 computer program.

RESULTS AND DICUSSION

Field studies are important and useful tools for investigating physiological and histological changes caused by the environmental pollutants [7].

Water Quality: Anthropogenic sources such as agriculture run-off, industrial and sewage have created both localized and regional pollution problems in nearly every country around the world. In some cases, the pollution has been extensive enough to lead to environmental disasters and ecosystem shutdown [8].

Physicochemical characteristics of water collected from the three studied stations are shown in Table (1). The results showed lower values of dissolved oxygen content and transparency and higher values of nitrite, nitrate and ammonia at all stations. The elevated levels in some physicochemical properties observed in water of the studied stations implicate pollution as the source of alteration in water quality [7, 8]. The negative impact of different sources of pollutants (i.e. agricultural, industrial and sewage) discharged into studied areas' water was confirmed by the highest values of nitrite, nitrate and ammonia with a concomitant decrease of dissolved oxygen [1-4, 8].

Hematological Studies: Blood parameters have been used as an indicator of healthy status of fish [28]. These parameters can be considered as an important indicator for knowing the effect of pollutants on the fish [29].

In the present study, the levels of the various blood parameters are presented in Table (1). It was found that, the red blood cells count, packed cell volume value and hemoglobin content in blood of *O. niloticus* samples reached its highest values of 1.755 10^6/mm^3, 13.2% and 6.97 g/100ml bloods, respectively at Tamalay station.

Table 1: Physicochemical characteristics of water, hematological and blood biochemical parameters (Mean ± standard deviation) of *Oreochromis niloticus* fish at different stations of the study area.

	Stations		
Parameters	Shanawan	Tamalay	Kafr El-Zyat
1-Physicochemical characteristics			
A) Physical characteristics			
Air temperature (°C)	31.800±0.200	27.600±0.141	30.300±0.100
Water temperature (°C)	28.733±0.404	25.750±1.909	28.733±0.153
Transparency (cm)	56.467±1.747	64.300±1.131	66.933±1.721
Electrical conductivity (µmohs/cm)	486.000±8.544	426.000±1.414	401.000±5.568
B) Chemical characteristics			
pH value	8.223±0.068	8.150±0.071	8.317±0.076
Carbonate alkalinity (mg/L)	15.000±0.200	7.950±0.071	17.867±0.306
Bicarbonate alkalinity (mg/L)	430.000±2.000	432.500±3.536	390.500±4.093
Total dissolved solids (mg/L)	249.667±4.041	249.000±1.414	196.067±2.101
Dissolved oxygen (mg/L)	5.680±0.052	6.505±0.035	6.367±0.153
Chloride (mg/L)	40.333±0.611	36.100±0.424	40.933±0.115
Ammonia (mg/L)	0.993±0.012	0.685±0.049	0.810±0.030
Nitrite (µg/L)	119.400±2.722	126.100±0.424	49.900±0.361
Nitrate (µg/L)	479.567±4.366	572.900±6.930	230.100±1.769
2- Blood parameters			
Red blood cells count(10^6/mm^3)	1.623±0.027	1.755±0.106	1.606±0.020
White blood cells count (10^3/mm^3)	7.258±0.451	6.983±0.111	7.740±0.496
Hemoglobin (g/100m)	6.327±0.082	6.968±0.573	6.278±0.081
Packed cell volume (%)	12.488±0.094	13.150±0.451	12.620±0.192
Glucose (mg/100m)	90.625±0.746	88.925±1.181	90.220±1.630
Protein (g/100m)	5.053±0.253	4.865±0.081	5.200±0.140
Albumin (g/100m)	0.325±0.040	0.310±0.026	0.366±0.011
Globulin (g/100m)	4.688±0.205	4.560±0.098	4.876±0.171
A/G Ratio	0.069±0.007	0.068±0.007	0.075±0.001

The increase in white blood cells counts of collected samples was not clearly varied between Shanawan and Tamalay stations but obtained slightly higher value of 7.740 $10^3/mm^3$ at Kafr El-Zyat station.

Also, it was obvious that the glucose was slightly lower at Tamalay station (88.93+1.181 mg/100ml) than that at Shanawan and Kafr EL-Zyat stations. The other blood biochemical properties of *O. niloticus* (protein, albumin, globulin and A/G ratio values were parallel in the nearest levels at all stations.

The decrease in red blood cells count and hemoglobin content collected from the samples of the *O. niloticus* living in the investigated areas especially at Kafr El-Zyat station may be due to anemia caused by increasing ammonia and nitrite which oxidized hemoglobin to methanoglobin and lead to hemolytic anemia [7] as well as intrahepatic and intraovarian hemorrhage induced by water pollution [11].

The increase in white blood cells count of collected samples especially at Kafr El-Zyat station indicates increasing in immunological responses as defensive mechanism against action of the highly polluted water [7, 30].

The increase of glucose especially at Shanawan station may be due to the withdrawn of water from blood to muscles to overcome the depletion of oxygen content in that area which polluted by sewage and agricultural wastes [31] or due to the breakdown of glycogen in liver as a result of water pollution [32]. Also, this hyperglycemia may be caused by enhanced glycogen breakdown in liver, probably because of anaerobic stress and/or the discharges of various types of wastes.

Diwan *et al.* [33] reported that environmental pollution may produce stress in fish and this enhances glycogen breakdown in liver and consequently raises blood glucose level. The reported hyperglycemia may be due to the increase in plasma concentration of catecholamines and corticosteroids as stress response of fish subjected to environmental alterations [11, 34].

The increase in protein, albumin and globulin may be due to the changes taking place in serum globulin metabolism or to the input of different pollutants [7, 35].

Histopathological Studies: Histological analysis represents a useful tool to assess the degree of pollution, particularly for sub-lethal and chronic effects [36, 37].

Liver: Liver of fish is responsible for the digestion, filtration and storage of glucose. The liver also produces many enzymes that stored in the gall bladder. These enzymes assist in the breakdown of food. The liver functions to store food energy [11]. The hepatic cells appear as polyhedral cells with central nuclei. Blood flows from branches of hepatic portal vein and hepatic artery through the sinusoids to central veins which empty into the hepatic vein [38].

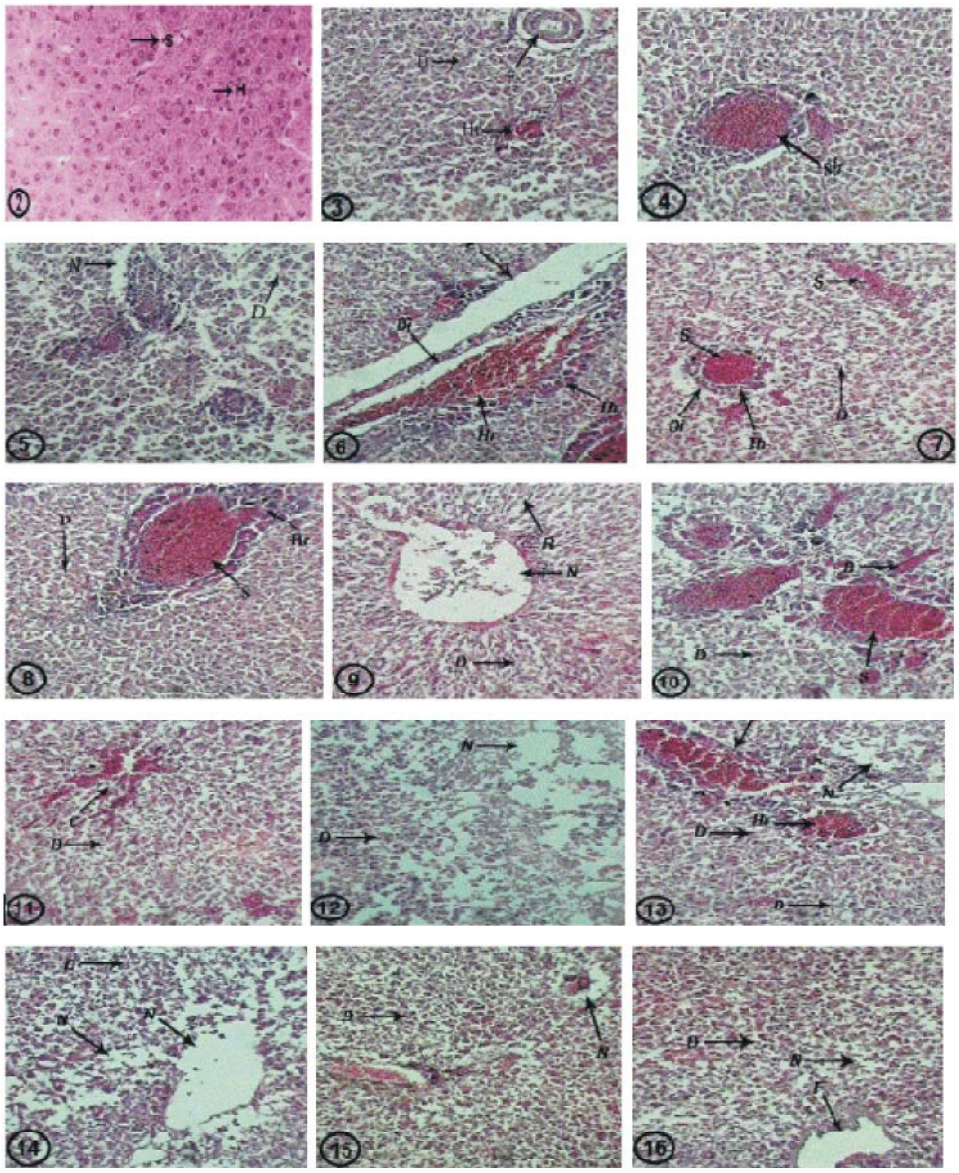
Liver of *O. niloticus* fish is found in the anterior part of the body cavity as a brownish red mass. Liver of control samples appear forming a meshwork and they are arranged in a definite cord, like pattern around well-defined sinusoids leading to central vein (Fig. 2).

Liver of collected *O. niloticus* fish from the three studied stations suffer from many histopathological changes. These changes were degeneration, necrosis, fibrosis and edema in hepatic cells, stagnant blood, dilation, hemorrhage, branching, thickness, congestion and hemolysis in blood vessels (Table 2).

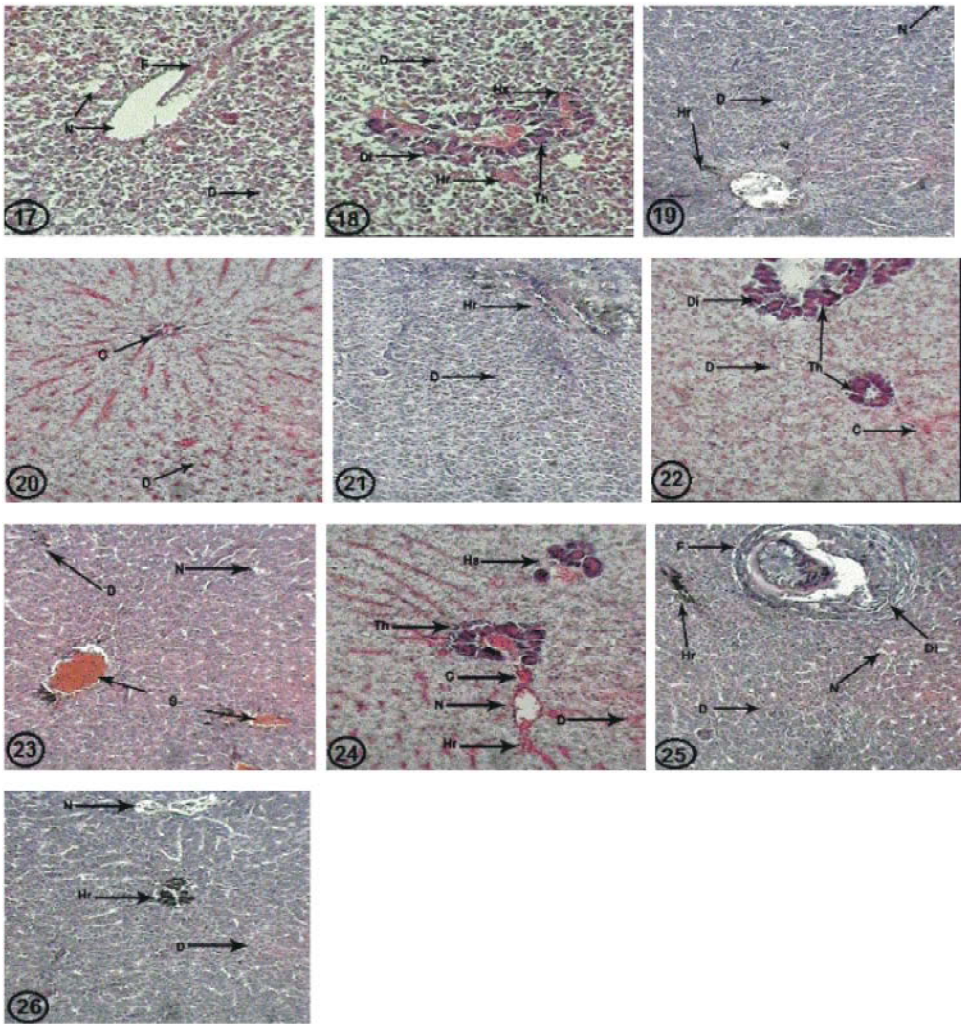
Table 2: Liver of collected *O. niloticus* from the three studied stations showed many histopathologic changes.

Lesions	Stations	Figures
Degeneration	I, II, III	(3-5), (7-10), (11-19), (20-22), (24-26)
Necrosis	I, II, III	(3, 5, 9), (12-17), (19), (23-26)
Fibrosis	I, II, III	(3), (15, 17), (25)
Edema	I	(6)
Stagnant blood	I, III	(4, 7, 8, 10), (23)
Dilation in B.V.	I, II, III	(6, 7), (13, 18), (22)
Hemorrhage in B.V.	I, II, III	(3, 6,16, 8), (13, 18, 19), (21, 22, 24-26)
Branching in B.V.	I	(10)
Thickness in B.V.	I, III	(6,7), (22, 24)
Congestion in bloods	II, III	(11), (20, 22, 24)
Hemolysis in B.V.	II, III	(18, 24)

I = Tamalay station, II = Shanawan station, III = Kafr El-Zyat station, B.V. = Blood Vessels.



Figs. (2-16): Histological sections in liver of *O. niloticus* stained with H&E, X400: (2) Normal structure of liver showing hepatic cell. (3) Liver section of *O. niloticus* fish obtained from Tamalay station showing degeneration (D), fibrosis (F), Necrosis (N). (4) Severe degeneration (D) in hepatic cells and stagnant blood (S) in blood vessels. (5) Severe degeneration (D) and necrosis (N) in hepatic cells, hemorrhage (Hr) in blood vessel and degeneration (D) in its wall. (6) Dilation (Di), hemorrhage (Hr) in blood vessel, in addition to thickness (Th) in its wall and edema (E) around it. (7) Dilation (Di), stagnant blood (S) and thickness (Th) of blood vessels and degeneration (D) in hepatic cells. (8) Severe degeneration (D) and hemorrhage (Hr) in hepatic cells and stagnant blood (S) in blood vessels. (9) Balloon necrosis (N) with remaining nucleus (R) and degeneration (D) in hepatic cells. (10) Branching blood vessels (B) with stagnant blood (S) inside it in addition to degeneration in its wall and degeneration (D) in hepatic cells. (11) Liver section of *O. niloticus* obtained from Shanawan station showing severe degeneration (D) in hepatic cells and congestion (C) in blood sinusoids. (12) Severe degeneration (D) lead to necrotic area (N) of hepatic cells. (13, 14) Dilation (Di), hemorrhage (Hr) and degeneration (D) in blood vessels and degeneration (D) and necrosis (N) in hepatic cells. (15) Degeneration (D), fibrosis (F) and necrosis (N) in hepatic cells. (16) Degeneration (D) and necrosis (N) with remaining of cytoplasm in hepatic cells.



Figs. (17-26): (17) Degeneration (D) of hepatic cells leads to necrotic area (N) and fibrosis (F). (18) Degeneration (D) in hepatic cells and dilation (Di), hemolysis (Hs), hemorrhage (Hr) and thickness in wall of blood vessels. (19) Liver section of *O. niloticus* obtained from Kafr El-Zyat station showing degeneration (D), hemorrhage (Hr), necrosis (N) with remaining nuclei and cytoplasm in hepatic cells. (20) Severe congestion (C) in blood sinusoids and degeneration (D) in hepatic cells. (21) Degeneration (D) and hemorrhage (Hr) in hepatic cells. (22) Degeneration (D) in hepatic cell, congestion (C) in blood sinusoids and dilation (Di), thickness (Th) and hemorrhage (Hr) with remaining of cytoplasm and nuclei in blood vessels. (23) Necrotic area (N) with stagnant blood (S) and degeneration of hepatic cells. (24) Congestion (C) in blood sinusoids, degeneration (D) and necrosis (N) in hepatic cells, hemorrhage (Hr), hemolysis (Hs) and thickness (Th) in blood vessels. (25) Congestion (C) in blood sinusoids, degeneration (D) and necrosis (N) in hepatic cells, hemorrhage (Hr), hemolysis (Hs) and thickness (Th) in blood vessels. (26) Degeneration (D), hemorrhage (Hr) and necrosis (N) in hepatic cells.

These alterations occur by severe degree in fish liver obtained from station II (which received agricultural and sewage wastes) and station III (which received industrial wastes).

The liver is the main organ for detoxification [39] that suffers serious morphological alterations in fish exposed to pesticides [40]. Alterations in the liver may be useful as markers that indicate prior exposure to environmental stressors. The cloudy selling, bile stagnation, focal necrosis, atrophy and vacuolization have been reported in the *Corydoras paleatus* exposed to methyl parathion [41].

Table 3: Ovary of collected *O. niloticus* fish from three studied stations showed many histopathological changes.

Lesions	Stations	Figures
Degeneration	I, II, III	(28, 30, 32, 34, 35), (40), (41, 43, 45, 47), (28, 29, 31-33, 34, 35), (36, 38, 41)
Necrosis	I, II, III	(41-44, 47, 48)
Atretic ova	I, II, III	(31, 34, 35), (36, 38), (42, 45, 46, 48)
Hyperplasia in granulose layer	I, II	(28, 29, 31, 32, 41)
Hemorrhage	I, II	(29, 30, 35), (36), (41, 45, 47)
Separation of ova from wall	III	(46)
Hemolysis	I	(30)
Separation of theca from granulose	I, II, III	(29), (40), (44)
Separation of theca	I, II, III	(33), (38,39,40), (41)
Separation of ova yolk from granulose	I	(35)
Granulose invade ova	III	(45)
Fusion	II, III	(46)
Fibrosis	III	(37), (45)
Atresia	III	(46)
Separation of yolk from theca	III	(47)
Separation of yolk from ova wall	III	(44)

I = Tamalay station, II = Shanawan station, III = Kafr El-Zyat station.

According to Myers *et al.* [42], the vacuolation of the hepatocytes with pycnotic nuclei in the liver of the studied fish was most likely due to deposition of fats. In general, this condition is not a result of uptake of abundant lipid precursors but is a problem of removing the fat from the hepatocytes [43].

Alterations in the size of hepatocytes nuclei in the hepatic tissue have been previously regarded by Paris-Palacios *et al.* [44] in *Brachydanio rerio* exposed to sublethal concentrations of copper sulphate.

Bayomy and Mahmoud [9] cited that industrial, agricultural and sewage wastes in River Nile cause liver damage. Aly *et al.* [45] obtained similar results in *Clarias gariepinus* due to water pollution. They found degeneration, necrosis and hemolysis in hepatic cells.

The present study suggests a strong link between water pollution with different wastes and liver lesions.

Ovary: The ovaries of the control fish are elongated, hollow, bilobed organs, attached to the dorsal body wall. It is soft in consistency and whitish in color. The ovary contains oogonia, oocytes and surrounding follicle cells, supporting tissue and stroma and vascular and nervous tissue. A space remains in the center of the lobe in ovary which is continuous with the short oviduct leading to the genital pore; this description was also reported by Tayel [3], Wallace and Selman [46] and Mamuri *et al.* [47].

Each oocyte during its early development becomes surrounded by a large of follicle cells with the growth of oocytes; follicle cells multiply and form a continuous follicular layer (granulose cell layer). These granulosa cells are surrounded by the thecal layer in outer and zona radiate layer in inner.

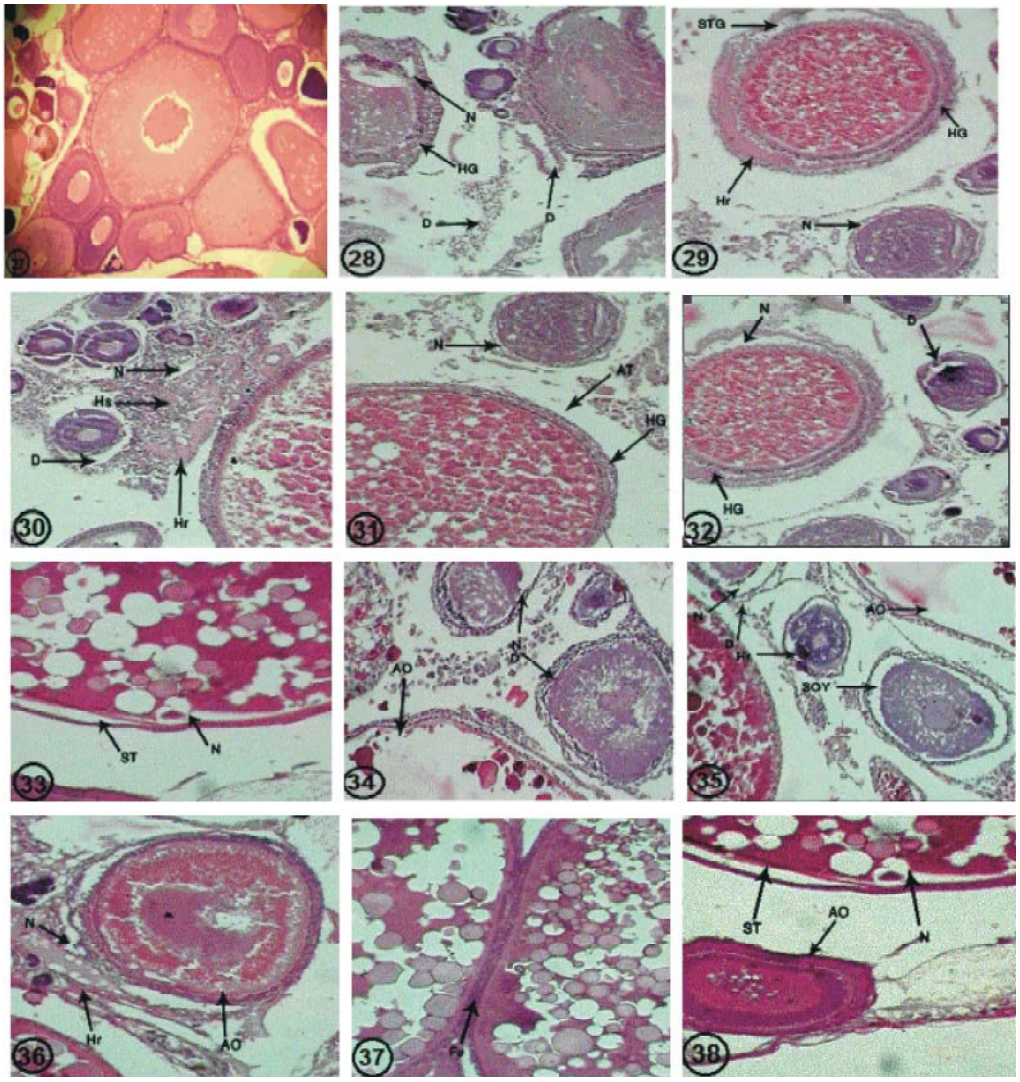
Oogonia undergo mitotic division and become primary oocyte, early perinucleolus, late perinucleolus, vesicle oocyte, primary yolk oocyte, secondary yolk oocyte and tertiary yolk oocyte stages. Then the mature oocyte stage (Migratory nucleus stages) are formed also (Fig. 27).

Ovary of collected *O. niloticus* fish from three studied areas suffer from many alternations including: degeneration, necrosis, atresia, hemorrhage, hemolysis, fibrosis, fusion of ova, hyperplasia in granulose, separation of ova from wall, separation of theca and separation of yolk from granulose (Table 3).

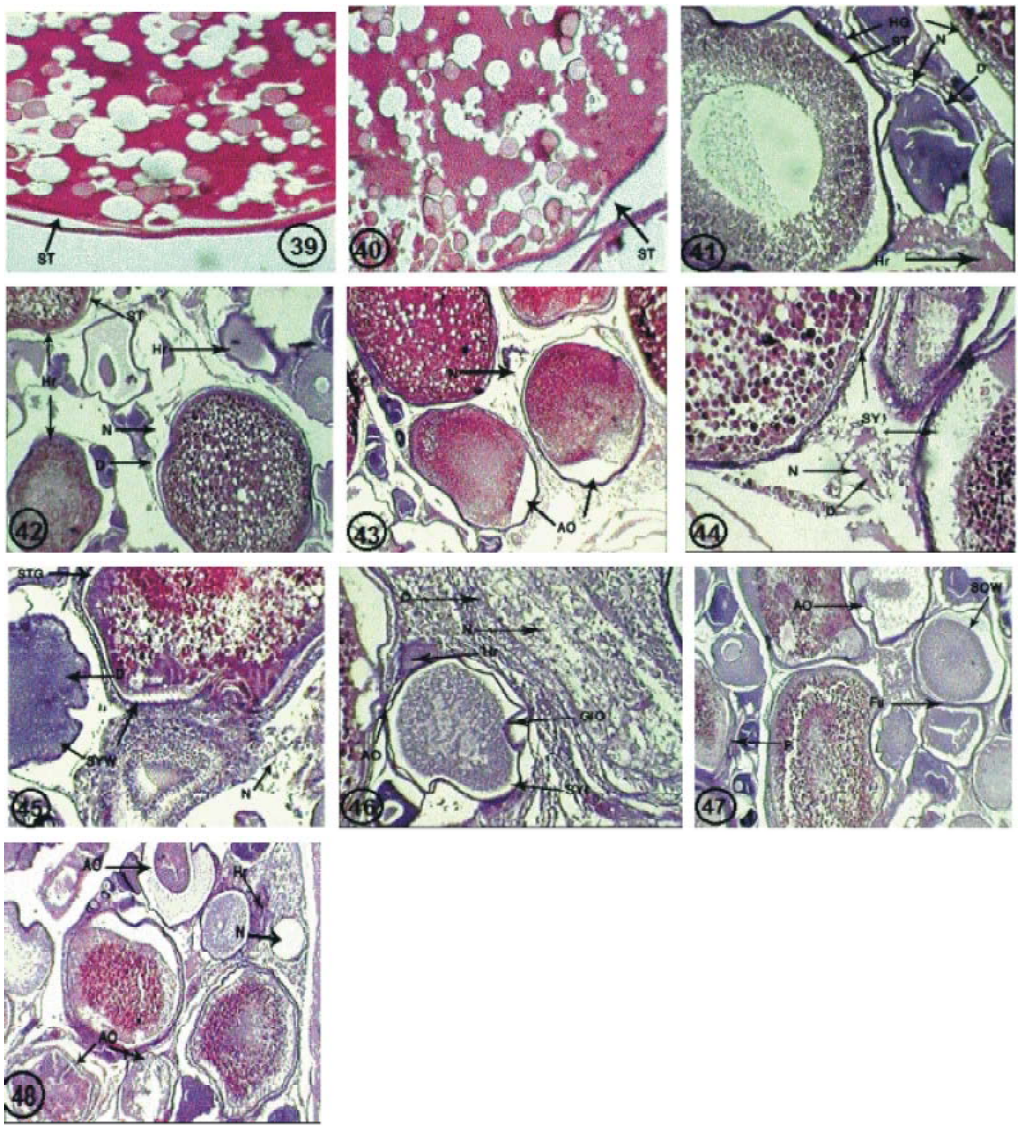
These malformations of ovary occur in three stations but by severe degree at station (III) Kafr El-Zyat which receive industrial wastes followed by Shanawan station (II) which receive agricultural and sewage wastes and station (I) Tamalay which receive agricultural wastes.

Hinton *et al.* [48] stated that atresia of oocytes or ovarian follicles are normal occurrence in female fish. However, oocyte atresia in developing ovaries may be an important toxicopathic response for fish exposed to contaminants. These lesions are significant because they may reduce the reproductive success of toxicant stress of fish population. The atresia induced could be due to an apoptotic programming mechanism as suggested by other researchers [49, 50].

Eller [51] found that endrine pesticide cause a reduction of ooplasm with proliferation of follicular cells. The disrupted gonadal maturation as a result of chlorinated and organophosphate pesticides was reported by Saxena and Mani [52]. The impairment of ovarian was also reported by Katti and Sathyanesan [53] as a result of chronic exposure to lead nitrate.



Figs. (27-38): Histological section in ovary of *O. niloticus* stained with H&E, X400. (27) Normal structure of ovary showing oogonia, oocytes and surrounding follicle cells, supporting tissue and stroma and vascular and nervous tissue. (28) T.S. in ovary of *O. niloticus* fish obtained from Tamalay station showing hyperplasia in granulose layer (HG), severe destruction (D) and necrosis (N) in connective tissue between ova with remaining of cytoplasm and nuclei. (29) Hyperplasia (HG) and hemorrhage (Hr) in granulose layer, separation of theca from granulose (STG) and necrosis (N) in connective tissue with remaining of cytoplasm and nuclei. (30) Necrosis (N), destruction (D), hemorrhages (Hr) and hemolysis (Hs) in connective tissue between ova destruction in all ova stages. (31) Necrosis (N) in connective tissue between ova with remaining of cytoplasm and nuclei, hyperplasia in granulose layer (HG) absence of theca layer (AT). (32) Hyperplasia in granulose layer (HG), necrosis in connective tissue (N) and destruction (D) in all ova stages. (33) Necrosis in connective tissue (N) and separation of theca layer (ST). (34) Atretic ova (AO), degeneration (D) and necrosis (N) in connective tissue between ova. (35) Separation of ova yolk from granulose layer (SOY), Atretic ova (AO), degeneration (D) and necrosis (N) in connective tissue between ova and hemorrhage inside (Hr) ova. (36) T.S. in ovary of *O. niloticus* fish obtained from Shanawan station showing Atretic ova (AO) and necrosis (N) in connective tissue in addition to hemorrhage (Hr). (37) Fusion (F) between two ova. (38) Atretic ova (AO), necrosis (N) in connective tissue between ova and separation of theca (ST) layer from ova.



Figs. (39-48): (39, 40) Separation of theca (ST) layer from ova. (41, 42) T.S. in ovary of *O. niloticus* fish obtained from Kafr El-Zyat station showing Hyperplasia of granulose layer (HG), Separation of theca layer (St) and destruction of ova in addition to hemorrhage (Hr) and destruction (D) and necrosis (N) in connective tissue between ova. (43) Atretic ova in all stages (AO) and necrosis (N) in connective tissue between ova. (44) Separation of yolk from theca layer (SY1), destruction (D) in ova and severe degeneration (D) and necrosis (N) in connective tissue between ova. (45) Separation of yolk from ova wall (SYW), separation of theca from granulose (STG) and necrosis (N) in connective tissue. (46) Granulosa layer invade ova (GIO), fusion between two ova (AO), separation of yolk from ova wall (SYl), degeneration (D) and hemorrhage (Hr) in connective tissue between ova. (47) Fibrosis (F) in connective tissue, atretic ova (AO) and separation of ova wall from ova content (SOW) and fusion between two ova (Fu). (48) Atresia in all ova stages (A) and degeneration (D), necrosis (N) and hemorrhage (Hr) in connective tissue between ova.

The same results described by Sloof and Dezwart [54] for organochlorine and aromatic hydrocarbons and by Johnson *et al.* [55] for Xenobiotics. Arockiari *et al.* [56] stated that change in water quality in the form of high salinity and temperature cause oocytes exhibit shrinkage nucleus and widen vitellogenic spaces of Tilapia species. Jafri [57] reported change on eggs size and egg biochemistry, reduced gonadal size and increased atresia

in the ovary. Mousa and Mousa [58] stated that the water conduction effects the secretion of the pituitary gland which in turns affects reproduction, osmoregulation, adaptation and distribution of *O. niloticus* in Lake Manzalah and also cause a decline in the gonadal activity by increasing atresia during the spawning season.

Waxman [59] detected a relation between the premature vitellogenesis in the polluted fish and change in steriodogenesis resulting in higher level of 17β-oestradiol or by a decrease in the catabolism of 17β-oestradiol as a result of the competitive inhibition of cytochromes P-450 in the liver by organic pollutants.

CONCLUSION

In the present study, it can be concluded that the hematological and histological alterations of the liver and ovary of *O. niloticus* indicated the effect of water quality change as a result of sewage, agricultural and industrial wastes in the three studied areas. It may be affect the production of the fish through their damaging effects on the vital organs of the body [60, 61], which in turn reduces the amount of energy exerted for spawning and hence the ability of the gonad to produce healthy and strong gametes which consequently affect fish health and production.

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