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Impact of diffused pollution on histological and hematological properties of *Mugil cephalus* and *Mugil capito* collected from lake Manzalah, Egypt.

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ABSTRACT
The objective of this study is to assess the physicochemical characteristics of water quality of Bahr El-Baqar, Ibn Salam and Hadous drains, as well as fish farms of Lake Manzalah and El-Matariya area. The impact of pollution on the histological structures of liver and kidney and some blood biochemical parameters, i. e. uric acid and urea levels and the activities of transaminases (ALT and AST) of some fish inhabiting these areas have been investigated. Water and fish samples were collected randomly from investigated areas during winter (2013). The results revealed changes in water quality that have negative impact on blood parameters and histological structures of selected organs. So, it is necessary to treat the drainage water before discharging into the lake to protect fish and human from the impacts of pollution.

1. INTRODUCTION

Lake Manzalah is considered as one of the most important sources of inland fishery in Egypt where it is estimated to yield about 38.02 % of the northern Nile Delta lakes and is considered as the second major source of fish after Lake Burollus. Importance of the lake fishery returns to two main targets as a source of animal protein for human consumption and a source of employment (El-Bokhty, 2010). It is the largest lake of the four brackish coastal lakes fringing the Nile Delta. The lake lies between 310 45\, 320 15\ E and 310 00\, 310 35\ N. It is bordered by Suez Canal from east, Damietta branch of Nile from west and Mediterranean Sea from north.

The lake is connected to the Mediterranean Sea *via* three outlets, permitting exchange the water and biota between the lake and the sea. These outlets are El-Gamil, El-Boughdady and the new El-Gamil (Elewa *et al*., 2007).

Lake Manzalah is shrinking in size; the rate of shrinking of the total area from 1922 to 1995 was estimated, being 5.22 km^2/yr. The greater losses of the lake areas were detectable along the western and southern borders of the lake (Frihy *et al*., 1998).

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As a result of presence of a large number of islets in the lake, the area of open water is only about 700 km^2 (El-Rakaiby and Youns, 1993).

Lake Manzalah receives about 7500 million cubic meters of untreated industrial, domestic and agricultural drainage water, discharged annually into the lake through several drain; Bahr El-Baqer Drains (domestic and industrial sewage), Hadous, Ramsis, El-Serw and Faraskour Drains (agricultural effluents). These amounts of water were reduced to about 4000 million cubic meters after construction of El-Salam Canal (Abdel Baky *et al*., 1998). Lake Manzalah can be divided into two main regions according to its salinities; the southern region of the lake which characterized by lower values of salinities and high concentration of nutrients and heavy metals as consequence of its receive high volumes of low salinity drainage water through different drains and the second region at the North Eastern area of the lake, near to the lake-sea connection (El-Gamil), which is characterized by high salinity values and low nutrient concentration as a result of seawater intrusion through the outlet openings (El-Gawady, 2002; Shakweer, 2005).

Lake Manzalah attracts attention of many scientists because of its important economical aspects. Several investigations have been carried out concerning its ecosystem. These studies dealt with different environmental aspects of the lake including geological aspects, hydrological regime, physicochemical properties, bacterial indices, phytoplankton composition, benthic invertebrates and fishery status (Khalil and Bayoumi, 1988; El-Ghobashy, 1990; Khalil, 1990; Frihy *et al*., 1998; Abdel-Satar, 2001; Flower, 2001; Fathi and Abdelzahar, 2003).

Fishes are considered as one of the most significant bio-monitors in an aquatic system for the estimation of water pollution concentration (Begum *et al*., 2005). In addition, fish are located at the end of the aquatic food chain and may accumulate metals and pass them to human beings through consumption causing chronic or acute diseases (Al-Yousuf *et al*., 2000).

Histopathological alterations can be used as indicators for the effects of various anthropogenic pollutants on organisms and are a reflection of the overall health of the entire population in the ecosystem (Saad *et al*., 2011). These histopathological biomarkers are closely related to other biomarkers of stress since many pollutants have to undergo metabolic activation in order to be able to provoke cellular change in the affected organism. Previous studies reported that the exposure of fish to pollutants (agricultural, industrial and sewage) resulted in several pathological alterations in different tissues of fish (Saad *et al*., 2012).

The blood of fish is sensitive to pollution induced stress and certain serum constituents may be used as markers for tissue damage (Patil and Kulkarni, 1993). Changes in the blood profile may indicate changes in metabolism and biochemical processes of the organism, resulting from the effect of various pollutants and make it possible to study the mechanisms of these pollutants (Luskova *et al.,* 2002). The increments in the alanine aminotransferase (ALT) and aspartate aminotransferase level (AST) activities in serum could consider as indicators for liver damage (Ibrahim and Mahmoud, 2005). However, elevation of the serum urea and creatinine may be attributed to kidney disorder (Zaki *et al.,* 2009).

The present study aimed to investigate the impact of the water pollution in Lake Manzalah on the histological structure of liver & kidney and changes in blood composition of *Mugil cephalus* and *Mugil capito.*

2. MATERIAL AND METHODS

2.1 Area of study

Lake Manzalah is considered as one of the most important sources of inland fishery in Egypt (Fig.1). It is the largest lake of the four brackish coastal lakes fringing the Nile

Delta .It lies between 310 45$^{\backslash}$, 320 15$^{\backslash}$ E and 310 00$^{\backslash}$, 310 35$^{\backslash}$ N. Lake Manzalah receives about 7500 million cubic meters of untreated industrial, domestic and agricultural drainage water, discharged annually into the lake through several drain; Bahr El-Baqer drains (domestic and industrial sewage), Hadous, Ramsis, El-Serw and Faraskour drains (agricultural effluents). These amounts of water were reduced to about 4000 million cubic meters after construction of El-Salam Canal (Abdel Baky *et al*., 1998).

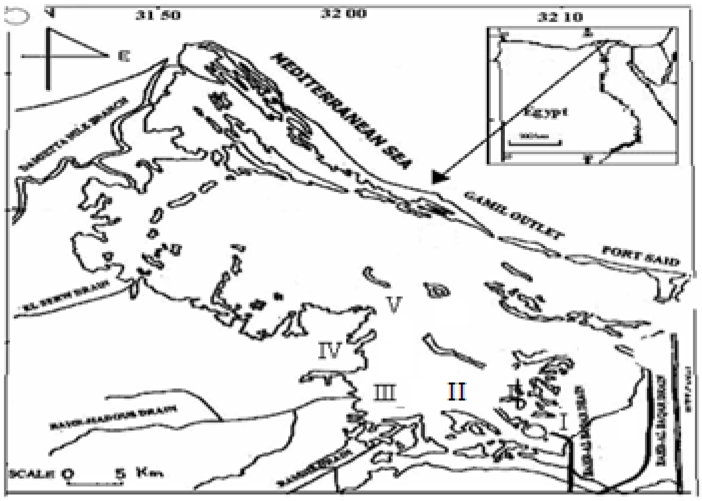

Fig. 1: Lake Manzala map showing the collection stations
I: Bahr El-Baker drain (Sewage) II: Ibn Salam drain (Sewage and Agriculture)
III: Hadous drain (Agriculture) IV: Farms of Lake Manzala V: El-Matariya area

2.2 Field observations

The water samples from Manzalah lake were collected during winter 2013 to measure water temperature (ºC) by a dry mercury thermometer, as well as electrical conductivity by using Hydrolab (Model Multo 3401/SET) and pH by pH meter (Orion Research Ion Analyzer 399).

2.3 Laboratory analysis

2.3.1 Water samples

Another water sample was kept in one liter polyethylene bottle in ice box to be analyzed in the laboratory. The dissolved oxygen content analysis was performed by azid modification and biological oxygen demand by incubation 5 days methods. Concentration of ammonia, nitrite and nitrate were determined using the colorimetric techniques according to the method described by APHA (2002).

2.4 Fish samples

2.4.1 Serum analysis:

The biochemical analyses were measured by using Spectrum Kits according to the manufacture instructions. Serum samples of fish (*M. cephalus* and *M. capito*) living in the water of El-Manzalah lake were collected and analyzed on the same day. Serum uric acid level was estimated according to uricase-POP enzymatic colorimetric method with 4-amino-antipyrine (Tietz, 1995). Serum urea level was determined according to urease colorimetric method (Tietz, 1990). The activities of serum AST and ALT were estimated colorimetrically according to the method of Reitman and Frankel (1957).

2.5 Histopathological studies:

Liver and kidney of fish (*M. cephalus* and *M. capito*) living in the water of El-Manzalah lake were carefully removed and then fixed in 10% neutral-buffered formalin, dehydrated in ascending grades of alcohol, and cleared in xylene. The fixed tissues were embedded in paraffin wax and cut in 4-6µm thick sections, using Euromex Holland microtome. Sections were stained with Harris Hematoxylin and Eosin method (cited by Saad *et al*., 2012). Consequently, these sections were examined microscopically and their photos were taken by microscopic camera. Finally these sections compared by those obtained from the controlled fishes collected from El-Kanater El-Khairya Fish Research Station.

3. RESULTS AND DISCUSSION

3.1 Water quality

3.1.1 Physical Characteristics

3.1.1.1 Temperature (^{0}C)

Temperature is a critical control parameter in the aquatic systems and it is a key parameter which influences the physical, chemical and biological transformations in the aquatic environment (Delince, 1992; Tayel *et al.*, 1996 and Tayel *et al*., 2008).

Temperature is an important factor in the aquatic environment since it affects directly or indirectly not only upon the survival and distribution of the aquatic organisms at any stage of life, but also their growth rate, development, activity, activation of reproduction processes and susceptibility to diseases (Abdel-Satar, 2005; Abdo *et al.*, 2010 and Moustafa *et al.*, 2010). Generally, water temperature plays an important role on bacterial activity, decomposition of organic matter, and the solubility of dissolved oxygen, the rate of phytoplankton photosynthesis (Kato, 1994 and Ahmed, 2007). The obtained results show that the surface water temperature ranged between 15.0°C at station III and 16.5°C at station I (Table 1).

Table 1: The physicochemical parameters of water samples collected from Lake Manzala water during winter season, 2013

Parameter	I	II	III	IV	V	Permissible limits WHO,(1993)
Water temp.	16.5	15.5	15.0	15.5	16.0	(25-35)
pH	7.76	8.49	8.65	8.95	8.09	7-8
EC (ms/cm)	4.48	2.96	4.30	3.06	2.4	400-1400
DO (mg/l)	2.0	4.0	7.4	8.2	7.4	(6-14)
BOD (mg/l)	12.5	2.0	4.8	7.2	4.6	(6 Up to)
NH_4^+ (mg/l)	4.43	1.185	1.104	0.801	2.509	≤ 1
NO_3^- (µg/l)	147.4	99.2	102.5	62.8	73.4	100
NO_2^- (µg/l)	17.2	27.1	39.9	37.4	122.5	25- 50

I: Bahr El-Baker (Sewage) II: Ibn Salam (Sewage and Agriculture)
III: Hadous (Agriculture) IV: Farms of El-Manzala Lake
V: El-Matariya

The variation in water temperature of the investigated area depends mainly on the climatic conditions, sampling times, the number of sunshine hours and also affected by specific characteristics of water environment such as turbidity, wind force, plant cover and humidity as cited previously (Mahmoud, 2002 and Tayel *et al*., 2008).

3.1.1.2 Electrical conductivity (EC)

Electrical conductivity is a measure of the ability of aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valance and temperature of the medium. Thus, the more abundant the ions, the higher is the conductivity and vice versa APHA (1995).

The values of EC ranged between 2.4 and 4.48 at stations V & I, respectively (Table 1). The high value of EC may be attributed to the high content of dissolved ions and cations or may be also attributed to the presence of high amount of organic and inorganic constituents in domestic wastes that discharged into lake. The decrease of electrical conductivity may be attributed to the increase of water level and the uptake of dissolved salts by phytoplankton. Generally, the high value of EC may be attributed to domestic and agricultural wastes that contain high amount of organic and inorganic constituents.

3.2 Chemical Characteristics

3.2.1 Hydrogen Ion Concentration (pH values)

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and waste water temperature, e.g. acid base neutralization, water softening, precipitation, coagulation, disinfection and corrosion control, is a pH dependent (Abdel-Satar, 2005). The pH of natural water affects biological and chemical reactions, controls the solubility of metal ions, and affects natural aquatic life (Tayel, 2003). The pH values of river water exceeding the legal allowance for public health can affect flora and fauna (Ahmed, 2007). Also the pH of water directly affects fish and other aquatic life (Brooks *et al.,* 2003). The United States Public Health Standards (USPHS) limits of pH for drinking water are 6.0-8.5 (De, 2002).

The principle system regulating the pH of water is carbonate system which includes CO_2, H_2CO_3, HCO_3^- and CO_3^{--} (Stumm and Morgan, 1970). The pH value of water is controlled by the dissolved oxygen, algal photosynthetic activity, temperature, sewage discharge, decomposition of organic matter and complex factors related to geology of the under-laying sediment (Abdel Satar, 1994; Rashad, 1994 and Tayel, 2003).

The pH values in present study were ranged between7.76 and 8.95 at station I & IV, respectively (Table 1). These values were found to lie on alkaline side

3.2.2 Dissolved Oxygen (DO)

Dissolved oxygen is a very important factor to the aquatic organisms, because it affects their biological processes, respiration and oxidation of the organic matter in water and sediments (Tayel *et al.,* 2008). The dissolved oxygen concentration represents the status of the water system at a particular point and time of sampling (Brooks *et al.,* 2003).

Dissolved oxygen is of fundamental importance to the life and health of aquatic organism (Mahmoud, 2002). Fishes and other aquatic organisms depend on the DO for their respiration which is affected by the solubility of many inorganic nutrients (Ahmed, 2007). The principle sources of dissolved oxygen in water are directly from the atmosphere through the exposed surface and from the photosynthesis of chlorophyll-bearing plants (Abdo, 2010). Absorption of oxygen from air is accomplished in two ways: (1) by direct diffusion at the surface and (2) through the various forms of surface water agitation, such as wave action, waterfalls and turbulence due to obstructions (El-Sayed, 2011).

Dissolved oxygen is considered as an important parameter in assessment of the degree of pollution in natural water (Mahmoud *et al*., 2008). This gas is controlled to susceptibility of fish to toxicity by chemicals which increases at low oxygen concentration (Erez *et al*., 1990). There are many factor effect on the amount of oxygen in natural water such as temperature, salinity, amount of mixing between air and water, pH, photosynthesis activity of phytoplankton, submerged plant and aeration by living organisms as well as decomposition of organic matter (Saad, 1978 and Das and Acharya, 2003).

The obtained values of DO were ranged from 2.0 to 8.2 mg/l at stations I & IV respectively (Table 1). The depletion of DO in present study may be attributed to the decomposition of organic matter and this may be due to dissolved oxygen exhaustion for oxidation of huge organic matter discharged into (El-Sayed, 2011).

3.2.3 Biological Oxygen Demand (BOD)

Biological oxygen demand measure the dissolved oxygen consumed by the present microorganisms to stabilize any biodegradable organic matter. Microorganisms metabolize the complex unstable molecules of pollutants such as proteins, carbohydrate, lipid into CO_2 and H_2O as a simple stable inorganic compounds. Microorganisms utilize either aerobic or anaerobic oxidation pathway according to the allowed conditions (APHA, 1992 and Ahmed, 2007).

The BOD is the amount of DO which used to decompose the organic matter in water by microorganisms. It depends on several factors such as: temperature, concentration of organic matter and density of phytoplankton. Also it increases by increasing the chemical oxygen demand. The BOD test is the mostly useful method in estimating the amount of biodegradable organic matter present in the aquatic environment (Siliem, 1993, Mahmoud, 2002 and Tayel, 2003).

Also, BOD rapidly deplete DO content of polluted water with sewage, so it is important to estimate the amount of these pollutants in the given water body (El-Sayed, 2011). Generally, the biological oxygen demand is a good indicator of organic pollution in sea (Loigu and Leisk, 1996).

The values of BOD were ranged between 2.0 and 12.5 mg/l at stations II & I, respectively (Table 1). The lowest value of BOD may be due to the lower photosynthetic activity and abundance of phytoplankton as cited by Ahmed (2007). While, the high value of BOD may be attributed to the presence of high load of wastes discharged (agricultural and sewage) into the water (Saad *et al*., 2011).

3.3 Nutrient salts

3.3.1 Ammonia

The dissolved organic nitrogen is the summation of concentration of ammonia, nitrite and nitrate. Nutrient conditions of water played an important role in phytoplankton production. Ammonia nitrogen exists in aquatic solution either as ammonium ion (NH_4) or ammonia (NH_3) depending on the pH of the solution (Emerson *et al*., 1975 and Mahmoud, 2002). The toxicity of ammonia–nitrogen is correlated by several factors to be toxic, low dissolved oxygen (Merkens and Downing, 1957), high carbon dioxide, low oxygen content (Herbert, 1971), high temperature, pH (Boyd, 1979) and high alkalinity (Siliem, 1984).

Generally, the high concentration of ammonia (> 1 mg/l) has been given as an indicator of organic pollution and it is toxic in concentration over 2.5 mg/l to aquatic organisms (WHO, 1992).

The values of ammonia were fluctuated between 0.801 and 4.43 mg/l at stations IV & I, respectively (Table 1). The high values of ammonia may be due to temperature (Saad *et al*., 2011), agricultural and sewage wastes (Abdel-Satar *et al*., 2010) discharged of wastes into the Suez Bay. While the low values of ammonia are related to the decrease in biological activities of aquatic organisms and nitrification occurs in the water column (Abou El-Gheit *et al.,* 2012). Oxidation of ammonia to NO_2 or NO_3 is a subject of much ecological uncertainly as cited by Mahmoud *et al.* (2008).

3.3.2 Nitrite

Nitrite is an intermediate oxidation state of nitrogen, both in the oxidation of ammonia to nitrate and in the reduction of nitrate, such oxidation and reduction occur in waste water treatment plants, water distribution systems, and natural water (APHA, 1998). Resistance to toxic effect of nitrite ion is enhanced by the presence of chloride or increased water hardness (Tamasso, 1986).

The values of nitrite were fluctuated between 62.8 and 147.4 at stations VI & I, respectively (Table 1). The low values of nitrite might be attributed to fast conversion of nitrite by nitrobacteria to nitrate (Tayel, 2007). However, the high nitrite level might be attributed to decomposition of organic matter present in the waste water where nitrosomonas bacteria oxidize ammonia to nitrite by denitrification (Saad *et al*., 2011).

3.3.3 Nitrate

Nitrate ion is the final oxidation product of nitrogen compounds in the aquatic environment, at the same time nitrate is considered the only thermodynamically stable form of nitrogen in the absence of oxygen (Ahmed, 2007).

The reduction of nitrate or nitrification can be brought about by certain nitrate reducing bacteria especially in the presence of organic matter and only limited amounts of oxygen (Tayel, 2003). This happens, for instances in heavily polluted, streams and in sewage percolating filters that have become pended or clogged (Bayomy and Mahmoud, 2007). During denitrification, nitrate were reduced to nitrite and finally to ammonia, under certain circumstances nitrous oxidation and nitrogen are also produced (Abdel-Satar, 2005).

The values of nitrate were fluctuated between 17.2 and 122.5 at stations I & V, respectively (Table 1). Nitrate showed high values than the corresponding values of nitrite due to the fast conversion of NO_2^- to NO_3^- ions by nitrifying bacteria (Abdel-Satar *et al*., 2010). The low values in nitrate concentration might be due to uptake of nitrate by phytoplankton and its reduction by denitrifying bacteria and biological denitrification (Abdo, 2002).

3.4 Serum analysis:

Serum ALT and AST activities as well as uric acid and urea levels have been used as indicators of healthy status of fish and illustrated the effect of pollutants on the fish (Saad *et al*., 2011).

Table (2) is showing the levels of the studied blood parameters of *M. cephalus* and *M. capito* living in the water of El-Manzalah Lake.

Table 2: Serum AST and ALT activities and uric acid and urea concentrations of *M. cephalus and M. capito* from Lake Manzalah water during winter season, 2013.

Parameter	*M. cephalus*		*M. capito*	
	Normal	Lake Manzalah Mean±SD	Normal	Lake Manzalah Mean±SD
AST (IU/L)	55.21±6.33	69.67±2.48	59.78±2.65	41.33±1.51
ALT (IU/L)	16.26±5.13	30.0±1.46	16.o1±5.11	5.33±1.31
Uric Acid (mg/100ml)	1.50±0.20	4.6±0.5	1.77±0.11	2.27±0.8
Urea (mg/100ml)	4.95±0.55	13.23±1.26	5.36±0.58	4.9±1.14

Data are represented as mean ± standard error (SE)

3.5 Alanine aminotransferase level (ALT) and Aspartate aminotransferase level (AST)

The lysosomal membranes which are very sensitive to many pathogenic factors are disrupted, thus their enzymes are released and caused degeneration and vacillation of the cytoplasm of liver cells (Bayomy and Mahmoud, 2007).

ALT and AST are two important key enzymes considered as sensitive markers to evaluate hepatocellular damage and biliary tract diseases (Aly *et al*., 2003). The increase in serum aminotransferase might also reflect myocardial and hepatic intoxication, leading to extensive liberation of the enzymes into the blood (Ibrahim and Mahmoud, 2007

In present study the values of serum AST levels were 69.67 ± 2.48 for *M. cephelus* and 41.33 ± 1.51 for *M. capito*. The values of serum ALT levels were 30.00 ± 1.46 for *M. cephelus* and 5.33 ± 1.31 for *M. capito*. These results showed a general trend of increase in ALT and AST activities. These results, also, indicate that the pollutants of the lake water affected the liver cells as evidenced by the alterations occurred in serum ALT and AST activities.

3.6 Uric acid

The values of serum uric acid levels in the present study were 4.6 ± 0.5 mg/100 ml for *M. cephelus* and 2.27 ± 0.8 mg/100 ml for *M.capito*.

The increase of uric acid may be due to disturbances and damage in the kidney (Maxine and Benjamine, 1985), or may be due to increase in calcium carbonate as a result of agricultural wastes discharge in water way (Zaghloul, 2000) and may be due to the action of copper accumulation on the glomerular filtration rate which causes pathological changes of the kidney (Oikari and Soivio, 1977)

3.7 Urea

The values of serum urea levels in the present study were 13.23 ± 1.26 mg/100 ml *M. cephelus* and 4.9 ± 1.14 mg/100 ml for *M. capito.* The obtained values were within the same range obtained by Haggag *et al*. (1993). Increase of urea may be due to sewage and agriculture waste of the lake and increase of ammonia, nitrate and nitrite (Hassaan, 2011).

3.8 Histopathological studies:

Histology has been used as a test for evaluating toxic effects of water pollutants in fish (EIFAC, 1983; Murty, 1986).

3.9 Liver:

Liver of fish is responsible for the digestion, filtration and storage of glucose (El-Naggar *et al*., 2009). It is found in the anterior part of the body cavity as a brownish red mass (Yacoub *et al*., 2008). The liver also produces bile that stored in the gall bladder (Tayel *et al.*, 2008). The bile assists in the breakdown of food (Ahmed, 2007). Generally, the liver is considered as the principal organ of detoxification in vertebrates and particularly in fish (Tayel, 2003). Meanwhile, fish liver is a good indicator of aquatic environmental pollution, where one of the important functions of the liver is to clean of any poisons or pollutants from the blood coming from the intestine (El-Naggar *et al.,* 2009). The organ most associated with the detoxification and biotransformation process is the liver and due to its function, position and blood supply, it is also one of the organs most affected by contaminants in water (Mohamed, 2009).

The results of the present study revealed that *M. cephalus* and *M. capito* from Lake Manzalah manifest histopathological alterations in the liver during winter season, which more or less similar. These alterations included degeneration, necrosis, fibrosis, pyknosis, fatty degeneration and hemosidrin in hepatocytes. In addition to dilation, branching, hemorraghe, hemolysis, hemosidrin, rupture in blood vessels. Besides congesion in blood sinsoud (Plates II & IV). The histolopathological alterations in the liver of both studied fish could be a direct result of fertilizers, salts and sewage, which are entered to the lake with the drainage water as recorded by Mabrouk (2004) who found the same histolopathological changes in kidney of Mugil species living in lake Manzalah.

The cellular degeneration in the liver may be also due to oxygen deficiency as a result of the vascular dilation and intravascular hemolysis observed in the blood vessels with subsequent stasis of blood (Mohamed, 2001).

Degeneration and necrosis of the hepatocytes may be due to cumulative effect of nutrient salts these results agreed with (Authman and Abbas, 2007) who stated that the liver has an important detoxical role of endogenous waste products as well as externally derived toxins as heavy metals. Accumulation of hemosidrin in liver cells may be due to rapid and continuous destruction of erythrocytes as recorded by Ibrahim and Mahmoud (2005).

3.10 Kidney:

The kidney is a vital organ of body and proper kidney function is to maintain the homeostasis. It is not only involved in removal wastes from blood but it is also responsible for selective reabsorption, which helps in maintaining volume and pH of blood and body fluid and erythropoieses (Iqbal *et al.*, 2004). In present study the kidney is one of the first organs to be affected by contaminants in the water (Thophon *et al.,* 2003). The kidney of both fish from lake Manzalah showed the same histopathological alterations with different degrees of severity. The most common features were degeneration, necrosis, fibrosis, hemorrhage, hemolysis and hemosidrin in all kidney tubules, Malpigian tubules and connective tissues (Plate I &III).

The obtained results revealed that kidney were found to be most affected by changes in water quality. This may be due to the fact that it is one of the principal site of detoxification in fish body .Similar to our finding Mahmoud *et al.,* 2008 found that agricultural, industrial and sewage wastes had caused renal injury in kidney of fish living in different parts of River Nile. Also these results are in agreement with those observed in *C. carpio* exposed to sewage (Kakutta and Murachi, 1997).

Capkin *et al*. (2006) found necrotic areas scattered throughout the hematopoietic tissue and renal tubules of the rainbow trout as a result of changes in water quality such as increase in pH, temperature, alkalinity and hardness. Kadry *et al.*, (2003) found injuries in kidney tissue of Liza Ramada fish obtained from water polluted with industrial and agricultural wastes in Lake Manzalah. The kidney injuries included degeneration and necrosis of renal tubules and distortion of glomerular capillaries.

Finally, Mabrouk (2004) found the same histolopathological changes in kidney of Mugil species living in Lake Manzalah as a result of water quality changes.

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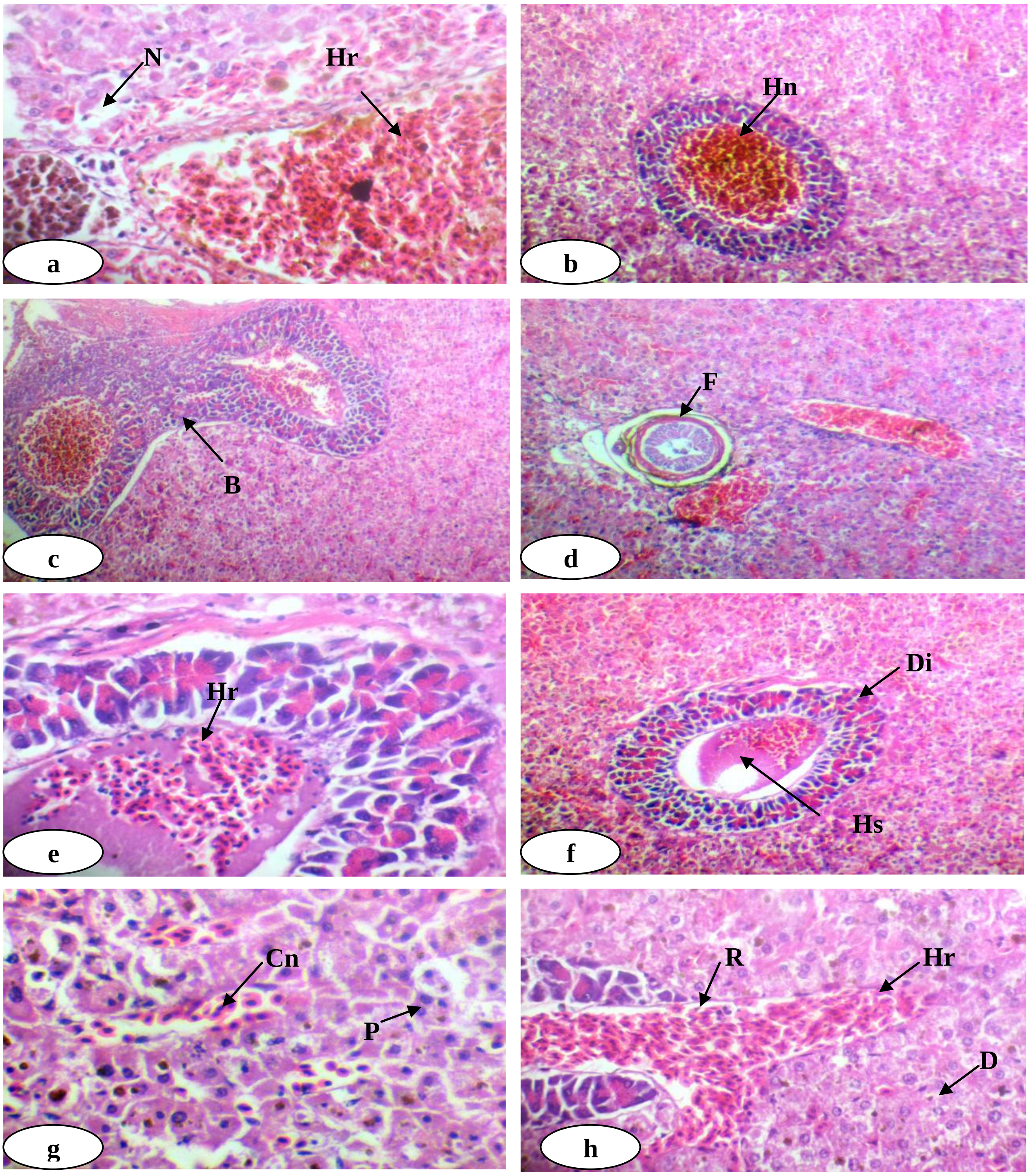
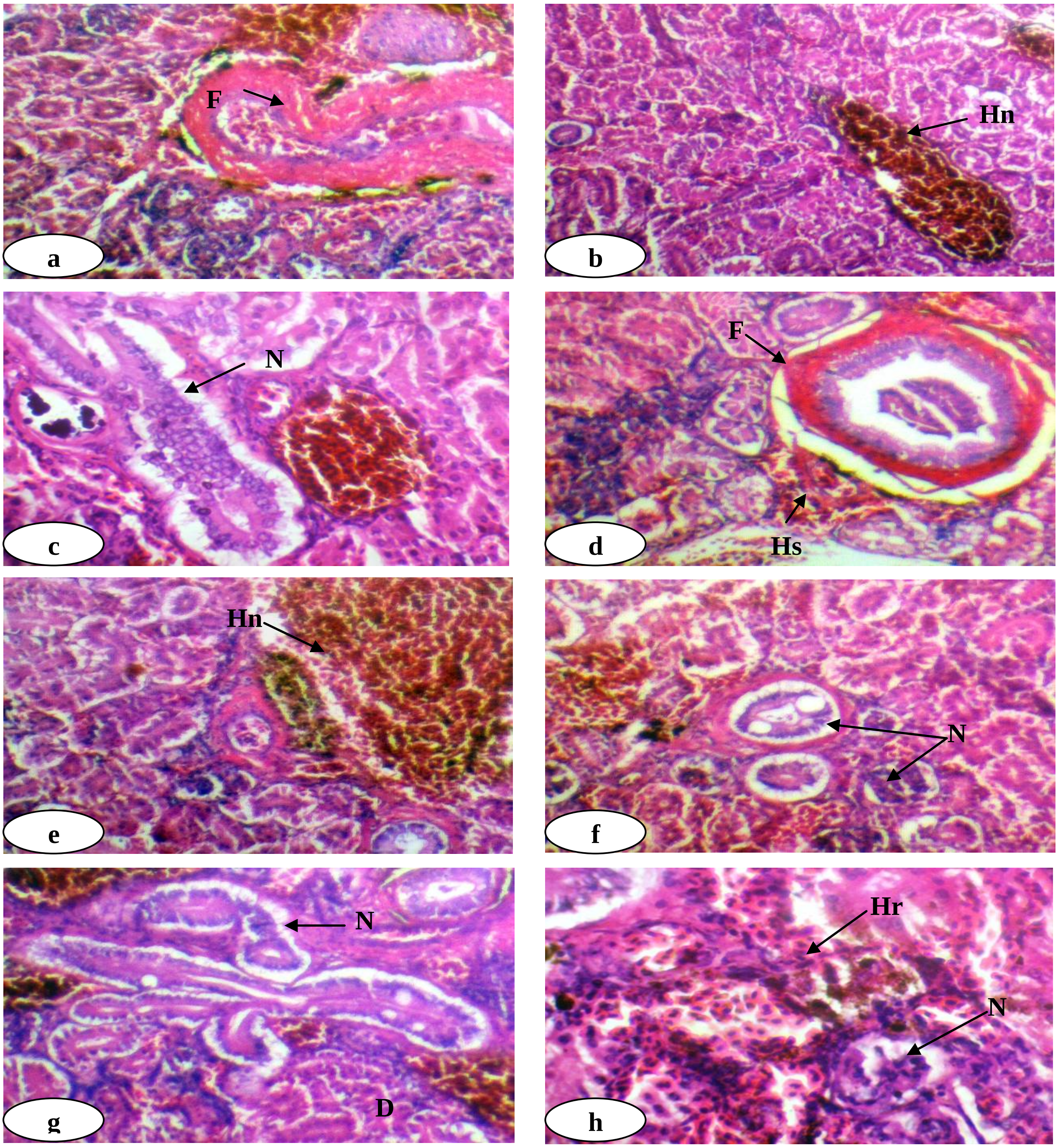
Plate I



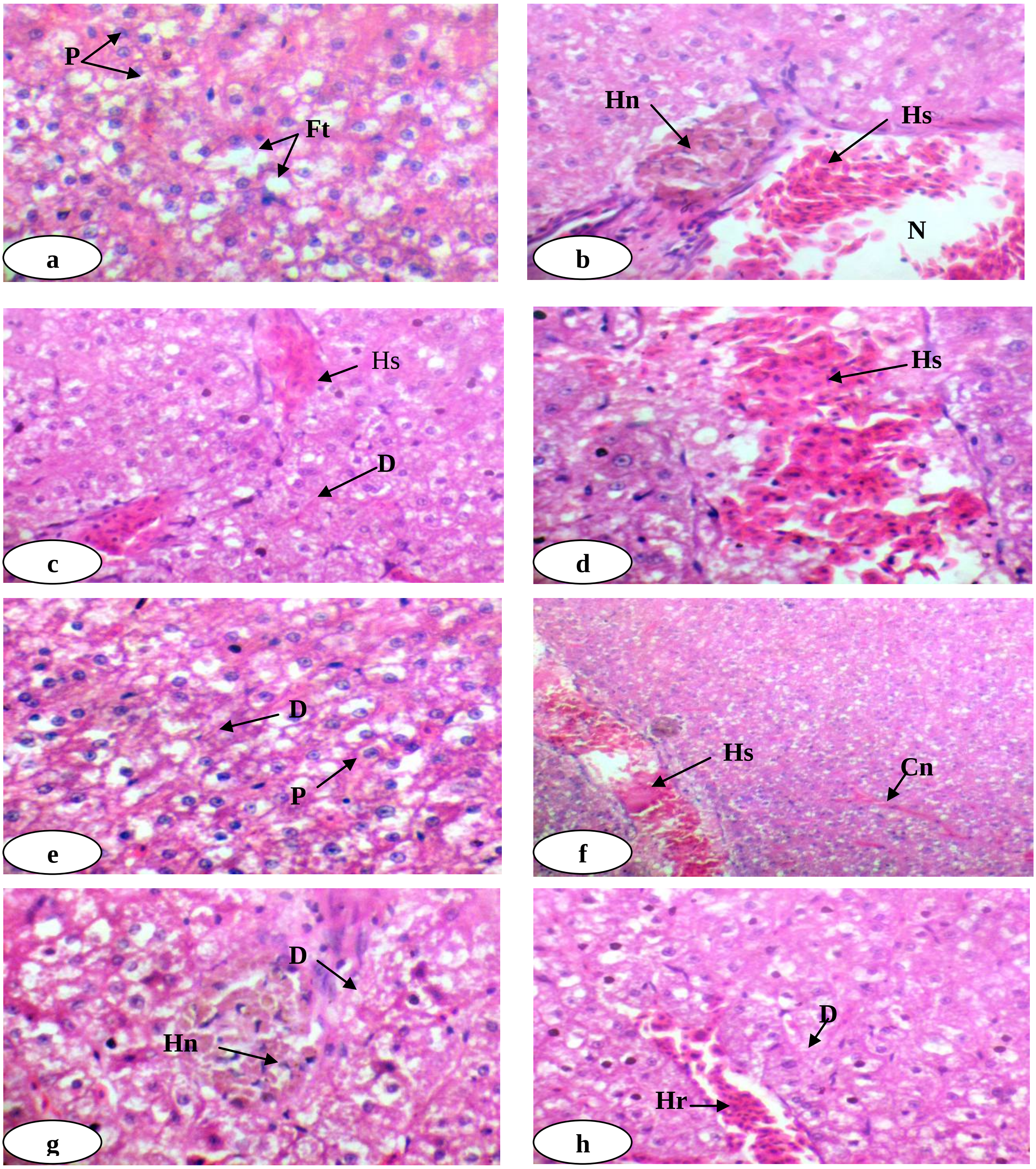
Figs. (a-h): Liver sections of *M. capito* obtained from Lake Manzalah stained with H&E, showing: Degeneration (D), Necrosis (N), Hemorrhage (Hr) and Pyknotic nuclei (P) in hepatocytes. Branching (B), Fibrosis (F), Dilation (Di), Hemorrhage (Hr), Hemolysis (Hs) and Hemosidrin (Hn) in blood vessels. With Rupture (R) in blood vessels wall and Congesion (Cn) in blood sinusoid.

Plate II



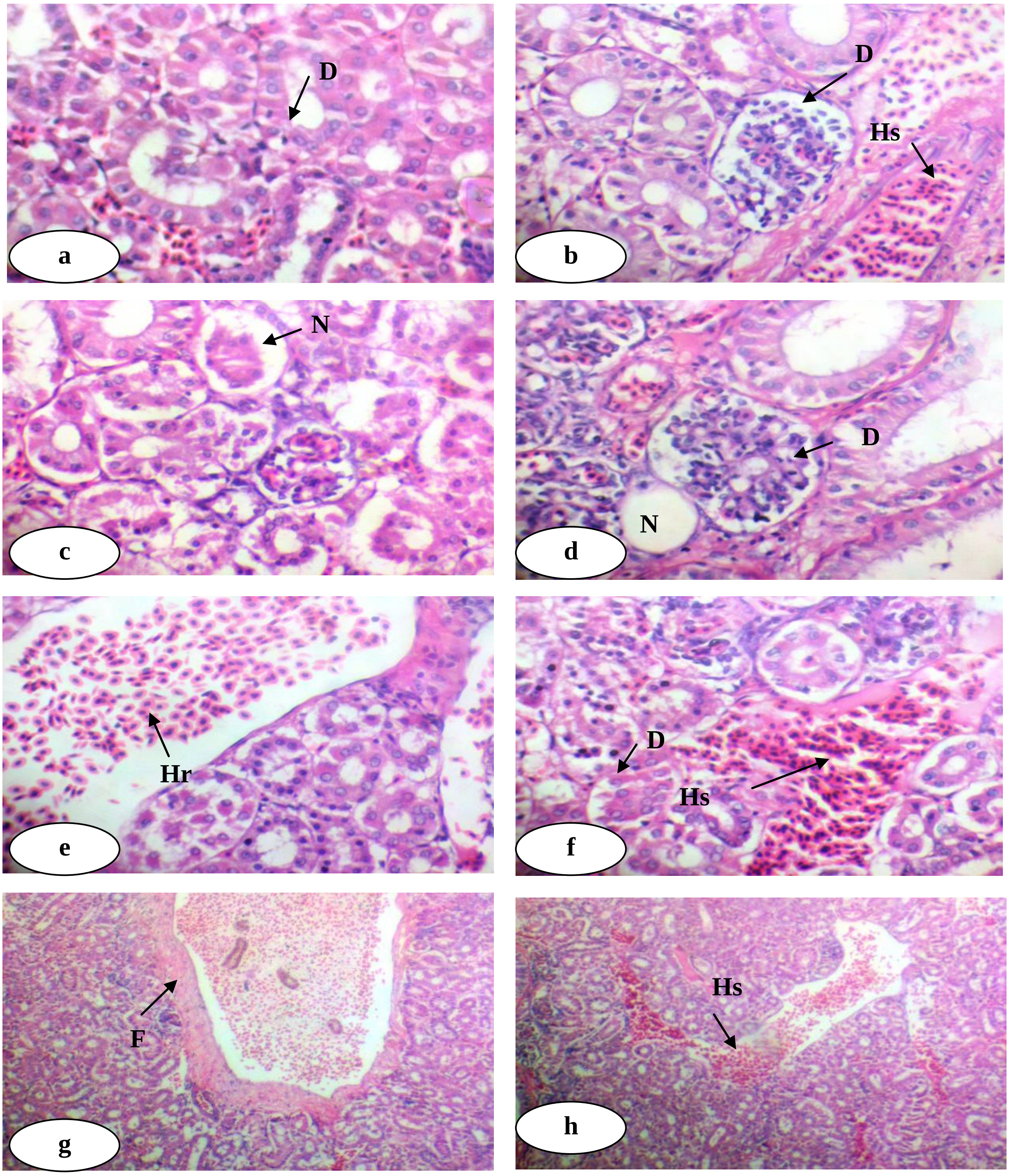
Figs. (a-h): Kidney sections of *M. capito* obtained from Lake Manzalah stained with H&E, showing: Fibrosis (F), Necrosis (N), Degeneration (D), Hemorrhage (Hr), Hemolysis (Hs), Hemosidrin (Hn) in kidney tubules. Degeneration (D), Necrosis (N) in Malpigian corpuscle

Plate IV



Figs. (a-h): Liver sections of *M. cephalus* obtained from Lake Manzalah stained with H&E, showing: Pyknotic nuclei (P), Degeneration (D), Necrosis (N) and Fatty Degeneration (F) in hepatic cells, and also Hemorrhage (Hr) Hemolysis (Hs) and Hemosidrin (Hn) between hepatocytes with Congesion (Cn) in blood sinusoid.

Plate IV



Figs. (a-h): Kidney sections of *M. cephalus* obtained from Lake Manzalah stained with H&E, showing: Degeneration (D), Necrosis (N), Hemorrhage (Hr) and Hemolysis (Hs) in kidney tubules. Degeneration (D), Necrosis (N) in Malpigian corpuscle, with Fibrosis (F) in blood vessels.