Cauvery River Pollutants Induced Histopathological Changes in Kidney and Muscle Tissues of Freshwater Fish, *Labio rohita* (Hamilton, 1822)

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Abstract

In the present investigation, the histopathological changes induced by Cauvery river pollutants in kidney and muscle tissues of freshwater fish *Labio rohita* have been studied. The Cauvery River receives pollutants from various sources, like municipal and domestic sewages, agricultural waste and the effluents from industrial complex which affect the inhabitants. The River pollutants were found to result in several histopathological changes in kidney and muscle tissues of one of the inhabitant's freshwater fish *Labio rohita*. In the present study, the kidney and muscle tissues of freshwater fish, *Labio rohita* collected from two stations viz., station-I (Less polluted region) and station-II (More polluted region) showed some histopathological changes of kidney and muscle. It has been revealed that the kidney and muscle tissues of the fish collected from station-I and station-II was much more affected than the control fish, this may be probably attributed by the river receiving of effluents from industrial, domestic and municipal wastes from nearby the town pallipalayam, Namakkal District, Tamilnadu. The results are discussed in details.

KEYWORDS*:* Cauvery River, *Labio rohita*, kidney and muscle

INTRODUCTION

Cauvery River contains effluents from different sources like untreated municipal and domestic wastes, agricultural wastes and industrial effluents which affect the aquatic system by depleting and enhancing different physico-chemical parameters thereby affecting the inhabitants. *Labio rohita* is the most common freshwater fish in India. Histological studies on fish have revealed that various toxicants have produced pathological changes in the tissues such as macrobiotic changes in the liver, tubular damage of kidneys, gill and lamellar abnormalities (Ramalingam, 2000). Due to growth of agriculture in and around freshwater bodies the pesticides are used abundantly during the cultivation season and found their way into water bodies.

Histopathological changes have been widely used as biomarkers in the evaluation of the health of fish exposed to contaminants, both in the laboratory (Wester and Canton, 1991) and field studies (Hinton *et al.*, 1992; Schwanger *et al.*, 1997; Teh *et al.*, 1997). One of the great advantages of using histopathological biomarkers in environmental monitoring is that this category of biomarkers allows examining specific target organs, including gills, kidney and liver, that are responsible for vital functions, such as respiration, excretion and the accumulation and biotransformation of xenobiotics in the fish (Gernhofer *et al.*, 2001). Furthermore, the alterations found in these organs are normally easier to identify than functional ones (Fanta *et al.*, 2003) and serve as warning signs of damage to animal health (Hinton and Lauren, 1990).

Investigations have been shown that the toxic pollutants and heavy metals induce histopathological changes in different tissues of fishes (Jayantha Rao, 1982 and Jayantha Rao *et al.,* 1985). The toxicity of such pollutants is assessed by the extent of histopathological damages induced in the test organism and the degree of cell damage is evident in relation to the concentration of pollutants employed. Mortality of fishes occurs due to the pathological lesions caused by pollutants (Tilak *et al.*, 2005 and Iyyappan *et al.*, 1998).

Metals and numerous other chemicals from industrial operations are toxic to animals and may cause sub lethal pathology of the liver, kidney, reproductive system, respiratory system, nervous system (Wilbur, 1969). Environmental stress is an inescapable component of the fish, compounded by the effects of adverse environmental conditions, including pollutants and land or water project developments within an area (Wedemeyer *et al.,* 1984).

Since fish population is an important component of the food chain any effect of such pollution would in the due course, have adverse influence on the nutritive value of fish and on man through their consumption. Some histopathological works are available on the effects of different pollutants on fish kidneys (Banerjee and Bhattacharya, 1994; Dhanapakiam and Premlatha, 1994) but much is not known about the effect of zinc on the histopathology of exposed fishes. Histopathological examination is usually used as a tool to evaluate the health of an organism, since the morphological structure of the cells and tissues reflect the well being of the organisms. The degree of divergence from normal cell structure indicates the relative abnormal health of an animal and it is considered as the precursor for the alteration of metabolic pathway of the cells.

Several authors have suggested that the histopatholgical studies can be used for monitoring the effects of aquatic pollutants. Investigations have been shown that heavy metals and industrial effluents histopathological changes in different tissues of fishes (Manosathiyadevan *et al.,* 2012). The toxicity of such pollutants is assessed by the extent of the histopathological damage induced in the test organisms and the degree of cell damage is evident in relation to the concentration of pollutant occurred. Mortality of fishes occurs due to the pathological lesions caused by pollutants..

From this review of literature, the works related to the effect of pollutants on freshwater fish are meagre. Therefore, it has been programmed in the present study to find out the effect of the Cauvery river pollutants on the kidney and muscle tissues of freshwater fish, *Labio rohita* collected from the river Cauvery at two stations, Station – I and Station - II, less polluted and more polluted regions, respectively.

MATERIALS AND METHODS

Description of Study Area

The Kaveri, also spelled Cauvery in English, is a large Indian river. The origin of the river is traditionally placed at Talakaveri, Kodagu in the Western Ghats in Karnataka, flows generally south and east through Karnataka and Tamil Nadu and across the southern Deccan plateau through the southeastern lowlands, emptying into the Bay of Bengal through two principal mouths. The Kaveri basin is estimated to be 27,700 square miles (72,000 km^2) with many tributaries. The river enters Tamil Nadu through Dharmapuri district leading to the flat plains where it meanders. It drops into the Hogenakkal Falls just before it arrives in the town of Hogenakkal in Tamil Nadu. The three minor tributaries, Palar, Chennar and Thoppar enter into the Kaveri on her course, above Stanley Reservoir in Mettur, where the dam has been constructed. The Mettur Dam joins the Sita and Pala mountains beyond that valley through which the Kaveri flows, up to the Grand Anicut. The dam in Mettur impounds water not only for the improvement of irrigation but also to ensure the regular and sufficient supply of water to the important Hydro-Electric generating station at Mettur. The river further runs through the length Erode district where river Bhavani, which running through the breadth of the district, merges with it. The confluence of the rivers Kaveri, Bhavani and Akash Ganga (imaginary) is at the exact place of Bhavani Kooduthurai or Tiriveni Sangamam, Northern a part of Erode City.

In the Namakkal District nearby pallipalayam town, it runs through Kaverykarai, Aavarampalayam, Solar, Odappalli, Vanichamber and Pappampalayam. In this river receives untreated municipal and domestic sewages from the town, pallipalaym are discharged regularly. Agricultural wastes also enter into this river from the nearby agricultural lands. In addition, untreated industrial effluents from the industries like, paper and sugar mill effluents are discharged into this river at Vanichamber which are the major pollutant agents of this river Cauvery near the pallipalayam town, Namakkal District, Tamilnadu.

In this river, Station-I is the less polluted region at the village Aavarampalayam. The Station-II is the more polluted region at the village Pappampalayam. Station-I is less polluted when compared to Station-II, due to the absence of direct discharge of effluents from industrial complex. The distance between Stations-I to Station-II is 7 kms. The depth of the river is more than 3 m.

The physico-chemical parameters were analyzed in both stations. All the physico-chemical parameters of the two Stations, like, temperature, pH, dissolved oxygen, salinity, total dissolved solids, calcium, phosphorus, nitrite and ammonia are significant differences between two Stations were found. Heavy metals like, mercury, lead, copper and cadmium also analyzed in water, sediment and the tissues like gill and liver. All the heavy metals are found to be higher at station-II than the station-I.

The freshwater fish *Labio rohita* were collected from the less polluted region Aavarampalayam (Station-I) and more polluted region Pappampalayam (Station-II) of the Cauvery river and the control fishes were collected from kaverykarai and transferred to the water filled plastic pools provided with continuous aeration and transferred to the rectangular fiber glass tank in the laboratory containing chlorine free aerated well water to acclimatize the fish for a maximum period of 10 days at the room temperature (28 ± 1^oC). The fishes were dissected in the field itself to collect the kidney and muscle tissues and immediately fixed in Bouin's fluid and brought the laboratory for histopathological studies (Gurr, 1958).

RESULTS

Histology of the kidney of the control fish

The histology of kidney of the control fish the proximal convoluted segments, distal convoluted segment, renal tubules and glomerulus showing the normal functioning of kidney (Fig 1, 2 and 3). The head of the kidney is composed of lymphoid haemotopoietic, internal and chromoffin tissue. The chromoffin cells are grouped together in bunches and surrounded by other collageous covering. There is no uniformity in the distribution of these cells which are found in the peripheral regions. The head kidney is not excreting in function. The trunk kidney is formed of a large number of nephrons, each consisting of a renal corpuscle of the malpighian body and the tubule. The tubule is differentiated into three regions viz, distal proximal and collecting convoluted tubules (Fig 1, 2 and 3).

Histopathology of the kidney of the fish collected from Station-I (Less polluted region)

The histopathology of kidney of the fish collected from less polluted region showed some conspicuous histopathological changes in the kidney. The distal and collecting convoluted tubules of the kidney undergo degeneration and have a large lumen due to hypertrophy. The cells of the kidney are destroyed; vacuolization, shrinkage and breakage of tissue, degeneration of tubular epithelium and swollen nuclei are seen in the kidney (Fig 4, 5 and 6). In the same areas, the cell boundaries are disrupted and hence the cells become indistinct. Disorganization of glomerulus, pycnotic nuclei, degeneration and atrophy of renal tubules, Intercellular spaces formation (Fig 4, 5 and 6) were found due to the presence of municipal and sewage wastes in the less polluted region.

Histopathology of the kidney of the fish collected from Station-II (More polluted region)

The histopathological studies of the kidney of the fish collected from more polluted region showed degeneration and atrophy of renal tubules, degeneration in glomerulus, disorganization of glomerulus, severe necrosis and highly pycnotic nuclei were observed (Fig 7, 8, 9 and 10). These changes are induced by untreated industrial effluents are discharged into the more polluted region.

Histology of the muscles of the control fish

The histological study of the muscle tissues of the control fish showed the presence of normal myotomes with equally spaced muscle bundles it indicates the fish in unstressed conditions (Fig. 11 and 12).

Histopathology of the muscles of the fish collected from Station-I (Less polluted region)

The histopathology of the muscle tissues of the freshwater fish *Labio rohita* collected from less polluted region showed some remarkable changes like, shortening of muscle bundles, thickening of muscle bundles and necrosis of muscle bundle were observed (Fig 13 and 14). This may be a less polluted region receives the untreated municipal and sewages wastes.

Histopathology of the muscles of the fish collected from Station-II (More polluted region)

The histopathology of the muscle tissues of the freshwater fish *Labio rohita* collected from less polluted region showed some remarkable changes like, severe damage of muscle bundles, shortening of muscle bundles, thickening of muscle bundles, severe intra muscular oedema and necrosis of muscle bundle were observed (Fig 15, 16 and 17). These changes are induced by untreated industrial effluents are discharged into the more polluted region.

Discussion

Kidney is an important organ of excretion and osmoregulation and is highly susceptible to toxic substance because of its high blood supply. The effect of cadmium on the histology of kidney in *Cirrhinus mrigala*, was observed. Rupture of tubule boundary cells, formation of melanomacrophage, congregation of nuclei, damage of epithelial cells and coagulated mass of blood cells were observed Nutan kumai *et al.*, (1989) studied the effect of cadmium chloride in *Channa punctatus* on kidney tissues where shrinkage of glomerulus was observed. Dubale and Punita Shah (1981) observed that the proximal tubules of the kidney were fully damaged when *Channa punctatus* exposed to cadmium chloride. Severe necrosis, vacuoles around renal tubule of the kidney and haemorrhage were observed in the kidney of fish *Cirrhinus mrigala* when it was exposed to fenvalerate (Anita Susan and Tilak, 2003).

In the present study, histopathological changes of the kidney of fish collected from more polluted region was much more pathological changes observed than the kidney collected from les polluted region such as degeneration and atrophy of renal tubules, degeneration in glomerulus, disorganization of glomerulus, severe necrosis and highly pycnotic nuclei were observed. These changes are induced by untreated industrial effluents are discharged into the more polluted region. These results are in agreement with findings of Kour and Singh, (1980); Banerjee and Bhattacharya, (1994); Dhanapackiam and Premlatha, (1994); Anitha Kumari and Sree Ram Kumar, (1997); Pallavi Gupta and Neera Srivastava, (2006); Chhaya Bhatnagar *et al.*, (2007); and Manosathiyadevan *et al.*, (2009), (2009a) and (2012).

Pathological changes have earlier been reported in the kidney of fishes exposed to various pollutants (Banerjee and Bhatacharya, 1994; Anitha Kumari and Sree Ram Kumar, 1997). Histopathological alterations can be used as indicators of the effects of various pollutants on the organism including fish, and reflection of the overall health of the entire pollution. According to studies by Mohamed (2009) shown that the exposure of fish to pollutants, that is agricultural and industrial chemicals, were resulted in several pathological changes in different tissues of fish. Similar alterations in histopathology were also reported in the *Oreochromis spp*. Exposed to hexavalent chromium (Abbas and Ali, 2007).

In fish, as in higher vertebrates, the kidney performs an important function to maintain the homeostasis. The kidney is one of the first organs to be effected by contaminants in water (Thophon *et al.*, 2003; Mela *et al.*, 2007). The kidney often showed cloudy swelling in tubule cells after lead exposure. More hyaline droplet degeneration was observed in control group. Cengiz (2006) observed degeneration in the renal tubule, pycnotic nuclei in the hematopoietic tissue and degeneration of glomerulus. Similar alterations in the kidney have also been reported in Nile tilapia exposed to ammonia (Benli *et al.,* 2008).

In the present study, the muscle tissues collected from more polluted region showed severe damages than the muscle tissues collected from less polluted region such as, severe damage of muscle bundles, shortening of muscle bundles, thickening of muscle bundles, severe intra muscular oedema and necrosis of muscle bundle were observed. All these changes indicate the fish under the highly stressful conditions due to the more polluted region receives the effluents from industrial complex. Similar changes have also been reported by Hawkes, (1980); Narayan and Singh, (1991); Mercy *et al.*, (1996); Kapila and Ragothaman, (1999); Das and Mukherjee, (2000); Gbem *et al.,* (2001); Bharat Bhusan Patnaik *et al.,* (2011) and Manosathiyadevan *et al.,* (2012).

Therefore, considering the kidney and muscle injuries of the organism exposed to pollutants, it has been shown that the conditions of this environment were not satisfactory for the development and survival of the fishes. The accumulation of the untreated municipal, sewage wastes, agricultural wastes and industrial effluents particularly the heavy metals and persistent chemicals in the fish tissues will reach the human beings through the food chain and will result in "biomagnifications". This hazardous situation may be prevented by treating the effluents properly before being let off into the river.

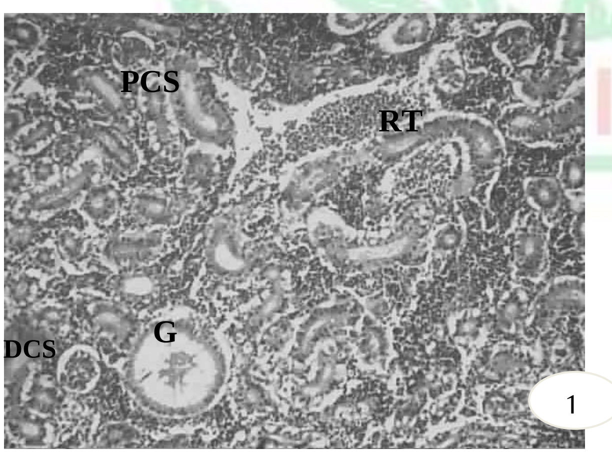

Fig.1. Photomicrograph of the kidney of the control fish X ca 10
PCS – Proximal convoluted segment
DCS – Distal convoluted segment
RT – renal tubules G - Glomerulus

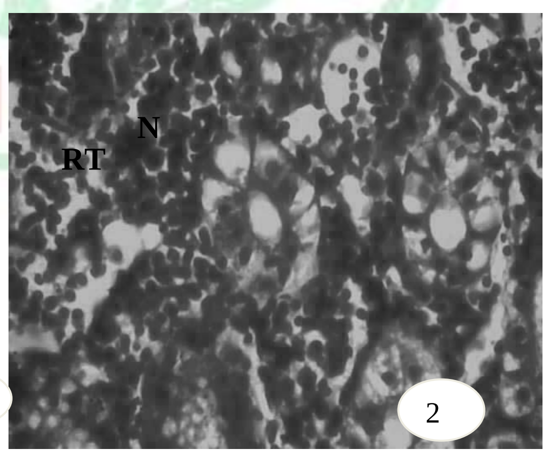

Fig.2. Photomicrograph of the kidney of the control fish X ca 40
RT – renal tubules
N - Nucleus

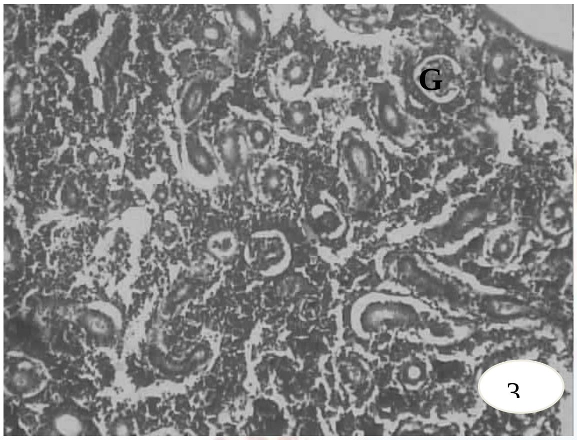

Fig.3. Photomicrograph of the kidney of the control fish X ca 10
G - Glomerulus

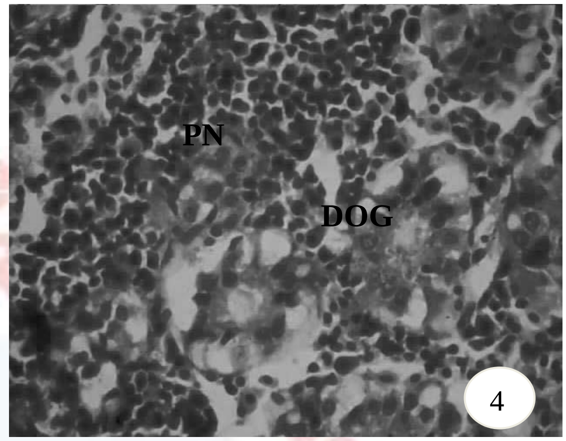

Fig.4. Photomicrograph of the kidney of the fish collected from less polluted region X ca 40
DOG – disorganization of glomerulus
PN – Pycnotic nuclei

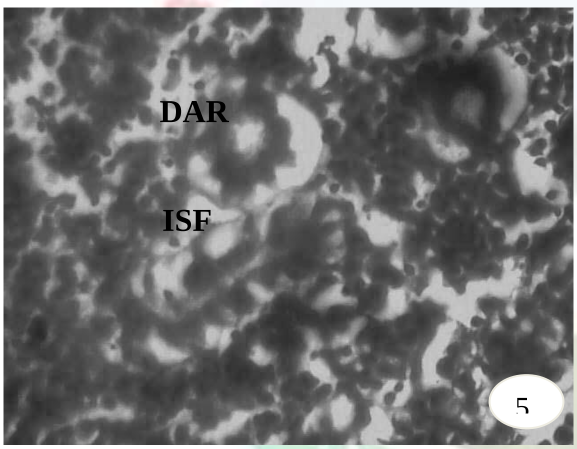

Fig.5 Photomicrograph of the kidney of the fish collected from less polluted region X ca 40
DART – degeneration and Atrophy of Renal Tubules
ISF – Intercellular spaces formation

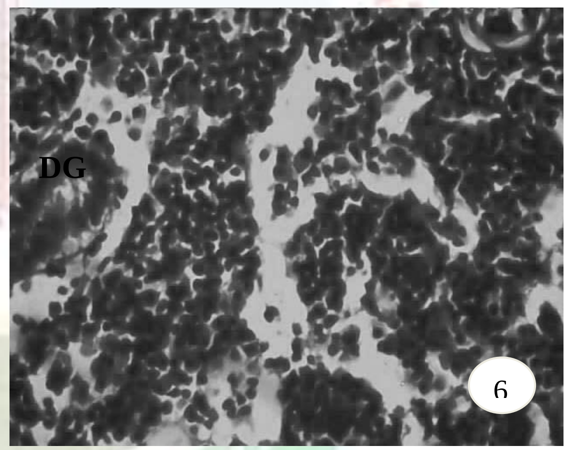

Fig.6. Photomicrograph of the kidney of the fish collected from less polluted region X ca 40
DG – degeneration in glomeruluS

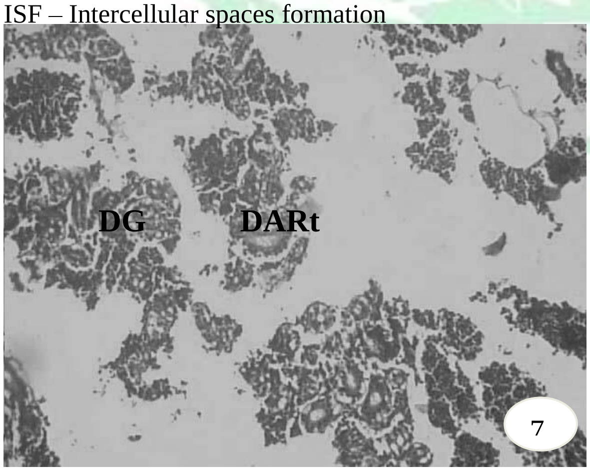

Fig.7. Photomicrograph of the kidney of the fish collected from more polluted region X ca 10
DARt – Degeneration and Atrophy of Renal tubules
DG – degeneration in glomerulus

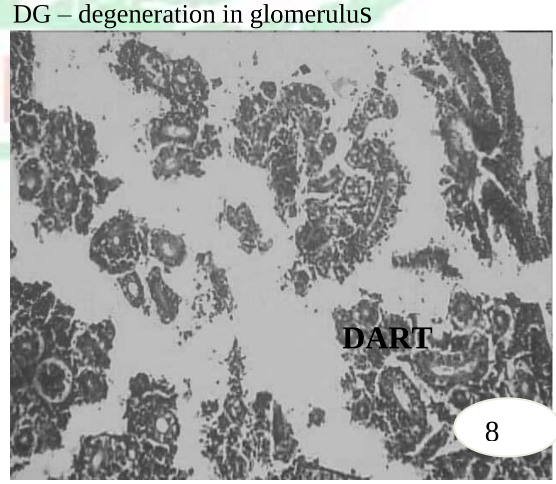

Fig.8. Photomicrograph of the kidney of the fish collected from more polluted region X ca 10
DART – Degeneration and Atrophy of Renal Tubules

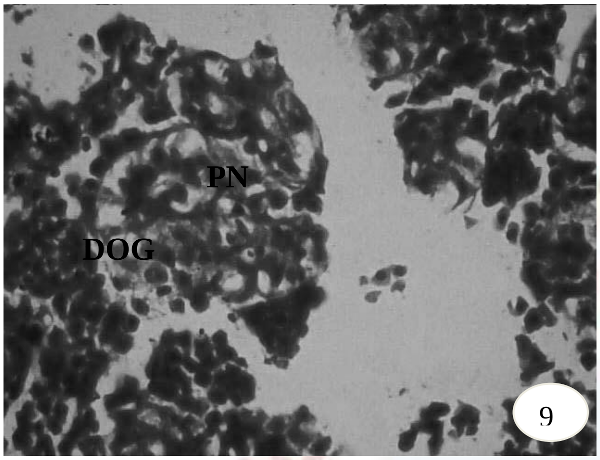

Fig.9. Photomicrograph of the kidney of the fish collected from more polluted region X ca 40
DOG – disorganization of glomerulu
PN – Pycnotic nuclei

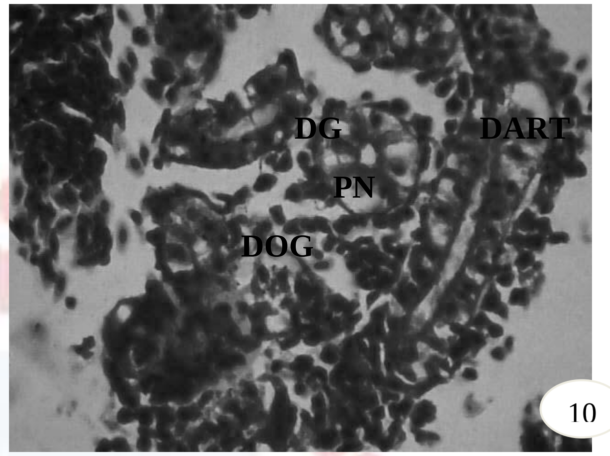

Fig.10. Photomicrograph of the kidney of the fish collected from more polluted region X ca 40
DG – degeneration in glomerulus
DART – degeneration and atrophy of Renal tubules
DOG – disorganization of glomerulus
PN – Pycnotic nuclei

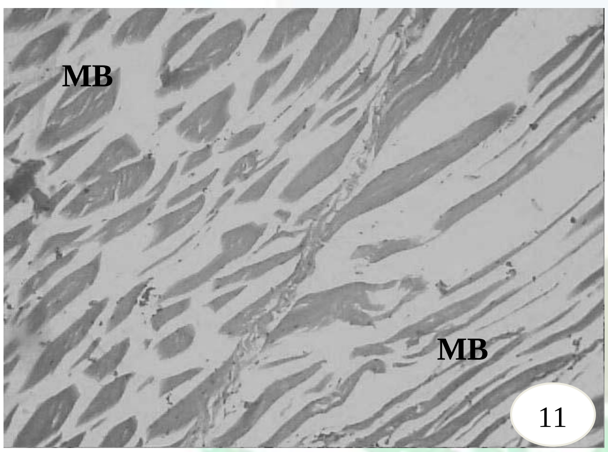

Fig.11. Photomicrograph of the muscle of the control fish MB – Muscle Bundles X ca 10

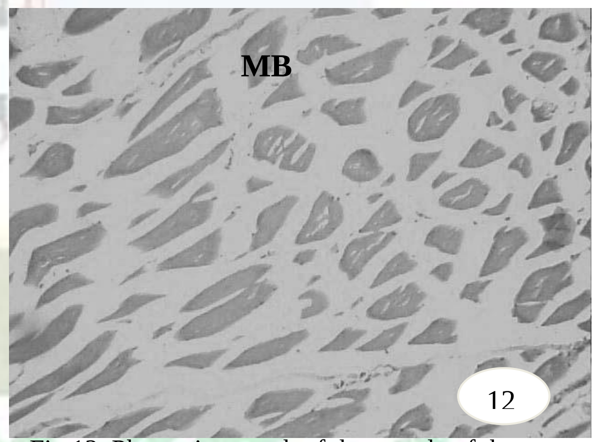

Fig.12. Photomicrograph of the muscle of the control fish X ca 10
MB – Muscle Bundles

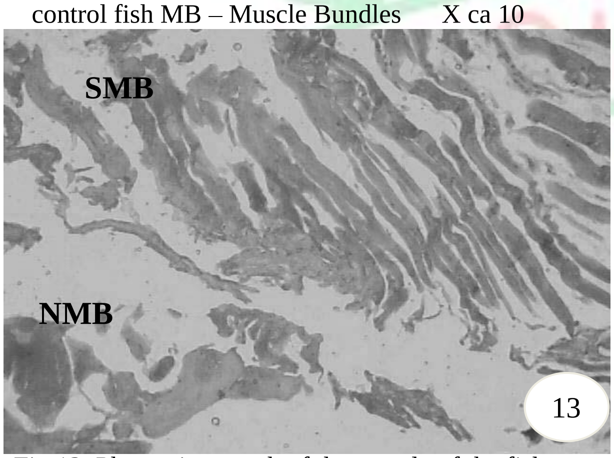

Fig.13. Photomicrograph of the muscle of the fish collected from less polluted region X ca 10
SMB – Shortening of Muscle Bundle
NMB – Necrosis of Muscle Bundle

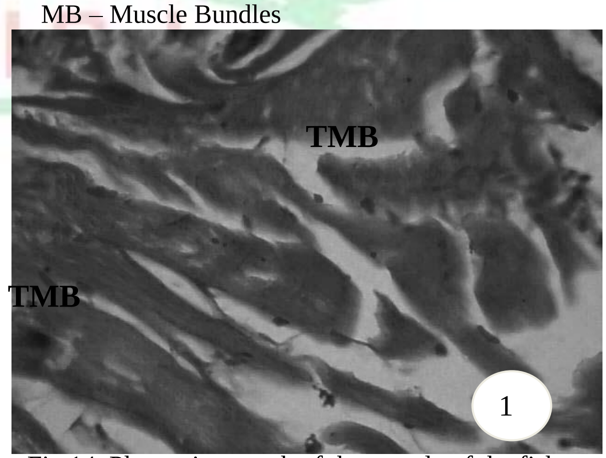

Fig.14. Photomicrograph of the muscle of the fish collected from less polluted region X ca 40
TMB – Thickening of Muscle Bundle
NMB – Necrosis of Muscle Bundle

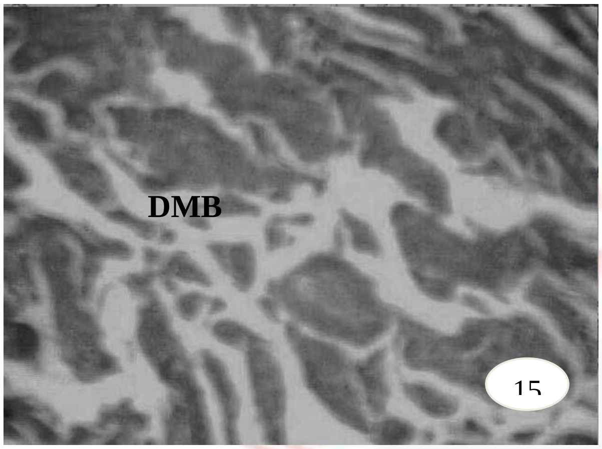

Fig.15. Photomicrograph of the muscle of the fish collected from more polluted region X ca 40
DMB – Disorganization of Muscle Bundle

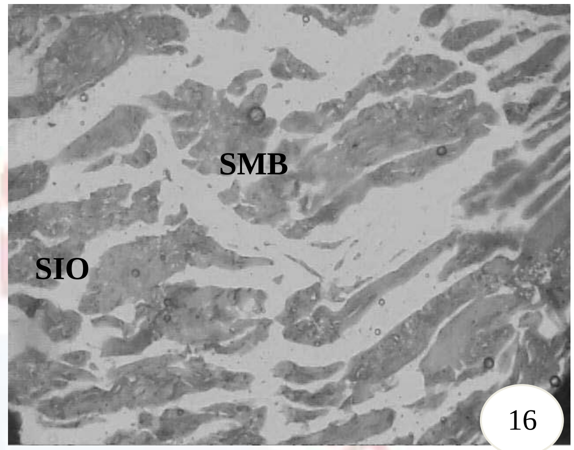

Fig.16. Photomicrograph of the muscle of the fish collected from more polluted region X ca 10
SMB – Shortening of Muscle Bundle
SIO – Severe Intra muscular Oedema

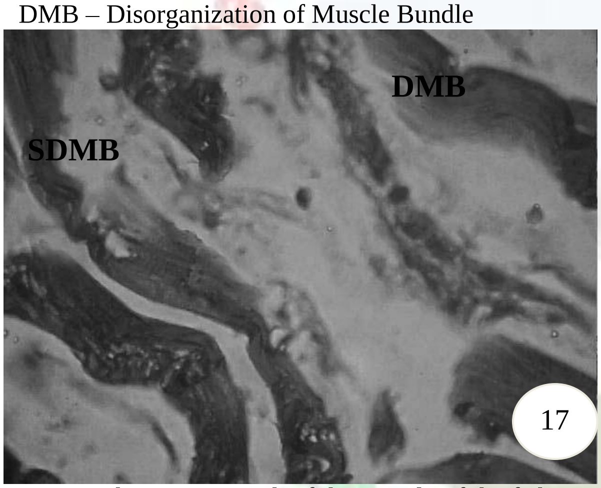

Fig.17. Photomicrograph of the muscle of the fish collected from more polluted region X ca 40
DMB – Disorganization of Muscle Bundle
SDMB – Severe Damage of Muscle Bundle

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