

FISHES: BIO-INDICATOR OF AQUATIC DEGRADATION

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IMPORTANCE OF FISH

The fishery resources and their fish stock are our national wealth. Due to presence of high quality animal protein, vitamins and minerals essential for vitality and growth, fish plays vital role in food and nutritional security. Blood cholesterol level is extremely low, therefore very useful in preventing death from heart diseases. Nutritive value of fish in human diet is being realized throughout the world. Therefore demand and consumption of fishes are constantly increasing, a bright prospect of fishing in our country.

Our inland fishery resources are unique, vast and varied due to presence of rich and wide variety of excellent stock of fishes, crustaceans, molluscs and aquatic micro and macro vegetation. Therefore prospect of fish production in the country is bright. The potential endowments available in the form of streams, rivers, lakes, flood plain wetland and estuaries harboring excellent stocks of mahseers, snow trouts, Indian major carps, large and small Catfishes, Hilsa, Featherbacks, Mulletts, livefishes, Murrels, eels, minor carps are playing key role in production of fresh water and brackish water fishes.

Today India is 4th largest fish producing country in world with an annual output exceeding more than 61.8 lakh ton. In farmed fish production India ranks second after China.

EMERGING CRISIS DUE TO ENVIRONMENTAL DEGRADATION

Though gains in fish production front have been significant, but unfortunately these valuable resources are losing their biogenic potentialities due to several reasons but the

environmental degradation and water pollution are one of the most important reasons inviting a loss of concern in the future development of fisheries. Aquatic pollution of major water bodies is caused mainly by the flow of industrial effluents, agricultural pesticides and chemicals, drainage, untreated urban sewage drainage, soil erosion, eutrophication and weed infestation, oil spills and a number of other factors. The pollutants cause increase in acidity of water, enhance the free CO₂ level, lower dissolved oxygen (DO) and change the concentration of many dissolved cations and anions. These changes have posed a serious threat to aquatic animals by interacting adversely with them. The functioning of the ecosystem may be pushed to a critical stage when it may not be possible to restore homeostasis through ordinary, non-emergency adjustment processes and therefore structural and functional change may occur in the organisms. Changes in the structure of vital organs like gills, skin, liver, kidney and gonads are evident in the fishes due to different types of pollution. The endocrine system is helpful in the coordination of physiological and biochemical processes to regain homeostasis. The toxicants also alter the endocrine coordination.

ADAPTATION OF FISHES IN RESPONSE TO TOXICANTS

Adaptation in skin in response to altered environmental condition

Various cellular components of the skin show changes in their histological organization and histochemical characterization in response to different toxicants.

CHANGE IN MUCOUS CELLS

Increase in number and volume of mucous cells in the skin epidermis of fish exposed to different toxicants has been observed which may be correlated with increased mucous secretion. Mucous hypersecretion after exposure to different toxicants has been reported frequently (Crespo, 1982; Burton et al., 1991; Garg & Mittal, 1993). Paul and Melodia (1990) pointed out that fish mucous has detoxifying action against ambient toxicants. Rajan and Banerjee (1994) opined that mucous helps in retarding the toxicity of irritants present

in the environment. Maurya (2006) suggested that enhanced mucous secretion by mucous cells forming thick slimy coat over the surface of the epidermis in *Channa striatus* at different duration of *Chlordecone* treatment provides an uninterrupted protective coating as slime preventing entry of pathogens through the damaged sites of the epidermal surface layer PLATE I (a) & (e)

CHANGE IN SACCIFORM CELLS

Sacciform cells present in the epidermis of some fish species (viz. *Channa striatus*, *Anabas testudineus*) show increase in density and dimension with significantly increased quality of their secretory contents (Devi R. and Banerjee, T.K., 2006; Singh et al., 2004) (PLATE I d,e). This suggests that secretory contents of these cells might also be playing some significant role in providing additional defensive role (along with carbohydrate moieties of mucous cells) against the stress of toxicants. The secretion of sacciform cells of *Channa striatus* exposed to lead nitrate contain very high concentration of proteins along with increased concentration of tryptophan (Devi, R. & Banerjee, T.K., 2006). Due to highly hydrophobic nature of tryptophan, the slime intermingled with secretory materials of sacciform cells neither gets easily dissolved out nor gets sloughed into surrounding water. Rather, the mucous along with lipid moieties perhaps remain glued on the surface of the skin causing delayed penetration of lead salt (Devi, R. & Banerjee, T.K., 2006). While studying the effects of toxicants and heliophysical factor on biochemical parameters of external mucous in carp, Labedena et al. (2002) noticed significant increase in protein concentration of the slime. Plate I (c)

CHANGE IN CLUB CELLS

When the fishes are exposed to toxicants the club cells in the epidermis show enormous increase and their membranes are broken (Maurya, 2006) (PLATE If, IIa) and their contents are squeezed out into the body surface (Singh and Banerjee, 2008), thus helping to prevent quick penetration of the toxicants via the skin. The ability to withstand

the stress of various physical as well as chemical hazards has been well accepted (Banerjee and Mittal, 1976; Rajan and Banerjee, 1991; Chandra and Banerjee, 2003; Devi, 2004).

CHANGE IN LYMPHOID SPACES

Increased lymphoid spaces are observed in skin and gill epithelium which play protective role and help in detoxification by accumulating the entered toxicants and expelling them out with the help of some energy pumps, specially by the mitochondria-rich cells (Dutta et al., 1996).

CHANGE IN PIGMENTATION

When the fishes are exposed to toxicants, darkening in the body colour of the fish is observed followed by lightening (Rajan and Banerjee, 1991; Maurya et al., 2007). Lightening of body colour is due to heavy lysis of pigment cells (PLATE I a, b, c) because melanin has capacity for binding aromatic and cyclic compounds and cations. They may selectively pick up harmful toxicants resulting in their lysis. Plate II (a) to (d)

Adaptive changes in gill in response to altered environmental condition

FUSION OF GILL LAMELLAE

Fusion of gill lamellae against the toxic effect of chemicals has been reported by (Ojha, 1991; Munshi and Singh, 1971; Singh et al., 2007). Fusion of lamellae is a natural defence mechanism to keep most of lamellar surface away from direct contact to toxic chemicals. Plate III (a) to (f)

INCREASE IN DENSITY AND DIMENSION OF MUCOUS CELLS

Increase in density and dimension of mucous cells in gills is markedly observed at different exposures related to enhanced mucous secretion which is an inbuilt defence mechanism of fishes against disturbed aquatic toxicants (Ojha, 1999; Singh et al., 2007). Increased density and dimension of mucous cells are environment.

PROLIFERATION OF CHLORIDE CELLS

Increase in density and dimension of chloride cells has been observed in gills at different exposures of toxicants. Neutralization of toxicants has been suggested. The chloride cell proliferation may occur with excretion of by Dutta et al., 1996; Ojha, 1999; Singh et al., 2006). The role of chloride cells in excretion and toxicants (Dutta et al., 1996). Ojha (1999) suggested that role of mitochondria in chloride cells is to provide energy for ionic regulation in disturbed aquatic environment.

TELANGIECTATIC SECONDARY LAMELLAE

In polluted water telangiectatic secondary lamellae have been observed (Ojha, 1999; Singh et al., 2007). The presence of telangiectatic lamellae indicates characteristic pathological changes in the gills associated with physical and chemical trauma due to polluted aquatic environment. The toxic chemicals diffuse into lamellar blood from ventilating ambient water cause lysis of pillar cell system to amalgamate lumens of blood channels. Collapse of pillar cell system which regulates the lamellar blood flow causes accumulation of blood with dilation of amalgamated lamellar blood channel.

Change in gonads

Marked histological changes are encountered in the testes of fish exposed to toxicants. Testicular lobules exhibit degenerated spermatogonia and primary spermatocytes (Pundir and Saxena, 1980; Shukla and Pandey, 1984; Shukla, 1995). The degenerative changes could either be on account of a direct toxic action of environmental poison or due to indirect effect via the hypothalamic pituitary testicular axis as suggested by Ram and Sathyaneshan (1987).

Ovary of fish exposed to various pollutants show increase in interfollicular spaces (Mukharjee, 1975; Shukla, 1995) and increase in number of atretic oocytes (Wani and lately, 1982; Nath, 1998).

CONCLUSION

Environmental regulation is a complex science and a challenge to mankind. The responsibility now lies not only with politicians who are at the helm of affairs but also with biologists. The valuable papers by scientists will go a long way to take this difficult problem.

PLATE I

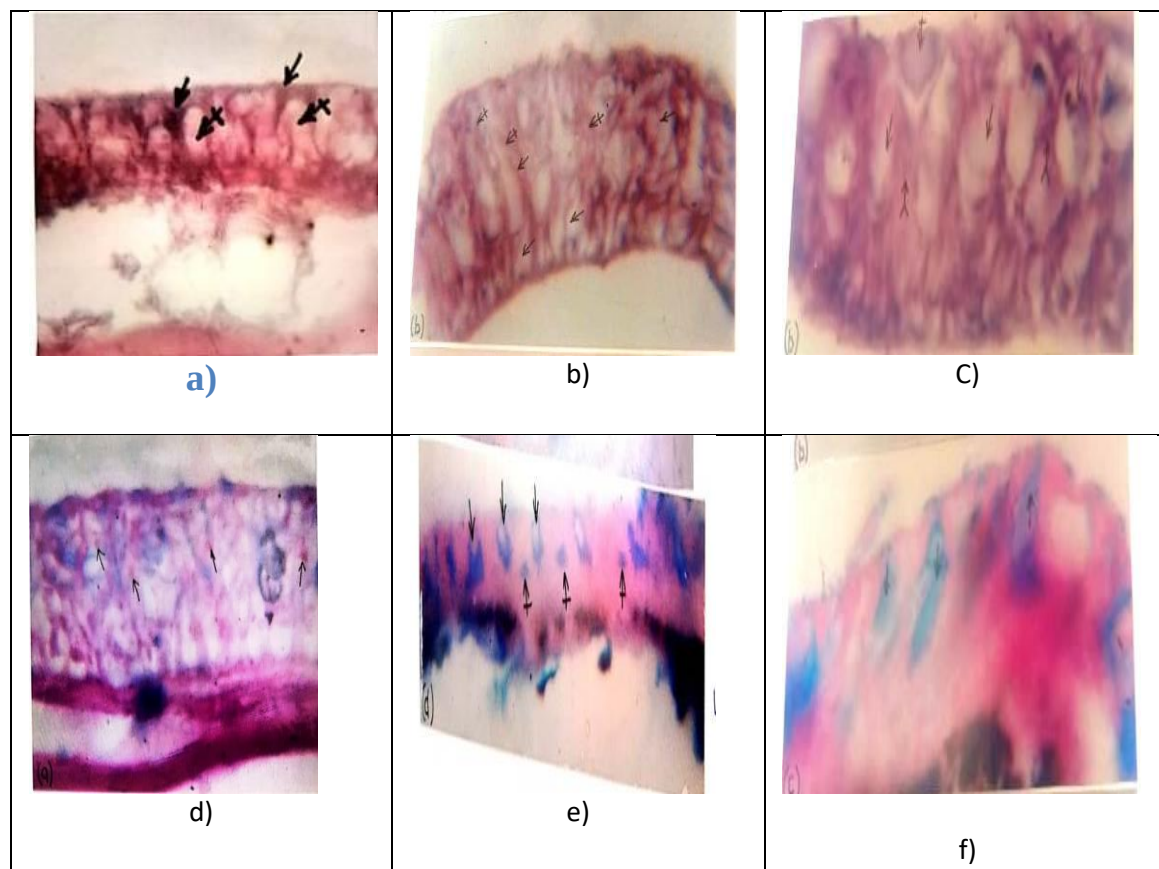


Plate I

- a) Figure 1 Showing epithelial cells (arrow) and mucous cells (barred arrow)
- b) Figure 2 Showing inter cellular spaces between epithelial cells (arrow) and pyknotic nuclei in epithelial cells (barred arrow) [6 HE $\times$ 100]
- c) Figure 3 Showing regeneration of epithelial cells appearing healthy distinct nuclei (arrow). Note numerous enlarged slightly basophilic numerous cells (barred arrow) and some saciform cells with eosinophilic content (winged arrow) [9d HE $\times$ 100]
- d) Figure 4 Showing magenta colour glycogen granules in the epithelial cells (arrow) [control PAS] $\times$ 100
- e) Figure 5 Showing mucous cells in the surface layer evacuating their content in the surface (arrow). Note Newly formed rounded mucous cells in the middle layer (barred arrow) [6h, AB/PAS] $\times$ 100
- f) Figure 6 Showing elongation of mucous cells (arrow) staining for acidic glycoprotein [2d, AB / PAS] $\times$ 100

PLATE II

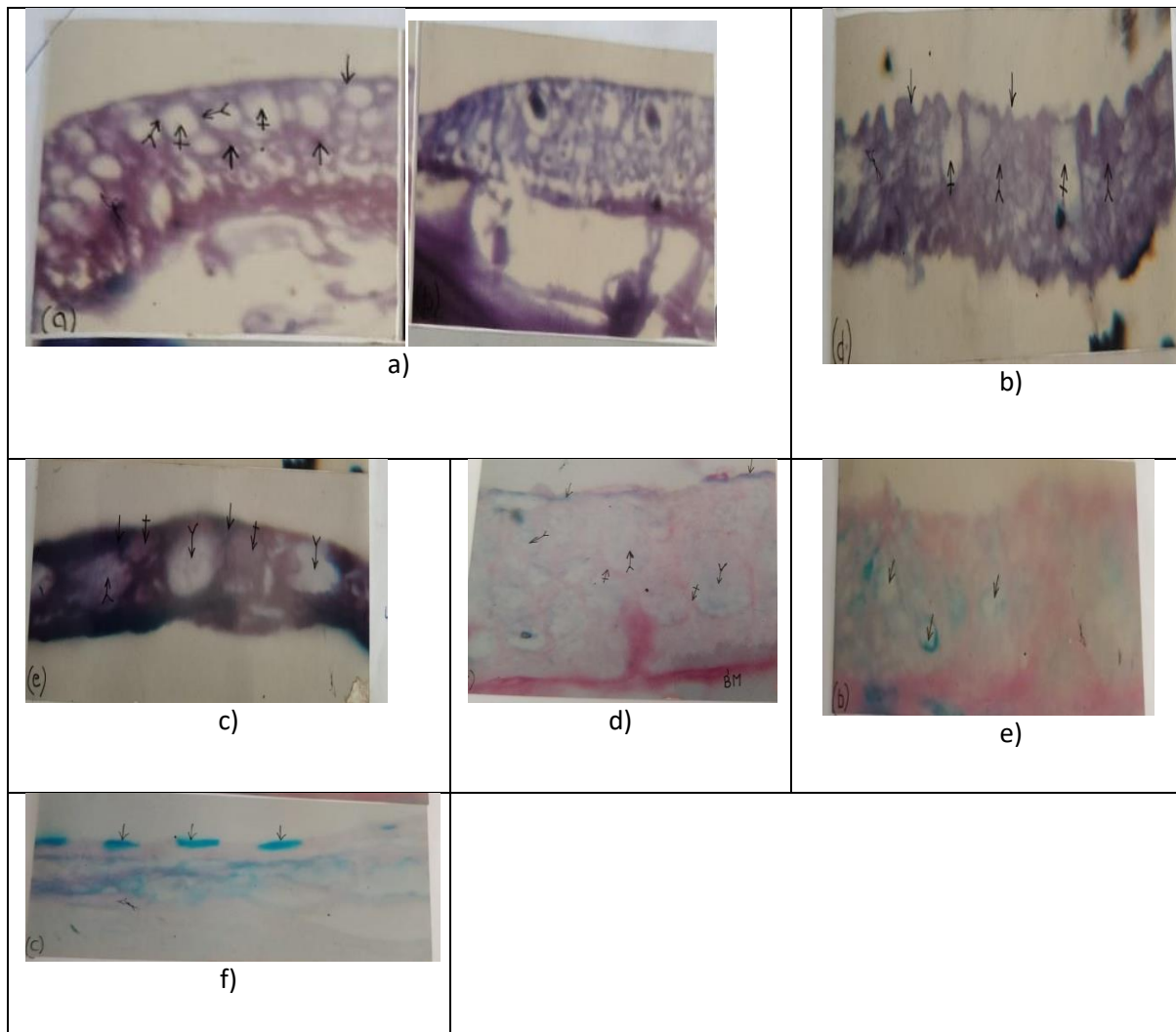


PLATE II

- Figure 7 Showing strong blue reaction in the epithelial cells (arrow), Note weak reaction in the mucous cells (barred Arrow) also note relatively reaction in the membranous covering of the mucous cells (winged arrow). [Control , MBPB] $\times 1000$
- Figure 8 Showing micro ridges in the superficial epithelial cells (arrow) mucous cells (barred arrow) and epithelial cells (winged arrow) [1D, MBPB] $\times 1000$
- Figure 9 Showing very strong blue reaction in the epithelial cells (arrow) also note relatively stronger reaction in the sacciform cells (barred arrow) and mucous cells (winged arrow) [2d MBPB] $\times 1000$
- Figure 10 Showing strong magenta colour basement membrane (BM) purple colour reaction in the outer margin of superficial layer epithelial cells (arrow) .; Strong magenta reaction in the periphery of mucous cells (barred arrow) and moderate purple colour reaction in the anterior of mucous cells (winged arrow) [control AB/PAS] $\times 1000$

- e) Figure 11 Showing evacuation of mucous cells (arrow) [lethal, 1d, AB/PAS] × 1000
 f) Figure 12 Showing extremely flattened mucous cells (arrow) containing acidic glycoprotein and arranged in superficial layer [lethal, 4d, AB/PAS] × 600

PLATE III

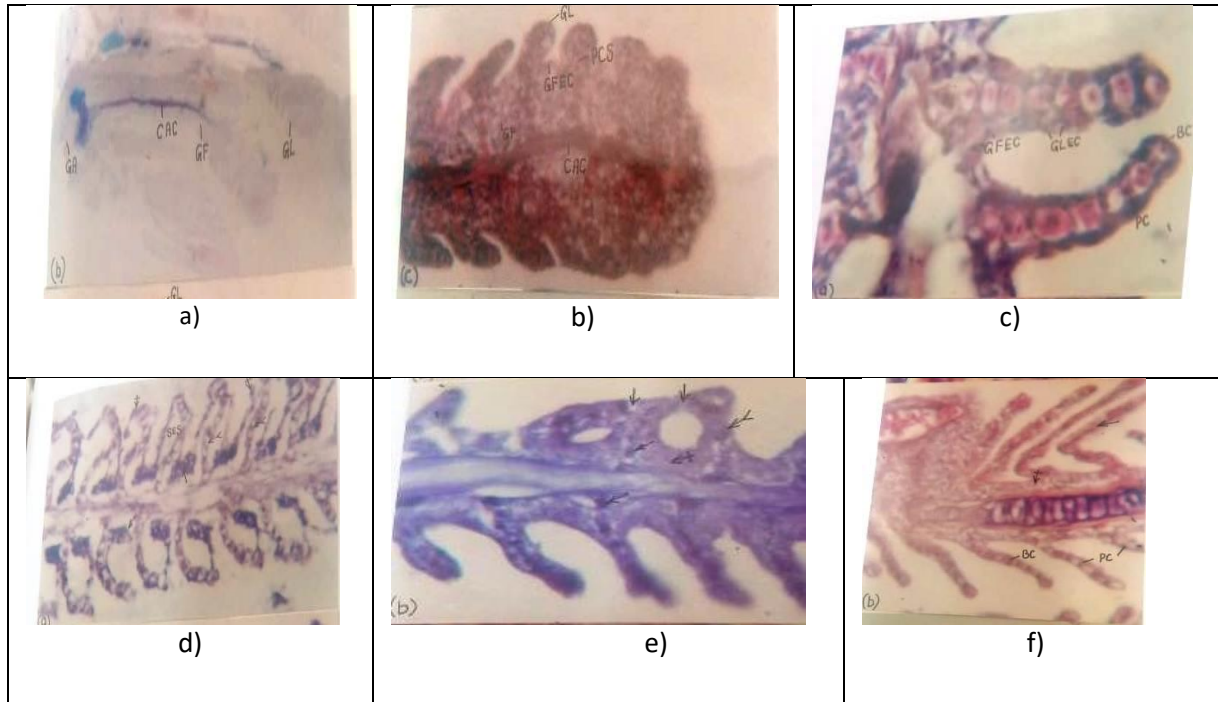


PLATE III

- a) Figure 13 showing gill arch (GA), gill filament (GF) Gill, lamellae, (GL) stained with AB/PAS techniques, Note strong purple colour reaction in the cartilaginous axis cells of the gill filament [Control AB/PAS] × 150
 b) Figure 14 Showing eosinophilic pillar cells system (TCS) in gill lamellae (GL) surrounded by gill lamellar epithelial cells. ALSO note gill filament constituted by multilayer gill filament epithelial cells (GLEC) and cartilaginous axis cells (CAC) [Control, HE] × 600
 c) Figure 15 Showing multilayer gill filament epithelial cells (GLEC). A pillar cell system constituted by round eosinophilic blood channel and small basophilic pillar cells (PC) enclosed within basement membrane (arrow) note gill lamellar epithelial cells arranged in two layers surrounding pillar cells system [Control HE] × 2000
 d) Figure 16 Showing accumulation of gill filament epithelial cells in sac like structure at the base of the inter lamellar region (arrow). Note upliftment of gill lamellar epithelial cells (barred arrow) from elongated pillar cells system (winged arrow) leaving sub epithelial space between PCS and gill lamellar epithelial cells [Lethal, 2d, HE] × 1000
 e) Figure 17 Showing very strong blue reaction in PCS (Arrow), strong reaction in the gill filament and gill lamellar epithelial cells (barred Arrow). Note fusion of adjacent lamellae at their tips (winged arrow) [lethal, 3d MBPB] × 1000

- f) Figure 18 Showing pillar cells system (arrow) With well dilated nucleated blood channels (BC) and pillar cells (PC). Note gill filament epithelial cells (barred Arrow) and cartilaginous cells axis cells (winged arrow); [sub - lethal 6d HE] *600

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