Chapter 4

Discussion
4. Discussion

4.1. Toxicity evaluation

Organophosphate pesticides are used preferably as insecticides in different parts of the world due to their photo and soil degradability, high effectiveness and low persistence in the environment (Fulton and Key, 2001). Excessive use of pesticides is one of the leading causes of water pollution which causes hazards to several non target organisms such as aquatic invertebrates and vertebrates. Adverse environmental situation causes not only by discarding industrial byproducts but our regular activities, culture system may also produce incompatible environment which leads to the accumulation of toxic substances and stressful environment. Stressful situation of toxicant in the environment may cause alarm reaction, like release of series of hormones or development of resistance and results in adaptation. However, severe and chronic effect may create a state of exhaustion (Madhyastha, 1996).

Sensory system of an organism may recognize the toxicants in the environment even at low concentrations and may avoid harmful effects. Motile organisms can protect themselves by running away from the polluted area. But the sedentary organisms such as bivalves, gastropods may avoid harmful effects by producing mucus which leads to reduction in exposure of external body surface or by taking the body into the shell or by closure of siphons. Shell closing mechanism might be the protective device against the toxicant and provides good tolerance in the molluscs (Nagaratnamma and Ramamurthi, 1982). Mucus secretion was observed in Lamellidens consobrinus against heavy metal exposure by Bhamre et. al., 2010.
In the present investigation, more mucus secretion was observed in bivalves treated with profenofos than \( \lambda \)-cyhalothrin and it was in accordance with the results of earlier researchers (Keller and Ruessler, 1997; Kumar et al., 2012).

Koppar et al., 1993, recorded the LC\(_{50}\) value of methyl parathion to Parreysia favidens as 33.5, 30.5, 23.5 and 15.5 mg/L for 24, 48, 72 and 96 hours and for another species Parreysia corrugate, the LC\(_{50}\) values were 32.0, 24.0, 22.2 and 17.0 mg/L for 24, 48, 72 and 96 hours. Fernandez et al., 1996, reported that survival rate decreases with increase in pollutant concentration.

Lata et al., 2001, recorded LC\(_{50}\) values for carbaryl and carbofuran exposed to Catfish, Calarias batrachus at 24, 48, 72 and 96 hours. It was between 16.27 to 2.75 ppm for carbaryl and between 1.47 to 3.84 ppm for carbofuran.

Hunt et al., 2003 studied six of nine toxicity identification evaluations (TIEs) and found that the organophosphate pesticides diazinon and/or chlorphyrifos were implicated as causes of observed toxicity and these compounds were the most probable causes of toxicity in two of the other three TIEs. Profenofos was shown to alter the filtration and pumping activity of mussels and fish dependent on stereochemical structure (Milam et al., 2005). Percentage mortality of catfish, Heteropneustes fossilis was observed after exposure to various concentrations of organophosphate insecticide, methyl parathion as 10.40, 9.60, 7.20 and 6.60 mg/L for 24, 48, 72 and 96 hours respectively (Mishra et al., 2005). The results of Boran et al., 2007, reveals that carbaryl and methiocarb were more toxic to rainbow trout, Ornearhynchus mykiss than guppy, Poecilia reticulata.

In the present investigation, LC\(_{50}\) values of profenofos were 3.1956 ppm for 24 hours, 2.6953 ppm for 48 hours, 2.2961 ppm for 72 hours and 1.7951 ppm for 96 hours while LC\(_{50}\) values of \( \lambda \)-Cyhalothrin were 2.1949 ppm for 24 hours, 1.6941
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94 ppm for 48 hours, 1.1928 ppm for 72 hours and 0.7887 ppm for 96 hours for *Lamellidens corrianus*. The present results are in agreement with the observations of **Koprucu and Seker, 2008**. Highly toxic effect of synthetic pyrethroid, deltamethrin on *Unio elongatulus eucirrus* as 8.99, 8.09, 7.30 and 6.60 mg/L for 24, 48, 72 and 96 hours was recorded by **Koprucu and Seker, 2008**.

**Pathan et al., 2009**, recorded LC$_{50}$ values of freshwater fish, *Rasbora daniconius* exposed to paper mill effluent as 11%, 10.52%, 10.1 % and 9.5% for 24, 48, 72 and 96 hours respectively. Recently, **Koprucu et al., 2010**, reported LC$_{50}$ values for cypermethrin on *Unio elongatulus eucirrus* as 96.50, 77.96 and 59.20 µg/L for 48, 72 and 96 hours respectively. The result of a study on zebra fish, conducted by **Ansari and Ahmad, 2010**, is evident that Lambda-cyhalothrin is more toxic than Neemgold. They observed that during the exposure of Lambda-cyhalothrin the LC$_{50}$ value after 24 hours was 1.127 µg/L, which decreased to 0.119 µg/L after 96 hours of exposure. On the other hand, the 24 hours LC$_{50}$ values of Neemgold was 23.125 µg/L which decreased to 2.890 µg/L after 96 hours of exposure. Hence, both the pesticides show time-dependent action.

**Patil, 2010**, reported LC$_{50}$ value of indoxacarb for 96 hours was found to be less (0.7811 ppm) than that of thiamethoxam (28.4229 ppm) to freshwater bivalve, *Parreysia cylindrical*. **Bhandare et al., 2011**, investigated the toxicity and behavioral changes in freshwater fish, *Puntius stigma* after exposure to various concentrations of organophosphates insecticide, Rogor for 24, 48, 72 and 96 hours and noted LC$_{50}$ values as 9 ppm, 8.31 ppm, 7.8 ppm and 7.1 ppm respectively.

**Jagtap et al., 2011**, recorded the median lethal concentration (LC$_{50}$) of tributyltin chloride on the freshwater bivalve, *Lamellidens marginalis* as 5.33, 4.02, 3.5 and 2.12 ppm after 24, 28, 72 and 96 hours respectively. The 24, 48, 72 and 96 hours
LC$_{50}$ values of Cypermethrin for Caspian roach were noted as 2.314, 1.023, 0.732 and 0.627 µg/L respectively. However, these values were recorded for the silver carp as 2.962, 1.653, 1.030 and 0.917 µg/L, respectively (Shaluei et al., 2012). Whereas, Jahanbakhshi et al., 2012 assessed the acute toxicity of Cypermethrin to Great sturgeon (Huso huso) juveniles and estimated the 24, 48, 72 and 96 hours LC$_{50}$ values as 6.860, 4.751, 2.677 and 0.952 µg/l, respectively. Kamble et al., 2012, studied the acute toxicity of thiodan in freshwater bivalve mollusc, Lamellidens corrianus and recorded the LC$_{50}$ values for 24, 48, 72 and 96 hours as 0.066, 0.049, 0.038 and 0.029 ppm. Kumar et al., 2012, investigation the LC$_{50}$ values for Lamellidens marginalis were recorded as 45.09, 40.52, 38.71 and 36.34 mg/L for 24, 48, 72 and 96 hours. These values indicate moderate toxicity of dimethoate towards the Lamellidens marginalis. Ariole and Ezevununwo, 2013, recorded the LC$_{50}$ of dichlorvos on freshwater snail, Pila ovate as 2.91, 1.74, 1.01 and 0.54 ppm for 24, 48, 72 and 96 hrs respectively and concluded that the mortality increased with increase in dichlorvos concentration.

4.2. Biochemical parameters

Glycogen

The most prominent carbohydrate stored in the marine bivalves is glycogen. It is the immediate source of energy, therefore under stressed conditions glycogen depot is exhausted first. Reddy and Bhagyalakshmi, 1994, observed significant decrease in the glycogen and total carbohydrate level in the tissues of crab exposed to fenvalerate.

Tripathi et al., 2003, examined the sublethal toxic effect of dimethoate on carbohydrate and nitrogenous metabolism in the tissues of freshwater fish Channa
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*Naveed et al., 2006*, studied the toxicity of lihocin from the fish, *Channa punctatus* and reported decreased glycogen and pyruvate level.

Study conducted by *Susan et al., 2010*, on fish reported that highly significant decrease in glycogen content in both sub lethal and lethal concentrations of technical grade, fenvalerate in most of the tissues.

In the present investigation, depletion in glycogen content was noted in the foot, mantle and gills of *Lamellidens corrianus* exposed to profenofos and λ-Cyhalothrin. The percent variation of glycogen over control after 96 hrs treatment with profenofos in foot was 6.65, in mantle were 16.80 and in gills were 9.68. The percent variation of glycogen over control after 96 hrs treatment with λ-Cyhalothrin in foot was 4.28, in mantle were 13.47 and in gills were 5.10. On the basis of percent variation, stress condition caused by organophosphate insecticide, profenofos was found to be more on carbohydrate metabolism.

*Suvare et al., 2010*, found that there was decrease in glycogen content in various tissues as compared to control. In LC<sub>10</sub> group, glycogen was decreased in gill, mantle, foot, male gonad and female gonad except in hepatopancreas, while in LC<sub>50</sub> group glycogen was decreased in all target organs. This decrease was more in foot, male gonad and female gonad in LC<sub>50</sub> group as compared to LC<sub>10</sub> group. Decrease in glycogen content indicates greater utilization of glycogen for metabolic purposes and to combat with Imidacloprid stress. *Kamble and Shinde, 2011*, showed depletion in glycogen level in freshwater bivalve, *Lamellidens corrianus* due to toxic effect of thiodan.

**Proteins**

Proteins are mainly involved in the architecture of the cell, which is the chief source of nitrogenous metabolism. Thus, the depletion of protein in tissues like
gills, foot and mantle may have been due to their degradation and possible utilization for metabolic purposes. A fall in tissue protein is indicative of reduced protein synthesis and low assimilation of food and low amino acid uptake for protein synthesis. Organophosphates are known to methylate and phosphorylate cellular proteins directly (Wild, 1975).

The physiological and biochemical alterations observed in an animal under any physiological stress can be correlated with the structural and functional changes of cellular proteins. Proteins occupy a unique position in the metabolism of cell because of the proteinaceous nature of all the enzymes which mediate at various metabolic pathways (Lehninger, 2008).

For the management of the stress situation, animals require high energy which could be derived from protein catabolism as well. Furthermore, this decrease in protein content might also be due to the repair of damaged cell and tissue organelles (Rambabu and Rao, 1994; Sancho et al., 1998). The highly reactive hydroxyl radical (OH·), which is one of the reactive oxygen species generated in the process leading to oxidative stress, is considered to be responsible for the formation of carbonyl groups in proteins (Oliver, 1987). Protein oxidation can lead to loss of critical sulf-hydryl groups in addition to modification of amino acids leading to the formation of carbonyl and other oxidized moieties (Stern, 1985). High oxygen tension in many areas of the circulation favours reactive oxygen species formation and membrane proteins are cross-linked. Oxidative modification leads to proteolytic degradation, which may affect the structure, function and integrity of proteins (Bainy et al., 1996).

Murty and Devi, 1982, recorded a decrease in the protein levels in the tissues of *Channa punctatus* following acute exposure to endosulfan. Increases in free amino
acid levels were the result of breakdown of protein for energy and impaired incorporation of amino acids in protein synthesis (Singh et al., 1996).

Parate and Kulkarni, 2003, discussed that depletion of the protein may be due to its utilization for the production of energy to alleviate the pesticide stress and to prevent fatigue which may occur due to the effect of pesticides. Kulkarni et al., 2005, found significant decrease in the total protein content in foot, hepatopancreas and gills of the fresh water mussel, Lamellidens corrianus on exposure to the sub lethal concentration of organochlorine insecticide, hildan. They further concluded that, decline in protein content indicates intensive proteolysis which is followed by corresponding decrease in total free amino acids.

A study conducted on the morphology and biochemistry of different developmental stages of fresh water snail, Lymnaea stagnalis after the treatment of baygon and nuvan by Bhide et al., 2006. They found decrease in protein fractions in most of the developmental stages. They suggested that nuvan is more toxic than baygon. Satyaparameshwar et al., 2006, observed decrease in total protein content on exposure to chromium in three different tissue viz. adductor muscles, gills and mantle of fresh water mussel, Lamellidens marginalis. The decrease was more pronounced in the gills followed by adductor muscles and mantle. Neelamegam et al., 2006, discussed the fall in protein level during exposure may be attributed to increased catabolism and decreased anabolism of proteins. The protein content decreased in gills when Spirolotelphusa hydrodroma treated with chloropyryphos (Senthilkumar et al., 2007).

In the present investigation, depletion in total protein content was noted in the foot, mantle and gills of Lamellidens corrianus exposed to profenofos and λ-Cyhalothrin. The percent variation of protein over control after 96 hrs treatment
with profenofos in foot was 15.02, in mantle were 16.70 and in gills were 27.35. The percent variation of protein over control after 96 hrs treatment with λ-Cyhalothrin in foot was 19.80, in mantle were 20.85 and in gills were 32.98. This was possibly due to stress condition caused by toxicity of both the insecticides. Stress condition caused by pyrethroid, λ-Cyhalothrin was found to be more on protein metabolism. Similar results were noted by Andhale and Zambare, 2011, during the nickel induced biochemical alterations in freshwater bivalve, Lammellidens marginalis and reported that the protein contents were decreased in treated animals than the control. Pardeshi and Gapat, 2012, also reported similar results during nickel intoxication in the freshwater bivalve. Waykar and Pulate, 2012, concluded that protein contents in the mantle, foot, gill, digestive glands and whole body of profenophos exposed bivalve, Lammellidens marginalis showed remarkable decrease as compared to control. Their result reveals that percent protein contents in the mantle, foot, gill, digestive glands and whole body of bivalve, on profenofos intoxication were 21.98 ± 2.54 (p<0.001), 41.48 ±1.87 (p<0.01), 22.78 ± 2.04 (p<0.01),16.68 ±1.03 (p<0.05) and 30.77 ± 2.09 (p<0.01) respectively. These results are in accordance with our results.

Lipids

Because most chemicals that are bioconcentrated are deposited in the lipid phase of aquatic organisms, and tissues and organelles have different levels and types of lipids, one normally assumes that the absorbed chemical is heterogeneously distributed in organisms. However, detailed analysis of chemical residues in mollusca tissues, such as clam, mussel, and oysters, indicates that pesticides are generally distributed in visceral mass, including digestive glands and gonads, rather than in mantle and gill (Bedford and Zabik 1973; Rajendran and
Venugopalan 1991; Uno et al. 2001; Sathe et al., 2005). Lipids in bivalves are multifunctional, one or more of the functions during the maturation of gametes, drastic environment conditions, starvation, pollution stress etc can be more noticeable. Such a role of lipid in body maintains metabolism during pesticide stress (Voogt, 1983).

Decrease in tissue lipid and proteins under pesticide stress could be due to several mechanisms viz., formation of lipoproteins which are utilized for repair of damaged cell and tissue organelles, direct utilization by cells for energy requirements, increased lypolyses, and damage to cellular organization, as noticed in Channa punctatus exposed to pesticides (Ghosh and Chatterjee, 1989). Deshmukh and Lomte, 1998, observed significant depletion in the lipid content in all the tissues of freshwater bivalve, Parreysia corrugate, tested after acute treatment of copper sulphate.

In the present investigation, depletion in total lipids content was noted in the foot, mantle and gills of Lamellidens corrianus exposed to profenofos and λ-Cyhalothrin. The percent variation of total lipids over control after 96 hrs treatment with profenofos in foot was 20.76, in mantle were 18.14 and in gills were 18.51. The percent variation of total lipids over control after 96 hrs treatment with λ-Cyhalothrin in foot was 13.31, in mantle were 12.92 and in gills were 13.48. On the basis of percent variation, stress condition caused by organophosphate insecticide, profenofos was found to be more on lipid metabolism.

Amanulla et al., 2004, studied effect of butylin on lipid metabolism in an esturine mussel, Sunetta scripta and reported that there was significant decrease in the lipid contents in digestive gland.
4.3. Enzymes

Acid phosphatase (ACP), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) are liver specific enzymes and they are more sensitive measure of hepatotoxicity and histopathologic changes (Balint et al., 1997). These enzymes are used as biochemical markers of hepatic cell necrosis (Henderson et al., 1983).

Oxidative stress is a reason of enhanced lipid peroxidation and changes in structure and function of other important cellular components, such as protein and DNA (Wang et al., 1990). It has been reported that lipid peroxides may be induced by a variety of environmental pollutants (Ahmad et al., 2000; Wilhelm-Filho et al., 2001; Oakes and Van der Kraak, 2003; Sivaperumal and Sankar, 2013).

The specific level of lipid peroxidation on profenofos and λ-cyhalothrin exposure during half of lethal toxicity exposure for 96 hours was might be higher than that of control bivalves. A direct consequence of failure of antioxidant system was might be due to the accumulation of ROS in the system, which led to higher rate of formation of lipid peroxides. This might be consequently resulted in tissues damage.

We, strongly assumed that the exposure to profenofos and λ-cyhalothrin enhanced ROS synthesis in the digestive gland and gills of Lamellidens corrianus and that antioxidant defenses were not able to effectively scavenged them, thus leading to lipid peroxidation. Lipid peroxides is considered a valuable indicator of oxidative damage of cellular components.

Lactate dehydrogenase mediates the inter-conversion of lactate and pyruvate, depending up on the availability of NAD. LDH is present in numerous tissues, cytoplasm, enzymes and marker of tissue damage and its increased level is reported in liver necrosis (Ramesh et al., 1993; Lemaire et al., 1991). Injured
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Toxicant causes a disturbance in the physiological status of the animals which affects enzyme activity. Toxicants bring about distortions in the cell organelles, which may bring about elevation or inhibition in the activity of various enzymes (Valarmathi and Azariah, 2003). Changes in the LDH activity may indicate the facility with which mussel can shift to anaerobic metabolism under adverse conditions. LDH is also involved in the conversion of pyruvate to lactate in the animal system (Nicholson and Lam, 2005). Other study, have demonstrated that dehydrogenase enzymes activity of microorganisms is among the most sensitive parameter for evaluation of toxicity (Alisi et al., 2008). LDH activity increased significantly in the ovary, gills, hepatopancreas, muscle and spermatheca of *Barytelphusa cunicularis* after 48 and 72 hours of exposure to copper sulphate (Chourpagar and Kulkarni, 2009). LDH activity is generally associated with cellular metabolic activity which acts as a pivotal enzyme between the glycolytic
pathway and the tricarboxylic acid cycle. Thus, elevation of LDH may suggest a bias towards the anaerobic glycolytic pathway. Amanullah et al., 2010, showed that the LDH level has increased in the muscle (166±2.8 U l⁻¹), gill (97±23 U l⁻¹) and hepatopancreas (146±1.4 U l⁻¹) of treated animals than in control.

Ezeji et al., 2011, concluded that the activity of lactate dehydrogenase (LDH) was significantly higher at all levels of pesticide contamination studied compared to the control.

In the present investigation, the percent variation of LDH over control after 96 hrs treatment with profenofos in digestive gland was 81.64 and in gills were 31.74. The percent variation of LDH over control after 96 hrs treatment with λ-Cyhalothrin in digestive gland was 69.44 and in gills were 48.42. This result reveals that the more release of LDH indicated, the damage to the digestive gland was more in the profenofos treated bivalves and damage to the gills was more in the λ-Cyhalothrin treated bivalves.

ALP is enzymes involved in the process of mineralization of calcium carbonate in invertebrates. ALP is mainly localized at the cell membrane; any damage to digestive gland tubules may result in the alteration of ALP activity.

In the present investigation, significant increase was observed in ALP activity in gills (P<0.05) and digestive gland (P<0.01) with an increase in the exposure time (72 hours) of both insecticides, indicating the action of profenofos and λ-cyhalothrin on cell membrane leading to cell damage.

Tietz, 1976, reported that increase in ALP could be a result of damage of liver cells and duct obstruction due to proliferation of its cells and/or related to the progressive liver necrosis. Bhatnagar et al., 1995, studied the effect of pyrethroid on the fish Clarias batrachus and found that alkaline phosphatase decreased in
response to the toxicants. Ahmed et al., 1997, concluded that degradation and necrosis induced by toxicants in hepatopancreas causes release of acid phosphatase.

Ogochukwu and Joseph, 2009, reported increased enzymatic activity of alkaline phosphatase in the fish Clarias gariepinus under the stress of Ariel detergent and suggested extensive damage of liver cells and rupture of blood vessels as possible reasons of increased ALP activity for compensatory action of physiological stress.

Ram and Singh, 1988, found an elevation in ALP and ACP activity in the liver of carbofuran-treated Channa punctatus. Anand et al., 2010, reported significant increase in ALP activity in the adductor muscle and intestinal diverticula of green mussel, Perna viridis exposed to heavy metals.

Acid phosphatase (ACP) is known to be localized in lysosomes, and surrounded by a lipoprotein membrane. The activities of the enzymes usually increase as an adaptive response to free radical overload.

ACP activity in the digestive gland and gills of Lamellidens corrianus after profenofos and λ-cyhalothrin exposure was found to be higher when compared to control (Table 23). This result showed that profenofos and λ-cyhalothrin leads to the release of this enzyme into cytoplasm consequently leading to the autolytic breakdown of cellular organs.

Acid phosphatase hydrolyzes large variety of organic phosphatase esters with the formation of an alcohol and a phosphate ion. The decreased profile of ACP enzyme estimated in the study conducted by Jana et al., 1985 is attributed to adverse effect of detergent on cell and its organelles.

Keshavan et al., 2005, demonstrated in their study on the mussel, Lamellidens marginalis exposed to Sevin that decrease in activities of acid and alkaline
phosphatase in hepatopancreas and foot muscles with increase in concentration and time of exposure. Rao, 2007, studied the sublethal effects of an organophosphorous insecticide, 2- butenoic acid-3- (diethoxyphosphinothioyl) methyl ester (RPR-II) on biochemical parameters of tilapia, Oreochromis mossambicus and found increase in ACP and ALP activities in plasma, gill and kidney.

4.4. Histological evaluation

In present work, gills of bivalve are severely injured due to profenofos and \( \lambda \)-cyhalothrin exposure. Since \( \lambda \)-cyhalothrin is found to be more toxic than profenofos, its destructive value is more than that of later. The epithelial cells and connective tissue cells have lost their cellular structure. Connective tissue and epithelium became oedematic, necrotic and vacuolated. There was fusion of secondary lamellae and space between water tubes and interlamellar junction was reduced due to hypertrophy and hyperplasia. 

Superoxide, peroxide, hydroxyl radical and other free radicals derived from oxygen are highly reactive and therefore threatening to the integrity of essential bimolecules such as DNA and RNA, enzymes and other protein and phospholipids responsible for membrane integrity.

Mattiessen and Brafield, 1973, reported necrosis of gill epithelium, vacuolization and sloughing of epithelial cells with changes in their cytoplasm in gills of sickle backs, Gasterosteus faculeatus due to dissolved zinc.

Vijayalaxmi and Tilak, 1996, studied histopathological changes in gills of Labeo rohita exposed to pesticide monocrotophos and found elongated secondary gill lamellae with bulging and bending tips, necrosis, atrophy and degeneration in the respiratory epithelial cells. Toxicants transformed curling of secondary lamellae,
rupture of gill rackers, displacement and necrosis of outer layer of lamellar epithelium in gills (Prasad et al., 2000).

Sultana and Sharief, 2004, observed extensive damages in the internal gill architecture of copper, lead and zinc exposed fish, Tilapia mossambica and examined as degenerative changes, swelling, fusion, atrophy etc. They also found reduction in the size of primary and secondary gill lamellae and necrosis of tissue, degeneration of secondary gill lamellae with bulging tips.

Histopathological changes in the gills of the fish, Channa punctatus exposed to sublethal concentration of herbicides, butachlor and machete was studied by Tilak et al. 2005. They found bulging tips of primary gill filaments, cutting of secondary filaments, degeneration of pillar cells, necrosis and formation of vacuoles in the secondary gill epithelium and concluded that, pesticides cause severe architectural changes in vital organs like gills which make the fish unfit for survival. These changes altered the physiological activities and affect metabolism.

Butchiram et al., 2009, observed histopathological changes like necrosis, vacuolar degeneration, fusion and atrophy of primary and secondary gill lamellae in gill of fresh water fish (Channa punctatus) exposed to sublethal concentration of a chloroacetanilide herbicide.

Generally, the digestive gland is composed of tubules that are bound by connective tissue and muscle fibers. The digestive epithelium consist of two cell types, the digestive cell which is involved in absorption and intracellular digestion and the basophilic cells which appear to be involved in synthesis of proteins and extracellular digestion (Zorita, 2006).

Unlu et al. 2005, observed irreversible necrotic changes in digestive glands of snail, Lymnaea stagnalis exposed to sublethal concentration of thiodan (35% EC.).
They found enlargement of lumen of digestive tubules. **Cengiz, 2005**, examined histopathological effects of thiodan on freshwater snail, *Galba truncatula* as accumulation of amoebocytes in the haemolymphatic spaces between the tubules of the digestive glands, exudation in the lumen of tubules, expansion of haemolymphatic spaces between the tubules and increase of vacuolization and necrotic changes in digestive cells.

**Usheva et al. 2006**, studied histopathology of digestive glands of the bivalve mollusc, *Crenomytilus grayanus* from south-eastern Peter, the Great Bay of Japan, subjected to the effect of polluted water. They found erosive disturbances and heavy vacuolization of digestive cells in the epithelium of the tubules and channels, lipofusion, necrosis and lyses of cells in connective tissue.

In the present investigation, pathological changes showed disruption of integrity of digestive tubules as a result of greater areas of intertubular spaces between tubules, separation of digestive cells from the basement membrane, reduced epithelium height, and tubular atrophy due to toxic action of profenofos and λ-cyhalothrin on digestive glands of bivalve *Lamellidens corrianus* (LEA).