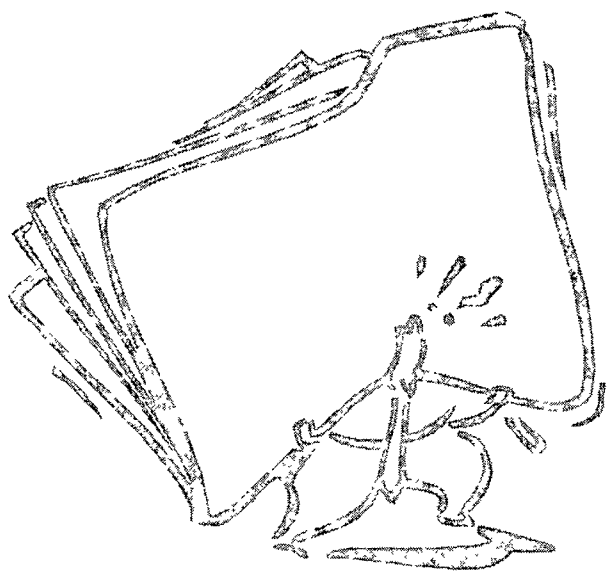
CHAPTER – 6



SUMMARY AND CONCLUSION

In view of the increasing awareness of the potentially detrimental long-term toxic effects of lead and cadmium, there is a general need for the safe and effective therapy like antioxidant. Consequently, antioxidants that scavenge reactive oxidants and modulate the cellular redox status may be useful.

The present study on the biochemical and toxicological investigations have suggested that the administration of lead and cadmium have induced oxidative stress in rats. The pharmacological studies indicate that the oxidative stress induced by these metals was reduced by the co-administration of vitamin E, vitamin C and *spirulina*. The following parameters were conducted to substantiate this finding.

- The lipid peroxidation products like malondialdehyde, hydroperoxide and conjugated diene formation were significantly increased in liver, kidney, lung and heart of the rats after 30 days exposure to 10, 30 and 100 ppm of lead acetate and cadmium chloride, indicating peroxidative damage to the organs. Vitamin E, vitamin C or *spirulina* administration significantly reduced the levels of these lipid peroxidation products in liver, kidney, lung and heart of animals exposed to 100 ppm of lead acetate and cadmium chloride indicating the protection against peroxidative damage. But there was no evidence of lipid peroxidation in brain of animals.

- There was a significant reduction in the levels of endogenous antioxidants like superoxide dismutase, catalase and reduced glutathione in liver, kidney, lung and heart of animals after 30 days exposure to lead acetate and cadmium chloride, suggesting the generation free radicals in the organs. Administration of exogenous antioxidants like vitamin E, vitamin C or *spirulina* significantly increased the superoxide dismutase, catalase and reduced glutathione levels in liver, kidney, lung and heart of animals

exposed to 100 ppm of lead acetate and cadmium chloride. However, the levels of these endogenous antioxidants in brain remain unchanged during the study.

- The glucose-6-phosphate dehydrogenase levels in liver were decreased significantly in animals exposed to lead acetate (10, 30 and 100 ppm) and cadmium chloride (30 and 100 ppm). Administration of vitamin E, vitamin C or *spirulina* significantly increased the glucose-6-phosphate dehydrogenase levels in liver of animals exposed to lead acetate and cadmium chloride.

- The membrane bound enzymes (sodium potassium ATPase, calcium ATPase and magnesium ATPase) levels in liver and kidney were significantly decreased in animals exposed to lead acetate (10, 30 and 100 ppm) and cadmium chloride (30 and 100 ppm). Supplementation of vitamin E, vitamin C or *spirulina* significantly restored the levels of membrane bound enzymes to normal in animals exposed to lead acetate. Vitamin C supplementation increased the magnesium ATPase levels in kidney of animals exposed to lead acetate. Vitamin E showed a protective effect against cadmium induced decrease in the levels of membrane bound enzymes, while *spirulina* has shown protective effect against cadmium induced reduction in sodium potassium ATPase levels in liver and kidney and calcium ATPase; magnesium ATPase levels in kidney. But vitamin C did not show any protection against cadmium chloride induced changes in membrane bound enzymes.

- There was a significant reduction in the levels of protein in liver, kidney, lung and heart of animals exposed to lead acetate (30 and 100 ppm) and cadmium chloride (30 and 100 ppm). At 10 ppm concentration, lead acetate decreased the protein levels in kidney and cadmium chloride showed significant reduction in the levels of protein in kidney and lung of rats. Supplementation of vitamin E, vitamin C or *spirulina* significantly restored the protein levels to

normal in liver, kidney, lung and heart of animals exposed to lead acetate and cadmium chloride. But there were no significant changes in the levels of proteins in brain of animals during the study.

- There was a significant increase in the lipid (cholesterol, triglyceride and phospholipid) levels in liver, kidney, lung and heart of animals exposed to lead acetate (10, 30 and 100 ppm) and cadmium chloride (30 and 100 ppm). There were few exceptions that, the triglyceride levels in liver remained unchanged in animals exposed to 10 ppm of lead acetate. The cholesterol levels in kidney were increased in animals exposed to cadmium chloride (10 ppm). Supplementation of vitamin E, vitamin C and *spirulina* have restored the lipid levels to normal in animals exposed to lead acetate. The cholesterol levels in heart were restored to normal by supplementation of vitamin E and *spirulina*, while vitamin E has protected the cholesterol levels in liver, kidney and lung of animals exposed to cadmium chloride. Amongst these exogenous antioxidants, vitamin E and *spirulina* have significantly reduced the triglyceride levels in liver and heart, while vitamin E was effective in maintaining the triglyceride levels to normal in kidney and lung of animals exposed to cadmium chloride. The elevated phospholipid levels in liver, kidney and lung were reduced by vitamin E and *spirulina* in animals exposed to cadmium chloride. Supplementation of vitamin C did not show significant effect on cholesterol, triglyceride and phospholipid levels of various organs of animals exposed to cadmium chloride.

- The GPT and GOT levels in serum were significantly increased in animals exposed to lead acetate (10, 30, 100 ppm) and cadmium chloride (30, 100 ppm). Supplementation with vitamin E, vitamin C or *spirulina* significantly decreased the elevated levels of GPT and GOT in serum of animals exposed to lead acetate. Similarly, supplementation of vitamin E or *spirulina* significantly restored the

elevated levels of GPT and GOT in serum of animals exposed to cadmium chloride.

- The alkaline phosphatase and acid phosphatase levels in serum were significantly increased in animals exposed to lead acetate (10, 30 and 100 ppm) while the levels of alkaline phosphatase and acid phosphatase were increased significantly in 10, 30, 100 ppm and 30, 100 ppm of cadmium chloride respectively. Administration of vitamin E, vitamin C or *spirulina* protected the levels of alkaline phosphatase and acid phosphatase in serum of animals exposed to lead acetate and cadmium chloride.

- There was a significant increase in the levels of lactate dehydrogenase in serum of animals exposed to lead acetate (100 ppm) and cadmium chloride (30 and 100 ppm), while supplementation of vitamin E, vitamin C or *spirulina* significantly decreased the elevated serum levels of lactate dehydrogenase of animals exposed to lead acetate and cadmium chloride.

- There was a significant increase in the levels of bilirubin and a significant decrease in the levels of protein in serum of animals exposed to lead acetate and cadmium chloride. Supplementation of vitamin E, vitamin C or *spirulina* have corrected the altered levels of bilirubin and protein in serum of animals exposed to lead acetate. Similarly, the administration of vitamin E, vitamin C or *spirulina* have decreased significantly the bilirubin levels in serum of animals exposed to cadmium, while the protein levels were increased significantly in serum of animals exposed to cadmium chloride along with vitamin E or *spirulina*.

- The cholesterol levels were decreased and phospholipid levels were increased significantly in serum of animals exposed to lead acetate and cadmium chloride (30 and 100 ppm), while the triglyceride levels were increased significantly in serum of animals exposed to

lead acetate and cadmium chloride (10, 30 and 100 ppm). Supplementation of vitamin E, vitamin C or *spirulina* have corrected the altered levels of cholesterol, triglycerides and phospholipid in serum of animals exposed to lead acetate. Similarly, co-administration of vitamin E, vitamin C or *spirulina* significantly corrected the altered cholesterol and triglyceride levels in serum, while the phospholipid levels in serum were decreased by vitamin E and *spirulina* supplementation to the animals exposed to cadmium chloride.

- The levels of lead and cadmium were estimated in organs like liver, kidney, lung, heart and brain of animals. The results indicated that there was a significant increase in the levels of the lead and cadmium in liver, kidney, lung, heart and brain of animals exposed to lead and cadmium at a given concentrations. This is because of accumulation of these metals in soft tissues. It is further noticed that, vitamin C administration to the animals exposed to lead and cadmium has significantly inhibited these metals from getting accumulated into the vital organs, while vitamin E or *spirulina* did not showed any beneficial effect on the accumulation of these metals in organs. It is surprising to note that *spirulina* significantly decreased the deposition of lead in brain.

- There were some major histopathological changes observed in liver, kidney, lung and heart of animals exposed to lead and cadmium. The liver, kidney, lung and heart have shown some signs of histopathological changes like fatty infiltration, swelling, and inflammation. Administration of vitamin E, vitamin C or *spirulina* protected these organs from the lead and cadmium induced histopathological damage.

Thus the present study have shown that the oxidative stress in various organs of rats through the generation of free radicals is an important consequence of exposure to lead and cadmium. It is further shown that vitamin E, vitamin C and *spirulina* by virtue of their antioxidant effect protected the organs of animals from the deleterious effects of lead and cadmium.