# Chapter III

## Alterations in Condition factor and Organosomatic index in *O. mossambicus* on sub-lethal exposure.

### Introduction

Environmental pollution caused by pesticides, especially in aquatic ecosystems, has become a serious problem. Contamination of water by pesticides, either directly or indirectly, can lead to fish kills, reduced fish productivity, or elevated concentrations of undesirable chemicals in edible fish tissue which can affect the health of humans consuming these fish (Josef *et al.*,2011).Fish has been particularly identified as one of the best biological indicators for evaluating aquatic health, owing to its wide distribution, easy identification and the ability of providing integral assessment results (Long and Walker 2005; Pinto *et al.*,2006; Pont *et al.*,2006, Tejerina-Garro *et al.*,2006, Zhu and Chang 2008, Kanno *et al.*,2010, Meixler 2011,Bergerot*et al.*,2008, Terra and Araújob 2011).

Studying the biological responses to environmental chemicals through the use of biomarkers provides means to understand environmental levels of pollutants in biological terms, and more importantly, it can be used for the assessment of environmental quality in specific situations(Praveen *et al.*,2012).Most rivers and their resources are constantly threatened by socioeconomic factors that compromise environmental conditions by altering water parameters as well as health quality (Belenguer *et al.*,2014 and Ayandiran and Fawole., 2014).

Biological indicators such as fishes are known to constitute veritable tools in the assessment of the ecological quality of aquatic environments (Bohmer *et al.*,2004; Roset *et al.*,2007;

Gabriels *et al.*,2010; Moya *et al.*,2011;Fonseca *et al.*,2011a and b; Ael *et al.*,2014).There are occupational hazards and safety concerns in the aquatic ecosystem, as some practices have caused environmental degradation due to burden of natural and man-made toxic substances, e.g., antibiotics, pesticides and persistent organic pollutants. Some compounds from PCB's as well as many of the agrochemicals have proved to be estrogenic and anti-estrogenic contaminants for aquatic environment and causes endocrine disruption affecting fish reproduction. Application of agrochemicals (Insecticides, Pesticides and herbicides etc) is for control of a wide variety of insectivorous and herbaceous pests which would otherwise diminish the quantity and quality of food production. Sadly, in spite of advantages, the synthesized chemical compounds have significant drawbacks as they threaten the long-term survival of major ecosystems disorder environmental relations between organisms, and the loss of biodiversity ( Farid and El-Deeb Mehana, 2015).

In aquatic ecotoxicology studies, the condition factor (K) is used in order to compare the "fatness" or wellbeing of fish and a useful index for the monitoring of feeding intensity, age, and growth rates in fish as well as status of the aquatic ecosystem in which fish live (Eqani *et al.*,2013; Ayandiran and Fawole., 2014). The variations in the condition factor can indicate variations related to the fitness of the fish, development and fat accumulation. K of fish species is very important parameter for understanding fish biology and pathology (Ridanovic *et al.*,2014). The condition factor (K) offish is a parameter which is used widely in order to understand survival, reproduction, maturity and health of fish, and often, it can be used as a good indicator of water quality or general health of fish populations which are inhabiting specific habitat or ecosystem (Tsoumani *et al.*,2006). K has been used as an indicator of health in fishing biology studies since the beginning of the 20 century, such as growth and feeding intensity (Sutton *et al.*, 2000). Le Cren (1951) proposed relative condition factor (Kn) in preference to 'K' as the former considers all the variations like those associated with food

and feeding, sexual maturity, etc., while the latter does so only if the exponent value is equal to 3. Thus 'K' factor measures the variations from an ideal fish, which holds the cube law while 'Kn' measures the individual deviations from the expected weight derived from the length-weight relationship. Any stresses in the natural environment can have an effect on fish overall health and condition; therefore, Kn can be employed as an integrative biomarker. Both anthropogenic and natural stressors are incorporated into Kn; however, there are natural fluctuations or differences in condition factor of fish due to species, sex, and season (e.g. temperature, spawning, photoperiod, prey quantity/quality) (Sutton *et al.*,2000; Azmet *et al.*,2007 and Zubia *et al.*,2014).Decrease in condition factor is considered a reflection of depletion in energy reserves because these indices are positively related to muscle and liver energy content (Azmat *et al.*,2007; David *et al.*,2010; Ael *et al.*,2014).It is strongly influenced by both biotic and abiotic environmental conditions. Numerous other studies have examined the effects of different environmental indices on the condition of inhabiting fish population in which many deformation and adverse effects have been reported and in relation to health (Kalyoncu *et al*., 2009; Kavanagh *et al.*,2014).

Organosomatic indices can be described as the ratios of organs to body weight (Ronald and Bruce, 1990), measured organ in relation to body mass can be directly linked to toxic effects of chemical on target organ (Giullo and Hinton, 2008). It is revealed through variation in size, and is known to be influenced by environmental factors. Size and weight of the liver, gonads, spleen, heart, among others are related to the length and weight of the fish and indicate the general status of health of the fish (Dekic *et al.,* 2016).It can also be used as indices of changes in nutritional and energy status (Maxwell and Dutta, 2005).Commonly used organosomatic indices in various stress related studies includehepatosomatic index (HIS), renosomatic index (RSI), spleenosomatic index (SSI) and Cardiosomatic index (CSI) and gonadosomatic index. Singh and Canario (2004) observed that hepatosomatic index is one of

the most investigated biomarker due to important role of liver in detoxification of pollutants, while Dogan and Can (2011), observed that organosomatic index is an appropriate bioindicator for endocrine disruption in fish consequent of chemical exposure.

A decrease in values of HSI is an indication of an adverse effect on the fish's liver. This result is akin to the result obtained by Edori (2007) when he exposed *Clarias gariepinus* to an organophosphate insecticide. Liver is responsible for enzymatic decontamination process, vitellogenin production and storage of glycogen as energy reserves, alteration of its function will affect the fish severely (Jenkin, 2004). The spleen produces Leukocytes, serves as a storage space for Red Blood Cells and destroys worn out red blood cells (Miller and Harley, 2004), any slight aberration from this function will surely affect the fish physiological functions. Changes in the size of the spleen may be a sign of dysfunction that affects the general health of the individual. Reduction of the size of the spleen can be in connection with acute nonspecific stresses, as well as with a number of chronic exposures to chemical contaminants, which are responsible for the necrosis and changes in cellular process (Dekic *et al.*,2016). According to Jenkins (2004), kidney is part of hematopoietic (blood producing) tissue in fish. Additionally, kidney is also involved in blood filtration, the development of new blood cells and the immunological interactions hence increase or decrease in their size may indicate a pathological response to the xenobiotic.

***Hence, keeping in mind the above facts, the present study is aimed to look into the alterations in the oraganosomatic index (HSI, GSI, KSI, SSI and CSI) as well as the condition factor (K) of freshwater teleost fish, Oreochromis mossambicus on exposure of the herbicide PE.***

**Materials and Methods:**

**Experimental design:**

Live and healthy male and female adult *O. mossambicus* was procured from the pure brooders of length 12±3cm and weight 25±3g. Fishes (5 males and 5 females) were kept in a clean glass aquarium for an acclimation period of 12-15 days in de-chlorinated water at 27 ± 4ºC, pH 7.4 ± 0.05, dissolved oxygen 8 ± 0.3 mg/L, total hardness 188 mg/L $CaCO_3$ with a 12:12 light: dark photoperiod. They were fed with the commercial available healthy food during the period of study. If in any batch, mortality exceeds 5% during acclimatization, that entire batch of fish was discarded. Animal maintenance and experimental procedures were in accordance with the guideline of A.P.H.A., A.W.W.A. and W.P.C.F. (1998).

**Sub-lethal exposure:**

On basis of 96 hrLC50 value sub-acute study dose $1/20^{th}$ LC50 (Low dose), $1/10^{th}$ LC50 (Medium dose), $1/5^{th}$ LC50 (High dose) were chosen for condition factor and indices studies. A control group was maintained. The experiment was performed semi statically with a group of 10 fish in triplicate, one control and one test aquaria. Condition factor and different indices examinations of the experimental as well as the control fish were carried out at $7^{th}$ and $14^{th}$ days of exposure. All the groups were kept under continuous observation during the experimental period. Commercially food pallets were given to fish once in day during the experiment *adlibitum.* Test chemical and test media were changed every 24 hours to maintain the toxicant strength and the level of dissolved oxygen as well as to minimize the level of ammonia during experiment.

- Group 1 served as control without any treatment of PE.
- Group 2 were treated with low dose of PE ($1/20^{th}$ $LC_{50}$- Low Dose)
- Group 3 were treated with medium dose of PE ($1/10^{th}LC_{50}$- Medium Dose)
- Group 4 were treated with high dose of PE ($1/5^{th}LC_{50}$- High Dose)

At the end of the experiment the fish were carefully netted to minimize stress. They were slowly released in the tough containing 1% clove oil to make it immobile, and then after each fish was held and wrapped with a clean, dry towel and the posterior half of its body were blotted with a clean coarse filter paper. The total body weight was noted. The caudal peduncle of the fish was severed with a single stroke from a heavy, sharp scissor. Then, the liver, kidney, heart, gonads and spleen along with the other organs for histological observations was carefully removed and weighed.

**Morphometric observation:**

**Condition factor:**

Sample of 10 fishes from each experimental setup was taken for measuring weight, length to determine K factor. The condition factor of fish was calculated according to the method of Anderson *et al.*,(1998) using the formula: $K = W \times 100 / L^3$

(Where K= Condition factor; W= Weight of the fish; L=Length of the fish).

**Organosomatic index**

The organosomatic indices of the liver, spleen, kidney, heart and gonads were then calculated for the ten fish according to Dogan and Can (2011) to get the organ weight to the body weight ratios of the fish as follows: weight of the fish/ weight of the organ x 100

HSI: liver weight/ fish weight x 100

SSI: spleen weight/ fish weight x 100

GSI: Gonad weight/ fish weight x 100

KSI: kidney weight/ fish weight x 100

CSI: Heart weight/ fish weight x 100

**Statistical analysis:**

Data were analyzed using two-way Analysis of Variance (ANOVA) followed by Tukey's multiple comparison test and by Bonferroni multiple comparison to determine differences between treatments means as well as control means at significant rate of $P<0.05$. Data were represented in mean ± SEM. All statistics were carried out using Statistical Analysis program Graph pad prism 6.

**Results:**

The mean organosomatic index and condition factor of *O. mossambicus* exposed to different concentrations of PE are presented in Table 3.1 and Fig: 3.1 to 3.12. The condition factor (K) calculated for *O. mossambicus* varied from 1.71 ± 0.025 to 1.65 ± 0.015 (low dose), 1.61 ± 0.010 (medium dose)($P<0.01$) followed by 1.57 ± 0.015 (high dose) ($P<0.01$) for $7^{th}$ day exposure period of PE while 1.72 ± 0.02 to 1.63 ± 0.02 (low dose)($P<0.01$), 1.61 ± 0.02 (medium dose)($P<0.01$) followed by 11.53 ±0.02 (high dose) ($P<0.01$) for $14^{th}$ day exposure period of PE.

A non-significant decrease of the HSI from 1.18 ± 0.053 to 1.111 ± 0.002 ($P>0.05$) at low dose, 1.108 ± 0.003 ($P>0.05$) at medium dose whereas a significant decrease up to 1.076 ± 0.057 ($P<0.05$) at high dose on $7^{th}$ day PE exposure. On the other hand $14^{th}$ day exposure PE the significant decrease was observed from 1.179 ± 0.054to 1.107 ± 0.003, 1.053 ± 0.013($P< 0.01$), 1.004 ± 0.002($P< 0.01$)at high dose for *O. mossmabicus.*

SSI index of *O. mossmbicus* showed a significant decrease from 0.049 ± 0.002 to 0.041 ±0.003, 0.040 ± 0.001 ($P<0.01$) and 0.033 ± 0.002 ($P<0.01$) on $7^{th}$ day PE exposure while 0.052 ± 0.003 to 0.043 ± 0.002, 0.023 ± 0.002 ($P<0.01$) and 0.018 ± 0.001($P<0.01$) on $14^{th}$ day PE exposure in a dose dependent manner. CSI index of *O. mossmbicus* showed a significant decrease only in the higher dose of $7^{th}$ and $14^{th}$ day exposure of PE.

Male GSI of *O. mossambicus* revealed a significant decrease on PE exposure at medium and high dose ($P<0.01$) for both the exposure period $7^{th}$ and $14^{th}$ day. Female GSI of *O. mossambicus* also exhibited a significant decrease ($P<0.01$) at low, medium and high dose of PE exposure. A non-significant decrease of the KSI from 0.237 ± 0.015to 0.217 ± 0.006 at low dose, whereas a significant decreased 0.210 ± 0.010 ($P<0.05$) at medium dose to 0.203 ±

0.006 ($P<0.05$) at high dose on $7^{th}$ day PE exposure while $14^{th}$ day exposure PE the significant decrease was observed from 0.25 ±0.015to 0.22±0.010 ($P<0.01$), 0.19 ± 0.010 ($P< 0.01$), 0.18 ± 0.010($P< 0.01$) at high dose for *O. mossmabicus.*

**Table: 3.1 Condition factor, HSI, SSI and GSI of *O. mossambicus* subjected to sub-acute concentrations of PE.**

| Exposure Period | INDICES | Control | LD | MD | HD |
|---|---|---|---|---|---|
| 7 Day | HIS | 1.18 ± 0.053 | 1.111 ± 0.002 | 1.108 ± 0.003 | 1.076 ± 0.057 * |
| | MALE GSI | 0.247 ± 0.006 | 0.234 ± 0.002 | 0.227 ± 0.003 ** | 0.218 ± 0.003 ** |
| | FEMALE GSI | 0.614 ± 0.023 | 0.524 ± 0.011 ** | 0.500 ± 0.021 ** | 0.449 ± 0.012 ** |
| | SSI | 0.049 ± 0.002 | 0.041 ± 0.003 | 0.040 ± 0.001 ** | 0.033 ± 0.002 ** |
| | KSI | 0.237 ± 0.015 | 0.217 ± 0.006 | 0.210 ± 0.010 * | 0.203 ± 0.006 * |
| | CSI | 0.0005 ± 0.002 | 0.0005 ± 0.007 | 0.0005 ± 0.008 | 0.0004 ± 0.006 * |
| | CF | 1.71 ± 0.025 | 1.65 ± 0.015 | 1.61 ± 0.010 ** | 1.57 ± 0.015 ** |
| 14 Day | HIS | 1.179 ± 0.054 | 1.107 ± 0.003 | 1.053 ± 0.013 ** | 1.004 ± 0.002 ** |
| | MALE GSI | 0.242 ± 0.005 | 0.227 ± 0.003 | 0.190 ± 0.014 ** | 0.158 ± 0.006 ** |
| | FEMALE GSI | 0.607 ± 0.028 | 0.508 ± 0.014 ** | 0.427 ± 0.015 ** | 0.395 ± 0.006 ** |
| | SSI | 0.052 ± 0.003 | 0.043 ± 0.002 | 0.023 ± 0.002 ** | 0.018 ± 0.001 ** |
| | KSI | 0.25 ±0.015 | 0.22±0.010** | 0.19 ± 0.010 ** | 0.18 ± 0.010 ** |
| | CSI | 0.0006 ± 0.002 | 0.0005 ± 0.005 | 0.0005 ± 0.006 | 0.0003 ± 0.001** |
| | CF | 1.72 ± 0.02 | 1.63 ± 0.02 ** | 1.61 ± 0.02 ** | 1.53 ± 0.02 ** |

**Each value represents the mean ± SEM.**

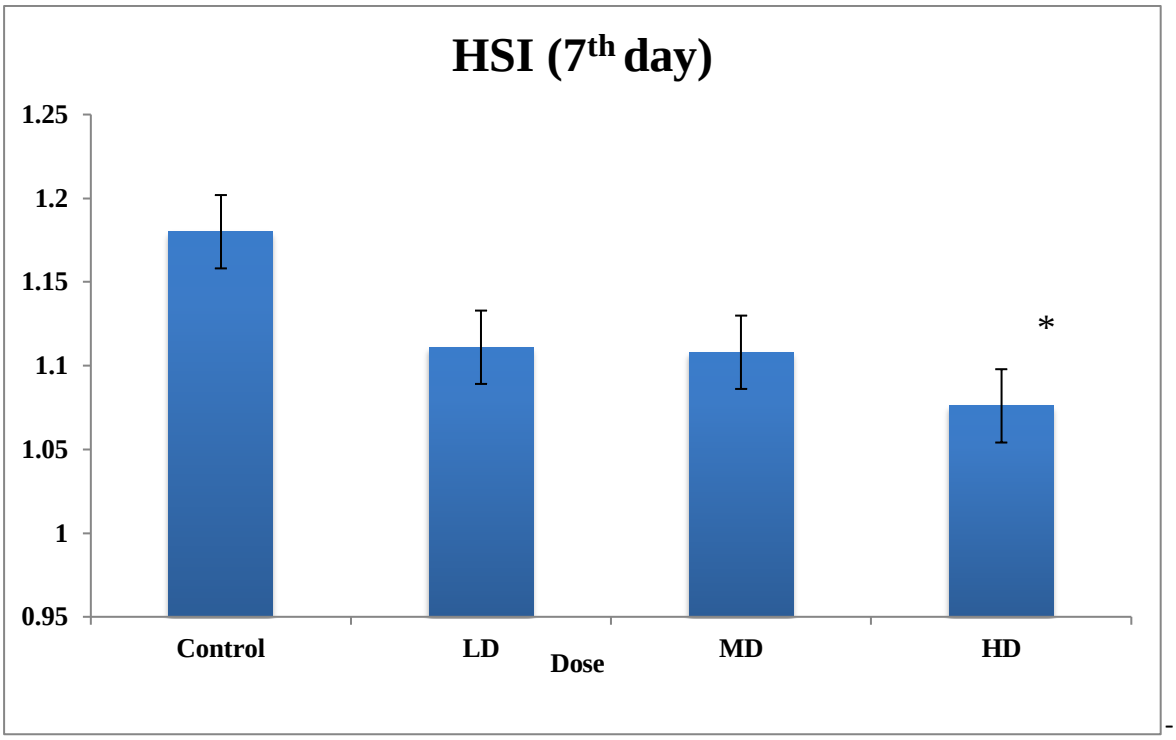
**Significant level indicated by * (P<0.05); **(P<0.01);***(P<0.001).**

**Table: 3.2 Bonferroni comparisons for HSI, SSI of *O. mossambicus* subjected to sub-acute concentrations of PE.**

| HIS | | | SSI | |
|---|---|---|---|---|
| | Bonferroni p-value | Bonferroni Inference | Bonferroni p-value | Bonferroni inference |
| A vs B | 0.364 | Ns | 0.008 | ** p<0.01 |
| A vs C | 0.325 | Ns | 0.0028 | ** p<0.01 |
| A vs D | 0.066 | Ns | 3.5993e-05 | ** p<0.01 |
| B vs C | 5.65 | Ns | 2.44 | Ns |
| B vs D | 1.818 | Ns | 0.0028 | ** p<0.01 |
| C vs D | 2.00 | Ns | 0.0081 | ** p<0.01 |
| A vs B | 0.08 | Ns | 0.0012 | ** p<0.01 |
| A vs C | 0.003 | ** p<0.01 | 2.2705e-07 | ** p<0.01 |
| A vs D | 0.0003 | ** p<0.01 | 7.0942e-08 | ** p<0.01 |
| B vs C | 0.267 | Ns | 4.4926e-06 | ** p<0.01 |
| B vs D | 0.011 | * p<0.05 | 8.8250e-07 | ** p<0.01 |
| C vs D | 0.368 | Ns | 0.074 | Ns |

**Table: 3.3 Bonferroni comparisons for Male GSI and Female GSI of *O. mossambicus* subjected to sub-acute concentrations of PE.**

| MALE GSI | | | Female GSI | |
|---|---|---|---|---|
| | Bonferroni p-value | Bonferroni Inferfence | Bonferroni p-value | Bonferroni Inferfence |
| A vs B | 0.010 | * p<0.05 | 0.0012 | ** p<0.01 |
| A vs C | 0.0006 | ** p<0.01 | 0.00025 | ** p<0.01 |
| A vs D | 4.6066e-05 | ** p<0.01 | 1.6091e-05 | ** p<0.01 |
| B vs C | 0.230 | Ns | 0.832 | Ns |
| B vs D | 0.0032 | ** p<0.01 | 0.0045 | ** p<0.01 |
| C vs D | 0.092 | Ns | 0.040 | * p<0.05 |
| A vs B | 0.278 | Ns | 0.0006 | ** p<0.01 |
| A vs C | 0.0002 | ** p<0.01 | 8.6879e-06 | ** p<0.01 |
| A vs D | 8.7771e-06 | ** p<0.01 | 2.4275e-06 | ** p<0.01 |
| B vs C | 0.003 | ** p<0.01 | 0.002 | ** p<0.01 |
| B vs D | 4.1947e-05 | ** p<0.01 | 0.00028 | ** p<0.01 |
| C vs D | 0.0086055 | ** p<0.01 | 0.315 | Ns |



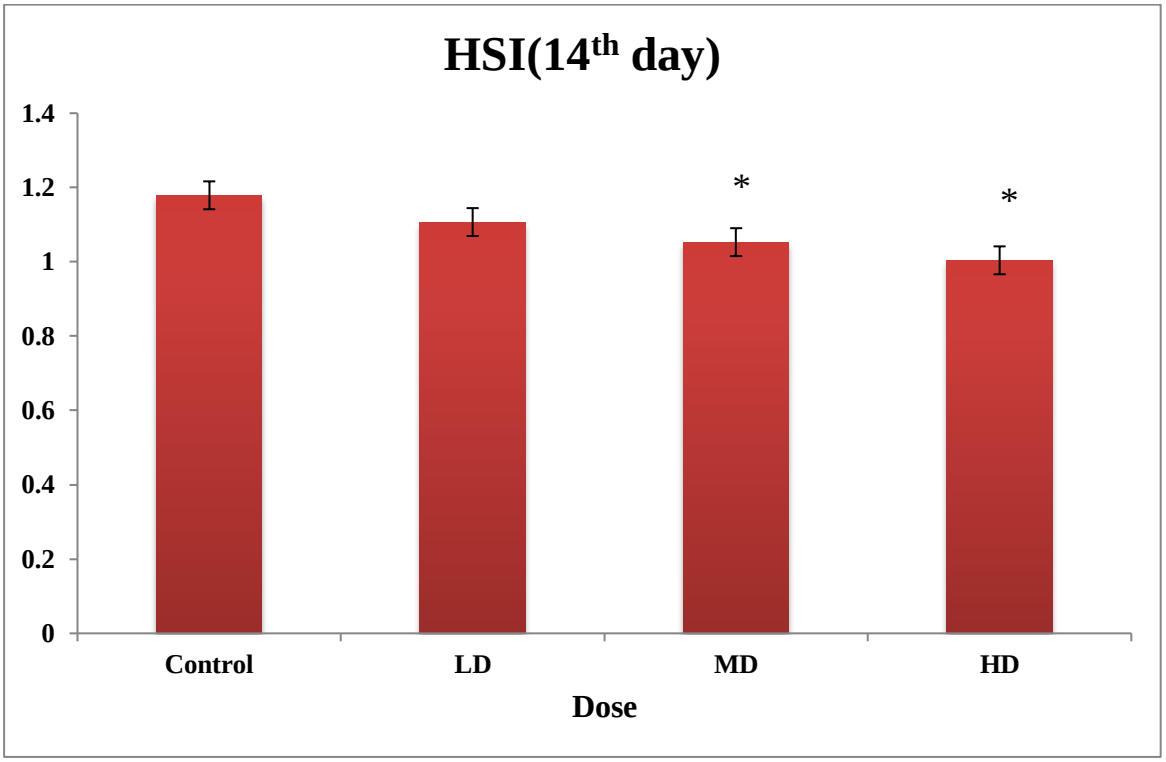
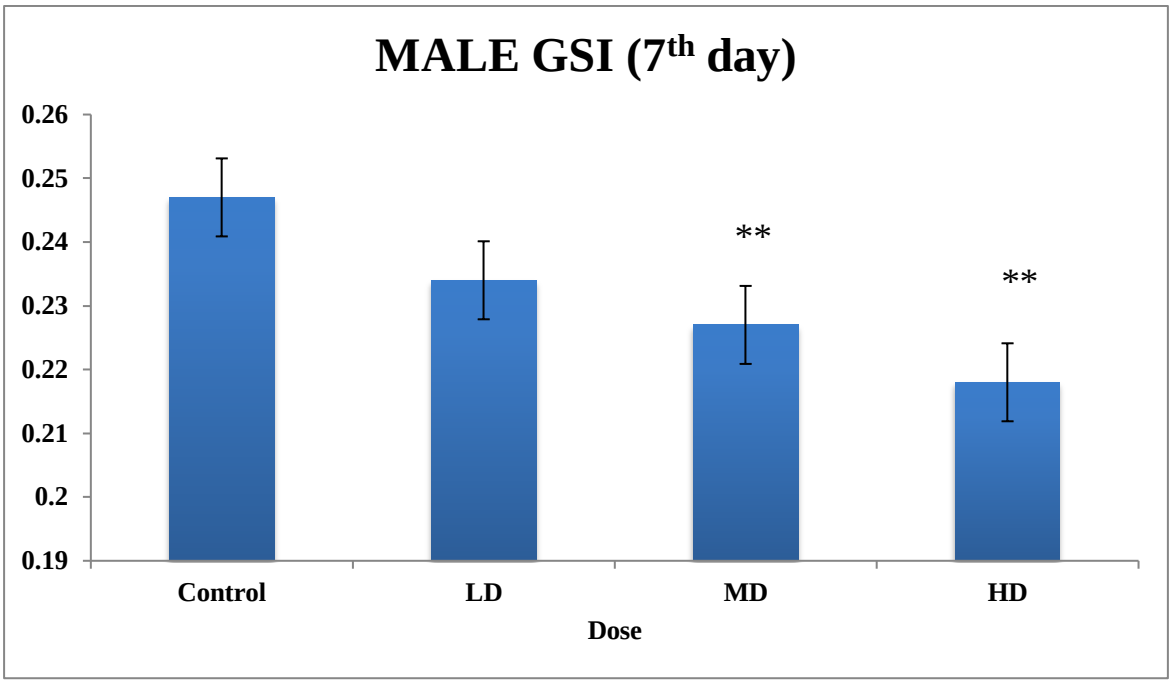




Fig: 3.1: Hepatosomatic indices of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th Day



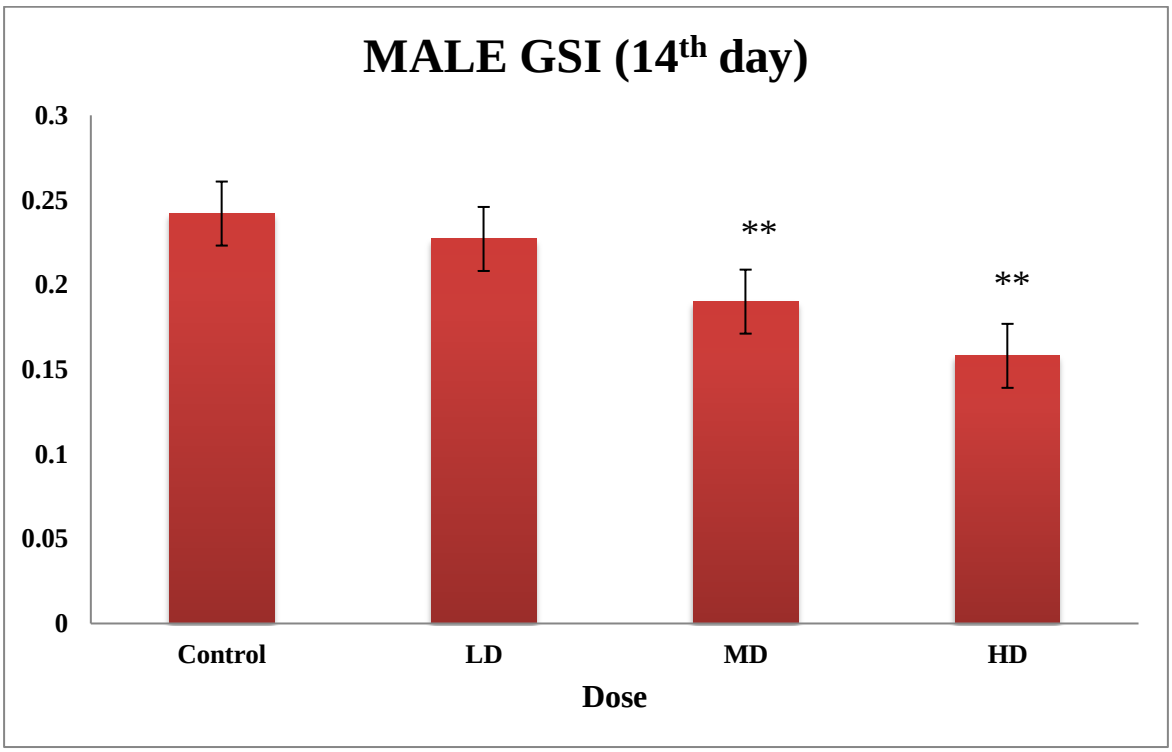
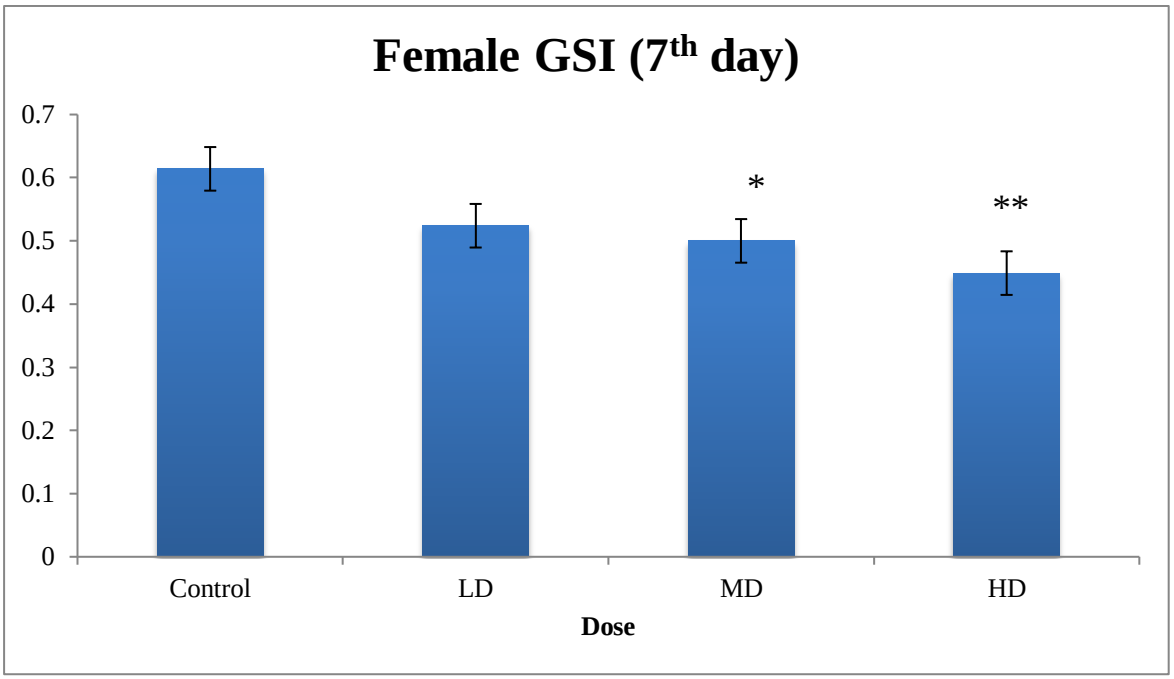




Fig:3.2: Male GSI of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th Days



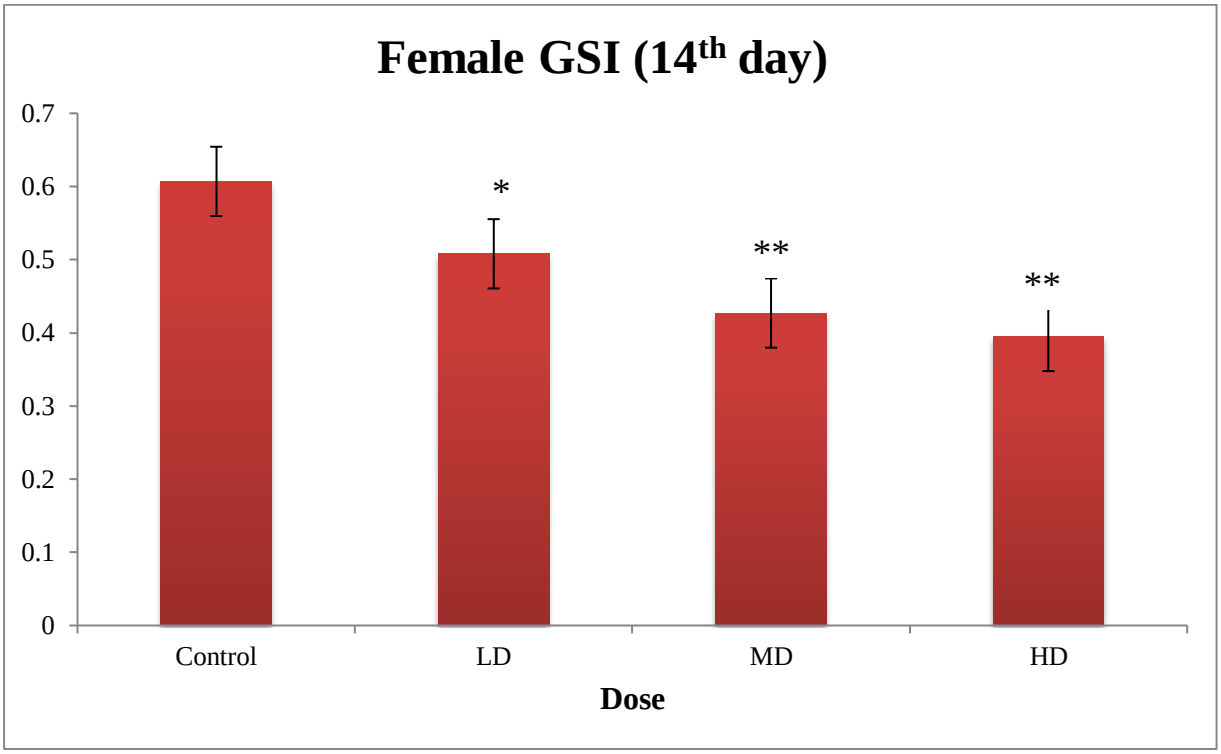
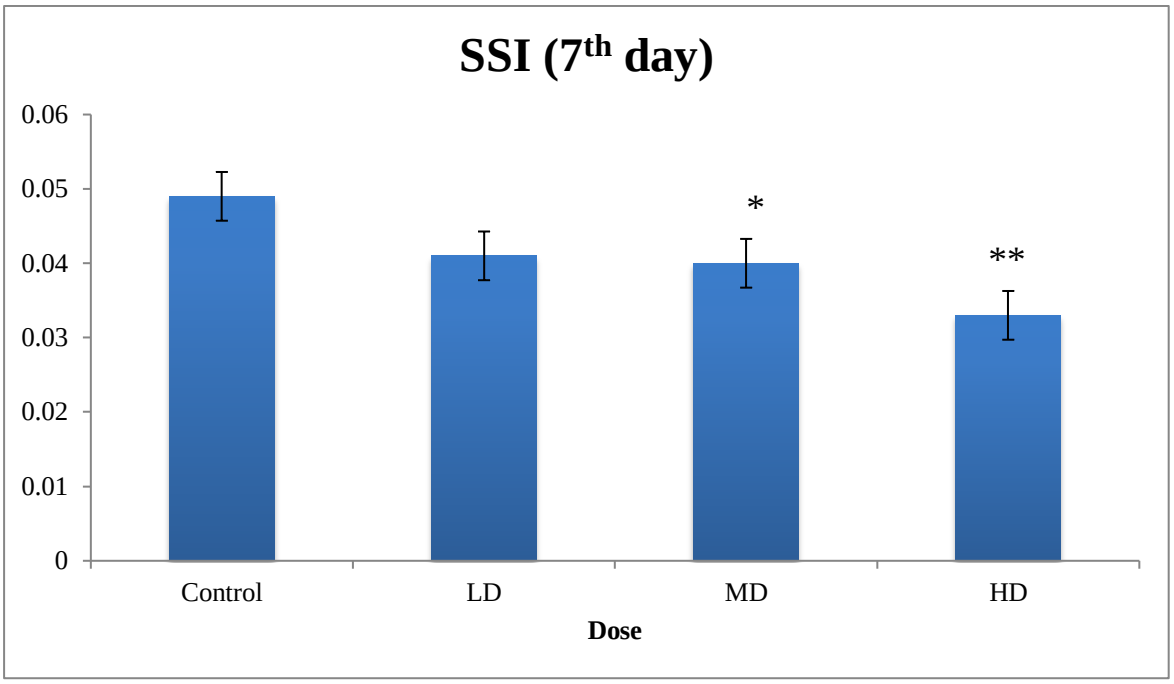




Fig:3.3: Female GSI of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th day



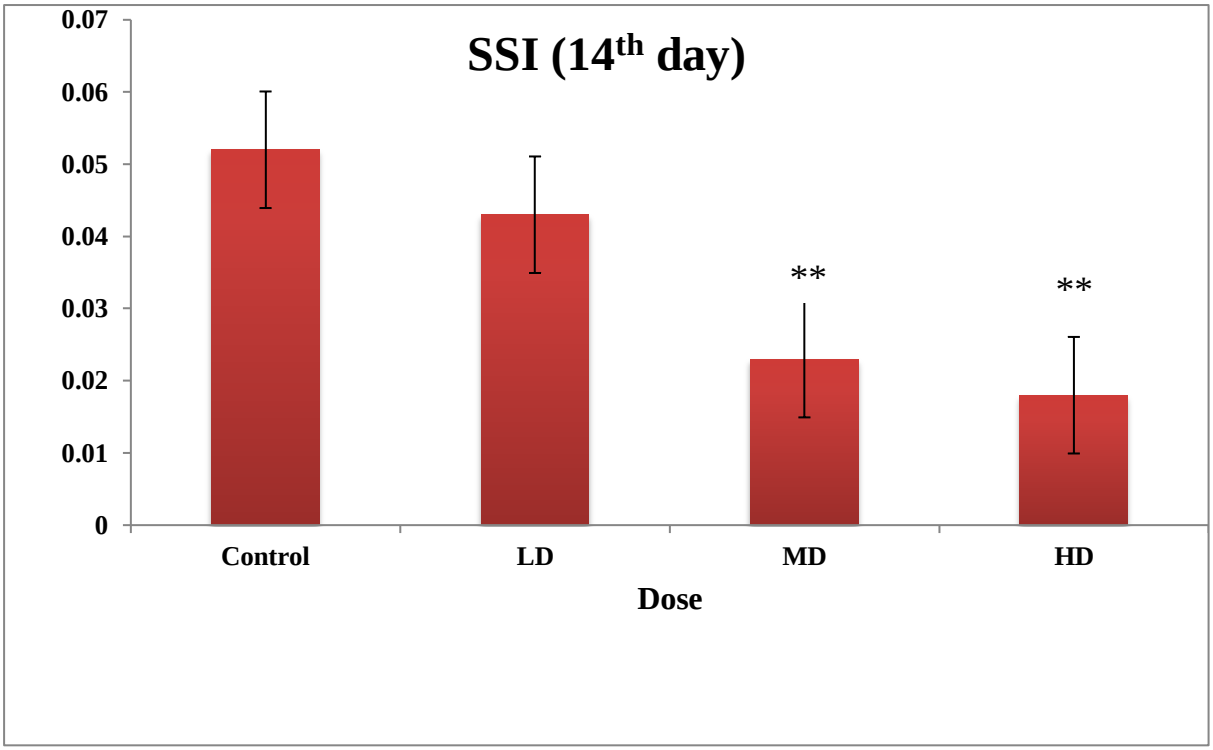
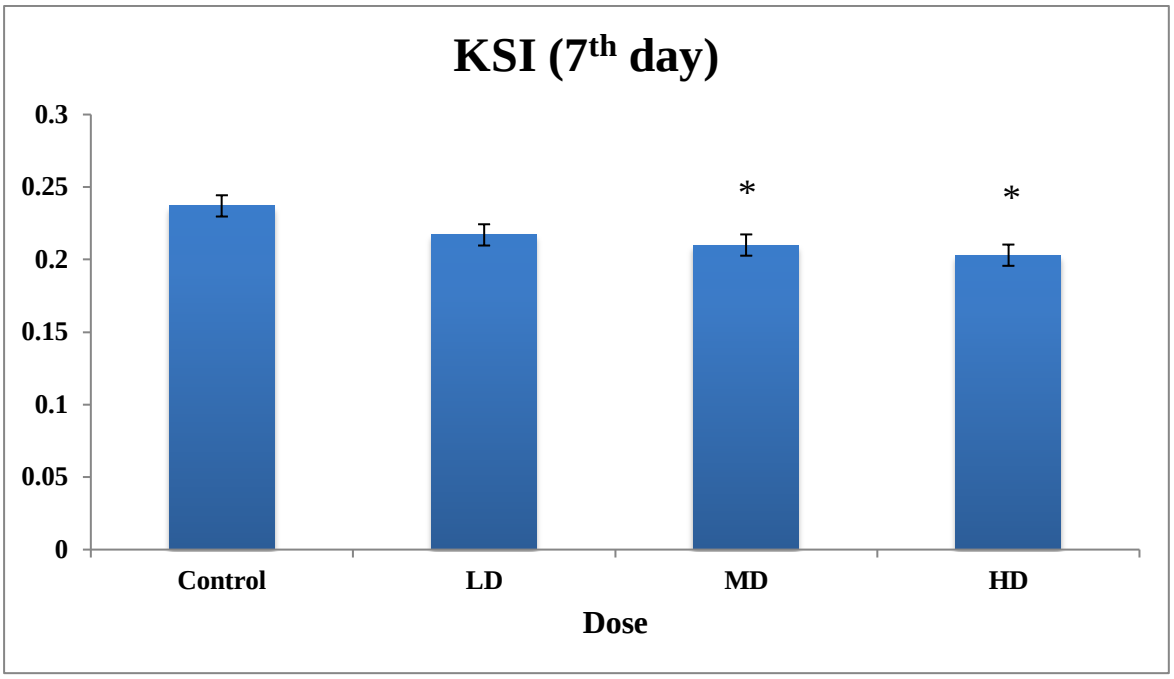




Fig: :3.4: SSI of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th days



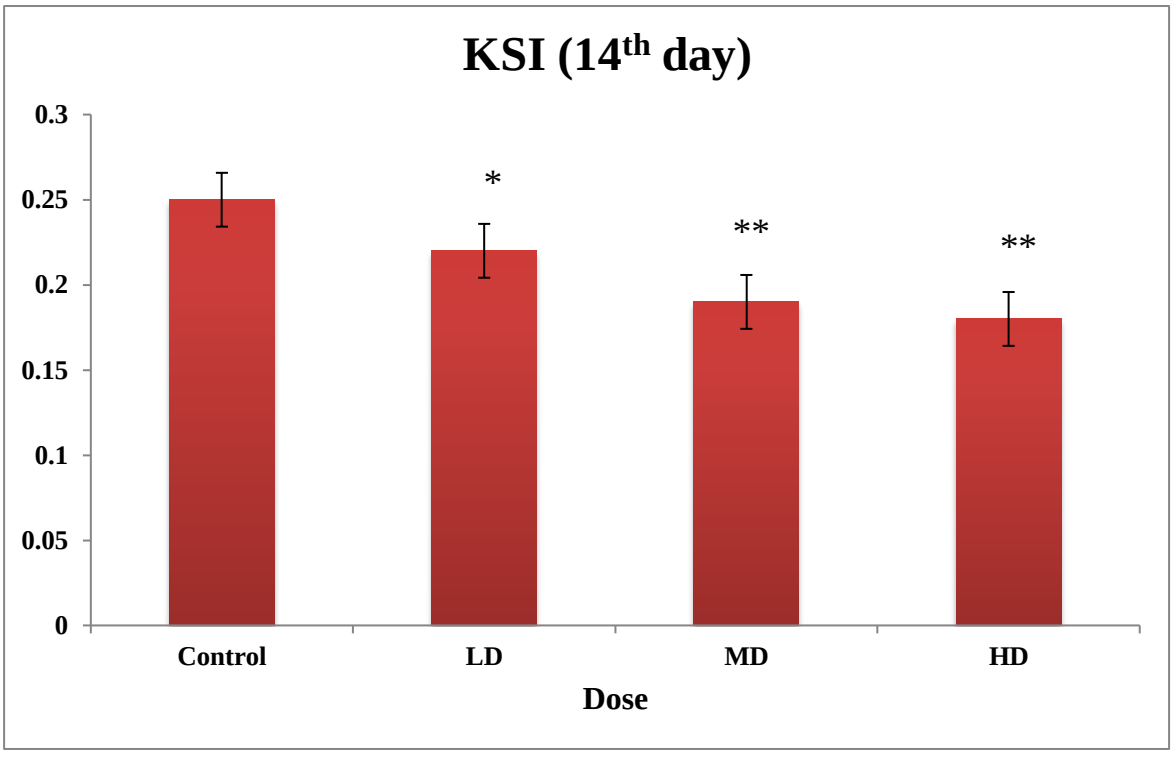
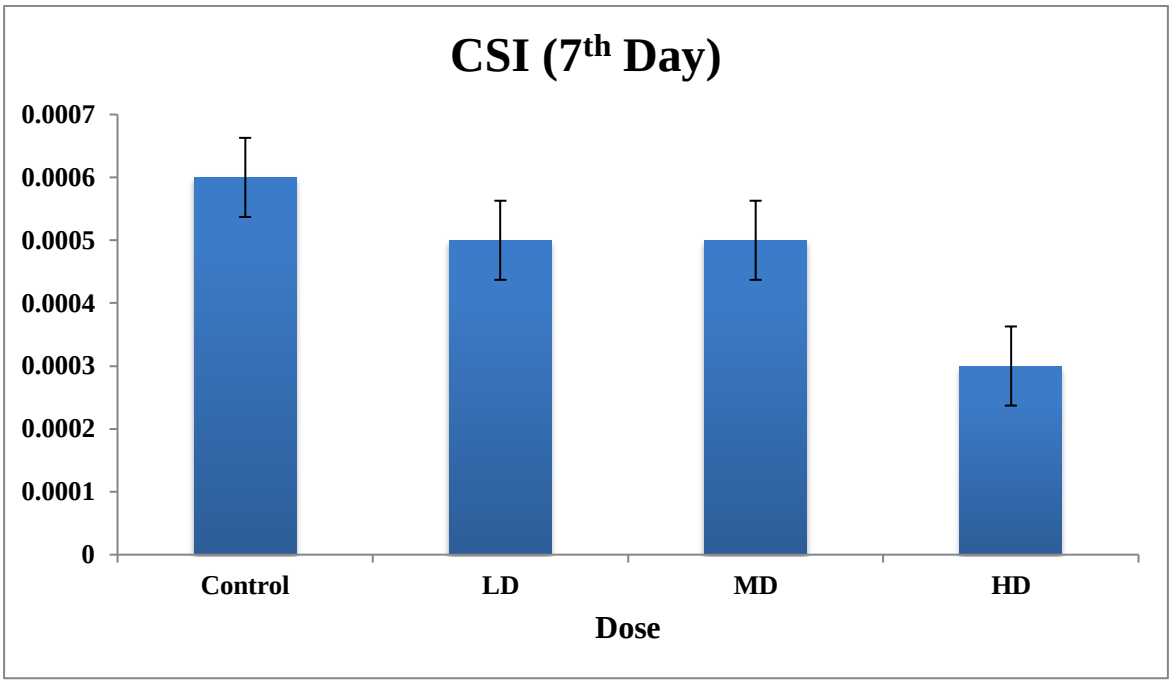




Fig:3.5: KSI of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th days



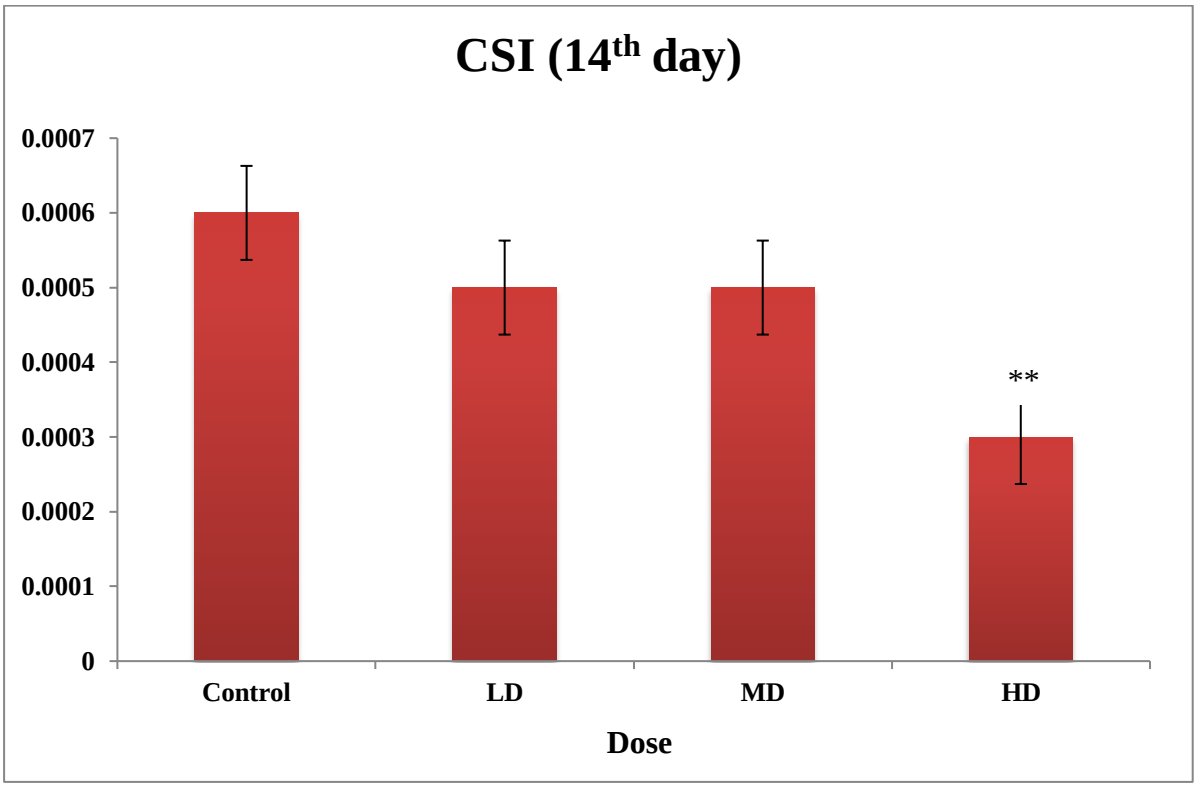
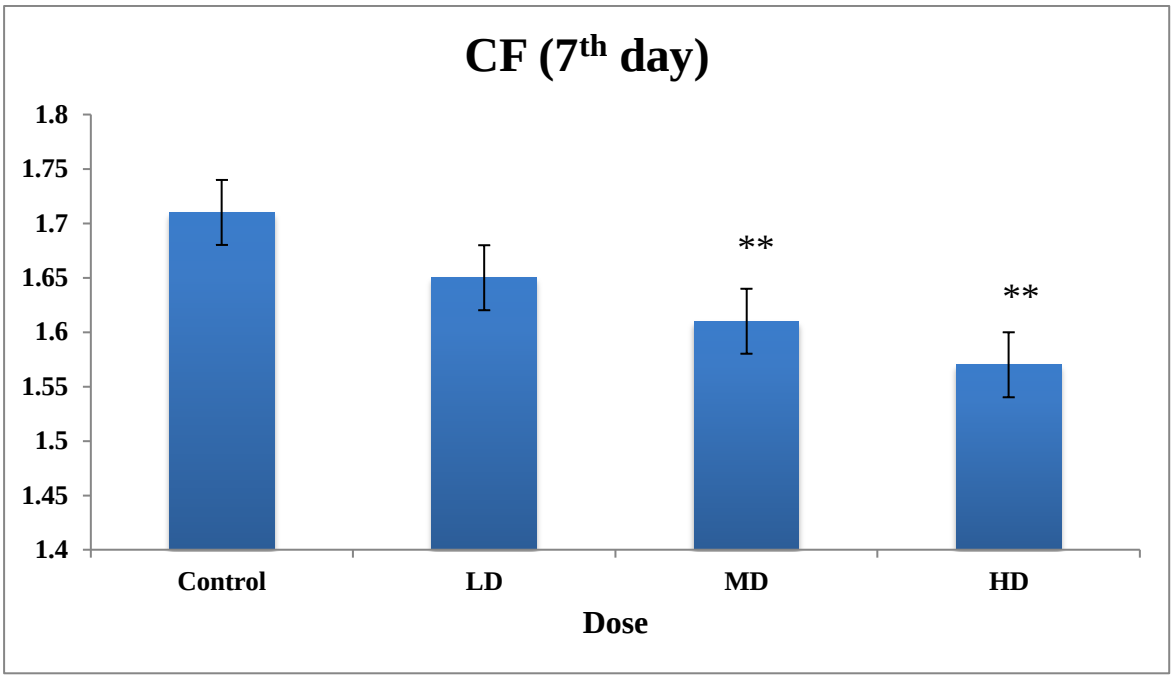




Fig 3.6: CSI of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th days



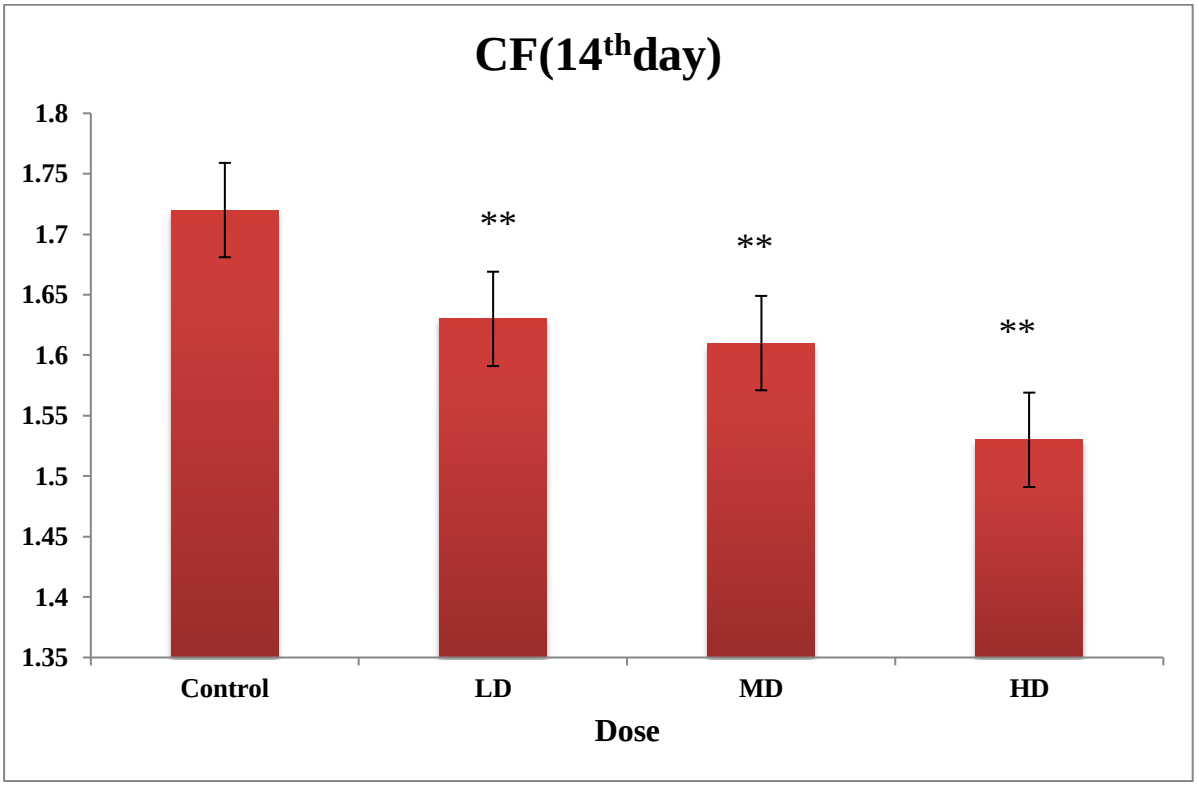




Fig:3.7: CF of *O.mossambicus* subjected to sub- acute concentration of PE on 7th and 14th days

**Discussions:**

HSI is associated with the liver energetic reserves and metabolic activity. Increase in the daily weight of the body is related to the increase in the HSI value and it is also observed that it also depends upon seasonal cycle. As liver is vital organ in the body and it performs various physiological functions such as it converts excess sugar into glycogen, it detoxifies the toxic substances, it also acts as a haemopoetic organ, destroy the old R.B.C. etc. So its healthy condition is essential for growth of fish.

The HSI gives us information about the condition of liver and body and also about the impact of exposure of the toxicant on it. HSI also provides an indication on status of energy reserve in fish. In poor environment fish usually have a smaller liver with less energy reserved in the liver. HSI has been reported to decrease in fish exposed to toxicant. Although these parameters are not very sensitive, they may serve as an initial screening bio meter to indicate exposure and effects body condition is a practical tool for biologist and managers to guess the overall health of fish population and a good indicator of fish habitat quality and pollution levels.

HSI is most important because it describes stored energy in fish, in the present study significant decrease with time and doses thus suggest the usage of the stores accumulated in the liver for supplying energetic requirements (Akermen *et al.*,2003, Garcia-Diaz *et al.*,2006, Kumar *et al.*,2007, Montaser *et al.*,2010). Decrease in the weight of liver suggests a decrease in the production of endoplasmic reticulum for protein synthesis in liver tissue under PE exposure (Bennet and Wolke, 2004), Further, liver reduction could also be as a result of decreased lipid storage. (Gabriel *et al.*,2010).The one way ANOVA result confirms the decrease HSI value more pronounced in $14^{th}$ day exposure of PE compared to $7^{th}$ day exposure (Fig.3.1 and Table 3.2). Further Bonferroni multiple comparison the between

control versus treated group at both the durations resulted into a significant decrease ($p<0.01$) at medium and high dose only on the 14th day exposure to PE in *O. mossambicus*. This rejects the null hypothesis that the treatment has no effect on the fishes. Our results are in agreement with the earlier reported decreased HSI in *(Oreochromis niloticus)* juvenile exposed to glyphosate herbicide by Ayoola (2008), *Clariasgariepinus* exposed to cypermethrin by Ariweriokuma et al (2011), *Channa punctata* exposed to butachlor by tilak *et al.,*(2007).

Gonadosomatic index (GSI) indicates the gonadal development and maturity of fish. Although it may be impractical to include detailed reproductive data into routine toxicity assessments, precise measurement of reproductive condition is essential for determining reproductive competence (Lowerre-Barbieri *et al.,* 2011). A variety of methods are available to assess reproductive condition in fishes, including microscopic gonadal staging, macroscopic gonadal staging, oocyte size–frequency distributions, sex steroid measurement and gonadal indices (Lowerre-Barbieri *et al.,*2011and Zeyl *et al.,*2013).In the present study a significant time and dose dependent decrease ($p<0.01$) in male and female GSI was witnessed. Further, Bonferroni multiple comparison for the duration as well as the dose also resulted into a significant decrease. HSI is related with GSI because of vitelogenes is process that synthesizes vitelogenin. In fish, vitelogenin is yolk precursor that is synthesized in liver and induced by estradiol 17β (Babin *et al*., 2007 and Yaron*et al*., 2011). Vitelogeninis secreted in blood and transported in oocytes causing the accumulation of yolk this accumulation cause the changes of oocytes size and enhancement of ovary weight. This vitelogenesis activity can increase HSI and in turn GSI (Le men *et al*., 2007).

On exposure of PE, HSI was found to be decreased, so a possible explanation for a decrease in GSI can thus be correlated with the titer of HIS (Intanurfemi *et al*., 2015). Furthermore the dose dependent decrease in the GSI is also suggestive that GSI is directly proportional to the

concentration of PE as proposed by Murthy *et al.,* (2013) for various pesticides. Our results are in agreement with the earlier work of Vasath *et al.,* (2015) who have reported a decrease in GSI and HSI on exposure of herbicide atrazine.

A significant decrease ($P<0.01$) in the SSI values was reported to be in the PE exposed group. The SSI is of interest due to the spleen's hematopoietic function which also makes it an immune system organ. Delta-aminolevulinic acid dehydratase (ALA-D) is one of the principle enzymes involved in haeme synthesis, converting delta- aminolevulinic acid (ALA) to porphobilinogen (PBG) and ferrochelatase, and inserting iron into protoporphyrinogen. An increase in ALA-D activity in the red blood cells would indicate a stimulation of haeme synthesis in the kidney and spleen, while a obstruct in the utilization of delta aminolevulic acid results in a subsequent decline in haeme synthesis (Re- hman, 1984, Nair *et al.,*2003). In present study our result of haemoglobin and RBC count was significant decrease (discuss in chapter 3) and it support that SSI and KSI ($P<0.01$) reduced in size also affect the production of red blood cells and haemoglobin. Alterations in relative spleen size could signal a dysfunction capable of affecting fish health. Decreased size has often been seen with acute, nonspecific stressors, but chronic exposure to a number of chemical contaminants also leads to this effect. The decrease seems to be due to necrosis and perturbations in cell processing, both of which could impact the overall condition of the individual fish. Reduced SSI may be the response of the fish to struggle herbicide PE stress (Gabriel *et al.,* 2010).

Kidney in fish is a basic organ forming the blood elements (Rombout *et al.,*2005). The activity of the blood elements formation differs among teleost fish; it can be organ-forming erythroid lineages only in some fish, or all types of organ-forming blood cells in other fish (Esteban *et al.,*2000; Stephens *et al.,*2004). In teleost fishes the pathogen or toxicant are trapped in three sites namely spleenic ellipsoids, sinusoidal blood vessels, reticular

phagocytic cells of kidney, atrial endocardial cells and ventricular endothelial cells of heart and to some extent liver and skin (Zapata and Cooper, 1990; Dannevig *et al.,* 1990, 1994; Press *et al.,*1994; Nakamura and Shimozawa, 1994; Zapata *et al.,*1996; Dalmo *et al.,*1997).

The biological indicator approach can be an effective technique to assess the integrative effect of stress on fish, as well as being a tool to obtain biological information in a system and could be used to manage contaminated sites or exposure of the pollutants (Pastor *et al.,*2004; Parikh *et al.,*2013; Sadekarpawar and Parikh, 2013; Parikh and Pandya, 2015). Most commonly used bioindicators are corporal indices such as condition factor (CF), gonadosomatic index (GSI), hepatosomatic index (HSI). Spleenosomatic Index (SSI), Renosomatic index (KSI) and cardiosomatic index (CSI) (Vives *et al.,*2004, Bastardo *et al,*. 2006). CF is an index reflecting interactions between biotic and abiotic factors in the physiological condition of a fish (Lizama and Ambrosio 2002) and is a quantitative indicator of individual wellbeing, since this bioindicator is sensible to stress in natural environment and thus is also employed as an integrative bioindicador (Sutton *et al.,*2000, Barrilli *et al.,*2015). The CF in the present study showed a significant decrease in dose and time dependent manner. A decrease in CF can thus be due to an indirect effect of toxicant on macromolecular syntheses which are secondary effects induced by physiological stress (Das and Gupta, 2014). CF has been shown to decrease in response to acidification as result of exposure of the agrochemicals through runoff (Upadhyay and Parikh 2014, Pandya and Parikh, 2015). Numerous studies have shown a decline in CF is usually interpreted as depletion of energy reserves such as stored liver glycogen or body fat which in turn reflect a change in feeding patterns or an increase in metabolic rate (Cook *et al.,*2005 and Marchand *et al.,*2008; Montenegro and González, 2012, Alvarez -Lajonchere, 2012, Kasimoglu, 2014, Mazumder *et al.,* 2016). The decrease CF reported in *Solea senegalensis* to cypermethrin by Arellano *et al.,* (1999) and Indian shad exposed to bleached kraft mill effluent by Anderson *et al.,* (1998)

which depicted a reduction in growth rate which may be due to a reduction in oxygen carrying protein levels and red blood cells. The decrease in condition factor may be due to the impairment of the olfactory systems which might have affected feeding, resulting in alterations of metabolic activities and energy allocation of the fish systems.

Thus in conclusion, it can be stated that PE exposure has resulted into an altered health of *O. mossambicus* reflecting the adverse effect of PE.