**Evaluation of antioxidant enzymes activities during phytoremediation of textile waste water exposed of structurally different dyes by some aquatic plants**

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**To cite this article:**

Al-Taee, M. M. S. and Witwit, R. T. A. Evaluation of antioxidant enzyme activities during phytoremediation of textile waste water exposed of structurally different dyes by some aquatic plants. *Mesop. Environ. J,* 2015*,* Vol. 1, No. 2 , pp.35-65.

**Abstract**

 The current study included invistigate a response of five aquatic plants used to removed some of the pollutants found in an industrial waste water disposed from Textile Industry. The study conducted in laboratory for a period of 13 days and the species of aquatic plants were *Phragmites australis* , *Typha domingensis , Ceratopyllum demersum , Potamegatone Perfoliatus and Hydrilla varcillata* in polyethylene contianor and with addition two azo dye ,Reactive blue , Reactive yellow and mixture of theme in three concentrations of 0.01, 0.02 and 0.03 mg / L in each of theme .chlorophyll and protein content was estimated, Malondialdehyde (MDA) and activity of catalase (CAT) and superoxide dismutase (SOD) enzymes were estimated , the result show a decrease in total chlorophyll in species *Phragmites australis* , *Typha domingensis , Ceratopyllum demersum , Potamegatone Perfoliatus and Hydrilla varcillata* while decrease in protein content in species *Phragmites australis* , *Typha domingensis , Ceratopyllum demersum , Potamegatone Perfoliatus and Hydrilla varcillata* .the study showed high content (MDA) during the period of the experiment (0.67-4.04) , (0.64-5.98) , (9.56-31.6) , (12.709-61.29) and (0.88-34.53) nmole/mg *P. australis* , *T. domingensis* , *C. demersum* , *P. perfoliatus* and *H. varcillata* respectively. and increasing the activity of (CAT) during the period of the experiment ranged (43.9-140.7) , (8.8-101.4) , (25.5-136.7) , (23.3-129.7) and (33.4-85.5) unit/mg for plants *P. australis , T. domingensis , C. demersum , P. perfoliatus and H. varcillata respectively*.and increasing the activity of (SOD) enzyme during the period of the experiment ranged (0.086-0.53) , (0.23-3.46) , (0.608-8.46) , (3.89-15.2) and (0.411-4.35) unit/mg for plants *P. australis* , *T. domingensis* , *C. demersum* , *P. perfoliatus* and *H. varcillata* respectively. this response were due to environmental stress for instance contaminants, by developing a complex antioxidant defense system against abiotic stress by aquatic plants .

 This study was conducted to determine the concentration of heavy metals(Fe, Cu, Zn, Ni, Cd, Cr and Pb) in canned tuna found in the local market of Hilla city, the results show that the concentarions of irons were above the limits and was ranged between 57.41 ppm to 101.55 ppm, while the concentration of copper was within the limits and was ranged between 5.43 ppm to 6.48 ppm, the concentration of zinc was also within the permited limits and was ranged between 17.5 ppm to 37.5, while all of nickel, cadmium, chromium and lead was not detected in all the samples.

**Keywords**; phytoremediation , reactive blue and reactive yellow, aquatic plant, antioxidant enzymes , photosynthetic pigments.

**Introduction**

 Synthetic dyes (e.g., azo dyes) are commonly used in the food, textile, cosmetic, plastic and pharmaceutical industries. These dyes designed to resist fading on exposure to soap, water, light and oxidizing agents, so that they can impart color on various raw materials. A majority of the synthetic dyes have been shown to disturb human health and are toxic to microorganizim[1]. Hence, the treatment of effluents containing dyes has been a challenging problem among environmental technologies. Therefore, it is necessary to find an effective method to eliminate these dyes from industrial effluents. The physical and chemical methods have numerous disadvantages, such as high cost, low efficiency, and formation of toxic by-products. In the last decades, biological methods that use living organisms including bacteria, fungi, algae and plants were developed as a low-cost and ecofriendly viable alternative[2]. The use of plants to detoxify polluted environments (phytoremediation) referred to as phytotechnology, uses vegetation to contain, sequester, remove, or degrade inorganic and organic contaminants in soil, sediment, surface water, and groundwater.has attracted a lot of interest. Consequently, some plant species have been identified in possessing the high potential to degrade textile dyes [3].

 The advantages of phytoremediation are the low capital costs, aesthetic benefits, minimization of leaching of contaminants, and soil stabilization . The operational cost of phytoremediation is also substantially less and involves mainly fertilization and watering for maintaining plant growth. In the case of heavy metals remediation, additional operational costs will also include harvesting, disposal of contaminated plant mass, and repeating the plant growth cycle.

 textile industries about 10–15% of the dye gets lost in the efﬂuent during the dyeing process[4] . Release of the colored efﬂuents into the environment is undesirable as it affects the aesthetics,the water transparency and the gas solubility in water bodies[5] . More over amajority of these dyes are either toxic to ﬂora and fauna or mutagenic and carcinogenic[6] .The efﬂuents from the textile sector are characterized by high BOD, high COD, high concentrations of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS),extreme pH (acidic or alkaline) and color which may distort the water quality,adds odor and signiﬁcantly, hinders economic activities, making its proper treatment of a great concern .

Textile industry generates highly polluting wastewater which contains dyes and their decomposition is creating very serious problem to wastewater treatment plant.

 Dyes have complex aromatic structures to provide intense coloration, high water solubility, resistance to fading, improve delivery to the fabrics and to have variety of shades, which makes them highly resistant to degradation . phyto remediation is a green technology that uses plant systems for remediation and restoration of the contaminated sites. Plants have inbuilt enzymatic machinery capable of degrading complex structures and can be used for cleaning of the contaminated sites.It is an ecologically sound and sustainable reclamation strategy for bringing polluted sites into productive use but is still in experimental stage; therefore it needs a lot of attention and scientiﬁc scrutiny [7].

**Materials and methods**

**Plant material and water sample preparation**

 five types of aquatic plants *P. australis , T. domingensis , C. demersum , P. perfoliatus and H. varcillata* collected from the drainage and washed with water drainage and well preserved in bags of clean polyethylene while access to the lab [8] .
 Fifteen plastic container size (15 liters) coated on the inside with aluminum foule were used and added (10) liters of textile industerial waste water were added in three concentrations (0.01, 0.02, 0.03)mg/L of the dyes Azo dyes (Reactive blue, Reactive yellow and Mixture from it) and with three replicates for each concentration will added and two control used the first containing industrial water only without plant and the second containing tap water with plant (250) g of aquatic plant used in the experiment Adapted in aqueous systems containing tap water for two weeks and then wash thoroughly with water and exposed to polluted water [9]. For a period of 13 days and testing during the days (1, 4, 7, 10 and 13) .

**Plant material and water sample preparation**

**Biochemical assays**

**Estimation of antioxidants**

 CAT activity was determined by monitoring the decrease in absorbance at 240 nm due to dismutation of H2O2 followed the method used by [10].

 SOD activity was determined by monitoring the decrease in absorbance at 420 nm followed the method used by [11] .

**Lipid peroxidation determination**

 Lipid peroxidation was estimated by formation of malondialdehyde (MDA) and its reaction with thiobarbituric acid Used the method use by[12] .

**Estimation of protein content**

 The protein content in the tissues of aquatic plants was estimated by using the method of Bradford using Bradford solution then absorbance was measured spectrophotometrically at 595 nm and expressed protein content mg/g tissue vegetarian [13] .

**Photosynthetic pigments analysis**

 Total chlorophyll Was estimated in the tissues of aquatic plants according to the method used by[14] . and the soft tissue of plant crushed with 80% of acetone .The extracts were centrifuged for 10 min at 2000 ×g. totall Chlorophylls content were determined spectrophotometrically at 645 and 663 nm .

**Results and discussion**

**Antioxidant enzymes responses**

 plants have developed a complex antioxidant defense system against abiotic stress. CAT is important antioxidative enzyme, present in the peroxisomes and mitocondria of cells, which degrades H2O2 to water and molecular oxygen, that catalyzed reaction by SOD. The CAT activity increase could be explained by plants adaptive mechanism to maintain H2O2 at a steady-state level within the cells [15]. The present study showed high enzymatic activity for (CAT) during the period of the experiment ranged (43.9-140.7) , (8.8-101.4) , (25.5-136.7) , (23.3-129.7) and (33.4-85.5) unit/mg for plants *P. australis , T. domingensis , C. demersum , P. perfoliatus and H. varcillata respectively*. “Fig. 1-15”.

 Superoxide dismutase activity directly regulates the amount of ROS and appears as a first line of defense, converting superoxide radicals into H2O2 [16]. The present study showed an increase in activity might reflect an enhanced superoxide radical production under chemical stress condition the activity of enzyme (SOD) Superoxide dismutase in aquatic plants during the period of the experiment ranged (0.086-0.53) , (0.23-3.46) , (0.608-8.46) , (3.89-15.2) and (0.411-4.35) unit/mg for plants *P. australis* , *T. domingensis* , *C. demersum* , *P. perfoliatus* and *H. varcillata* respectively. “Fig. 16-30”.

 MDA is a cytotoxic product of lipid peroxidation and an indicator of free radical production and consequent tissue damage [17]. Thus, cell membrane stability has widely been utilized to study the effects of stress on plants [18]. The current study showed high content (MDA) Malondialdehyde in aquatic plants during the period of the experiment the chang in MDA content were by (0.67-4.04) , (0.64-5.98) , (9.56-31.6) , (12.709-61.29) and (0.88-34.53) nmole/mg *P. australis* , *T. domingensis* , *C. demersum* , *P. perfoliatus* and *H. varcillata* respectively. “Fig. 31-45”.

 protein being an important organic constituent plays significant role in cellular metabolism and as constituents of cell membrane. It regulates the process of interaction between the intra and extracellular media [19]. It is known that soluble protein content is an important indicator of physiological status of plants[20] . Stressfull environments induce the generation of reactive oxygen species (ROS) such as superoxide radicals (O2-), hydrogen peroxide (H2O2) and hydroxyl radicals (OH−) etc . in plants there by creating a state of oxidative stress in them [21]. This increased ROS level in plants caused oxidative damage to biomolecules such as lipids, proteins and nucleic acids, thus, altering the redox homeostasis [22].The protein content of the results show decrease in protein content during the period of the experiment (1.54-3.22) , (2.62-9.44) , (0.55-3.49) , (0.81-4.28) and (0.42-2.21) mg / g in weight for tender plants *P. australis , T. domingensis , C. demersum , P. perfoliatus and H*. *varcillata* respectively. “Fig. 46-60”.

 The total chlorophyll content of aquatic plants were decreased under dye stress condition may be a protective response to limit ROS by-product formation in chloroplasts [23]. during the period of the experiment from to (1.39-0.48) , (1.25-0.94) , (4.10-0.92) , (1.08-0.46) and (1.61-0.36) mg / g in weight for tender plants *P. australis* , *T. domingensis , C. demersum . P. perfoliatus and H. varcillata* respectively . “Fig. 61-75”.

***Figure 1.*** *Variation in Catalase of p.australis that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 2.*** *Variation in Catalase of p.australis that exposed in different concentration of Reactve yellow dye* unit/mg

***Figure 3.*** *Variation in Catalase of p.australis that exposed in different concentration of mixture dye(Reactive Blue, Reactive yellow)* unit/mg

***Figure 4.*** *Variation in Catalase of T.domingensis that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 5.*** *Variation in Catalase of T.domingensis that exposed in different concentration of Reactive yellow dye* unit/mg

***Figure 6.*** *Variation in Catalase of T.domingensis that exposed in different concentration of mixture dye(Reactive Blue, Reactive yellow)* unit/mg

***Figure 7.*** *Variation in Catalase of C. demersum that exposed in different concentration of Reactve Blue dye* unit/mg

***Figure 8.*** *Variation in Catalase of C. demersum that exposed in different concentration of Reactve yellow dye* unit/mg

***Figure 9.*** *Variation in Catalase of C. demersum that exposed in different concentration of mixture dye(Reactive Blue, Reactive yellow)* unit/mg

***Figure 10.*** *Variation in Catalase of P. perfoliatus that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 11.*** *Variation in Catalase of P. perfoliatus that exposed in different concentration of Reactive yellow dye* unit/mg

***Figure 12.*** *Variation in Catalase of P. perfoliatus that exposed in different concentration of mixture dye(Reactive Blue, Reactive yellow)* unit/mg

***Figure 13.*** *Variation in Catalase of H. varcillata* *that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 14.*** *Variation in Catalase of H. varcillata* *that exposed in different concentration of dye Reactve yellow* unit/mg

***Figure 15.*** *Variation in Catalase of H. varcillata* *that exposed in different concentration of mixture dye(Reactive Blue, Reactive yellow)* unit/mg

***Figure 16.*** *Variation in superoxide dismutase of P. australis* *that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 17.*** *Variation in superoxide dismutase of P. australis* *that exposed in different concentration of Reactive yellow dye* unit/mg

***Figure 18.*** *Variation in superoxide dismutase of P. australis* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* unit/mg

***Figure19.*** *Variation in superoxide dismutase of T.domingensis that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure20.*** *Variation in superoxide dismutase of T.domingensis that exposed in different concentration of Reactive yellow dye* unit/mg

***Figure 21.*** *Variation in superoxide dismutase of T.domingensis that exposed in different concentration of mixture (Reactive Blue, Reactive yellow dyes)* unit/mg

***Figure 22.*** *Variation in superoxide dismutase of C. demersum that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 23.*** *Variation in superoxide dismutase of C. demersum that exposed in different concentration of Reactive yellow dye* unit/mg

 ***Figure 24.*** *Variation in superoxide dismutase of C. demersum that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* unit/mg

***Figure 25.*** *Variation in superoxide dismutase of p. perfoliatus* *that exposed in different concentration of dye Reactive Blue* unit/mg

***Figure 26.*** *Variation in superoxide dismutase of p. perfoliatus* *that exposed in different concentration of Reactive yellow dye* unit/mg

***Figure 27.*** *Variation in superoxide dismutase of p. perfoliatus* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* unit/mg

***Figure 28 .*** *Variation in superoxide dismutase of H. varcillata* *that exposed in different concentration of Reactive Blue dye* unit/mg

***Figure 29 .*** *Variation in superoxide dismutase of H. varcillata* *that exposed in different concentration of dye Reactive yellow* unit/mg

***Figure 30 .*** *Variation in superoxide dismutase of H. varcillata* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* unit/mg

***Figure 31.*** *Variation in* Malondialdehyde *P. australis* *that exposed in different concentration of Reactive Blue dye* nmole/mg

***Figure 32.*** *Variation in* Malondialdehyde *P. australis* *that exposed in different concentration of Reactive yellow dye* nmole/mg

***Figure 33.*** *Variation in* Malondialdehyde *P. australis* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* nmole/mg

***Figure 34.*** *Variation in* Malondialdehyde *T. domingensis* *that exposed in different concentration of Reactive Blue dye* nmole/mg

***Figure 35.*** *Variation in* Malondialdehyde *T. domingensis* *that exposed in different concentration of Reactive yellow dye* nmole/mg

***Figure 36.*** *Variation in* Malondialdehyde *T. domingensis* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* nmole/mg

***Figure 37.*** *Variation in* Malondialdehyde *C. demersum that exposed in different concentration of Reactive Blue dye* nmole/mg

***Figure 38.*** *Variation in* Malondialdehyde *C. demersum that exposed in different concentration of Reactive yellow dye* nmole/mg

***Figure 39.*** *Variation in* Malondialdehyde *C. demersum that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* nmole/mg

***Figure 40.*** *Variation in* Malondialdehyde *P. perfoliatus that exposed in different concentration of Reactive Blue dye* nmole/mg

***Figure 41.*** *Variation in* Malondialdehyde *P. perfoliatus that exposed in different concentration of Reactive yellow dye* nmole/mg

***Figure 42.*** *Variation in* Malondialdehyde *P. perfoliatus that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* nmole/mg

***Figure 43.*** *Variation in* Malondialdehyde *H. varcillata* *that exposed in different concentration of Reactive Blue dye* nmole/mg

***Figure 44.*** *Variation in* Malondialdehyde *H. varcillata* *that exposed in different concentration of Reactive yellow dye* nmole/mg

***Figure 45.*** *Variation in* Malondialdehyde *H. varcillata* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* nmole/mg

***Figure 46.*** *Variation in protein of p.austeralis* *that exposed in different concentration of Reactive Blue dye* mg/gm

***Figure 47.*** *Variation in protein of p.austeralis* *that exposed in different concentration of Reactive yellow dye* mg/gm

***Figure 48.*** *Variation in protein of p.austeralis* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes* mg/gm

***Figure 49.*** *Variation in protein content of T.domingensis that exposed in different concentration of* Reactive Blue *dye mg/gm.*

***Figure*** *50. Variation in protein content of T.domingensis that exposed in different concentration o f* Reactive yellow *dye mg/gm.*

***Figure 51.*** *Variation in protein content of T.domingensis that exposed in different concentration of* mixture (Reactive Blue, Reactive yellow) *dyes mg/gm.*

***Figure 52.*** *Variation in protein content of C.demersum that exposed in different concentration of Reactive Blue dye mg/gm*

***Figure 53.*** *Variation in protein content of C.demersum that exposed in different concentration of Reactive yellow dye mg/gm*

***Figure 54.*** *Variation in protein content of C.demersum that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes mg/gm*

***Figure 55.*** *Variation in protein content of P. perfoliatus that exposed in different concentration of Reactive Blue dye mg/gm*

***Figure 56.*** *Variation in protein content of P. perfoliatus that exposed in different concentration of Reactive yellow dye mg/gm*

***Figure 57.*** *Variation in protein content of P. perfoliatus that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes*

***Figure 58.*** *Variation in protein content of H. varcillata* *that exposed in different concentration of Reactive Blue dye mg/gm*

***Figure 59.*** *Variation in protein content of H. varcillata* *that exposed in different concentration of Reactive yellow dye mg/gm*

***Figure 60.*** *Variation in protein content of H. varcillata* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow )dyes mg/gm*

***Figure 61.*** *Variation in total chlorophyll* *of P. australis that exposed in different concentration of Reactive Blue dye mg/g .*

***Figure 62.*** *Variation in total chlorophyll* *of P. australis that exposed in different concentration of Reactive yellow dye mg/g .*

***Figure 63.*** *Variation in total chlorophyll* *of P. australis that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dye*

***Figure 64.*** *Variation in total chlorophyll* *of T. domingensis* *that exposed in different concentration of Reactive Blue dye mg/g .*

***Figure 65.*** *Variation in total chlorophyll* *of T. domingensis* *that exposed in different concentration of Reactive yellow dye mg/g .*

***Figure 66.*** *Variation in total chlorophyll* *of T. domingensis* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dye mg/g .*

***Figure 67.*** *Variation in total chlorophyll of C. demersum that exposed in different concentration of Reactive Blue dye mg/g .*

***Figure 68.*** *Variation in total chlorophyll of C. demersum that exposed in different concentration of Reactive yellow dye mg/g .*

***Figure 69.*** *Variation in total chlorophyll of C. demersum that exposed in different concentration of* mixture (Reactive Blue, Reactive yellow) *dyes mg/g* ***.***

***Figure 70.*** *Variation in total chlorophyll* *of P. perfoliatus that exposed in different concentration of Reactive Blue dye mg/g .*

***Figure 71.*** *Variation in total chlorophyll* *of P. perfoliatus that exposed in different concentration of Reactive yellow dye mg/g .*

***Figure 72.*** *Variation in total chlorophyll* *of P. perfoliatus that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes mg/g .*

***Figure 73.*** *Variation in total chlorophyll* *of H. varcillata* *that exposed in different concentration of Reactive Blue dye mg/g*

***Figure 74.*** *Variation in total chlorophyll* *of H. varcillata* *that exposed in different concentration of Reactive yellow dye mg/g*

***Figure 75.*** *Variation in total chlorophyll* *of H. varcillata* *that exposed in different concentration of mixture (Reactive Blue, Reactive yellow) dyes mg/g .*

**Conclusions**

 Aquatic plants developed a complex antioxidant defense system against abiotic stress for instance contaminants . the study show decrease in total chlorophyll and protein content in aquatic plants and high content in malondialdehyde and increasing the activity of catalase and superoxide dismutase enzyme in aquatic plants .

**Acknowledgement**

The authors are gratefull for department of Biology in collage of science Babylon university.

**References**

1. **Kagalkar, A .; Jagtap, U. ; Jadhav, J .; Govindwar, S. and Bapat, V.** Studies on phytoremediation potentiality of Typhonium flagelliforme for the degradation of Brilliant Blue R. Planta. Vol. 232, No.1, pp. 271--285. 2010.
2. **Ho, W . ; Ang, L . and Lee, D .** Assessment of Pb uptake, translocation and immobilization in kenaf (Hibiscus cannabinus L.) for phytoremediation of sand tailings, Journal of Environmental Sciences, Vol.20, No.11, pp. 1341--1347.2008.
3. **Davies, L .; Cabrita, G. ; Ferreira, R .; Carias, C .; Novais, J. and Martins-Dias, S .** Integrated study of the role of Phragmites australis in azo-dye treatment in a constructed wetland: From pilot to molecular scale, Ecological Engineering, Vol. 35, No.9, pp. 961--970. 2009.
4. **Spadaro, J., Gold, M. and Renganathan, V.** Degradation of azo dyes by the lignin degrading fungus Phanerochaete chrysosporium, Applied and Environmental Microbiology, Vol. 58, No. 8, pp. 2397–2401, ISSN 0099-2240.
5. **Banat , I. ; Nigam , P. ; Singh, D. and Marchant , R.** Microbial decolourisation of textile – dye-contianing effluen ,a review .Bioresource Technol, Vol. 58, pp.,217-227. 1996.
6. **Hu, M.; Chao, Y.; Zhang, G. ; Xue, Z. and Qian, S.** laccase mediator system in the decolorization of different types of recalcitrandyes.J.Indust, microbial Biotechnol,Vol. 36, pp.45-51 . 2009.
7. **APHA, “**Standard Methods for the Examination of Water and Wastewater”, 21st Edition.2005.
8. **Hamish, M.; Norhashimah, M.; Fera, F. and Ahmad, F**. Phytoaccumulation of Copper from Aqueous Solutions Using Eichhornia Crassipes and Centella Asiatica, International Journal of ESD, Vol. 2, No.3, pp.26-27. 2011.
9. **Rai , P.** Heavy Metal Phytoremediation from Aquatic Ecsystems with Special Reference to Macrophytes, Critical Reviews in Environmental Science and Technology, Vol. 39, No. 9, pp. 697-753 .2009.
10. **Aebi, H.** Catalase in vitro, Methods Enzymol, Vol. 105, pp.121-126. 1984.
11. **Marklundand, S. and Marklund, G.** Involvement of the superoxide anion radical in the autoxidation of pyrogallol and a convenient assay for superoxide dismutase. Eur J. Biochem , Vol. 47, pp. 469-474. 1974.
12. **Kramer, G. ; Norman, H.; Krizek, D. and Mirecki, R.** Influnce of Uv-B radiation on polyamines ,Lipid peroxida tion and membranelipidsinCucumber,Phytochemistry,Vol. 30 pp. 21-28 . 1991.
13. **Bradford M.M .** A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding, Analytical Biochemistry, Vol..72, No.1, pp. 248-254. 1976.
14. **Aminot, A. and Rey, F.** Standard procedure for determination of chlorophyll by spectroscopic methods , ICES Techniques IN Marine Environ.Sci. , Denmark , pp.1 – 17. 2000.
15. **Mishra, S.; Srivastava, S.; Tripathi, R.D.; Kumar, P. ; Seth, C.S. and Gupta, D.K.** Lead detoxification by coontail (Cerato phyllum demersum L.) involves induction of phytochelatins and antioxidant system in response to its accumulation,Chemosphere, Vol. 65,pp. 1027–1039. 2006.
16. **Halliwell, B.** Reactive species and antioxidants. Redox biology is a fundamental theme of aerobic life, Plant Physiology, Vol. 141, No.2, pp. 312--322. 2006.
17. **Ohkawa, H .; Ohishi, N . and Yagi , K.** Assay for lipid peroxidetion in animal tissues by thiobarbituric acid reaction”, Anal. Biochem , Vol. 95, NO.351. 1979.
18. **Zhang, F .; Wang, Y.; Lou, Z. and Dong , J .** Effect of heavy metal stress on antioxidative enzymes and lipid peroxidation in leaves and roots of two mangrove plant seedlings Kandelia candel and Bruguiera gymnorrhiza , Chemosphere, Vol. 67, pp. 44-50. 2007.
19. **P. Kharat; L .Ghoble; K.Shejule; R .Kale; and B .Ghoble.** Impact of TBTCl on total protein content in creshwater prawn, Macrobrachium kistnensis”, Middle-East J. Sci. , Vol.4,No.3, pp. 180-184. 2009.
20. **Doganlar, Z .; Demir, K .; Basak, H . and Gul , I .**Effects of salt stress on pigment and total soluble protein contents of three different tomato cultivars”, Afr. J. Agric, Vol. 5, No.15, pp. 2056-2065. 2010.
21. **Asada, K.** Production and action of active oxygen species in photosynthetic tissues. In: Foyer CH, Mullineaux PM (Eds.). Causes of photooxidative stress and amelioration of defence system in plants, C.R.C, Boca Ration, pp. 77-104. 1994.
22. **Smirnoff, N.** The role of active oxygen in response of plants to water deficit and desiccation”, New Phytol , Vol.125, pp. 27-58. 1993.
23. **Khataee,A.; Movafeghi,A.; Torbati,S.; Salehi, S. and Lisar, M .Z.** Phytoremediation potential of duckweed (Lemna minor L.) in degradation of C.I. Acid Blue 92: Artificial neural network modeling, Ecotoxicology and Environmental Safety, Vol. 80, No.6, pp. 291--298. 2012.