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Single Binary and Ternary Effects of Cu, Cd and Hg on Photosynthetic Pigmnets of Isabgol and Lepidium

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ABSTRACT

In environment Heavy metals are the most important sorts of contaminant. The present work aimed to study the interactive effects of copper (Cu), cadmium (Cd), mercury (Hg) on photosynthetic pigments of Isabgol and Lepidium. The present data suggest that decrease in carotenoids may be the reason for loss in pigments in heavy metal treated plants. Plants may be suffered from oxidative damage. The poor vegetative and reproductive growth may be due to loss in photosynthetic pigments in heavy metal treated plants.

KEYWORDS: Isabgol, Lepidium, heavy metals, photosynthetic pigments, interaction

INTRODUCTION

Heavy metals interfere in biochemical reaction of plant and induced physiological disorders like reduction in leaf chlorophyll (Khan *et. al.*, 1988). Heavy metals like Cu, Cd, Hg, Pb, Se, Zn, Co and Mn damage the photosynthetic apparatus, impair the uptake of nutrient or leakage the nutrients, ultimately reduce the growth (Bishnoi *et. al*., 1993). Excess Cu decreased the chlorophyll content in spinach leaves (Nautiyal and Chatterjee, 2002). Prolonged exposure damaged photosynthetic systems, carotenoids pigments (Wisniewski and Dickinson, 2003). Many researchers have studied the effects of single heavy metals on different plant speci.es but in medicinal plants there are rare. Heavy metals such as copper (Cu), zinc (Zn), cobalt (Co), and iron (Fe) are essential in trace amounts for various metabolic activities in plants but excess of any kind of metal (essential or non-essential) adversely affects plant metabolism (Hall 2002). The effects of Cd and lead (Pb) on Brassica juncea L. exhibited a decline in growth, chlorophyll content, and carotenoids; however, Cd was found to be more detrimental than Pb (John et al. 2009). According to Hattab et al. 2009 for the study of physiological effects of Cd and Cu on pea (*Pisum sativum*), photosynthetic pigments and photosynthetic rates declined at all concentrations of Cd and at high Cu concentrations. For normal plant growth and development essential Heavy metals such as Cu and Zn are since they are constituents of many enzymes and other proteins. However, elevated concentrations of any heavy metal either essential or non-essential can express to toxic symptoms and growth inhibition in plants. Plant photosynthetic efficiency of plant decreases and could be partly responsible for the overall decrease in plant growth and biomass production. The content of chlorophyll 'a' and chlorophyll 'b' and carotenoid were relatively during early stages of *Cajanus cajan* development under the effect of Cd. the net photosynthetic rte was reduced significantly in Cd treated plants. The protein content was lowered compared with control (Khudsar *et. al.*, 2001) Aggarwal et al. 2012 suggested Toxic effects of metals show in plants mostly by damaging chloroplasts and disturbing photosynthesis. Photosynthetic inhibition is the consequence of interference of metal ions with photosynthetic enzymes and chloroplast membranes. Romika Chandra & Hoduck Kang (2016) experimented short term exposure of poplar hybrids to mixed heavy metals does seriously affect the overall photosynthetic pigments and photosynthesis, poplar hybrids exhibited a decrease in chlorophyll content and carotenoids except for hybrid 1 (Eco 28) which results in increase at heavy metal concentrations of 200 and 500 ppm. The photosynthetic rate decreased with increasing heavy metal concentrations; however, an increase was observed at the highest concentration of 500 ppm. Transpiration rates were significantly affected by increased heavy metals. Hybrid 1 (Eco 28) was deduced as the hybrid that has the ability to tolerate high levels of mixed heavy metals. Pandit and Kumar (1999b) also reported that combination of Cu, Cd and Zn decreased the chlorophyll content in jowar seedlings. Interaction between heavy metals may occur at plant root surface, affecting metal uptake, and within the plant, affecting heavy metal translocation and toxicity (Luo and Rimmer, 1995). Cd and Zn as a single heavy metal decreased the chlorophyll content in *Hydrilla*, the effect was related with concentration. Cd was more effective than Zn. Zn+Cd decreased the adverse effects on chlorophyll i.e., Zn act as antagonistic element over Cd (Arunachalam *et. al*., 1996). Siedlecka and Krupa (1997) reported Cd/Fe interaction in higher plants as a consequence for the photosynthetic apparatus. Cd and Hg individually as well as in combination decreased the chlorophyll ‘a’ and ‘b’, carotenoids and xanthophylls in fenugreek. The combinations were more effective, with increasing concentration inhibitory effect was increasing (Madhavi and Charulu, 1998). Hg treatment inhibited the amount of chlorophyll and carotenoids in cucumber plants, higher concentration was more severe (Thomas and Singh 1995). Increase in concentration of Pb, Cd and Hg decreased the chlorophyll ‘a’, chlorophyll ‘b’, carotenoids and xanthophylls in fenugreek (Madhavi and Charyulu, 1998). Hg decreased the chlorophyll ‘a’ and chlorophyll ‘b’ in *Albizia lebbeck* (Tripathi and Tripathi 1999). In the present investigation heavy metal also lowered the carotenoids pigments thus the chlorophyll pigments may not be protected against photochemical damage. Thus, lowering in pigments reduced the photosynthesis and ultimately it will result into poor growth of the plants. Sewelam et al., 2016 demonstrated that the chloroplast is the primary site of attack by air pollutants turned into considerable degradation of chlorophyll.

MATERIALS AND METHODS

The fourth leaf in replicate from 15, 45, 75 days old plants was selected and photosynthetic pigments, viz chlorophyll ‘a’, chlorophyll ‘b’, total chlorophyll and carotenoids were estimated using the method of Arnon, (1949). Weighed fresh leaf material was crushed in 80% acetone (80ml acetone + 20ml DW) with a pinch of sand. The homogenate was filtered using Whatmann filter paper No. 1 and the filtrate was made upto a specific volume. The absorbance of the chlorophyll suspension was read on Systronic 106 spectrophotomer at 480, 510, 645 and 663nm wavelength. The following formulas were used to calculate the quantity of photosynthetic pigments:

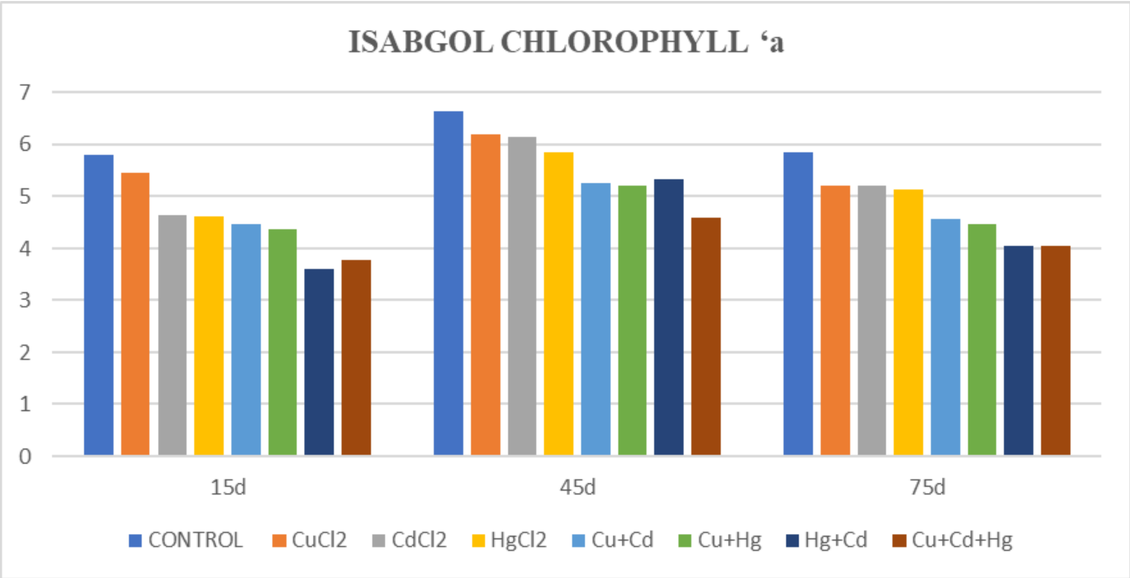
Chlorophyll ‘a’ (mg / g fr wt) = 12.7 (D663) - 2.69 (D645)

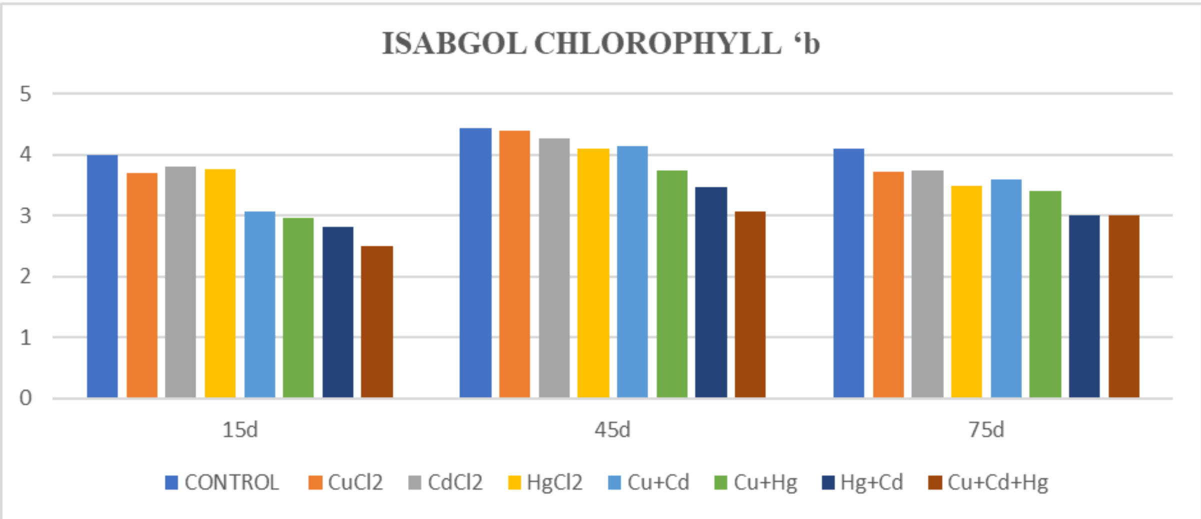
Chlorophyll ‘b’ (mg / g fr wt) = 22.9 (D645) - 4.68 (D663)

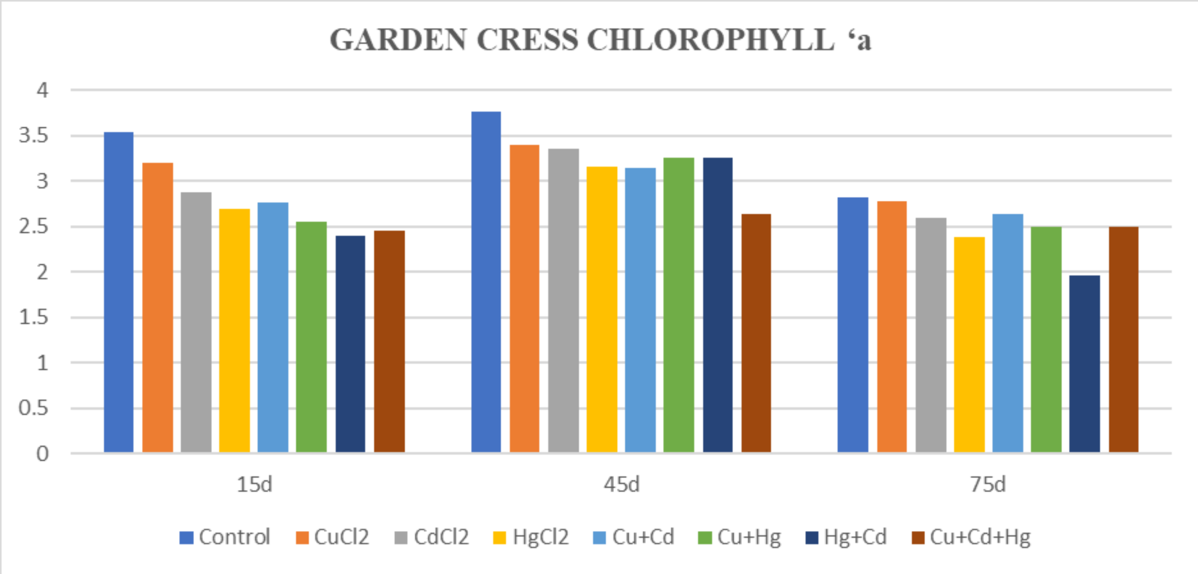
The ratios of chlorophyll 'a': chlorophyll 'b' and total chlorophyll: carotenoids were also calculated. Where, D = Optical Density.

RESULTS:

FIG.1: ISABGOL AND GARDEN CRESS CHLOROPHYLL 'A' AND 'B' CONTENT (200ppm Mg/G Fr Wt) GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL







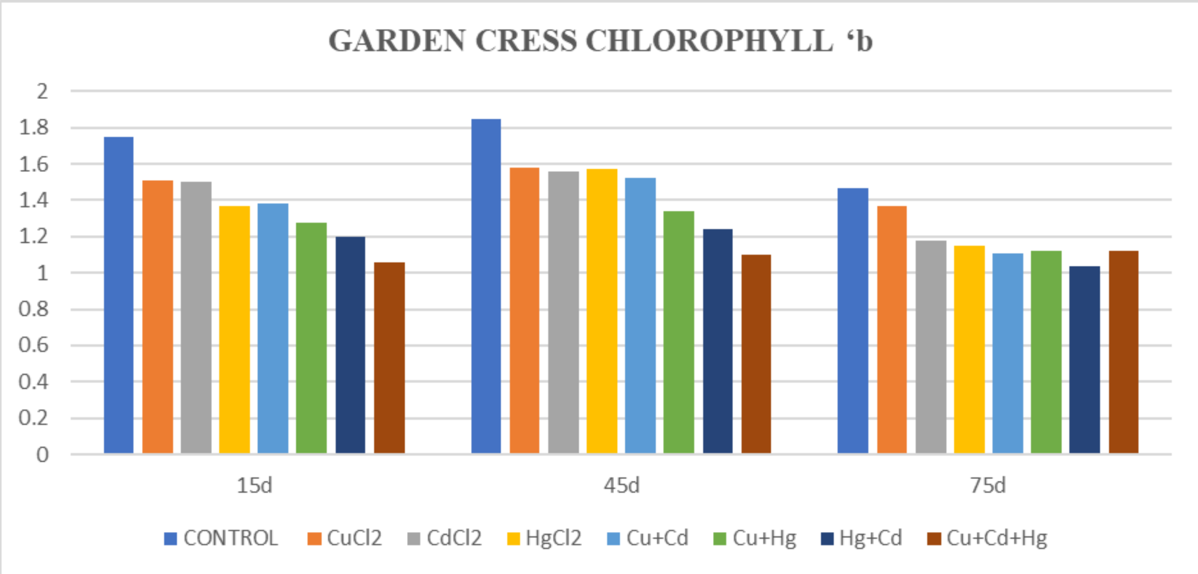
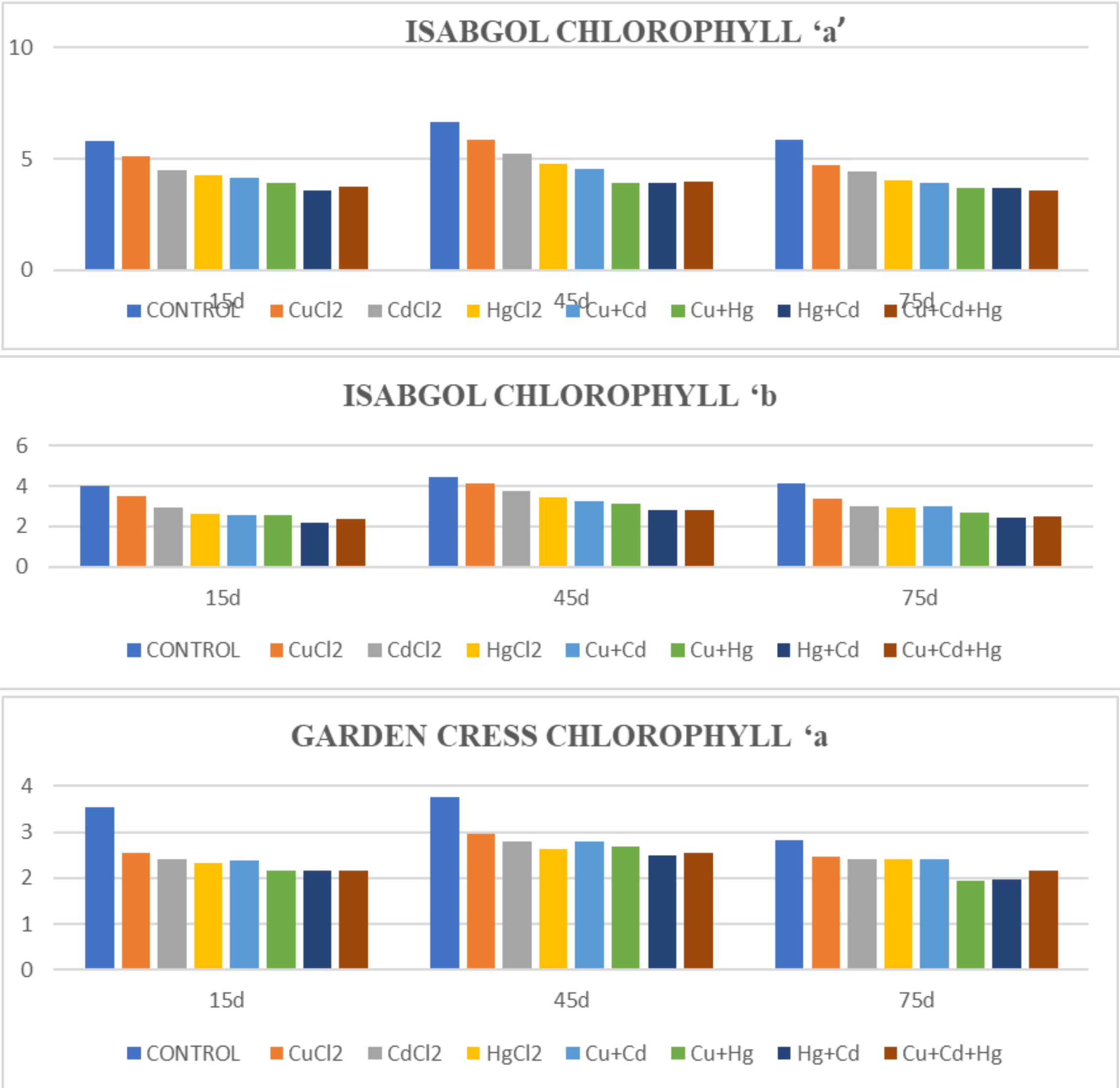


Fig 1 shows the data on chlorophyll 'a' and chlorophyll 'b' content of Isabgol and Garden cress grown without and with heavy metal **(200ppm** mg/g fr wt**)** contaminated soil. The amount of chlorophyll 'a' was much lower in Cu+Cd treated plants than that in Cu or Cd treated plants shows that interaction was more powerful in degradation of chlorophyll pigments than single metals. Similar effects were found with Cu+Hg and Hg+Cd interactions. 200ppm $CuCl_2$, $CdCl_2$ and $HgCl_2$ did not cause much effect on chlorophyll 'b' upto 45days then except Cu all the treatments lowered it. The effectiveness of the 200ppm treatment was in the order of Cu+Cd+Hg>Hg+Cd>Cu+Hg> Cu+Cd>Hg>Cd>Cu. In Garden cress presence of 200ppm of Cu, Cd, Hg and their interactions in the soil lowered the amount of chlorophyll 'a' and chlorophyll 'b'. The mixture gave additive effects. 200ppm Cu+Cd+Hg was more effective than 200ppm of Hg+Cd but 600ppm of Hg+Cd. Chlorophyll 'a' and chlorophyll 'b' were equally sensitive heavy metals and adverse effects of heavy metals on chlorophyll 'a' and chlorophyll 'b' were noted even in 15days old plants

Fig 2 represents the data on chlorophyll 'a' and chlorophyll 'b' content of Isabgol and Garden cress grown without and with heavy metal **(600ppm** mg/g fr wt**)** contaminated soil.

In Isabgol 600ppm of all the treatments lowered chlorophyll ‘b’. The binary mixture of Cu+Hg, Hg+Cd and ternary mixture each having 600ppm significantly lowered chlorophyll ‘b’ content. 600ppm effect was in the order of Hg+Cd>Cu+Cd+Hg> Cu+Hg> Cu+Cd>Hg>Cd>Cu. In Garden Cress 600ppm of Cu, Cd, Hg and their interactions in the soil lowered the amount of chlorophyll ‘a’ and chlorophyll ‘b’. 600ppm of Hg+Cd and 600ppm of Cu+Cd+Hg caused similar effects. Chlorophyll ‘a’ and chlorophyll ‘b’ were equally sensitive heavy metals and adverse effects of heavy metals were noted even in 15days old plants.

FIG.2: ISABGOL AND GARDEN CRESS CHLOROPHYLL ‘a’ AND ‘b’ CONTENT (600ppm mg/g fr wt**) GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL**



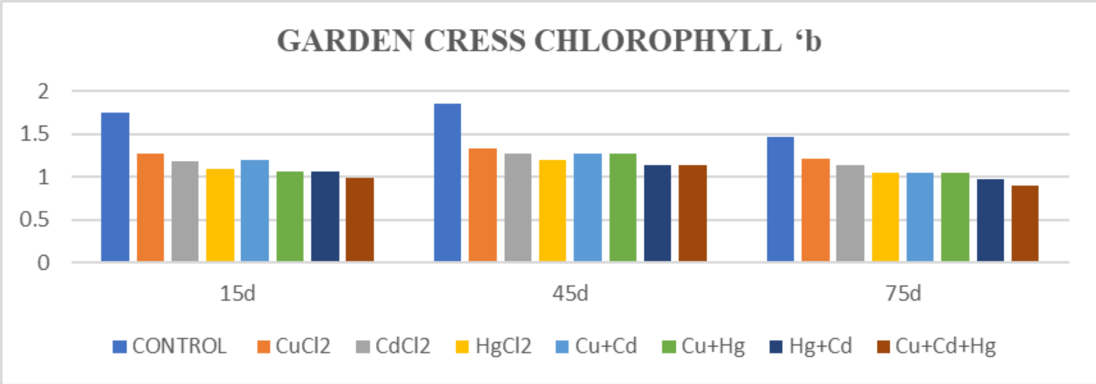
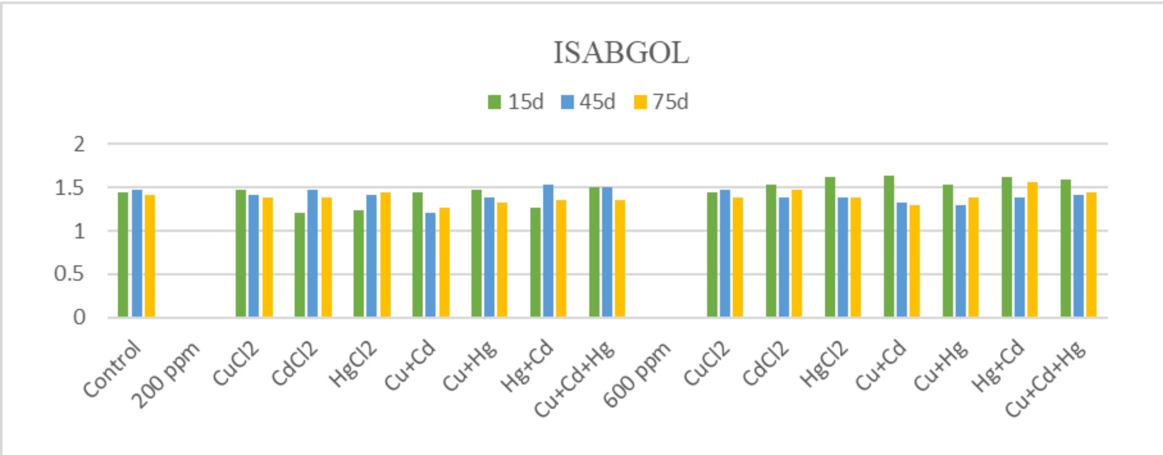
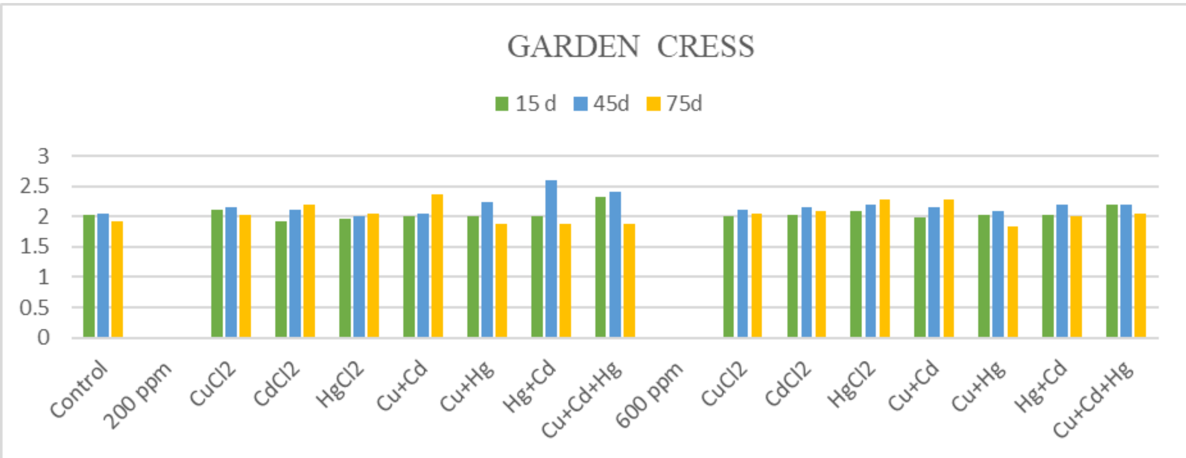


Fig 3 represents the ratios of chlorophyll 'a' to chlorophyll 'b' in leaf of Isabgol and Garden cress without and with heavy metal contaminated soil. Heavy metal altered the ratio of chlorophyll 'a' to 'b' in Isabgol and Garden cress. Hg+Cd and Cu+Cd+Hg drastically lowered the photosynthetic pigments, 600ppm was more effective than 200ppm. In Isabgol the values were higher grown with 600ppm of Hg+Cd, Cu+Cd+Hg but these values were lowered in same plants during 45days and 75days. In Garden cress heavy metal slightly altered the ratio of chlorophyll 'a' to chlorophyll 'b', indicating that chlorophyll 'a' and chlorophyll 'b' were more or less equally affected by heavy metal treatment.

Fig 3 RATIO OF CHL-'a' TO CHL-'b' IN THE LEAF OF ISABGOL AND GARDEN CRESS GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL





CONCLUSION

Many physiological and metabolic processes in plants alters Heavy metal stress. The data presented demonstrate the amounts of photosynthetic pigments i.e., chlorophyll 'a', chlorophyll 'b' was lowered in the leaf of heavy metal treated Isabgol and Garden Cress, effect was correlated with concentration of heavy metal. Mixtures of heavy metals were more adverse than single metal. concentration of each metal. More than one metal significantly lowered pigments and effects of heavy metal on photosynthetic pigments were noted even in 15days old plants. Very common effect of heavy metals in plants is their attack to the photosynthetic apparatus and related to all heavy metals rather than specific which leads photosynthetic activities a good screening method for detecting heavy metal stress (Appenroth, 2010). Heavy metal interactions may be predicted by studying the growth and metabolism of very young plants treated with heavy metals for a short duration. Before using the seeds for drug purpose, seeds must be analyzed for presence of toxic heavy metals. Medicinal plants have an increasing economic importance and Products based on natural increasing value. Due to anthropogenic activity in environment shown that some plants have also responded by producing specific secondary metabolites that can detoxify some of toxic metals on the changing environmental situations so plants can have use in phytoremediation technologies. To protect our environment remediation of heavy metals needs special attention. Phytoremediation or Bioremediation of metals is a cost-effective, efficient and green technology based on the use of metal-accumulating plants to remove toxic metals.

REFERENCES

1. Aggarwal A, Sharma I, Tripati BN, Munjal AK, Baunthiyal M, Sharma V. 2012. Metal toxicity and photosynthesis. In: Photosynthesis: overviews on recent progress & future perspectives. 1st ed. New Delhi: I K International Publishing House Pvt. Ltd; p. 229-236.
2. Appenroth, K.-J., 2010. Definition of ''Heavy Metals" and Their Role in Biological Systems. pp. 19–29. https://doi.org/10.1007/978-3-642-02436-8_2.
3. Arnon DI. 1949. Copper enzymes in isolated chloroplast, polyphenol oxidase in Beta vulgaris. Plant Physiol. 24:1-15.
4. Bishnoi N R, Sheoran I S and Singh R, (1993). Influence of cadmium and nickel on photosynthesis and water relations in wheat leaves of different insertion level. *Photosynthetica*. 28: 473 - 479.
5. John R, Ahmad P, Gadgil K, Sharma S. 2009. Heavy metal toxicity: effect on plant growth, biochemical parameters and metal accumulation by Brassica juncea L. Int J Plant Prod. 3:65-75. Lichtenthaler HK. 1987. Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. Method Enzymol. 148:350-382.
6. Hall JL. 2002. Cellular mechanisms for heavy metal detoxification and tolerance. J Exp Bot. 53:1-11.
7. Hattab S, Dridi B, Chouba L, Kheder MB, Bousetta H. 2009. Photosynthesis and growth responses of Pisum sativum L. under heavy metal stress. J Env Sci. 2: 1552-1556.
8. Khan M R, Singh S K and Khan M W, (1988). Response of lentil to cobalt as soil pollutant. TAC 9, *Ann. Appli. Biol.* (Suppl.). 112: 104 - 105.

9. Khudsar T, Mahmooduzzafar and Iqbal M (2001). Cadmium-induced changes in leaf epidermis, photosynthetic rate and pigment concentrations in *Cajanus cajan*. *Biologia Planta*. 44:59-64.
10. Luo Y and Rimmer DL. Zinc-copper interaction affecting plant growth on a metal-contaminated soil. Environmental Pollution 1995; 88:79-83.
11. Madhavi R and Charyulu N Y, (1998). Role of certain chelates like EDTA, Gypsum and Serpentine soil in reducing the toxic effect of lead, cadmium and mercury on the growth and metabolism of *Trigonella foenumgracum*. *Plant Physiol. and Biochem.*, 25: 95 - 108.
12. Nautiyal N and Chatterjee C., (2002). Iron application ameliorates copper toxicity effects in spinach. *Indian J. Plant Physiol*., 7:198-200.
13. Pandit BR and Kumar PG, (1999b). Effects of metals on jowar (*Sorghum bicolour* L.) seedling growth-II, biochemical changes. *Pollun. Res.*, 18: 483-488.
14. Romika Chandra & Hoduck Kang (2016) Mixed heavy metal stress on photosynthesis, transpiration rate, and chlorophyll content in poplar hybrids, Forest Science and Technology, 12:2, 55-61.
15. Sewelam, N., Kazan, K., Schenk, P.M., 2016. Global plant stress signaling: reactive oxygen species at the cross-road. Front. Plant Sci. 7, 1–21. https://doi.org/ 10.3389/fpls.2016.00187.
16. Siedlecka A and Krupa Z, (1997). Cd/ Fe interaction in higher plants- its consequences for the photosynthetic apparatus; *Photos.*, 36: 321-331.
17. Thomas R M and Singh V P, (1995). Effect of three triazole derivatives on mercury induced inhibition of chlorophyll and carotenoid accumulation in cucumber cotyledons. *Indian J. Plant Physiol.* 38: 313 - 316.
18. Tripathi A K and Tripathi S, (1999). Changes in some physiological and biochemical characters in *Albizia lebbek* as bio-indicators of heavy metal toxicity. *J Environ. Biol*., 20: 93 - 98.
19. Wisniewski L and Dickinson N M, (2003). Toxicity of copper to *Quercus robur* (English Oak) seedlings from a copper rich soil. *Environ. and Experm. Bot.*, 50: 99-107.