International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

The Effect of Marble-Slurry on Total Chlorophyll Content and Chlorophyll A/B Ratios in Some Tree Species

Dr Vibha Khanna[1], Lata Gahlot[2]

[1]Lecturer (Botany), SPC Government College, Ajmer

[2]Research scholar, Department of Botany, SPC Government College, Ajmer

Abstract: ***The tree species growing in the green belt area are subjected to stress conditions and this impacts their basic physiology. Among tree species the major impact of suspended particulate matter is on the photosynthetic pigments particularly the chlorophyll content. This study is an attempt to understand the impact of marble slurry on some tree species growing on the embankment of the marble-slurry dump-yard at Kishangarh, Ajmer. The seasonal trend in Chl a/b ratio relative to the total chlorophyll a and b were studied. This ratio can be applied for rapid detection of plant stress. For the present study three dominant tree species of the region i.e., Azadirachta indica, Callistemon lanceolata and Albizia lebbeck have been chosen. The prevalent stress conditions, in general, led to reductions in the chlorophyll a+b content and to an increase in the chlorophyll a/b ratio.***

Keywords: Marble slurry, green belt, chlorophyll content, chlorophyll a/b ratio

1. Introduction

Plants being an important component of an ecosystem are affected by environmental pollution, particularly the air pollution. Trees are planted for mitigating the air pollution by filtering, intercepting and absorbing pollutants in a sustainable manner (Gareth et al., 1992; Andy, 1991; Ruth and William, 1994; Sharma and Roy, 1997). Particulate Matter produced during the marble crushing is usually of relatively large size. The chemical composition of the dust tends to be homogenous mixture of oxides of calcium, potassium, aluminum, silica and sodium, which settles into a head mass when it comes in contact with water (Raina et al., 2008).

At the marble-city, Kishangarh, Ajmer, the slurry is transported to the dump-yard on whose embankment, plantation has been done. The vegetation is exposed to the fine dust of marble which deposits on the leaves. The survival of the tree species is supposed to be altered under the impact of pollutants including suspended particulate matter. The suspended particulate matter is trapped by the phyllo-plane, which in turn alters the various physiological processes, particularly photosynthesis. Chlorophyll, the green pigment present in the leaves, is one of the chief internal factors affecting the process of photosynthesis.

Photosynthesis is the most important process in biological system defining the limits of biomass production (Sofi et al., 2006), and is the main physiological parameter in stress process that is affected (Arabzadeh, 2009; Satisha et al., 2007; Misra et al., 2002). Chlorophyll is the basic catalyst of photosynthesis that as green pigments exists in all plant tissues that do photosynthesis (Masinovsky et al., 1992). Composition of chlorophyll is relatively unstable, that, at the time of extraction should be prevented from its decomposition (Masinovsky et al., 1992). It is well established that PS II play a key role in photosynthetic response to unfavorable environmental conditions (Misra et al., 2011, 2012).

The Chl *a*/*b* ratio, is an indicator of the functional pigment – system and light adaptation of the photosynthetic apparatus (Lichtenthaler et al., 1981). Chlorophyll *b* is present exclusively in the antenna system, whereas Chlorophyll *a* is present in the reaction centers of photosystems I and II and in the pigment antenna. The light-harvesting pigment protein LHC-I of the photosynthetic pigment system PS I has *a*/*b* ratio of ~3, that of LHC-II of PS II exhibits *a*/*b* ratio of 1.1 to 1.3. The level of LHC-II of PS II is variable and exhibits an adaptation response.

Stress due to air pollution can cause chronic photo-inhibition through impairment of photosystem II (PSII) reaction centers in leaves of plants (Mulkey and Pearcy 1992; Araus and Hogan 1994; Lovelock, Jebb and Osmond 1994). LHCII contains the majority of Chl b, and consequently it has a lower Chl a/b ratio (1.3–1.4) than other Chlorophyll binding proteins associated with PSII (Evans 1989; Green and Durnford 1996). Under stress conditions the damage to the plant is reflected in the constitution of the components of the photosynthetic apparatus, which is expressed by a faster breakdown of Chlorophyll. Chlorophyll (Chl) *a*/*b* ratio has been predicted to increase with the increase in irradiance.

2. Material and Method

Leaves were collected from the lowest branches of the selected trees on a regular monthly basis.

The chlorophyll a and b content were determined by following Yoshida's method which is a modification of the Arnon's method.

The following formula was made use of to calculate chlorophyll a and b content and the results are expressed in mg/g fresh weight:

Chl a (mg g-1) = [(12.7 × A663) - (2.6 × A645)] × ml acetone / mg leaf tissue
Chl b (mg g-1) = [(22.9 × A645) - (4.68 × A663)] × ml acetone / mg leaf tissue
Total chlorophyll = Chl a + Chl b

3. Results and Discussion

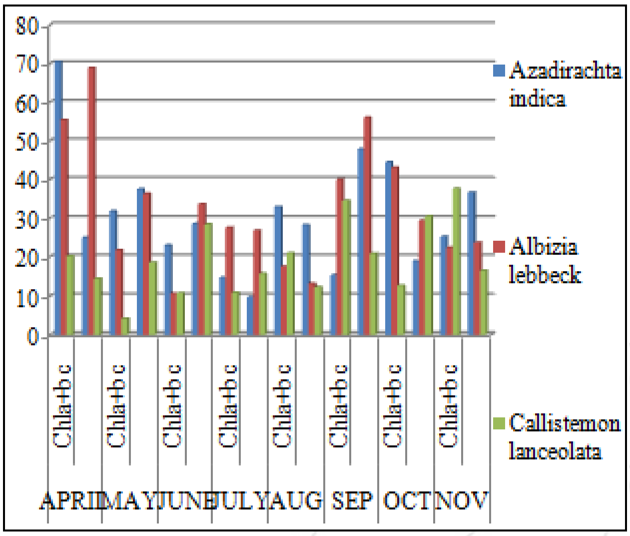

Figure 1: Chlorophyll a+b content in control (c) and Pollution effected (p) selected tree species

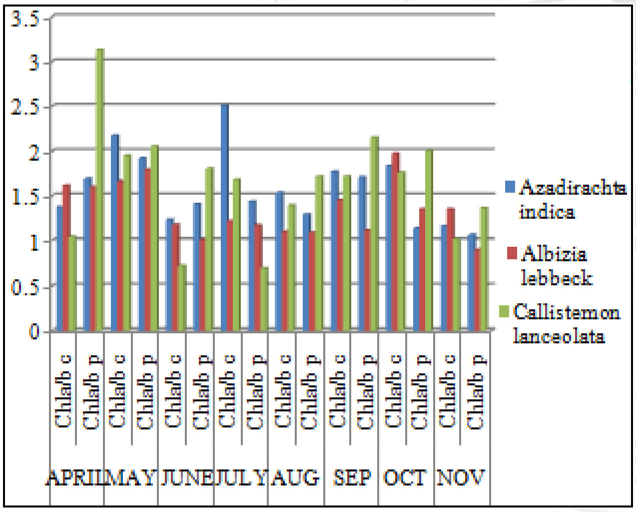

Figure 2: Chlorophyll a/b ratio in control (c) and Pollution effected (p) selected tree species

In control samples the maximum chl a/b ratio is found to be in *Azadirachta indica*, followed by that in *Callistemon lanceolata* and then *Albizia lebbeck.* Under the impact of marble slurry this ratio was found to be the maximum in *Callistemon lanceolata, which* due to the micro-morphology of its phylloplane entraps the maximum suspended slurry. However, during the month of July, i.e., at the onset of rains when the deposited slurry is washed off from the leaves, the ratio again was found to be maximum, for *Azadirachta indica. In Azadirachta indica* and *Albizia lebbeck* the ratio was more in case of the polluted samples in general. However, in case of *Callistemon lanceolata* a reduction in the ratio was observed in the polluted samples except during the month of July.

The total chlorophyll was recorded to be more in polluted samples of *Callistemon lanceolata* during the months of May, June, July and October. In *Albizia lebbeck* total chlorophyll was less in polluted samples during the months of July and October, while in *Azadirachta indica* the total chlorophyll content decreased in the polluted samples during the months of April, July, August and October. In general the total chlorophyll in control samples was found to be the maximum in case of *Azadirachta indica* except during the rainy months and during November. In polluted samples *Albizia lebbeck* had the maximum total chlorophyll content, in general.

Bhatnagar et al., (1985) concluded that less chlorophyll in leaves of plants growing in polluted area was due to toxic effect of industrial dust and other gaseous pollutants on leaf. The reduction in chlorophyll concentration in the polluted areas may be due to chloroplast damage (Pandey et al., 1991), inhibition of chlorophyll biosynthesis (Esmat 1993) or enhanced chlorophyll degradation. Prusty et al., (2005) had also described that photosynthetic pigments are most likely to be damaged by air pollution. Chlorophyll a is assumed to be degraded to phaeophytin, whereas chlorophyll b molecule loses its phytol group (Rao and Le Blanc 1966). The reduced exposure to direct sun light, due to deposition of suspended particulate matter on the leaf surface may be the reason for this decrease in the concentration of chlorophyll in tree species.

Air pollution-induced degradation in photosynthetic pigments was also observed by a number of workers (Agarwal and Sharma 1984, Bansal 1988; Singh et al., 1990; Sandelius et al., 1995). Chlorophyll pigments exist in highly organized state, and under air pollution stress they may undergo several photochemical reactions such as oxidation, reduction, pheophytinisation and reversible bleaching (Puckett et al., 1973).

Deposition of slurry-dust on the leaves of the trees reduces the irradiance and results in an enhancement of Chlorophyll (Chl) *a/b* ratio and a decrease in total chlorophyll content. The results revealed that Chl *a/b* ratio increased with the progression in seasonal courses while chlorophyll concentration [Chl] decreased. Greater values of the chlorophyll a/b content in case of *Callistemon lanceolata may* be attributed to its greater dust holding capacity of the leaf surface.

The Chl a/b ratio increased while Chlorophyll content decreased in response to the exposure of the leaves to marble slurry in the selected tree species. Adjustment of the Chl a/b ratio was apparently an integral feature of acclimation to high slurry deposition on the phyllo-plane.

The relationship between the Chl a/b ratio and total Chlorophyll for the study species exhibited uniformity. On average, leaves with greater dust holding capacity had higher total Chlorophyll and correspondingly lower Chl a/b ratios than did leaves having lesser affinity for the suspended slurry particles. The result is a uniformly low Chl a/b in *Callistemon lanceolata.*

An increase in the Chl a/b ratio for leaves from the control plants may be viewed as a response to higher intracellular light intensity, (Terashima and Hikosaka 1995). Excess light per PSII core must be dissipated in order to avoid photodamage. Stress significantly reduced chlorophyll content but increased the Chl a/b ratio. This is because the reduction velocity of total chlorophyll rate increased with increasing stress.
The phenomena of chlorophyll loss in stress conditions have been reported in many plants (Balaguer et al., 2002; Steinberg et al., 1990). Reduction of leaf chlorophyll content which is under stress reduces photosynthetic efficiency in the plants. The plants that are able to maintain their chlorophylls can also have higher photosynthesis (Arabzadeh, 2009). According to survey results (this study) and studies of other researchers (Balaguer et al., 2002; Steinberg et al., 1990), it can be admitted that increase in stress is a major factor in the breakdown of chlorophyll, and is an essential obstacle in the process of making new chlorophylls. Chlorophyll fluorescence is considered as a strong indicator of photosynthesis and as a decisive factor in stress physiology (Misra et al., 2001, 2006, 2012).

Some of researchers believed that one of typical symptoms of oxidative stress is decreasing of chlorophyll content which may be the result of chlorophyll degradation or be due to chlorophyll synthesis deficiency or changes of thylakoid membrane structure (Bussis, 1998; Smirnoff, 1993). Indeed, stress due to suspended air particles can cause an oxidative stress due to the inhibition of the photosynthetic activity and imbalance between the light capture and its utilization (Foyer and Noctor, 2000). Therefore, we can suggest that an important approach for evaluating the photosynthetic process under stress caused by marble slurry is determination of chlorophyll content and chlorophyll a/b parameters and this method can be a rapid technique for detecting plants tolerance to such environmental conditions.

References

[1] Agarwal, S.K. and Sharma A.P. (1984): Air pollution induced deranged Pysiology in Plant - 1 changes pertaining to chlorophyll, carotene and Dalbergia sissoo Roxb. Acta Ecologia, 6, 37.
[2] Andy, C. (1991). Dictionary of environmental and development. Earth Scan Publications Ltd., London.
[3] Arabzadeh, N. (2009).The examination of dryness induction effect in growth, some of physiological relations (parameters of water relations), physiological changes and increasing of drought tolerance range in *Haloxylon persicum* and *H. aphyllum*, Thesis submitted for degree of Ph.D in plant physiology. Department of Biology Sciences, Teacher Training (Tarbiyat Moallem) University of Tehran.
[4] Araus, J.L. and Hogan, K.P. (1994).Leaf structure and patterns of photoinhibition in two neotropical palms in clearings and forest understory during the dry season. *American Journal of Botany*. 81:726–738.
[5] Arnon, D. (1949). Copper enzymes in isolated chloroplasts, polyphenol oxidases in Beta vulgaris.*Plant Physiol. J.* 24:1-15.
[6] Balaguer, L., Pugnaire, F.I., Martinez-Ferri , E., Armas, C., Valladares, F. and Manrique, E. (2002). Ecophysiological significance of chlorophyll loss and reduced photochemical efficiency under extreme aridity in *Stipatenacissima* L., *Plant Soil J.* 240:343-352.
[7] Bansal, S., (1988). “Studies on the effect of certain atmospheric pollutants on fruit diseases of *Lycopersicon esculentum* Mill. Caused by Alternaria alternate”, PhD thesis, Bhopal, Bhopal University.

[8] Bhatnagar, A.R., A.B. Vora and T.S. Patel, (1985). Measurement of dustfall on leaves in Ahmedabad and its effects on chlorophyll. Indian J. Air Pollut. Control, 6: 77-90.
[9] Bussis, D., Kauder, F. and Heineke, D. (1998.)“ Acclimation of potato plants to polyethylene glycol-induced water deficit. I. Photosynthesis and metabolism”. *J Exp Bot.* 49:1349–1360.
[10] Esmat, Ali. (1993). Damage to plants due to industrial pollution and their use as bioindicators in Egypt. Environmental pollution (Barking, Essex : 1987). 81. 251-5. 10.1016/0269-7491(93)90207-5.
[11] Evans, J.R. (1989.) Partitioning of nitrogen between and within leaves grown under different irradiances. *Australian Journal of Plant Physiology*. 16:533–548.
[12] Foyer, C. H. and Noctor, G. (2000).Oxygen processing in photosynthesis: regulation and signaling”. New Phytol. 146:359-388.
[13] Gareth, J., Alan, R., Jean, F. and Graham, H. (1992). *Environmental science.*
[14] Green, B.R. and Durnford, D.G. (1996). The chlorophyll-carotenoid proteins of oxygenic photosynthesis. *Annual Review of Plant Physiology and Plant Molecular Biology* .47:685–714.
[15] Lichtenthaler, H.K., Buschmann, C., Döll, M., Fietz, H.-J., Bach, T., Kozel, U., Meier, D., and Rahmsdorf, U. (1981). Photosynthetic activity, chloroplast ultrastructure, and leaf characteristics of high-light and low-light plants and of sun and shade leaves. *Photosynthesis Res.* 2:115- 141.
[16] Lovelock, C.E., Jebb, M. and Osmond, C.B. (1994). Photoinhibition and recovery in tropical plant species: response to disturbance. Oecologia ,97:297–307.
[17] Masinovsky, Z. Lozovaya, G.I. and Sivash, A.A.(1992). Some aspects of the early evolution of photosynthesis. *Adv. Space Res*. 12(4):199-205.
[18] Misra, A.N., Biswal, A.K. and Misra, M. (2002). Physiological, biochemical and molecular aspects of water stress responses in plants, and the biotechnological applications. *Proc. Nat. Acad. Sci*. 72(2):115-134.
[19] Misra, A.N., Latowski, D. and Strzalka, K. (2006). The xanthophylls cycle activity in kidney bean and cabbage leaves under salinity stress. *Russian J. Plant Physiol*. 53:102-109.
[20] Misra, A.N., Misra, M. and Singh, R. (2011). Nitric oxide ameliorates stress responses in plants. *Plant Soil Environ*. 57(3):95-100.
[21] Misra, A.N., Misra, M. and Singh, R. (2012). Chlorophyll fluorescence in plant biology. Biophysics. (Ed. Misra A N) ISBN 979-953-307-290-5.
[22] Misra, A.N., Srivastava, A. and Strasser, R.J. (2001a). Utilisation of fast Chlorophyll *a* fluorescence technique

in assessing the salt/ion sensitivity of mung bean and brassica seedlings. *J. Plant Physiol.* 158:1173-1181

[23] Misra, A.N., Srivastava, A. and Strasser, R.J. (2001b). Fast chlorophyll a fluorescence kinetic analysis for the assessment of temperature and light effects: A dynamic model for stress recovery phenomena. Photosynthsis PS2001. CSIRO Publ., Melbourne, Australia S3-007.

[24] Mulkey, S.S. and Pearcy, R.W. (1992). Interactions between acclimation and photoinhibition of photosynthesis of a tropical forest understory herb, *Alocasia macrorrhiza*, during simulated canopy gap formation. *Functional Ecology* 6: 719–729.

[25] Pandey DD, Sinha CS, & Tiwari MG (1991) Impact of coal dust pollution on biomass, chlorophyll and grain characteristics of rice. J Biol, 3: 51-55.

[26] Prusty, B.A.K., Mishra, P.C., and Azeez, P.A. (2005) “Dust accumulation and leaf pigment content in vegetation near the national highway at Sambalpur, Orissa, India” Ecotoxicology and Environmental Safety 60 (2005) 228–235

[27] Puckett, K.J., Nieboer, E., Flora W.P., and Richardson, D.H.S. (1973) “Sulphur dioxide: Its effect on photosynthetic 14C fixation in lichens and suggested mechanism of phytotoxicity” The New Phytologist, vol. 72, pp. 141–154.

[28] Raina, A.K., Rathore, V. and Sharma, A. (2008).Effect of stone crusher dust onleaves *Melia azadarach* linn. and *Dalbergia sissoo* roxb. in Jammu(J and K). *Natural Environ. Pollut . Technol.* 7: 279-282.

[29] Rao, D.N. and F. Le Blanc (1966). “Effect of SO2 on the lichen algae with special reference to chlorophyll.” Bryologist, 69, 69-75

[30] Ruth, A.E. and R .E. William (1994). The encyclopedia of the environment. Therene dubor centre for human environments, Houghton Miffin Company,USA.

[31] Sandelius, A.S., Naslund., K., Carlson, A.S., Pleijel, H., and Sellden, G., (1995) .“Exposure of spring wheat (Triticum aestivum) to ozone in open top chambers. Effects on acyl lipid composition and chlorophyll content of flag leaves”, The New Phytologist, vol. 131, pp. 231–239.

[32] Satisha, J., Prakash, G.S., Bhatt, R.M. and Kumar, P.S. (2007). Physiological mechanisms of water use efficiency in grape rootstocks under drought conditions. Int. J. Agric. Res. 2(2):159-164.

[33] Sharma, S.C. and Roy, R.K. (1997). Green belt-an effective means of mitigating industrial pollution. Ind. *J . Environ. Protect.* , 17, 724-727.

[34] Singh, N., Singh, S.N., Srivastava., K., Yunus, M., Ahmad, K.J., and Sharma S. C., (1990). “Relative sensitivity and tolerance of some Gladiolu s cultivars to sulphur dioxide”, Annals of Botany, vol. 65, pp. 41–44.

[35] Smirnoff, N. (1993). “The role of active oxygen in the response of plants to water deficit and desiccation”. *New Phytol*. 125:27–58.

[36] Sofi, P., Rather, A.G. and Zargar, M.Y. (2006). Breaking yield barriers in rice: Remodeling photosynthesis. *Am. J. Plant Physiol*. 1(2):113-126.

[37] Steinberg, S.L., Miller, J.C. and McFarland, M.J. (1990). Dry matter partitioning and vegetative growth of young peach trees under water stress. Australian J. *Plant Physiol*. 17:6-23.

[38] Terashima, I. and Hikosaka, K. (1995).Comparative ecophysiology of leaf and canopy photosynthesis. *Plant, Cell and Environment* 18:1111–1128.