Carpathian Journal of Earth and Environmental Sciences, February 2014, Vol. 9, No. 1, p. 163 - 169

STUDY OF AIR POLLUTION TOLERANCE INDEX (APTI) AND DISTRIBUTION PATTERN BY USING IMPORTANCE VALUE INDEX (IVI) OF PLANTS IN DISTURBED AND UNDISTURBED LOCALITY AROUND ANAND CITY (INDIA)

Mitul KOTECHA[1*], Kasturi NAIK[1] & Leena ABRAHAM[2]

[1]School of Environmental Science & Natural Resources, Doon University, Dehradun-248001, Uttrakhand, India
[2]Department of Biological & Environmental Sciences, N. V. Patel College of Pure & Applied Sciences, Anand-388001, Gujarat, India, e-mail: [*]mitulkotecha@ymail.com

Abstract: Air pollution tolerance index (APTI) is mostly used to select plant species tolerant to air pollution. The different physiological and biochemical parameters were used to develop APTI. In the present communication, we represent a comparative study to understand the effect of air pollution on vegetation composition in disturbed and undisturbed community investigated based on Importance Value Index (IVI). This study also suggest that plants have the potential to serve as excellent quantitative and qualitative indices of pollution as biomonitoring of plants is an important tool to evaluate the impact of air pollution on plants. Among the trees *Azadirachta indica* A.juss showed high degree of tolerance. Such plants species can be used as an important bioindicator and bioaccumulator along with economical importance.

Keywords: Air pollution tolerance index (APTI), Air Pollution, Importance Value Index (IVI), Bioindicator, Bioaccumulator, *Azadirachta indica* A.juss, *Acacia nilotica* L.Del.

1. INTRODUCTION

The Air pollution can be defined as the anthropogenic introduction of chemicals, particulate matter or biological materials into the atmosphere, which in considerable concentration cause harm or discomfort to humans, other living organism and also damages the environment (Rai, 2013). Air pollution can directly affects plants via leaves or indirectly via soil acidification. The main pollution in studied disturbed community is produced by combustion processes (auto transport). These can include sulphur and nitrogen oxides, carbon monoxide and soot particles as well as smaller quantities of toxic metals, organic molecules and radioactive isotopes (Agbaire & Esiefarienrhe, 2009).

In terrestrial plant species, the enormous foliar surface area acts as a natural sink for pollutants especially the gaseous ones, which have already been well documented (Dasgupta 1957, Keller & Schwanger 1977, Agarwal et al., 1991, Rayappa & Singaracharya 1993). Bannett & Hill (1973) have recorded the ability of plants to reduce air pollution. The efficiency of plants in absorbing pollutants is such that it can produce pocket of clean air (Gilbert, 1986). Bernatsky (1969) has suggested that green belts might help to reduce air pollution. Plants growing in air polluted environment often respond and show significant changes in their morphology, physiology and biochemistry (Bernatsky, 1969).

Plants develop characteristic response and symptoms to different types of pollutants and degrees of air pollution. Such information can be used in the field survey. The concept of plant as indicators of air pollution was firstly developed by Clements (1920). Sensitive plant species are suggested as bio-indicators (Tripathi et al., 1999; Raina & Sharma 2006). Different plant species showed a different behavior for different pollutants and any plant part could be indifferently used as biomonitors (Mingorance et al., 2007). Studies also showed the impact of air pollution on ascorbic acid content, chlorophyll content, leaf extract, pH and relative water content (Agbaire & Esiefarienrhe, 2009; Odilara et al., 2006; Raza & Murthy, 1988; Singh & Rao, 1983). These separate parameters gave conflicting results for same species however the air pollution tolerance index (APTI) based on all four parameters has been used for

identifying tolerance levels of plant species (Singh & Rao, 1983). Air pollution tolerance index is used by landscapers to select plant species tolerance to air pollution. The aim of the study is to determine the APTI values of keystone tree species.

2. SITE OF STUDY

In order to satisfy the objectives decided for the present study, two communities were selected in Gujarat state based on the level of pollution stress (Fig. 1 and 2).

Figure 1. Disturbed site

Figure 2. Undisturbed site

2.1. Disturbed Community

Air Pollution Tolerance Index (APTI) of plants growing around the National Highway No. 8, near Vadodara which is predominantly polluted area and a major transport corridor, was selected as a disturbed community (Fig. 1). This site is geographical located at 22^0 39" latitude and 73^0 14" longitudes.

2.2 Undisturbed Community

For the undisturbed community, the selection was done based on fact that ecosystem will be least polluted and hence plant community will be least under the pollution stress. A plant community near the Nature Park of Sindhrot was selected as an undisturbed community as (Fig. 2). This site is geographical located at 22^0 30" latitude and 73^0 18" longitudes.

3. MATERIALS AND METHODS

The analysis has been carried out for the selected disturbed and undisturbed community using basic ecological methods (Odum, 1971). For tree species, belt transect was laid (20m X 10m) while for undercover 1m X 1m quadrate was laid down in three replicates at each site. For recording the herbaceous understory vegetation, the quadrate was laid at the two extreme ends and in the centre of the belt transect. Density, frequency and dominance were obtained by measuring the Girth Breast Height (GBH). GBH was measured at the height of 1.37m and correspondingly the basal area was calculated. In each transect, all the stems having 30cm and above girth were considered as trees, while those measuring less than 30cm but greater than 3cm were considered as shrubs while others were considered as undercover or herbaceous population (Pande, 2005). Basal area (BA) of individual tree and Total Basal Area (TBA) of the forest were calculated as follows (Ravindranath et al., 2000).

$$BA\ (cm^2) = (GBH/2\pi)^2 \times \pi$$

$$TBA\ (\text{in } m^2 \text{ per ha}) = \sum BA/10{,}000$$

3.1. Primary Data Analysis

Field data collected was subjected to various ecological methods for assessment of the species diversity and dominance pattern of the selected sites. Different ecological indices were used to show the species compositional package and distribution pattern. These indices are:

3.1.1. Importance Value Index (IVI)

IVI = Relative Frequency (RF) + Relative Density (RD) + Relative Dominance (RDo) (Cottam & Curtis, 1956).

$$\text{RF of a species} = \frac{\text{No. of occurrence of species}}{\text{No. of occurrence of all the species}} \cdot 100$$

$$\text{RD of a species} = \frac{\text{No. of individuals of the species in all quadrates}}{\text{No. of individuals of all species in all quadrates}} \cdot 100$$

$$\text{RDo of a species} = \frac{\text{Total basal area of the species in all the quadrates}}{\text{Total basal area of all the species in all the quadrates}} \cdot 100$$

3.1.2 Index of General Diversity (H)

H = -∑ *(ni/N)* log*(ni/N)*, (Shannon & Weaver, 1949).

Where, ni = Number of individual of each species in all the quadrates & N = Total no of species.

3.1.3 Index of Dominance (C)

C = (ni/N) (Simpson, 1949).

Where, ni = Number of individual of each species in all the quadrates &N = Total no of species.

3.2. Measurement of APTI

This was done following the method of Singh & Rao, (1983). The formula of APTI is given as:

$$APTI = \frac{A(T+P)+R}{10}$$

Where, A = Ascorbic acid content (µg/ml)

T = Total chlorophyll mg/g

P = pH of leaf extract

R = Relative leaf water content of leaf (%)

3.2.1. Estimation of Ascorbic Acid

Estimation of Ascorbic acid content, a homogenate was prepared by using 4% Oxalic acid and was dehydrogenated by bromination. The dehydroascorbic acid was then added with 2, 4-dinitrophenyl hydrazine to form osazone and dissolved in sulphuric acid to give an orange – red colour solution which was measured at 540 nm using spectrophotometer (Arnon, 1949).

3.2.2 Estimation of Chlorophyll

0.5gm fresh leaves material was grounded and diluted to 10ml in distilled water. A sub-sample of 2.5 ml was mixed with 10ml acetone and filtered. Optical density was read at 645 nm and 663nm. Optical density of Total Chlorophyll (CT) is the sum of chlorophyll a (D645) density and chlorophyll a (D663) density (Arnon, 1949). Calculation:

mg Chlorophyll a/gm tissue =

= 12.7 (A663) --2.69(A645)*V /1000*W

mg Chlorophyll b/gm tissue =

= 22.9(A645) -4.68(A663)*V/1000*W

mg total Chlorophyll (per gm tissue) =

= 20.2(A645)+8.02(A663)*V/1000*W

Where, A=Absorbance at specific wavelengths, V=Final volume of chlorophyll extract in 80% acetone, W=Fresh weight of the tissue extracted.

3.2.3 Measurement of pH

This was done following the method adopted by 5gm of the fresh leaves was homogenized in 10ml of deionised water. This was filtered and the pH of the leaf extract determined after calibrating pH meter with buffer solution of pH 4 and 9 (Agbaire & Esiefarienrhe, 2009).

3.2.4 Measurement of Relative Leaf Water Content (RWC)

To determine the RWC, Following the method described by (Singh, 1977). Calculation:

RWC = [(FW-DW) / (TW-DW)] x 100

Where, FW = Fresh weight (gm), DW = Dry weight (gm), TW = Turgid weight (gm). Fresh weight was obtained by weighing the fresh leaves. The leaves were then immersed in water over night, blotted dry and then weighed to get the turgid weight. After that, the leaves were dried overnight in an oven at 70°C and reweighed to obtain the Dry weight.

4. RESULTS

The present investigation proved effective in bringing out difference in the air pollution tolerance of the keystone species for a disturbed and an undisturbed plant community. Air Pollution Tolerance Index (APTI) proved as effective tool in calculating the tolerance level of different species when compared to individual bio-chemical parameters such as pH of the plant extract, relative leaf water content, ascorbic acid content and chlorophyll content (Singh & Rao, 1983). Several other workers have advocated the use of APTI for comparing a disturbed and an undisturbed community (Agarwal et al., 1991; Odilara et al., 2006).

4.1. Phytodiveristy

Species diversity of the undisturbed site was found to be higher than disturbed sites for both tree species as well as undercover. The community floor comprised of few climbers, very few grasses and epiphytes.

4.2. Composition of Disturbed Site

Studies of the disturbed site revealed that the number of plant species (trees and herbs) was low when compared to undisturbed site. The maximum importance value index of tree species was that of *Acacia nilotica* L.Del. (92.88) followed by *Azadirachta indica* A.juss *(*55.09), (Table 1). The observation also shows that *Peltophorum pterocarpum* Backer has lowest IVI (20.61) in them. Composition of undercover is mainly controlled by density of the canopy cover. Gaps in the canopy cover promote very good growth of undercover due to better availability of light. Among undercover maximum IVI was found of *Achyranthus aspera* L. *i.e.* 118.6 (Table 2).

Table 1. Importance Value Index of Canopy Cover in Disturbed Site

Name of Species	Frequency	Density	Basal Area (cm^2)	RF	RD	RDo	IVI
Polyalthia logifolia B&H False	33.33	1.33	0.31	11.11	11.76	03.12	25.99
Azadirachta indica A.juss	66.66	2.33	1.25	22.22	20.59	12.28	55.09
Acacia nilotica L.Del.	66.66	3.33	4.21	22.22	29.41	41.25	92.88
Albizia lebbeck Benth	33.33	0.66	0.57	11.11	05.88	05.63	22.62
Peltophorum pterocarpum Backer	33.33	0.33	0.66	11.11	02.94	06.56	20.61
Calotropis procera R.Br	33.33	0.66	0.63	11.11	05.88	06.24	23.23
Cesalpinia pulcherima Swarz	33.33	2.66	2.54	11.11	23.53	24.95	59.59

Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo).

Table 2. Importance Value Index of Undercover in Disturbed Site

Name of Species	Frequency	Density	Basal Area(cm^2)	RF	RD	RDo	IVI
Ziziphus mauratiana Lamk	33.33	3.00	0.18	12.50	16.07	37.97	66.54
Achyranthus aspera L.	100.0	9.66	0.14	37.50	51.78	29.40	118.6
Parthenium hysterophorus L.	33.33	1.66	0.01	12.50	08.92	03.92	25.35
Sida acuta Burn	33.33	2.00	0.07	12.50	10.71	15.57	38.78
Abutilon indicum L.	66.66	2.33	0.06	25.00	12.50	13.12	50.62

Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo).

4.3. Composition of Undisturbed Site

Species composition of the undisturbed site was found to be higher due to lack of disturbance. Maximum IVI was that of *Acacia nilotica* L.Del. (119.00) followed by *Azadirachta indica* A.juss (54.62), (Table 3). However among the undercover species, *Launaea procumbans* L. showed highest IVI values i.e. 115.8 (Table 4).

4.4. Diversity and Dominance Index

Shannon function or H index, which gives the picture of general diversity of any ecosystem while Simpson dominance Index predicts basically the heterogeneity of community. The diversity and dominance values for undercover and canopy cover for disturbed and undisturbed community is depicted in (Table 5).

4.5. APTI Measurements

APTI calculation was successful in bringing out important results.

4.5.1 Ascorbic Acid

Ascorbic acid content was found to be higher in tree species of disturbed area when compared to undisturbed area (Tripathi & Gautam, 2007). Among tree species *Azadirachta indica* A.juss showed highest ascorbic acid level in disturbed site (Table 6).

4.5.2 Total Chlorophyll Content

The chlorophyll content of the *Azadirachta indica* A.juss of undisturbed area was 29.34 mg/gm, which is more than the same species of disturbed area which is 21.58 mg/gm (Tripathi & Gautam, 2007). So from this result we can say that plant of disturbed area is under stress which leads to decrease in chlorophyll content (Table 6).

4.5.3 Measurement of pH

pH of the key stone species is slightly acidic. The key stone species *Acacia nilotica* L.Del. of undisturbed area is more acidic than that of the disturbed area. The pH is 6.5 and 6.8 respectively, (Table 6).

4.5.4 Relative Leaf Water Content (RWC)

RWC of stressed plants were found to be more than non stressed plants (Tripathi & Gautam, 2007). The relative leaf water content of the *Acacia nilotica* L.Del. is highest 88% of disturbed area followed by *Azadirachta indica* A.juss 64% (Table 6).

4.5.5 Air Pollution Tolerance Index (APTI)

After all the biochemical estimations, APTI was calculated. From the present study it was found that *Azadirachta indica* A.juss is the most air pollution tolerant tree species. An APTI value of *Azadirachta indica* A.juss was found to be higher than *Acacia nilotica* L.Del. (Table 7, 8).

5. DISSCUSION AND CONCLUSIONS

Ascorbic acid acts as antioxidants and protects the cell membrane from the toxic action of powerful oxidizing agent (Raza & Murthy, 1988).

Table 3. Importance Value Index of Canopy Cover in Undisturbed Site

Name of Species	Frequency	Density	Basal Area (cm^2)	RF	RD	RDo	IVI
Balanites aegyptica L.Del.	66.70	1.33	01.1	11.76	04.65	01.33	17.75
Azadirachta indica A.Juss	100.0	6.67	11.6	17.65	23.26	13.71	54.62
Acacia nilotica L.Del.	100.0	9.33	58.3	17.65	32.56	68.80	119.0
Streblus asper Lour	100.0	2.67	04.9	17.65	09.30	05.88	32.83
Holoptelea integrifolia Planch	66.70	3.67	0.00	11.76	12.79	00.00	24.56
Pithocelobium dulci Benth	33.30	1.00	06.1	05.88	03.49	07.23	16.60
Wrightia tinctoria R.Br	66.70	3.00	01.2	11.76	10.47	01.43	23.66
Discrostachys cineria L.Wt & Arn	33.30	1.00	01.3	05.88	03.49	01.61	10.98

Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo).

Table 4. Importance Value Index of Undercover in Undisturbed Site

Name of Species	Frequency	Density	Basal Area (cm^2)	RF	RD	RDo	IVI
Withania somnifera Dunal	66.70	5.00	0.06	13.33	09.43	09.31	32.08
Launaea procumbans L.	66.70	18.6	0.45	13.33	35.22	67.33	115.8
Sida rhombifolia Var.Ratusamas	33.30	1.00	0.008	06.67	01.88	01.27	09.82
Achyranthus aspera L.	66.70	3.33	0.01	13.33	06.28	01.69	21.31
Sehima nervosum L.	66.70	9.33	0.01	13.33	17.61	02.10	33.04
Corchorus acutangula Lam.	66.70	5.67	0.06	13.33	10.69	09.66	33.68
Acalypha indica L.	33.30	2.33	0.03	06.67	04.40	05.13	16.20
Ocimum basilicum L. var thysiflora Benth.	33.30	1.00	0.004	06.67	01.88	00.69	09.24

Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo).

Table 5. Dominance and Diversity Index of Selected Site

Indices	Floristic Composition	Disturbed Site	Undisturbed Site
Diversity Index	Canopy Cover	0.74	0.78
	Under Cover	0.58	0.80
Dominance Index	Canopy Cover	0.20	0.20
	Under Cover	0.33	0.19

Table 6. Biochemical Parameters of Important Species of the Selected Sites

Study Area	Species	Ascorbic Acid (µg/ml)	Total Chlorophyll Content (mg/gm)	RWC (%)	pH
Disturbed site	*Acacia nilotica* L.Del.	4.19	07.70	88	6.8
	Azadirachta indica A.juss	5.00	21.58	64	6.6
	Achyranthus aspera L.	0.87	38.12	22	6.4
Undisturbed site	*Acacia nilotica* L.Del.	2.81	10.86	71	6.5
	Azadirachta indica A.juss	2.19	29.34	54	6.6
	Launaea procumbans L.	1.10	32.12	52	7.0

Table 7. APTI for Disturbed Site

Site	Species	APTI Values
Disturbed site	*Acacia nilotica* L.Del.	14.87
	Azadirachta indica A.juss	19.30
	Achyranthus aspera L.	06.07

Table 8. APTI for Undisturbed Site

Site	Species	APTI Values
Undisturbed site	*Acacia nilotica* L.Del.	11.97
	Azadirachta indica A.juss	13.27
	Launaea procumbans L.	09.50

Its strong ability to work under stress condition was well depicted from the results as the trees species viz. *Azadirachta indica* A.juss and *Acacia nilotica* L. Del. showed high levels under pollution stress in disturbed site in the present work. Being a very important reducing agent, ascorbic acid also plays a vital role in cell wall synthesis, defence and cell division (Conklin, 2001). Its reducing power is directly proportional to its concentration (Raza & Murthy, 1988). However it's reducing activity is pH dependent.

High pH may increase the efficiency of conversion from hexose sugar to Amino Acid (AA), while low leaf extract pH showed good correlation with sensitivity to air pollution (Agarwal et al., 1991). Measurement of pH is one of the most common and useful analytical procedures in biochemistry since the pH determines many important aspects of structure and activity of biological macromolecules. In our study of APTI of disturbed and undisturbed area the pH of the tolerant species is slightly acidic.

The total chlorophyll content of the plants in disturbed sites was found to be much lower than the plants found in undisturbed site. High levels of automobile pollution decreases chlorophyll content in higher plants near roadsides (Tripathi & Gautam, 2007). Photosynthetic efficiency was noted strongly dependent on leaf pH. Photosynthesis reduced in plants when the leaf pH was low (Agarwal et al., 1991).

The relative leaf water content in a plant body helps in maintaining its physiological balance under stress conditions such as exposure to air pollution when the transpiration rates are usually high (Raina & Sharma, 2006). If the leaf transpiration rate reduces due to the air pollution, plant cannot live well due to losing its engine that pulls water up from the roots to supply photosynthesis. Relative leaf water content of the tolerant species of disturbed area is higher than that of undisturbed area. In the present study it was found that *Acacia nilotica* L.Del. showed much higher Relative leaf Water Content (RWC) when compared to all other plants indicating its drought resistant property.

The observations in this study suggest that plants have the potential to serve as excellent quantitative and qualitative indices of pollution. Since biomonitoring of plants is an important tool to evaluate the impact of air pollution on plants. Thus the results of the study reveal that the tolerant plant species such as *Azadirachta indica* A.juss and *Acacia nilotica* L. Del. serve as sink to air pollutants, act as an indicator and are also economically very important plants.

APTI determinations are of importance because with increase in industrialization and vehicular emissions. The results of such studies are therefore handy for future planning. It is worth noting that combining a variety of parameters gave a more reliable result than when based on a single biochemical parameter. This study also provides useful information to select tolerant species fit for landscape on sites continuously exposed to air pollutants. The results showed that *Azadirachta indica* A.juss among the trees showed high degree of tolerance. Such species can be used as bio indicators. By this study we can conclude that plantations which are done along the side of the road may include these species so that air pollution can be controlled to certain extent.

REFERENCES

Agarwal, Singh, M. J. & Rao, D. N., 1991. *Biomonitoring of air pollution around urban and industrial sites.* Environ, BIO 211-222.

Agbaire, P. O. & Esiefarienrhe, E., 2009. *Air Pollution Tolerance Indices of Some Plants around Otorogun Gas Plants in Delta State, Nigeria.* Journal of Applied Sciences and Environmental Management, 13:11-14.

Arnon, D. I., 1949. *Copper enzymes in isolated chloroplasts polyphenol oxidase in Beta vulgaris.* Plant Physiol, (24) 1-15.

Bannett, J. H. & Hill, H. C., 1973. *Inhibition of apparent photosynthesis by air pollutants.* J. Environ. Qual, (2): 526-530.

Bernatsky, A., 1969. *Proc. First European conger. On the influence of air pollution on plants and animals.* wageningen, pp. 383-395.

Clements, F. E., 1920. *Plant Indicators, The relation of plant communities to process and practice.* Carnegie Inst. Wash., Publ. No. 290-388.

Conklin, P. L., 2001. *Recent advances in the role and biosynthesis of ascorbic acid in plants.* Plant Cell Environ, (24): 383-394.

Cottam, G. & Curtis, J. T., 1956. *The use of distance measures in physiological sampling.* Ecology, 37: 451-460.

Dasgupta, S. N., 1957. *Air Pollution in relation to plant disease. Presidential address, section of Botany,* 45th session. Proc. Indian Sci. Cong. Associ, 43:88-107.

Gilbert, O. L., 1986. *Biological indicators of air pollution,* Ph.D. Thesis, univ. of New castle.

Keller, T. & Schwanger, H., 1977. *Air pollution and ascorbic acid.* European Jour, pathology, 7: 338-378.

Mingorance, M. D., Valdes, B. & Oliva, S. R., 2007. *Strategies of heavy metal uptake by plants growing under industrial emissions.* Environ. Intern; 33: 514-520.

Odilara, C. A., Egwaikhide, P. A. & Esekheigbe, A., Emua, S. A., 2006. *Air pollution Tolerance Indices (APTI) of some plant species around llupeju Industrial Area, Lagos.* Journal of Engineering Science and Applications, 4(2)97-101.

Odum, E. P., 1971. *Fundamentals of Ecology,* 3rd Edition. W. B. Saunders and Co., Philadelphia, USA, pp. 574.

Pande, P. K., 2005. *Ecological Assessment of Vegetation in JFM Adopted Village Forests in Satpura Plateau, Madhya Pradesh.* The Indian Forester, 131(1): 97-114.

Rai, P. K., 2013. *Environmental magnetic studies of particulates with special reference to biomagnetic monitoring using roadside plant leaves.* Atmos. Environ. 72:113-129.

Raina, A. K. & Sharma, A., 2006. *Assessment of air pollution and its impact on the leaves of some plant species.* Pollute. Res, 25: 543-547.

Rayappa, M. & Singaracharya, M. A., 1993. *Pollution tolerance index in some common plants around some major industries in Warangal city Andhrapradesh.* Poll. Res, 12: 57-59.

Raza, S. H. & Murthy, M. S. R., 1988. *Air Pollution Tolerance index of certain plants of Nacharam Industrial Area, Hyderabad.* Indian J. Bot, 11(1): 91-95.

Ravindranath, N. H., Murali, K. S. & Malhotra, K. C., (Editors) 2000. *Joint Forest Management and Community Forestry in India: An Ecological and Institutional Assessment.* Oxford & IBH Publishing Co., New Delhi, India, pp. 318–324.

Shannon, C. E. & Weaver, W., 1949. *The Mathematical Theory of Communication.* University of Illinois Press, Urbana, Illinois. pp. 144.

Simpson, E. H., 1949. *Measurement of Diversity.* Nature, 163: 688.

Singh, A., 1977. *Practical plant Physiology.* Kalyani Publishers. New Delhi, pp. 266.

Singh, S. K. & Rao, D. N., 1983. *Evaluation of plants for their tolerance to air pollution.* Symp. On Air Pollution Control. New Delhi, Proceedings. pp. 218-224.

Tripathi, A., Tripathi, D. S. & Prakash, V., 1999. *Phytomonitoring and NOx pollution around silver refineries.* Environ. Pollute, (25) 403-410.

Tripathi, A. K. & Gautam, M., 2007. *Biochemical parameter of plants as indicator of air pollution.* J. Environ. Bio, (28) 127-132.

Received at: 27. 04. 2013
Revised at: 06. 01. 2014
Accepted for publication at: 12. 01. 2014
Published online at: 17. 01. 2014