World Journal of Environmental Biosciences
eISSN 2277- 8047 Available Online at:
www.environmentaljournals.org
Volume 3, Issue 2: 116-120

Open Access **Research Article**

Air Pollution Tolerance Index Assessment of *Quisqualis indica* Linn. in Pollution Prone Areas of Thiruvananthapuram District in Kerala State, India

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Abstract:
The study was undertaken with the objective to assess the pollution induced changes in major physio-biochemical parameters in the plant *Quisqualis indica* Linn. in various types of land use patterns in the selected stations of Thiruvananthapuram district in Kerala state, India. The study also aims to evaluate the air pollution tolerance index (APTI) of *Quisqualis indica* Linn. and to find whether it is sensitive or tolerant to air pollution. The present study was conducted in Thiruvananthapuram district in Kerala in June–July of the year 2013. The results of the study showed that APTI values of the study plants in different study stations ranged from 6.26 to 13.43. The plants in station IV, Karamana, the station with high vehicular intensity showed lowest APTI values compared to that in other stations studied. The *Quisqualis indica* Linn. plants in control station (Chempakamangalam) showed highest air pollution tolerance index values. The study reveals that *Quisqualis indica* Linn. plants are sensitive to pollution, and it can serve as an indicator species of air pollution.

Keywords: APTI index, Ascorbic acid, chlorophyll, Relative water content, *Quisqualis indica* Linn.

1.0 Introduction:
Air pollution in roadsides and the industrial areas are the major consequences of environmental problems. The absorption of gaseous pollutants by plants provide natural means of cleansing the atmosphere and they act as effective indicators of air pollution (Rai *et al.,* 2009). The indiscriminate discharge of untreated industrial and domestic effluents, the spew out of thousands of tons of particulates and air borne gases into the atmosphere, the "throw away" attitude towards solid wastes and the use of newly developed chemicals without considering potential consequences have resulted in major environmental disasters. The air pollution is increased in the roadsides of Thiruvananthapuram, the capital city of Kerala, primarily due to the emissions of various industries, motor vehicles and other types of gasoline powered transportation (Singh and Chakraborty, 2010). Bio-monitoring of plants is an important tool to assess the impact of air pollution on plants.

Ecological indicators can be used to assess the condition of the environment, to provide an early warning signal of changes in the environment or to diagnose the cause of an environmental problem. Ideally the suite of indicators should represent key information about structure, function and the composition of the ecological system. As habitat fragmentation, changes in the ecological condition, and loss of biodiversity escalate, society turns to science for guidance on dealing with the complex environmental issues (Noss and Cooperrider, 1994). Ecological indicators have several purposes (Cairns *et al*., 1993) and leaf is the most sensitive part to be affected by air pollutants as major physiological processes are concentrated in the leaf (Renjini and Janardhanan, 1989). Plants are exposed to many harsh and unavoidable environmental stress conditions, which will affect their developmental, physiological, biochemical, morphological and molecular integrity. The air pollution tolerance index is based on four parameters, namely total chlorophyll, ascorbic acid, pH and relative water content, which have been used for identifying tolerance levels of plant species (Tripathi and Gautam, 2007). The ability of each plant to absorb pollutants by their foliar surface varies greatly and depends on several biochemical, physiological and morphological characteristics. The sensitive species helps to indicate air pollution and tolerant ones help in abatement of air pollution (Singh and Verma, 2007). The tolerant species of plants function as pollution sink and therefore a number of environmental benefits can be obtained by planting tolerant and sensitive species in polluted areas.

The plant selected for the present study was *Quisqualis indica* Linn. (Combretaceae) is a climber for the tropics, sub tropics and warm temperate regions which is found in Asia and grown widely in many parts of India. A fresh green leaf set off clusters with pendulous trumpet shaped blooms open first, first white and then turn pink and even deep pink and then bright or reddish purple over three days period displaying the various coloring stages. It is mainly an ornamental plant, but almost all parts of the plant can be used. It was used as traditional medicines and over as long period of time either used individually or it was given with other synergistic ingredients simultaneously. Generally the parts which are traditionally used plant parts are leaves, flowers, seeds, fruits and roots. These parts contains some active ingredients which is responsible for particular pharmacological activity, but it will taken under some expert supervision as it giving some side effects also such as stomach aches or headaches, especially when the seeds will taken freshly or eaten frequently (Jyoti *et al*., 2012).
The aim of the present study is to evaluate the changes in pigment content and biochemical constituents in *Quisqualis indica* Linn. plants in the pollution prone areas of Thiruvananthapuram district in Kerala, and to assess the air pollution tolerance index of *Quisqualis indica* Linn. plants.

2.0 Materials and Methods:

2.1. Study Area

The study area is in Thiruvananthapuram district, located in Kerala state, South India. A detailed field study was conducted to select stations of various land use types with the plant species, *Quisqualis indica* Linn. Seven study stations were selected including one control station. The roadside stations are Mangalapuram (S I), 20 km away from Thiruvananthapuram Central Railway Station ;Kazhakuttom (S II), 14 km away from Thiruvananthapuram Central Railway Station; Murinjapalam (SIII), 4 km away from Thiruvananthapuram Central Railway Station; Karamana (SIV), 1 km away from Thiruvananthapuram Central Railway Station); the Travancore Titanium Product Ltd. industrial area station, Veli (SV), 8 km away from Thiruvananthapuram Central Railway Station; and clay mining area, Sasthavattom (S VI), 27 km away from Thiruvananthapuram Central Railway Station. The control station selected is in Chemapkamangalam (S VII) that is situated 24 km away from Thiruvananthapuram Central Railway Station and is in a benign environment. Description of the study stations is given in Table 1.

2.2. Plant materials

Quisqualis indica Linn. plants with flowers (Fig.1) were collected and identified using the keys in 'Flora of the Presidency of Madras'. The plant samples were collected from the selected study stations during the months, June and July, of the year 2013.

Fig 1: *Quisqualis indica* Linn.

The morphological characteristics of the plants in the study stations were noted. Fresh mature leaf samples from the selected stations were collected in labeled polythene bags. Leaves were washed thoroughly with distilled water to make it free from dust and pest, adhered on the samples. Then cut into small pieces avoiding veins and mixed properly, to get composite sample of each plant species. Replicates of each sample were taken for the estimation of the biochemical parameters following the standard procedures.

Total chlorophyll concentration was determined following the procedures of Sadasivan and Manickam (1997). The chlorophyll was extracted in cold 80% acetone and the absorption at the wavelengths 663nm and 645 were measured using a spectrophotometer. Leaf extract pH of the sample was analyzed by the method suggested by Singh and Rao (1983). Fresh leaf sample was homogenized using deionised water and the supernatant obtained after centrifugation was collected for the determination of pH using a digital pH meter. Relative water content (RWC) of the samples was calculated by the method proposed by Barrs and Weatherley (1962) and Singh (1977). The relative water content in terms of percentage was computed by using the fresh weight, turgid weight and dry weights of the leaf samples. The total ascorbic acid content in the plant samples were determined by spectrophotometry (Sadasivan and Manickam, 1996). For the determination of ascorbic acid content, a homogenate was prepared by using 4% oxalic acid and was dehydrogenated by bromination. The dehydroascorbic acid was then reacted with 2,4-diphenylhydrazine to form osazone and dissolved in sulphuric acid to give an orangish red coloured solution and the absorbance was measured at 540 n.m.

Air pollution tolerance index (APTI) was determined based on the four important leaf parameters namely total chlorophyll, ascorbic acid, pH and relative water content (Singh and Rao, 1983).

$$APTI = A (T+P) + R/10$$

Where, A = Ascorbic acid, T = Total Chlorophyll,
P = Leaf Extract pH, R = Relative Water Content.
The APTI index range is as follows:

APTI value : Response
<1 : Very sensitive
1 to 16 : Sensitive
17 to 29 : Intermediate
30 to 100 : Tolerant

3.0 Results and Discussion:

3.1. Changes in Total chlorophyll:

Total chlorophyll concentration in the plant samples varied from 0.514 mg/g f.wt to 0.897 mg/g f.wt (Table 2). The total chlorophyll content was lowest in the plants in Travancore Titanium factory area and highest concentration was reported in the plants in Station VII, the control station. The photosynthetic pigments are the most likely to be damaged by air pollution. Chlorophyll pigments exist in highly organized state and under stress they may undergo several photochemical reactions such as oxidation, reduction, pheophytinisation and reversible bleaching. Hence any alteration in chlorophyll concentration may change the morphological, physiological and biochemical behavior of the plant (Zengen and Kirbag, 2007).

3.2. Changes in pH:

The *Quisqualis indica* leaves from selected stations in the study area showed acidic pH. The pH of the plant sample varied from 4.11 to 5.41 (Table 2). The pH was detected lowest (4.11) in the plants in Station IV, Karamana, and the pH (5.41) was recorded highest in the Station I (Mangalapuram). The pH helps in the physiological responses caused by stress, pH changes influence the stomatal sensitivity and leaves with low pH are more susceptible to pollution, mainly the samples with slightly neutral pH are more tolerant (Krishnaveni, 2013). In the rainy season, dust accumulation is least due to the washing of leaves, which may be the cause of low leaf extract pH (Das and Prasad, 2010). Altering the pH of the leaf surface and that of extract, is highly damaging and is the primary cause of reduction in chlorophyll contents (Shweta, 2012). Study on physiological and biochemical changes in the evergreen trees in the road side areas of Thiruvananthapuram was done by Jyothi (2011) reported that the pH of the leaf samples ranged from 4.3 to 6.9,which may be due to the presence of acidic air pollutants and soil characteristics of that particular area.

3.3. Changes in Ascorbic acid:

The concentration of ascorbic acid, the non enzymatic antioxidant in the leaf samples varied from 0.566 mg/g f.wt to 2.468 mg /g f.wt (Table 2), and the concentration of ascorbic acid recorded highest (2.468 mg /g f.wt) in the control station. The plants in Station II (Kazhakuttom) showed lowest ascorbic acid content (0.566 mg/g f.wt). Ascorbic acid is a very important metabolite in plants and it activates the resistance mechanism in plants under stress. Present study shows changes in the level of ascorbic acid content in *Quisqualis indica* Linn. in different land use areas, and depends on the variations in the pollution stress factors in these areas.

3.4. Changes in Relative Water Content:

The relative water content in the *Quisqualis indica* Linn. leaves in different stations varied from 47.48 % to 73.66 % (Table 2). The plant leaves from the station I showed highest relative water content (73.66 %) and the lowest concentration (47.48 %) was estimated in the plants in the control station.

Table 1: Description of Study Stations

Station	Land use Type
Station I (Mangalapuram)	Road side area
Station II (Kazhakuttom)	Road side area
Station III (Murinjapalam)	Road side area
Station IV (Karamana)	Road side area
Station V (Veli Travancore Titanium Pvt. Ltd)	Industrial area
Station VI (Sasthavattom)	Mining site
Station VII (Chempakamangalam)	Benign environment

Table 2: Leaf Parameters and Air Pollution Tolerance Index of *Quisqualis indica* Linn

Station	pH	Total Chlorophyll (mg/g FW)	Total Ascorbic acid(mg/g FW)	Relative Water Content (%)	Air Pollution Tolerance Index(APTI)
S I	5.41	0.626	0.924	73.66	8.063
S II	5.41	0.533	0.566	66.18	6.945
S III	5.17	0.698	1.29	56.6	9.352
S IV	4.11	0.601	1.497	55.6	6.265
S V	4.72	0.514	1.298	64.83	9.319
S VI	5.20	0.698	0.888	52.42	7.772
S VII (Control)	5.20	0.897	2.464	47.48	13.43

3.5. Air Pollution Tolerance Index:

The Air Pollution Tolerance Index values have been extensively used to rank plant species in their order of tolerant or sensitivity to air pollution. The air pollution tolerance indices (APTI) of *Quisqualis indica* Linn. in different study stations ranged from 6.26 to 13.43 (Table 2). The plants in station IV, Karamana, with high vehicular intensity showed lowest air pollution tolerance index (6.26) compared to other stations, while the control station, Chempakamangalam showed highest value (13.43). Many reports have indicated that the species with low APTI values are sensitive to air pollution (Lakshmi *et al*., 2008; Babu *et al*., 2013). The level of APTI exclusively depends on the intrinsic nature of each species since the level of total chlorophylls, ascorbic acid, pH and relative water contents varies greatly from species to species. The station VII (Control station - Chempakamangalam) showed higher values of air pollution tolerance index (APTI) for *Quisqualis indica* and may be due to the presence of increased concentration of total chlorophyll, ascorbic acid, pH in leaves. Also the relative water content was comparatively lower in the control station plant leaves. The lowest value for air pollution tolerance index (APTI) was reported in the plants of stations, S II (Kazhakuttom) and S IV (Karamana).

4.0 Conclusions:

The air pollution tolerance index (APTI) of *Quisqualis indica* Linn. in different study stations were determined for identifying tolerance levels of the plant species. APTI values in the plants in different study stations ranged from 6.26 to 13.43. The plants in station IV, Karamana showed lowest APTI values compared to other stations while the plants in control station, Chempakamangalam showed highest air pollution tolerance index. The physio-biochemical parameters such as chlorophyll, ascorbic acid, pH can affect the air pollution tolerance index values. The reduction in air pollution tolerance index of *Quisqualis indica* Linn. from the control station (benign environment) to other polluted environments (roadside and industrial areas) shows that *Quisqualis indica* Linn. is sensitive to pollution and it act as an indicator species of air pollution.

5.0 Acknowledgement:

The authors are thankful to the Head, Department of Environmental Sciences, University of Kerala for the laboratory and library facilities provided for this study.

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