



Biomonitoring the impact of air pollution on plants by air pollution tolerance index in Amlī industrial estate

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Abstract

Biomonitoring allows for more sustainable and easier study of environmental impacts. It is possible to gauge the severity of air pollution in a certain area by consulting the air pollution tolerance index. The APTI is determined by taking into account the four most important biochemical characteristics in plants. To get the APTI, we combine the ascorbic acid, total chlorophyll, and relative water content of the leaf. How sensitive or resistant a plant is to air pollution is shown by its APTI rating. In the study eight plants (Trees and Shrub) are taken from different parts of industrial area and their APTI was calculated. The shrubs in study could be used for landscaping and development of green belt of the area. This study was conducted in the Amlī industrial region, which is home to numerous chemicals, pharmaceutical, packaging, and textile industry, is known for both industrial and vehicular pollution. This study was conducted there. Research revealed that among shrubs, *Ixora coccinea*, or jungle geranium, has the highest APTI (13) and *Cupressus macrocarpahas* the lowest APTI (7), Among trees *Tecoma stans* (trumpet vine) was found to have highest APTI (12) and lowest is *Artocarpus heterophyllus* (8). The correlation between the various parameter and APTI was statically done.

Keywords: APTI, air pollution, plants, industrial and vehicular pollution, sensitive, tolerant

Introduction

Anthropogenic activities such as the disposal of garbage, the improper burning of fossil fuels, the use of firewood in cooking, and the production of various hazardous that are toxic to living things are the main causes of pollution. The oxygen we breathe is one of our body's primary energy sources. The primary necessity of all living things is air, but due to industrial and vehicular pollution, this basic need is no longer met. In addition to seriously harming plants and other living things, air pollution causes several health problems for human being.

Anonym (2008) states that when chemicals, particulate matter, or harmful organisms are released into the air, they contribute to air pollution. This, in turn, hurts or discomforts humans and other living things, and has a negative effect on the environment. Numerous research investigations have been conducted regarding air pollution (Khanna *et al.*, 2013^[10]; Khanna *et al.*, 2014)^[9].

Plants are one of the most important components of ecosystem. The plant are immobile so there are more chances of them being impacted by ambient air pollution, as plants are immobile, they are continuously exposed by the pollutant present in the air and they can be directly correlated with the level of pollution. Different pollutants affect distinct responses in plants, and every part of a tree can serve as a bio-monitor (Migorance *et.al* 2007). As they are essential to maintaining the gaseous and nutrient cycles, plants play a critical role in maintaining the equilibrium of the ecosystem. Many scientists concur that air pollution has a negative impact on plant growth (Swami, A *et.al* 2004^[19], Roa *et.al* 1991)

Due to their abundance and wide surface area, leaves are highly exposed to air pollution, which causes them to exhibit noticeable symptoms. Because of their exceptional

ability to absorb contaminants, plants can produce zones with clean air (Gilbert, 1968). The effects of air pollution on plants have been the subject of much research and writing. [Dasgupta, 1957; Keller, 1983; Agarwal *et al.*, 1991; Yunus and Iqbal, 1996^[27]; Krupa, 1997; Iqbal *et al.*, 2000] etc. According to Lakshmi *et al.* (2009)^[12], more delicate plant species can be used as biological indicators of air pollution. Air pollution may harm plants in two ways: first, through their leaves, and second, by the acidity of the soil (L. Steubing *et al.*, 1989)^[20]. Sox, NO_x, CO, and soot particles are among the gases and particulates released into the air by cars and industries. Also, they don't let out as many harmful metals and chemical compounds, which can stunt plant development. It has been shown that dust can affect the efficiency of stomatal function, photosynthesis, and leaf production (M Chaurasia *et al* 2022^[14], S Zia-Khan *et al* 2014^[17], A Torahi, *et.al* 2021). Metabolic changes in plants are useful for studying air pollution. An effective approach for assessing many plants for air pollution vulnerability is the APTI evaluation. In order to determine an individual's APTI, four crucial biological procedures are employed. The ingredients that the APTI uses include ascorbic acid, chlorophyll, the leaf's relative water content, and the pH of the leaf extract. Plants can be categorized as either tolerant or sensitive using APTI. Plants with a low APTI are very vulnerable to air pollution, whereas those with a high APTI can withstand it. One application for the tolerant species is in land scaping or green belts, while another is as bioindicators.

Material and methods

Located in the union territory of Dadra and Nagar Haveli, Daman and Diu, Amlī Industrial Estate is a center for small-scale companies. Located about 13 miles (21 km) southeast

of Daman and about 15 miles (25 km) inland from the Arabian Sea lies the union territory. Its location on the Ganga Daman River is ideal. Its precise location is at the intersection of 73.008308 E and 20.276266 latitude. The GPS coordinates of Dadra and Nagar Haveli are 20° 16' 34.5576' N and 73° 0' 29.9088' E. The climate of Dadra and Nagar Haveli is mild. Temperatures range from 11.6

degrees Celsius at night to 37.2 degrees Celsius during the day. The area experiences its most rains from June to September, with humidity levels ranging from 24 to 100%. About 1830 mm of rain had fallen in the area. The Amli industrial area was selected for the study due to the abundance of chemical, textile, pharmaceutical, plastic rubber and packaging industries in the vicinity.



Fig 1: Map showing the study area selected for APTI evaluation

Methodology

Sampling

Researchers in Amli looked examined the APTI values of eight types of natural plants. It was between eight and nine in the morning that we collected leaves from specific plants. Samples were taken from each species three times. We took

every precaution to ensure that each plant species was exposed to the identical levels of light, water, soil, and pollutants. The leaf extract was evaluated for ascorbic acid, chlorophyll, pH, and relative water levels in the samples that were collected.

Table 1: List of the plant species in the study and their characteristics

Sr.No.	Scientific name	Common name	Life form	Life span	Family	Native
1	<i>Artocarpus heterophyllus</i>	Jackfruit	Tree	Perennial	Moraceae	Tropical Asia
2	<i>Syzygium cumini</i>	Jamun, Java plum	Tree	Perennial	Myrtaceae	Southeast Asia, Indian subcontinent
3	<i>Tecoma stans</i>	Trumpet vine	Tree	Perennial	Bignoniaceae	West Indies, Mexico to Peru.
4	<i>Tabernaemontana divaricata</i>	Pinwheel	Shrub	Perennial	Apocynaceae	South Asia, Southeast Asia and China.
5	<i>Ixora coccinea</i>	Jungle geranium	Shrub	Perennial	Rubiaceae	Southern India, Bangladesh, and Sri Lanka.
6	<i>Hibiscus rosa-sinensis</i>	Show flower	Shrub	Perennial	Malvaceae	Southwestern China, South Asia,
7	<i>Nerium oleander</i>	Kaner	Shrub	Perennial	Apocynaceae	Mediterranean Basin
8	<i>Cupressus macrocarpa</i>	lemon cypress	Shrub	Perennial	Cupressaceae	New Zealand, and Australia

The following physiochemical characteristics were looked at: the leaf extract's pH, the leaves' total chlorophyll (TC), the relative water content (RCW), and the ascorbic acid concentration (AAC). The APTI value was evaluated using these.

The Singh (1977) [18] method was used to estimate RWC. Weighing the fresh leaves allowed us to determine the fresh weight. We then submerged the leaves in water for the whole night. They were blotted with What man filter paper and weighed was taken. This weight was regarded as turgid. Afterwards, the leaves were reweighed after being dried for 2 hours at 110° C in the oven. This provided dried weight.

$$RWC = \left(\frac{FW - DW}{TW - DW} \right) \times 100$$

Where FW = Fresh weight, DW = Dry weight and TW = Turgid weight

After pulverizing and mixing 0.5 g of leaf sample with 50 mL of deionized water, the pH was determined with the use of a pH meter. The mixture was centrifuged before the supernatant was collected.

A spectrophotometer was employed to measure the amount of ascorbic acid in a leaf sample. A 20 ml extraction solution was prepared by dissolving 5 grams of oxalic acid and 0.75 grams of sodium EDTA salt in 1 liter of distilled water. The fresh leaf sample, weighing half a gram, was mixed well in this solution. Using a continual shaking speed to centrifuge the homogenized leaf sample yielded Dichlorophenol Indophenol (0.02 g L⁻¹). An optical density (Es) reading was taken at 520 nm for the pink solution. To eliminate any trace of pink, just one drop of a 1% ascorbic acid solution was used. Then, using the same wavelength, we calculated the turbid solution's optical density (Et). Keller and Schwager (1977) [25] provided the formula that was used to determine the amount of ascorbic acid.

In order to find the total chlorophyll content, half a gram of fresh leaves was ground into a paste and mixed with twenty milliliters of 80% acetone. Refrigerate for a minimum of 24 hours following transfer to a test tube. Once the liquid phase of the reaction has been strained, the absorbance at 645 and 663 nm may be measured with a UV Spectrophotometer. Agarwal *et al.* (1991), Sadasivam and Manickam (1996) [21], Smirnoff (1996), Singh and Rao (1983) [22], and others all noted that the data were given in milligrams per gram of dry weight. This is how chlorophylls were calculated.

$$\text{Chlorophyll-a (mg/g)} = \frac{[2.69 (A_{645}) - 12.7 (A_{663})] \times \left[\frac{V}{1000} \times W \right]}{[4.68 (A_{663}) - 22.9 (A_{645})] \times \left[\frac{V}{1000} \times W \right]}$$

$$\text{Total chlorophyll (mg/g)} = [20.2 (A_{645}) + 8.02 (A_{663})] \times \left[\frac{V}{1000} \times W \right]$$

Where, A₆₄₅ = Absorbance at 645nm
A₆₆₃ = absorbance at 663nm

V = Total volume, W = weight of the leaf.

The Calculation for air pollution tolerance index (APTI) was done by taking all the four parameters for species are quantified and computed together in formulation to get an empirical value signifying the 'Air Pollution Tolerance Index' (APTI) of the species by using the formula developed by Singh and Rao (1983) [22]:

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

Where,

- A = Ascorbic acid content of leaf in mg g⁻¹ dry weight
- T= Total chlorophyll of leaf in mg g⁻¹ dry weight
- P= Leaf extract pH
- R= Percent relative water content of leaf tissue

Results and discussion

The results of all biochemical parameters are shown in table 2.

Relative water content (RWC)”

The RCW helps in understanding the water balance of plant. Water plays pivotal role in physiological and biochemical process of plants.

The relative water content of all the plant species of were from moderate to high. The highest RWC was found in *Ixora coccinea* which is 97.20% and the lowest was found in *Cupressus macrocarpa* 64.39%. The other species have between 70% to 95%.

pH of leaf extract

The susceptibility towards is SO₂ pollutant is hilly affected by pH. The pH of leaf extract is responsible for plants capability to tolerate pollution level. The higher pH enables the plant to survive in polluted condition. pH is related to plants tolerance

The pH of leaf extract of all the plant is found to be acidic except the *Nerium oleander* has alkaline pH (7.59). The pH that was found to be the most acidic was of *Syzygium cumini* (4.8).

Ascorbic acid

Ascorbic acid is anti-oxidant therefore it plays very vital role in plants tolerance towards pollution. The highest ascorbic acid was found in in *Ixora coccinea* and lowest in *Artocarpus heterophyllus*. The range was found in be between 1.62 to 4.92mg/g.

Chlorophyll content of the leaf

Chlorophyll enables a plant to withstand several types of pollution. The plants with high chlorophyll have high potential to tolerate high pollution. The highest chlorophyll content was found in *Hibiscus rosa-sinensis* (1.94). The lowest chlorophyll was found in *Syzygium cumini* (0.545)

Table 2: Plant species arranged in the of their APTI, determined on the basis of leaf extract pH, ascorbic acid, total chlorophyll and percent relative water content of leaves.

S.No.	Plant Species	Ascorbic acid (mg/g)	Total chlorophyll (mg/g)	pH of leaf extract	Relative water content (RWC) (%)	APTI	Rounded figure
1	<i>Artocarpus heterophyllus</i> (Jackfruit)	1.62	0.549	6.39	72.77	8.401	8
2	<i>Syzygium cumini</i> (Jamun, Java plum)	4.14	0.5456	4.86	90.13	11.252	11
3	<i>Tecoma stans</i> (Trumpet vine)	3.82	0.948	6.93	87.35	11.728	12
4	<i>Tabernaemontana divaricate</i> (Pinwheel)	3.91	1.019	6.27	93.68	12.211	12
5	<i>Ixora coccinea</i> (jungle geranium)	4.92	0.9250	5.64	97.20	12.937	13
6	<i>Hibiscus rosa-sinensis</i> (Show flower)	2.64	1.194	6.29	85.23	10.598	11
7	<i>Nerium oleander</i> (Kaner)	2.82	0.701	7.59	78.22	10.160	10
8	<i>Cupressus macrocarpa</i> (Lemon cypress)	1.74	0.603	5.19	64.39	7.448	7

Air Pollution Tolerance Index (APTI)

There is a lot of air pollution, but the Air Pollution Tolerance Index will help you figure out which plants can handle it and which ones can't. By plugging the values of all the biochemical parameters into the APTI formula, an APTI was calculated for each plant species that was taken into account in the study. This allowed us to learn how different plant species react to pollution and how much we can tolerate. A great way to help the environment is to plant tolerant plants in polluted regions. These plants can remove some of the pollutants by acting as "sinks." Knowing how much exposure a plant can withstand to air pollution may,

Therefore, be crucial. The Air Pollution Tolerance Index (APTI) is an empirical figure that Singh and Rao (1983) [22] arrived at by utilizing four leaf metrics in their study on the tolerance of various plant species to air pollution. The air pollution tolerance indices of the plants showed a wide range of values, as shown in Table 1. Their findings indicate that chlorophyll is the primary photoreceptor during photosynthesis. Chlorophyll is an important plant metabolic component, and its depletion has a direct influence on plant development, making it a useful indicator of air pollution's impact on plants (Joshi *et al*) [18]

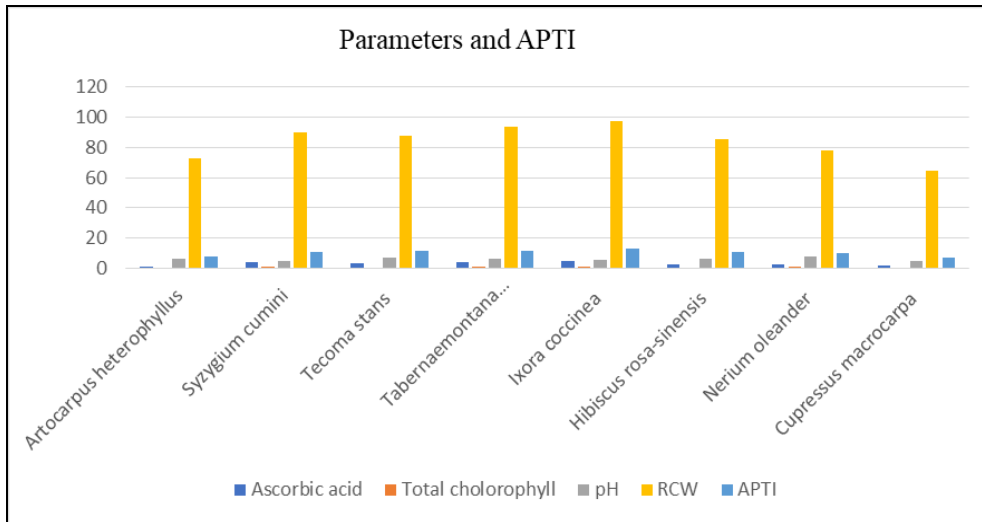


Fig 2: Percentage variations of ascorbic acid, total chlorophyll content, leaf extract pH, relative water content (rwc) and air pollution Tolerance Index (APTI) values for the eight plant species.

The highest APTI was found to be of *Ixora coccinea* (13) shrub. The lowest APTI was of *Cupressus macrocarpa* (7) shrub. Among the trees the highest APTI was of *Tecoma stans* (12). All the plants found in study are found to be sensitive. According to Kalyana and Singaracharya (1995), the plants can be categorized into the following groups based on their APTI values:

APTI value	Response
30 to 100	Tolerant
29 to 17	Intermediate
16 to 1	Sensitive

To find the statistical relationship between four parameters and APTI, correlation was calculated and shown in Table 3. With an APTI value of 0.9850 and a relative water content of 0.9818, respectively, a link between ascorbic acid and these variables existed. Chlorophyll and APTI score are somewhat correlated ($r=0.5807$). You won't find any meaningful relationship between pH and APTI levels. The APTI value is thus positively associated with chlorophyll to a lesser extent and strongly with ascorbic acid and relative water content. Total chlorophyll, relative water content, pH, and ascorbic acid are among the elements that influence the APTI value, as stated by A. Chauhan (2010). (Graphs showing the relationship between the parameters are shown in Fig 3, 4, 5, and 6.)

Table 3: Correlation between different biochemical parameters and APTI values

	Total chlorophyll (mg/g)	Relative water content (RWC) (%)	pH of leaf extract	Ascorbic acid (mg/g)	APTI
Total chlorophyll (mg/g)	1				
Relative water content (RWC) (%)	0.5534	1			
pH of leaf extract	0.2930	-0.0417	1		
Ascorbic acid (mg/g)	0.3583	0.9277	-0.1514	1	
APTI	0.5807	0.9818	0.0767	0.9450	1

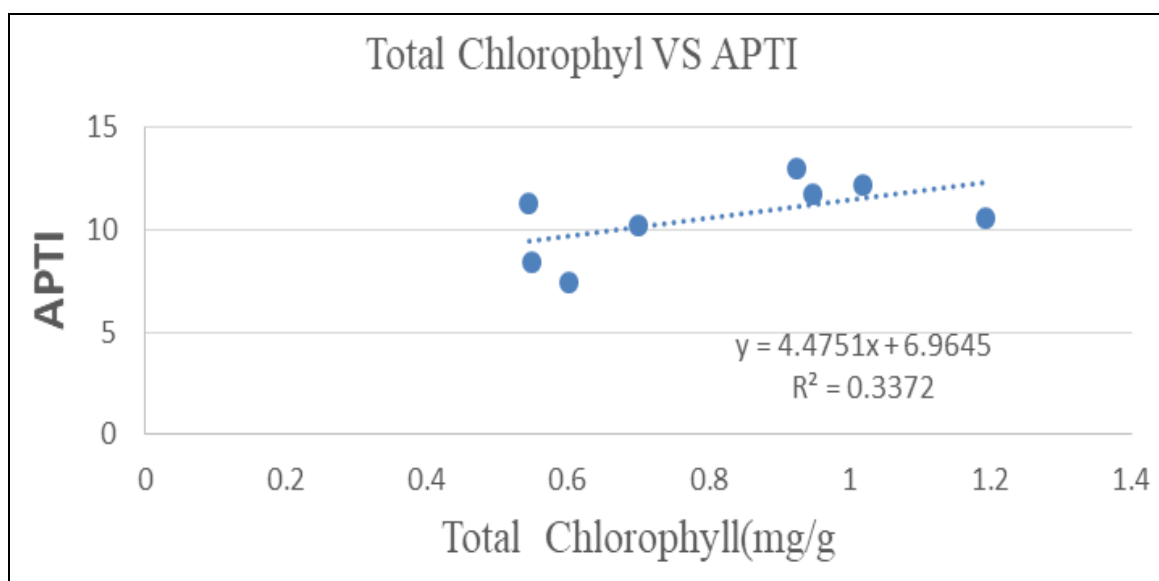


Fig 3: Correlation between total chlorophyll and APTI

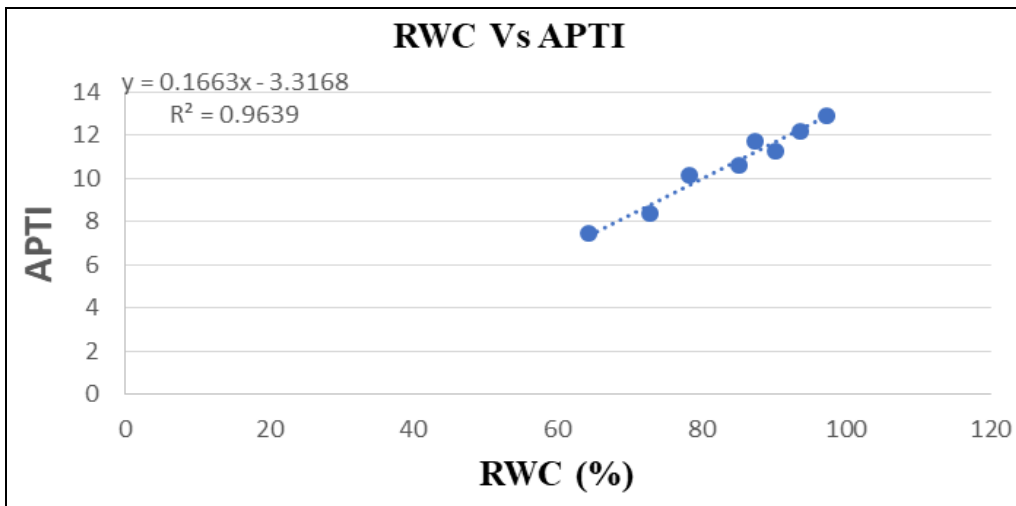


Fig 4: Correlation between relative water content and APTI

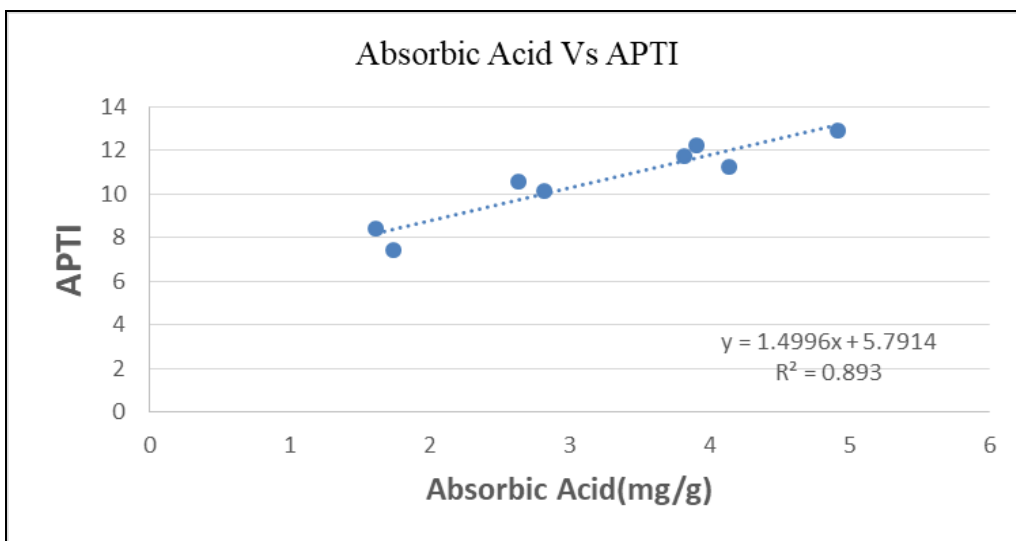


Fig 5: Correlation between ascorbic acid and APTI

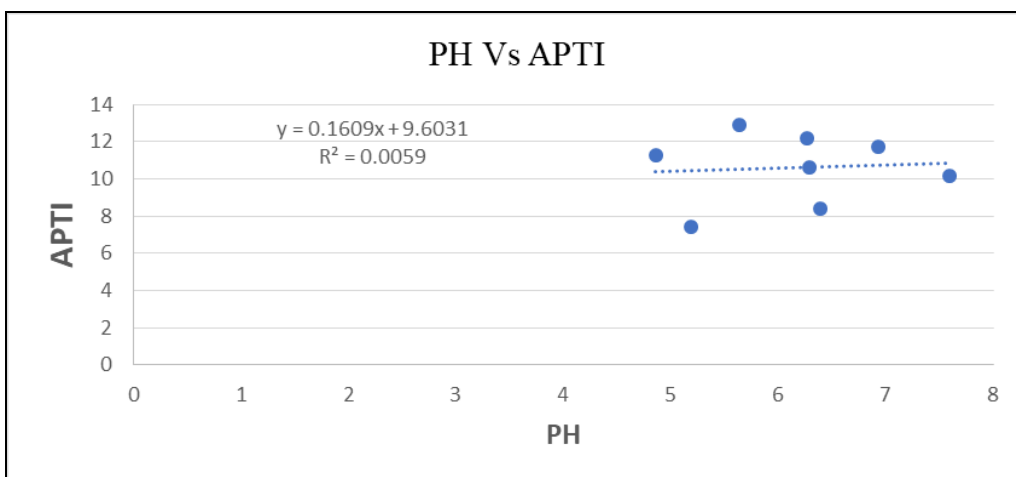


Fig 6: Correlation between total chlorophyll and APTI

Conclusion

The most accurate method for comparing plant species' air pollution tolerance index (APTI) is to observe their responses to varying degrees of air pollution. In this study, we found that various plant species react differently to air pollution. It is especially crucial to conduct biomonitoring in densely populated industrial locations to learn how various

plant species are affected by air pollution. Landscaping with plants that have a high APTI might help reduce air pollution, while planting plants with a low APTI could help determine the local air pollution status and be used for biomonitoring. You may utilize the plants appropriately because they were all sensitive in this study.

Acknowledgement

Authors are thankful to DNH Spinners, Silvassa for providing laboratory facilities, their equipment and encouragement.

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