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A Review On: Nature's Bio Sensors - Plants

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Abstract: Plant leaves help with air pollution by absorbing pollutants through both their surface and their tiny pores (stomata) and by participating in photosynthesis, which removes carbon dioxide and releases oxygen.
Plants are exposed to various harmful air pollutants, which cause oxidative stress and pose a threat to plant health, agriculture production, and vitality of ecosystems. Despite the climate actions and technological development, most ecosystems and agricultural areas are exposed to high levels of tropospheric ozone, nitrogen oxides, and particulate matters (PMs). To use plant trees to investigate the air pollution. Leaf surfaces were heavily loaded by dust particles but the stomata were not occluded, the cuticle was thinner, other anatomical properties were unaffected.
Keyword: Air pollution, plants, filtering, leaf anatomy, chlorophyll, dust, bioassessment ecology.

I. INTRODUCTION

The objective of this study is to compare particulate deposition and basic chemical markers on leaves from multiple urban sites (e.g., busy road, residential street, park) and relate these measurements to pollution exposure. Air pollution is a serious problem in many heavily populated and industrialized areas in the world. A growing share of the world's population is living in urban centres and is demanding a cleaner environment. In many urban areas of the world, motor vehicle traffic is a major source of air pollution contributing 57%-75% of total emission (WHO2006). In general, metropolitan areas have higher pollution than rural areas. Air pollution from motor vehicle exhausts has both direct and indirect effects on the metabolism of roadside plants even before visible symptoms appear. Urban forests and tress in the urban can improve air quality through filtering and uptake of gases and particles. Therefore, urban trees are at high importance for the inhabitants, but may also be endangered by exposure to pollution. For example, in leaves of a typical urban roadside tress species, platanus orientalis air pollution caused changes in chlorophyll content and peroxidase activities.

A. Materials & Equipment (Basic & Inexpensive)

1) Fresh Leaves of the Same Species

Neem and Mango Leaves (2-3 leaves of the same species from different places.)
Ensure leaves are from the same age/position on the plant.

2) Other Materials

- Forceps, scissors, paper bags, permanent markers (for sample identification)
- Electronic digital balance (+0.01 g) or kitchen scale (if digital balance is unavailable)
- Pre-weighed filter papers (Whatman or similar) or coffee filters (less accurate)
- Measuring cylinders (10-100 mL), beakers, glass bottles
- Distilled water (30 ml per leaf)
- pH strips or pH solution
- Oven or drying tray (for drying filters/leaves)
- Glass stirring rod, shaker (or shake by hand)
- Gloves, safety goggles
- 10 ml 80% acetone per leaf
- Notebook/printed data sheet, camera/phone for photos

B. Site & Sampling Plan

Choose 3-4 sites representing different pollution exposures, such as:

- Site 1: Busy road/intersection (high traffic)
- Site 2: Residential street (medium traffic)

- Site 3: Park/green area (low traffic)
- Site 4: Industrial area (if available)
- Areas – PCCOE, Ravet, Pimple Saudagar, Bhosari.

For each site:

- Select 3-4 replicate trees/plants to reduce sampling noise.
- Collect 3-4 mature leaves from each tree, ensuring they are from similar height/position and the same side (sun vs. shade).

C. Sampling & Lab Procedure

1) Collection

a) Label paper bags with place and leaf number.

b) Using clean scissors, cut 3-4 similar mature leaves per tree and place them in the labelled bag. Avoid touching leaf surfaces with bare hands (wear gloves).

c) Transport to the lab the same day in shade.

2) Leaf Surface Particulate Wash

These extracts deposited dust/particles and soluble surface contaminants for measurement.

a) Measure and record fresh leaf count and optionally, fresh leaf mass. Alternatively, measure leaf area by tracing leaves on graph paper and counting squares.

b) Place the known number of leaves into a clean beaker containing 200 mL distilled water.

c) Gently shake for 5 minutes (or use an orbital shaker at 100-150 rpm for 10 minutes).

d) Remove leaves; label and air-dry them for later comparison of visible damage.

e) Filter the wash water through pre-weighed filter paper using a funnel (or vacuum filter setup).

f) Dry the filter paper with trapped particulate matter in an oven at 105°C for 30-60 minutes (or until constant weight). Cool in a desiccator and weigh the filter paper.

g) Calculate particulate mass:Particulate Mass (mg) = (Weight of filter + particles) − (Weight of clean filter)

h) Normalize particulate deposition by total leaf area or by number of leaves (e.g., mg/leaf or mg/cm²).

3) Quick Pollution Indicators (pH)

a) Grind the leaf in 30ml distilled water

b) By using pH paper, measure the pH

c) Lower the pH, higher is the pollution.

4) Chlorophyll content test

a) Grind 1 leaf with 10ml of 80% acetone

b) In a bowl of warm water (50 degrees Celsius) heat the mixture.

c) Allow it to cool down.

d) Analyse the colour.

e) Higher the chlorophyll content (green colour), lesser the pollution.

D. Data Recording & Sample Datasheet

Record the following for each sample:

1) Sample ID, Site, Tree replicate, Date, Time, Weather, Traffic rating

2) Number of leaves, total leaf area (or average leaf area)

3) Volume of wash water used

4) Filter paper ID & tare mass, filter + particles mass, particulate mass (mg)

5) pH of wash

6) Photos of leaves (front/back) and sampling site

7) Notes on visible leaf damage (e.g., chlorosis, necrosis, dust layer)

E. Analysis & Presentation

1) Calculate mean ± standard deviation for each measurement per site (e.g., mean particulate mg/leaf).
2) Normalize particulate deposition to leaf area if measured.
3) Create plots:
- Bar chart: Particulate mass (mg) for each site with error bars.
- Scatter plot: Particulate mass vs. traffic rating or distance from road.
- pH/conductivity comparisons across sites.

4) Perform basic statistics (e.g., t-test or ANOVA) to check if differences between sites are significant.
5) Discuss correlations, such as:
- Higher traffic = higher particulate mass.
- Use photos as visual evidence.

Timeline (Suggested)

- Week 1: Finalize sites, obtain permissions (if needed), and gather materials.
- Week 2: Sampling across all sites (1-2 days).
- Week 3: Lab processing (wash, filtration, drying, instrument readings).
- Week 4: Data analysis, graphs, report writing, and prepare presentation.

F. Safety & Ethical Notes

1) Wear gloves and goggles when handling filters, reagents, and drying samples.
2) If working near roads, follow traffic safety protocols and work with an accompanying person.
3) Dispose of wash water and used filter papers according to institutional rules.

G. Expected Results

1) Busy roads: Highest particulate deposition, possibly lower pH (if acidic pollutants) and higher conductivity.
2) Parks: Lowest particulate deposition.
3) Leaf damage: You may observe visible dust layers on leaves and leaf edge browning near heavy traffic areas.

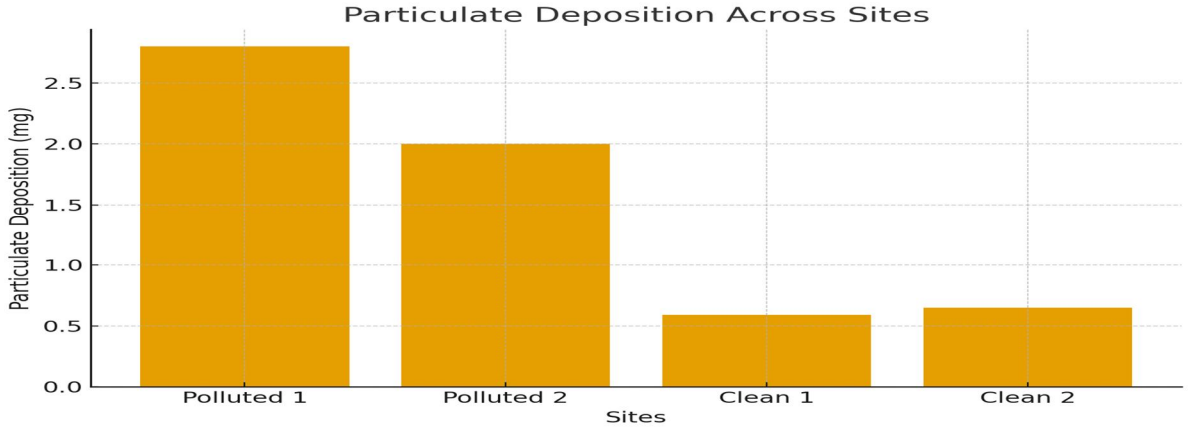
H. Result & Conclusion

Leaf samples were collected from two polluted areas (Pimple Saudagar and Bhosari) and two less-polluted areas (PCCOE Campus and Ravet). After performing particulate wash, pH testing, and chlorophyll analysis, the following patterns were observed:

1) Particulate Deposition (Dust / PM)

- Polluted sites showed the highest particulate load on the leaf surface.
  The filter papers from these areas showed noticeably heavier dust deposition.
- Leaves from cleaner sites had significantly less dust, with lighter and finer particles.

Overall trend:
Polluted areas > Less-polluted areas (in dust accumulation)



Graph 1: Particulate content in Mango leaves

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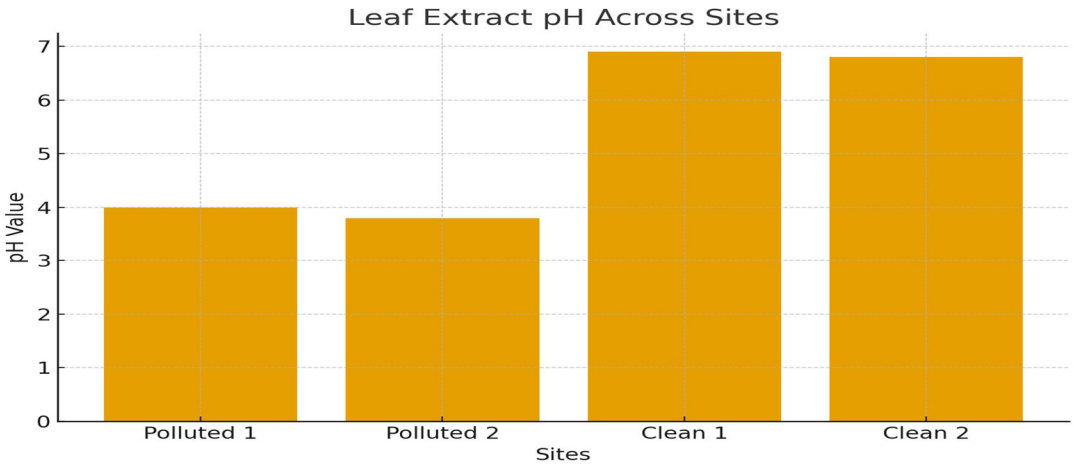
2) pH of Leaf Extract

- Leaves collected from polluted areas showed lower pH values (more acidic). This indicates the presence of acidic pollutants such as SO_2, NO_x, and carbon particles.
- Leaves from cleaner sites recorded near-neutral pH.

Overall trend:
Higher pollution → More acidic leaf extract

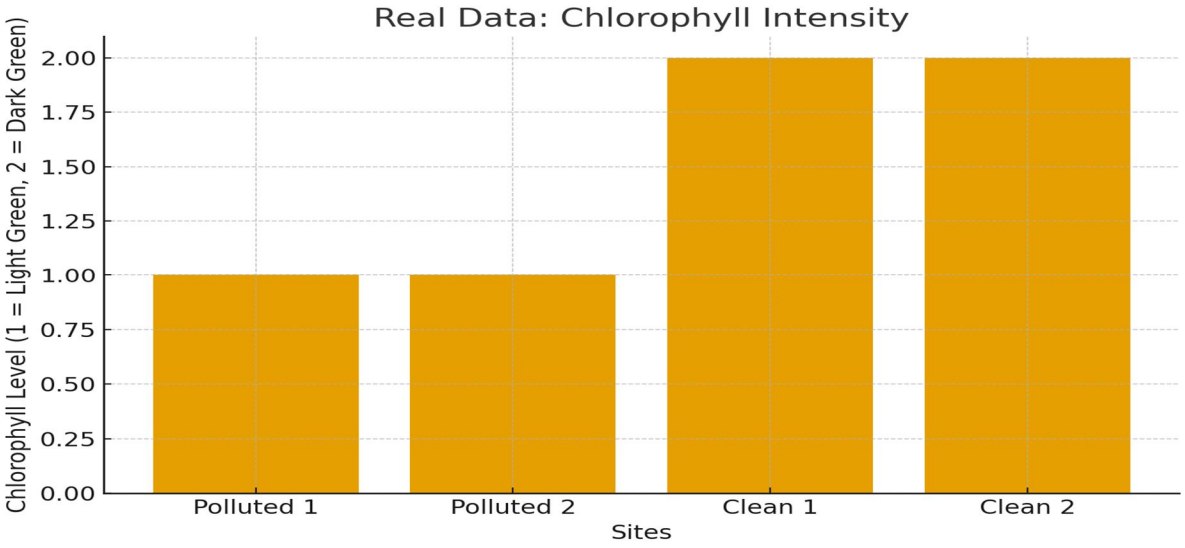


Graph 2: pH value content in Mango leaves

3) Chlorophyll Content (Green Pigment)

- Leaves from polluted areas showed lighter green colour, indicating lower chlorophyll content.
  This happens due to:
  - oxidative stress
  - blocked stomata
  - reduced photosynthesis
- Leaves from less-polluted sites appeared darker green, showing higher chlorophyll concentration.

Overall trend:
Cleaner areas → Higher chlorophyll
Polluted areas → Chlorophyll reduced



Graph 3: Chlorophyll content in Mango leaves

4) Visible Leaf Condition

- Polluted area leaves:
  - Visible dust layer
  - Minor yellowing or edge browning
  - Slightly dull surface due to particulate deposition
- Non-polluted area leaves:
  - Cleaner surface
  - Healthy green colour
  - No major surface abnormalities

II. FINAL CONCLUSION

Based on the comparison of leaves from 2 polluted and 2 less-polluted regions, the study clearly shows that air pollution has a measurable impact on plant leaves.

1) Higher particulate deposition was consistently found on leaves from polluted sites.
2) Leaf extracts from polluted areas showed lower pH, meaning greater exposure to acidic pollutants.
3) Chlorophyll content was reduced in polluted area leaves, indicating stress and lower photosynthetic activity.
4) Visible differences in leaf colour and dust deposition further support the laboratory findings.

A. Final Interpretation

Plants act as natural bio-sensors of air pollution. Leaves collected from highly polluted places showed more dust, lower pH, and reduced chlorophyll, proving that they can be used effectively to monitor environmental pollution levels.

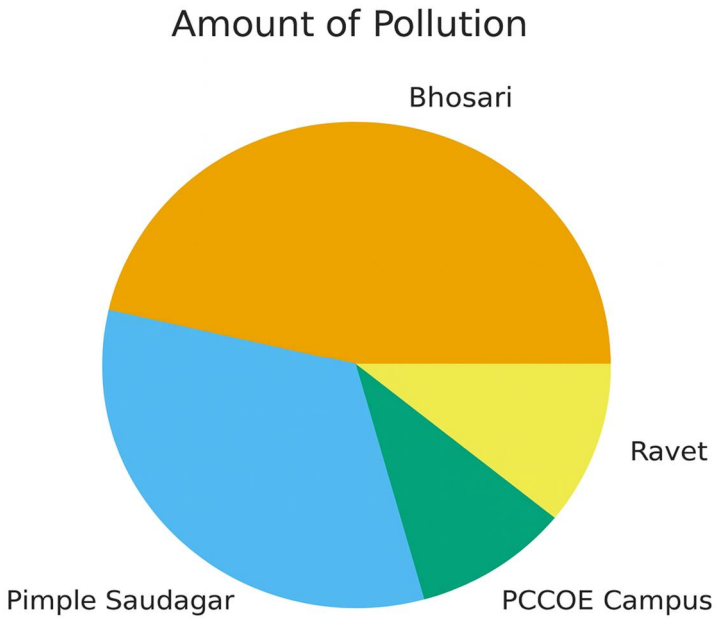


Fig: Pie-chart showing amount of pollution areawise

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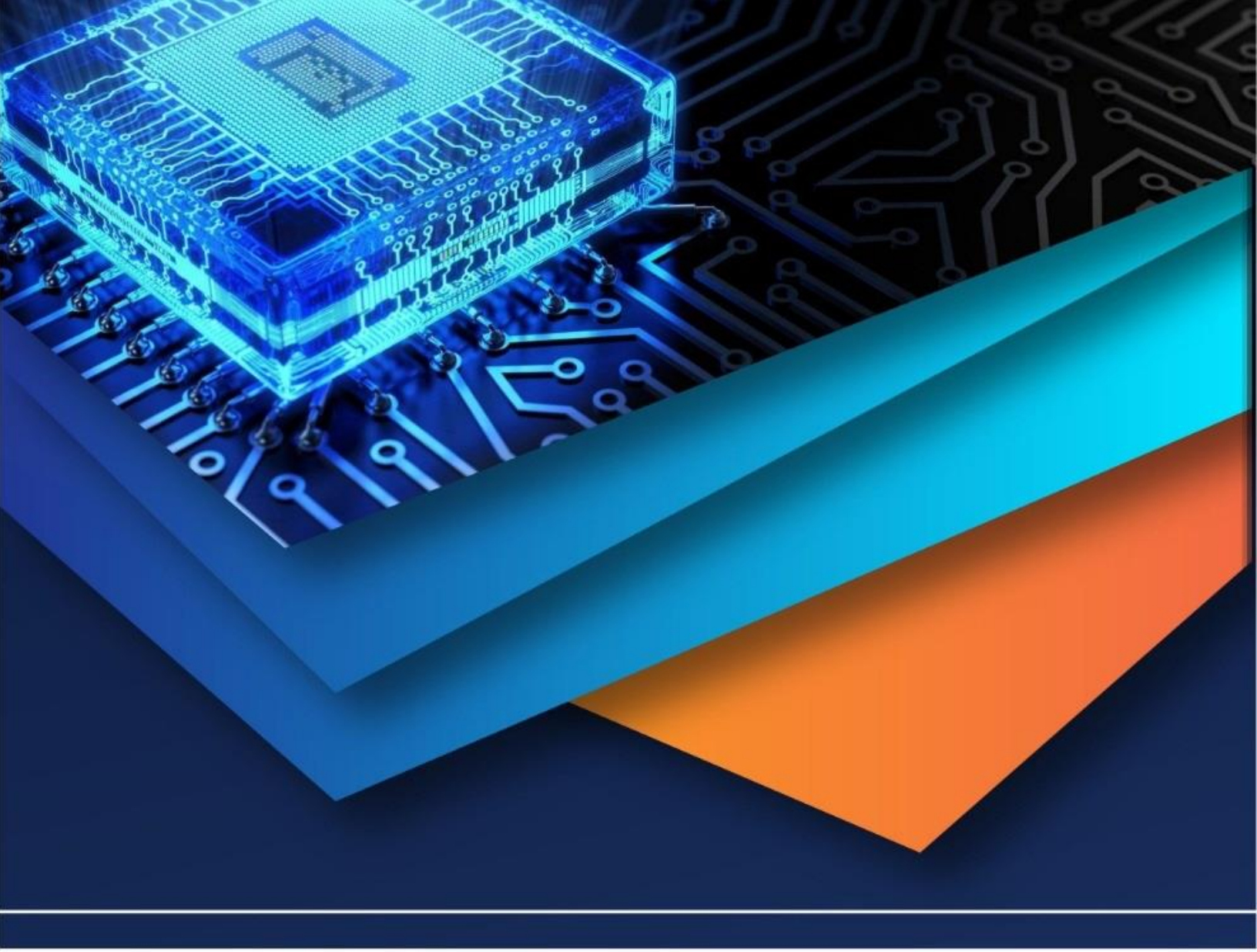

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