Ministry of Earth Sciences

Indian Institute of Tropical Meteorology, Pune

Metropolitan Air Quality and Weather Forecasting Services

Multi-year observations of particulate matter and gases over Mumbai

Introduction

In recent years, high levels of $PM_{2.5}$ have become one of the most serious environmental problems in Indian megacities. Many studies have revealed a significant association between adverse respiratory health and $PM_{2.5}$. Generally, $PM_{2.5}$ contains mineral dust, metals, organic compounds, and biological materials Mumbai is one of the most densely populated cities in the world and particulate pollution increased in recent years in Mumbai Therefore, it is essential to study the characteristics of $PM_{2.5}$ and its dependency on gas-to-particle conversion in view of the increase in pollution and its health effect. The present study reveals the climatology of $PM_{2.5}$ and its precursors gases over Mumbai from 2016-2021 along with an insight into its chemical nature.

Objective

Investigate the contribution of gaseous pollutants and meteorological parameters in $PM_{2.5}$ distribution and development over coastal city Mumbai .

Methodology & Study Area

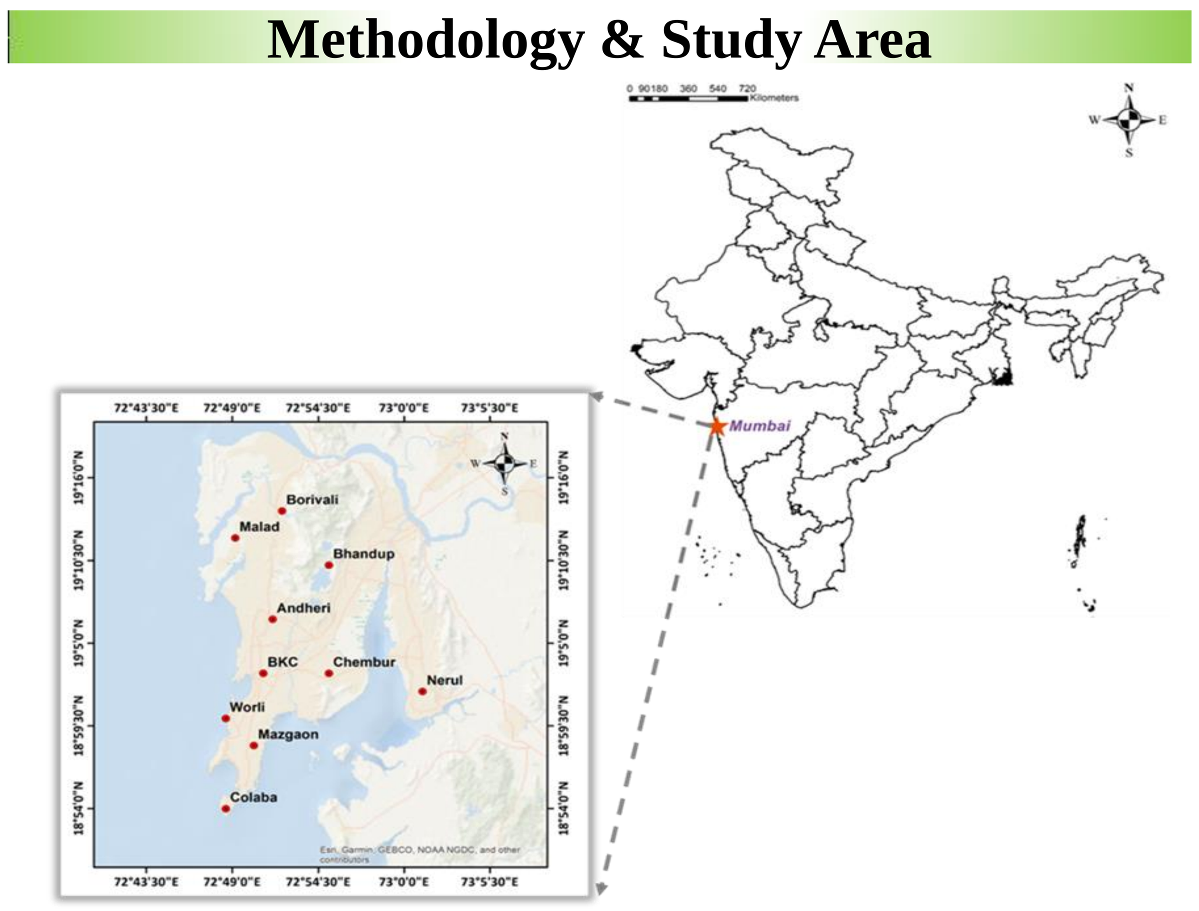

Fig. 1 – Geolocation of the study area and SAFAR - AQMS network in Mumbai, with red dots showing AQMS locations

- Mumbai is located on the west coast of India (18.53º N to 19.16º N latitude and 72º E to 72 .59º E longitude).
- The data for the study is obtained from the SAFAR air quality monitoring stations (AQMS) network for the period 2016 to 2021.The continuous measurements of $PM_{2.5}$, Ozone, CO, NO_2, SO_2, and NH_3 are made 3 meters above ground at each AQMS with the (US-EPA) approved online analyzers.
- To understand the contribution of gaseous pollutants and meteorological parameters in $PM_{2.5}$ distribution and development, we applied a statistical adjustment method based on the Generalized Additive Model (GAM) model.

Results

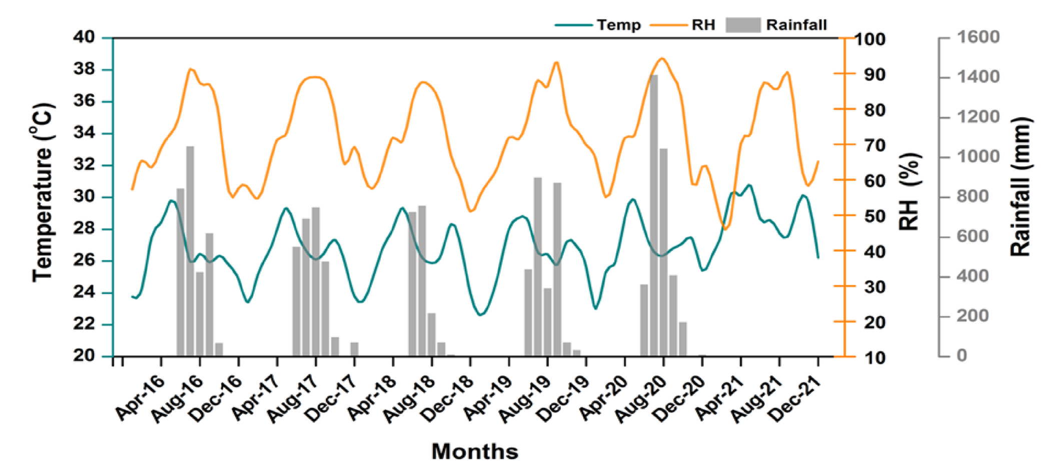

Fig. 2 Monthly variation in temperature, relative humidity, and rainfall for 2016- 2021.

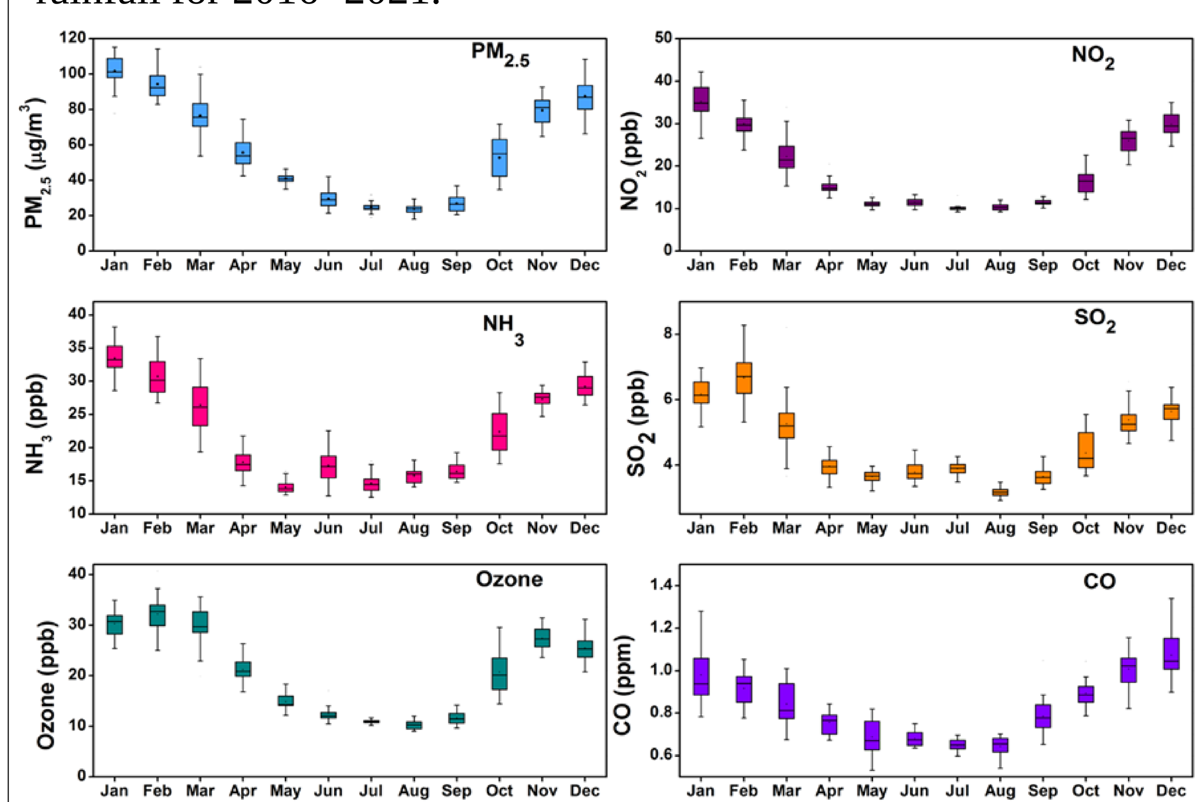

Fig. 3 .Monthly variation in $PM_{2.5}$, NO_2, NH_3, SO_2, O_3, CO for 2016- 2021

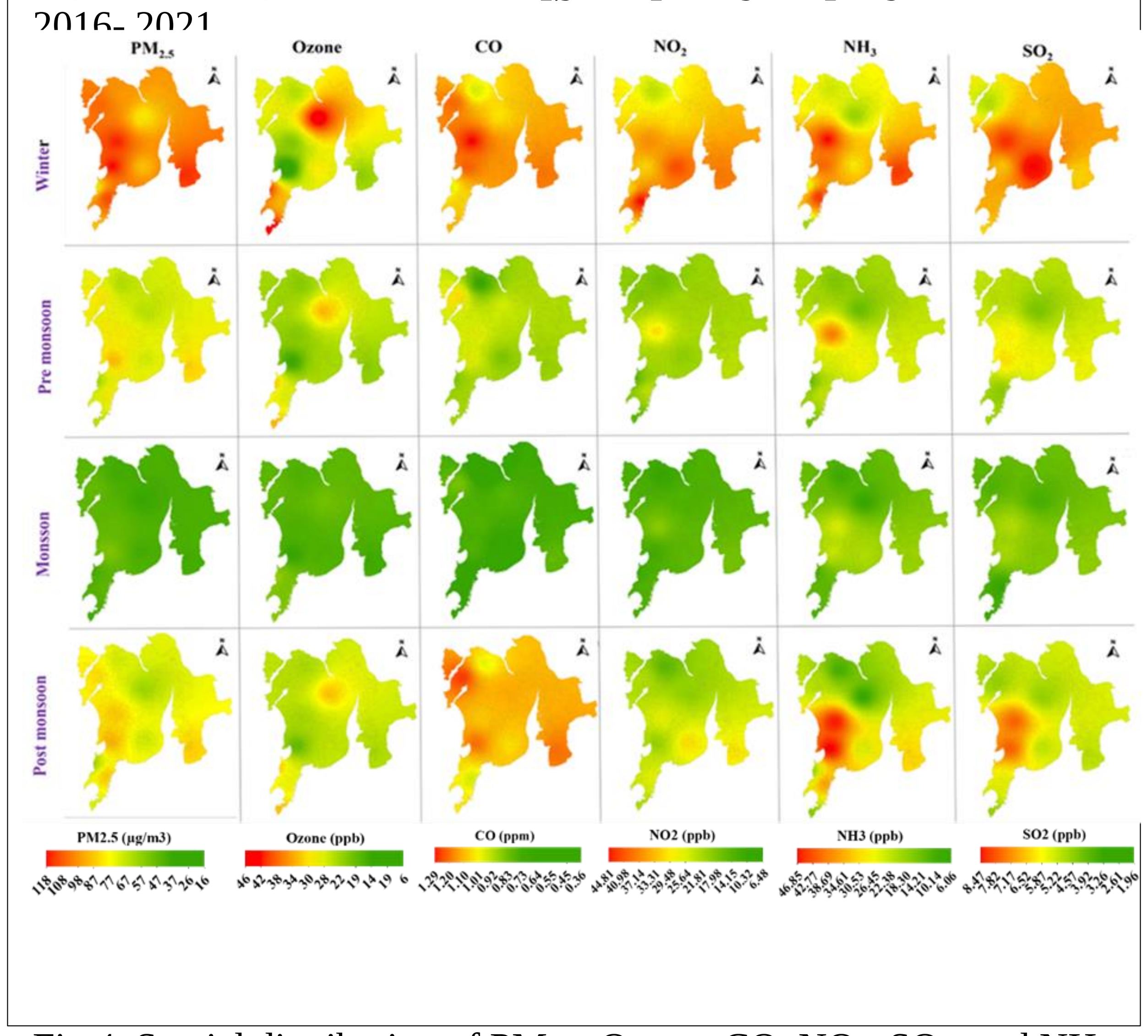

Fig 4 .Spatial distribution of $PM_{2.5}$, Ozone, CO, NO_2, SO_2, and NH_3 in different seasons.

- Monthly concertation of $PM_{2.5}$, Ozone, CO, NO_2, SO_2, and NH_3 shows U-shaped variability.
- The monthly value of $PM_{2.5}$ varies between 25-100 µg/m3, downward trend from February to May and then remain stable with a significant decrease from June to August,
- Heavy rains and strong winds influence the $PM_{2.5}$ from June to August. The highest concentration of $PM_{2.5}$ was observed in January (100 µg/m³).
- Generalized Additive Model (GAM) to investigate the non-linear relationship of $PM_{2.5}$ to other precursor gases and meteorological parameters.
- $PM_{2.5}$ linearly correlates to NO_2 during the study period as the EDF value is equal to 1 for NO_2 and $PM_{2.5}$

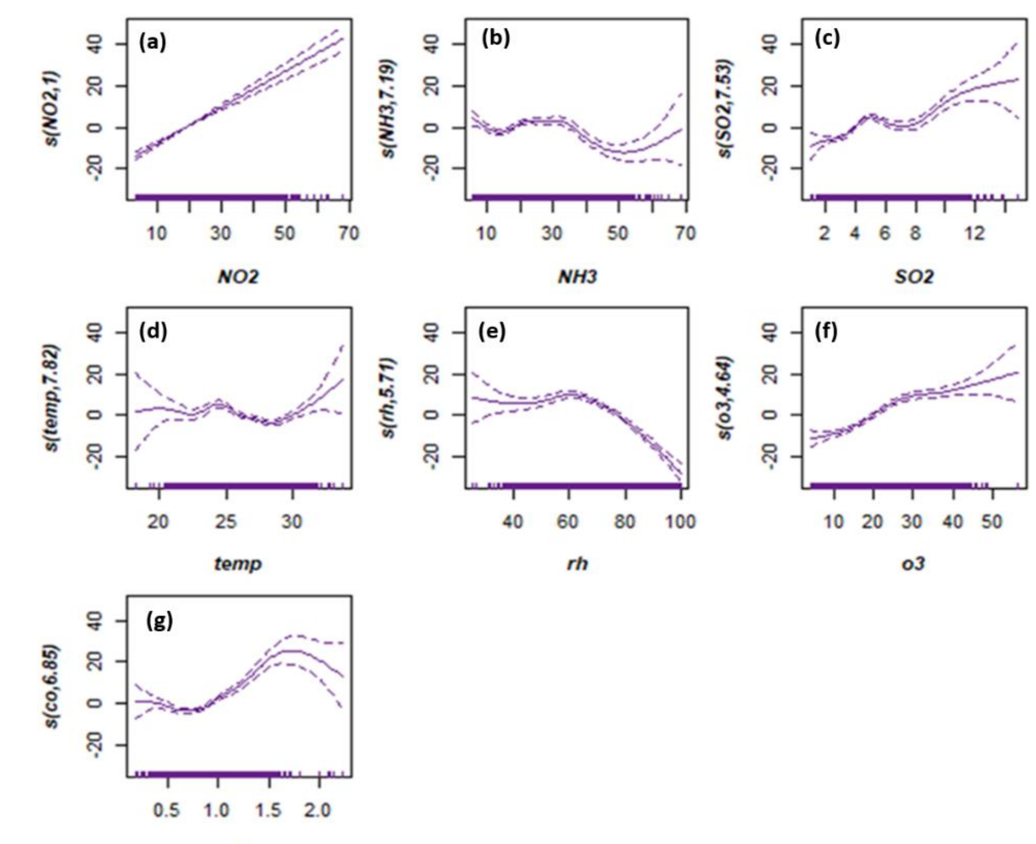

Fig. 5 Response curves of $PM_{2.5}$ concentration to changes in (a) NO_2, (b) NH_3, (c) SO_2, (d) Temperature (temp), (e) relative humidity(rh), (f) Ozone (O_3), (g) CO.

Conclusion

- Levels of $PM_{2.5}$ and NO_2, SO_2, NH_3, Ozone, and CO are consistently high in the winter season. Prevailing lower temperature and associated reduced vertical mixing are the main reasons for the increased level of pollution during the winter season months with no discernible change in anthropogenic activity.
- The values Sulfur oxidation ratio (SOR) and Nitrogen Oxidation ratio (NOR) confirmed that due to oxidation, SO_2 in the atmosphere incessantly undergoes secondary aerosol formation thus adding to particulates load other than through direct emission, hence control of gaseous emission is essential to reduce particulate pollution
- GAM model analysis of observations denote the non-linear relationship between $PM_{2.5}$ and gases with various degrees, which should be considered for formulating relevant measures and policies.

Low Volume Sampler with Directional Sampling Feature

Objective

Customizing the existing Low Volume Sampler with Directional Sampling Feature by protecting standard flow 16.7 LPM.

Need

The current design of the low volume sampler, lacks the ability to collect sample of PM_{10} and $PM_{2.5}$ in a particular direction, Existing machine (LVS) is only able to suck the air from all (360 degree) directions. collecting sample of PM_{10} and $PM_{2.5}$ in a particular direction is crucial in certain applications, where fine particulate matter measurements and airflow direction need to be considered and rejecting other directions.

Working

Only Solution to protect the flow is to divert the airflow from point A and B (Fig 2) that will bypass the suction through filter paper i.e. simply stops the deposition. But air flow is continued through bypassing solenoid valves i.e. Ay and By

Air flowing through the Ay and By would go through flow sensor and controlling valve and hence it would control the flow and maintain at 16.7 LPM for both PM_{10} and $PM_{2.5}$

How the system would understand the user need and the airflow direction? Here the wind vane would come into picture as an input transducer and user would set the angle in which he/she wants to do sampling.

How to use

User can set the angles SA1 and SA2, the angle between SA1 and SA2 would considered as sampling angle and deposition on filter will continue only is the direction of air flow is in between SA1 and SA2. The display includes the SA1, SA2 as well as WD and WS instantaneous values.

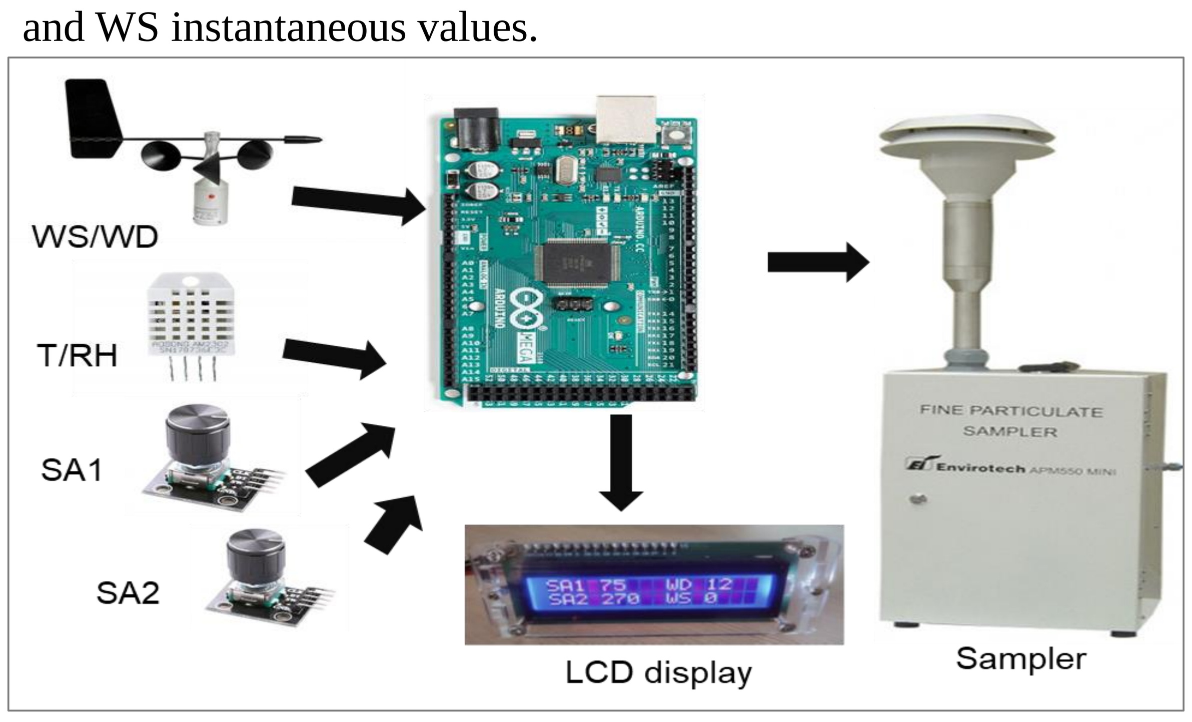

Fig.1 Components

Conclusion

The customization of the low volume sampler with directional sampling feature without changing the standard flow rate of 16.7 LPM is a significant improvement in the device's capabilities. This will provide a more accurate and representative measurement of air quality in a range of industrial, environmental, and scientific applications. The results of the laboratory and field tests will provide further information about the effectiveness of the customization and helps ensure that the device meets the requirements of its intended users.

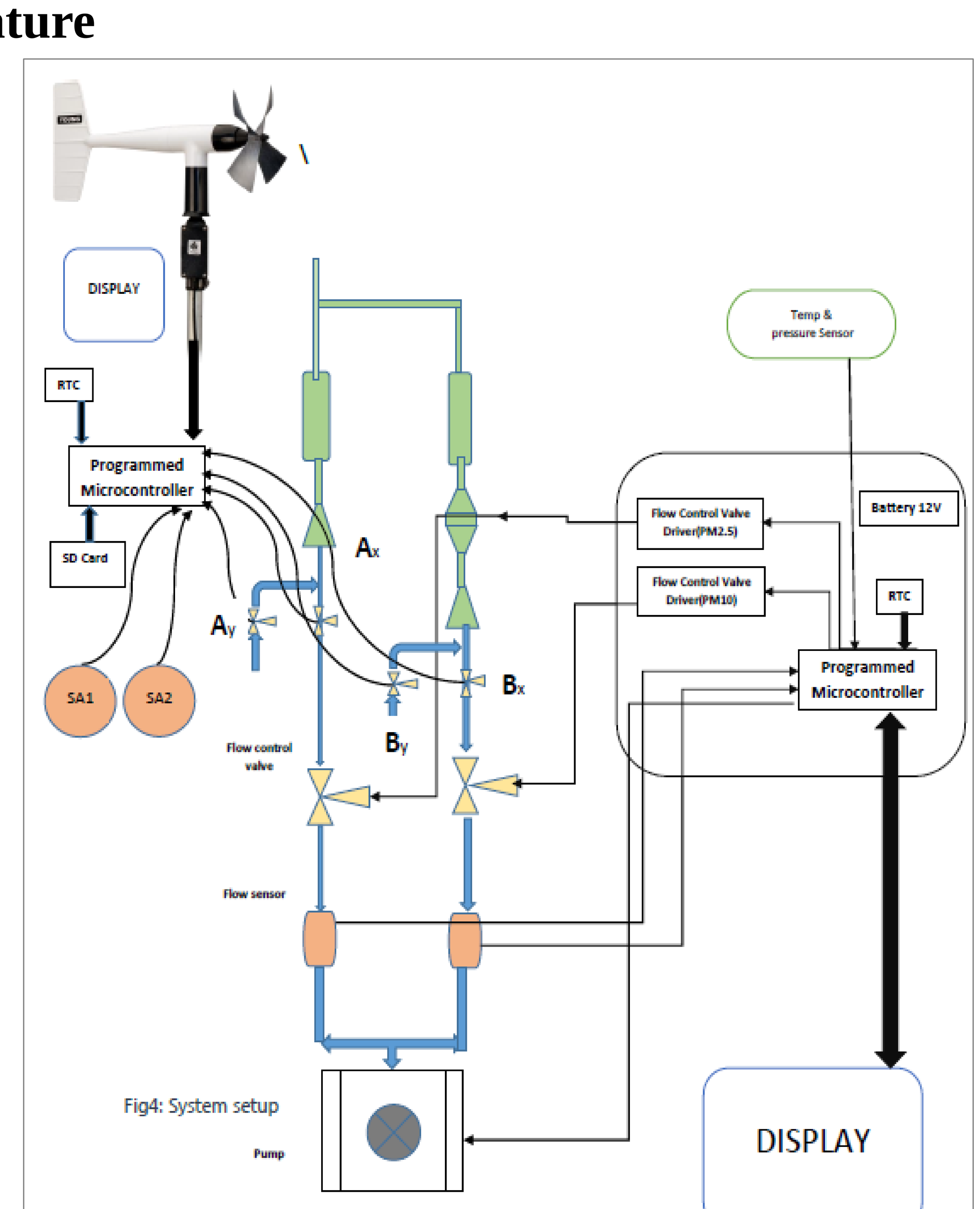

Fig.2 System setup

Acknowledgement s

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