ESW Project - Progress Details

Team Name : Male and Female
Team No. : 46
Project Name : Secondary Pollutant Estimation near Pharma Industrial Cluster.
Venue : Lab 114

Participants:

Team Members:

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Faculty:

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TA:

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Progress made till 08-09-25

- Research into the working principles of the sensors has been completed.
- The sensors (which had been provided by the lab) have been coded and connected, followed by initial testing.
- Code integration and preliminary testing have been performed.
- The system's design planning is in the works.
- The remaining components are in the process of being ordered.

Following are the details of the project in depth.

Primary Aim

To analyse the formation of ozone (a secondary pollutant) by the reaction of primary pollutants such as NOx and VOCs under the presence of UV radiation.

Other Aims

- To estimate the concentration of PAN by use of other sensors.

List of Sensors, Working Principle and Purpose

RTC Module

- [Buying from here]()
- **Working Principle**: An RTC module works by using a **crystal oscillator** to generate a precise, high-frequency signal, like a steady heartbeat. An integrated circuit counts these signals to keep track of seconds, minutes, hours, and the date. A small **backup battery** ensures it keeps time continuously, even when the main device is powered off, allowing it to provide accurate time to a microcontroller on demand.
- **Purpose:** To get highly accurate timestamps for the data.

SGP30 (TVOC + eCO2 Sensor)

- Given by lab
- **Working Principle**: It works using a tiny metal-oxide plate that is heated to a high temperature. When airborne pollutants interact with this hot surface, they cause a chemical reaction that changes the plate's electrical resistance. The sensor's electronics measure this change in resistance and use an algorithm to calculate the final TVOC and eCO_2 concentrations.
- **Purpose**: To get TVOC (total VOC concentration in PPM and *equivalent* CO2 concentration)

MQ131 (Ozone Sensor)

- [Buying from here]()
- **Working Principle**: It works using a **chemiresistive** principle. Inside the sensor is a sensing element made of tin dioxide (SnO_2), which is heated by a small internal coil. In clean air, this material has a specific electrical resistance. When ozone comes into contact with the hot sensing element, it causes a chemical reaction that **increases** the material's resistance. An electronic circuit measures this change in resistance, and the magnitude of the change is proportional to the concentration of ozone in the air.
- **Purpose**: To get ozone concentration in air.

MiCS-2714 (NOx Sensor)

- [Buying from here]()
- **Working Principle**: It works using a sensitive layer of tungsten oxide (WO_3) on a micro-machined silicon structure. An integrated heater keeps this layer at a specific temperature. When NO_2 molecules come into contact with the heated

sensing layer, they cause a chemical reaction that **increases** the material's electrical resistance. This change in resistance is directly proportional to the concentration of NO_2 in the air.
- **Purpose**: To get NO and NO_2 concentration in air.

SDS011 (PM Sensor)

- Given by lab
- **Working Princple**: It works on the principle of laser scattering. A small internal fan draws a sample of air into a measurement chamber. Inside, a laser beam illuminates the air, and when airborne particles pass through the beam, they scatter the laser light. A photodiode detector measures the amount and intensity of this scattered light. The sensor's electronics then analyze this data to calculate the concentration of PM2.5 and PM10 particles.
- **Purpose:** To get PM2.5 and PM10 concentration in ppm.

CJMCU-GUVA-S12SD (UV Intensity Sensor)

- Buying from here
- **Working Principle:** It works using a specialized photodiode made from Gallium Nitride (GaN). This material is highly sensitive to UV light in the 240-370nm range (covering UVB and most of the UVA spectrum). When UV photons strike the photodiode, they generate a tiny electrical current that is proportional to the intensity of the UV radiation. An onboard operational amplifier then converts this small current into a more usable analog voltage, making it easy to read with a microcontroller.
- **Purpose:** To measure intensity of UV ray in sunlight.

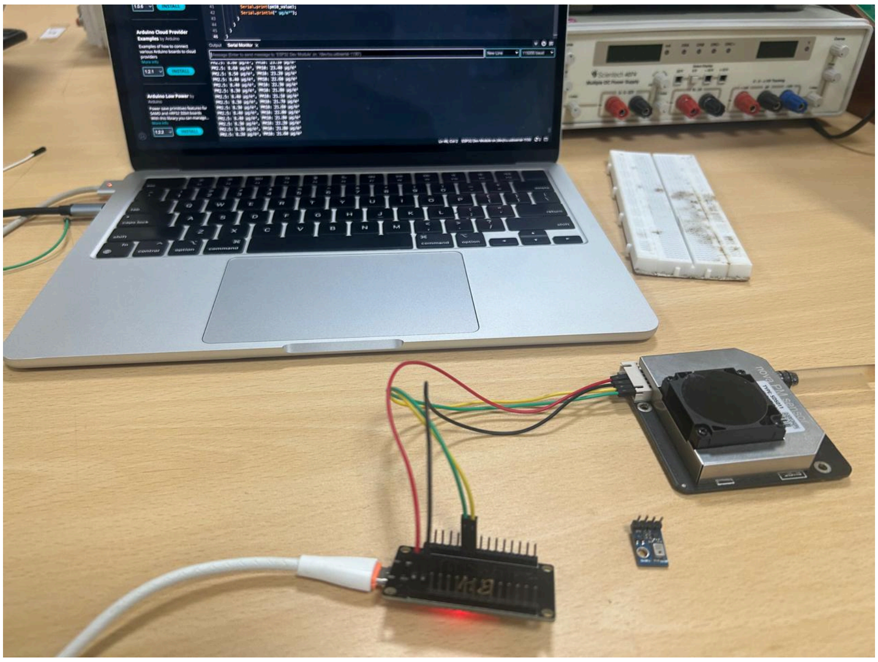
AHT10 (Air temperature sensor)

- Given by Lab
- **Working Principle**: It works using a **capacitive humidity sensor** and a **band-gap temperature sensor** integrated onto a single chip. For humidity, a polymer dielectric material absorbs or releases water vapor, which changes its capacitance; the onboard electronics measure this change to determine the humidity. For temperature, it uses a semiconductor element whose voltage output changes predictably with temperature. An integrated circuit then processes both raw signals, performs calibrations, and outputs a clean digital signal.
- **Purpose:** To measure air temperature.

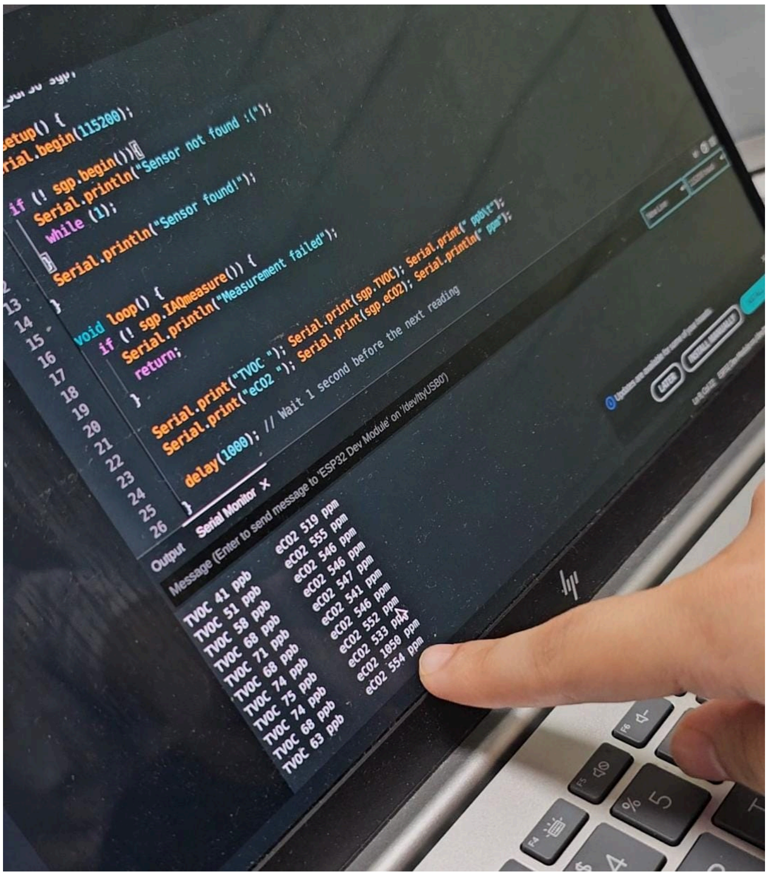
Sensors used till 08-09-25

Code for the individual sensors as well as combined code of all sensors can be found at this github repository : https://github.com/UberCuber/ESW-Project

AHT10

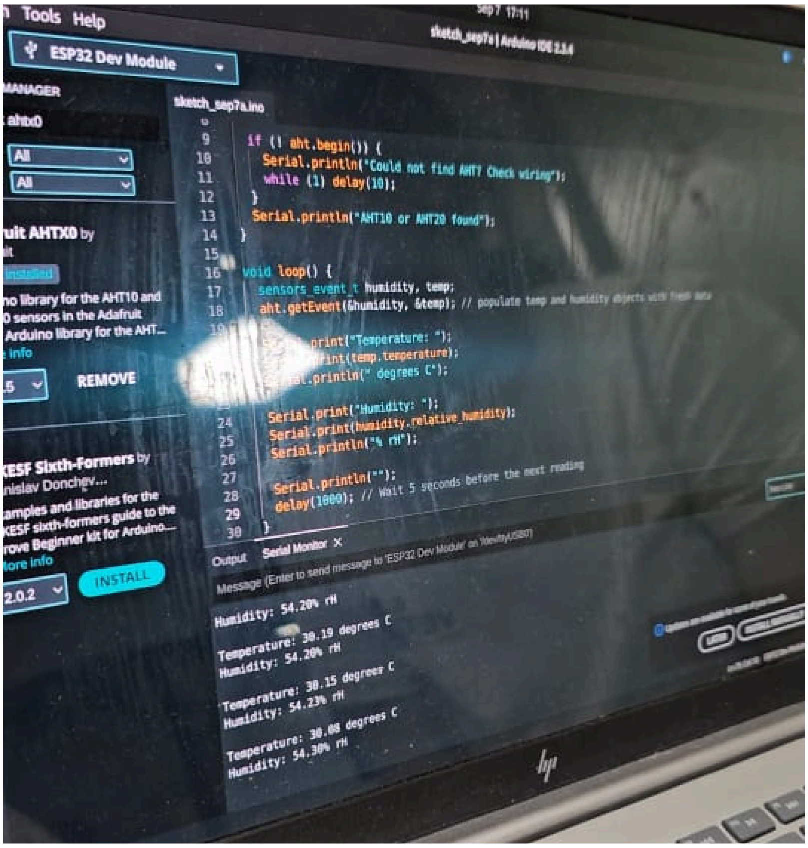


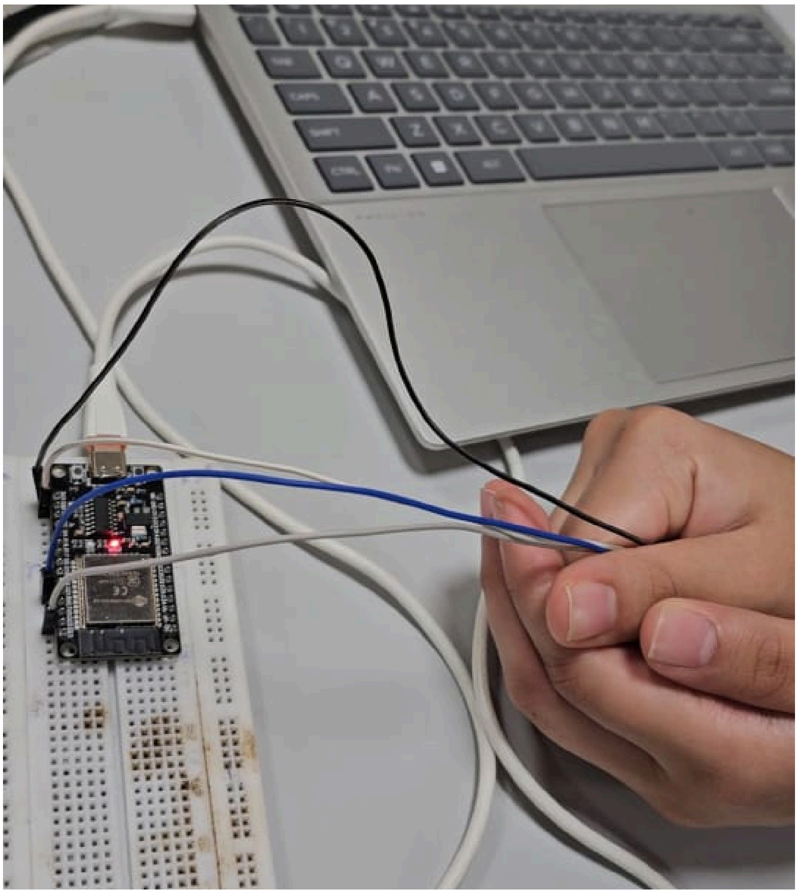
SGP30



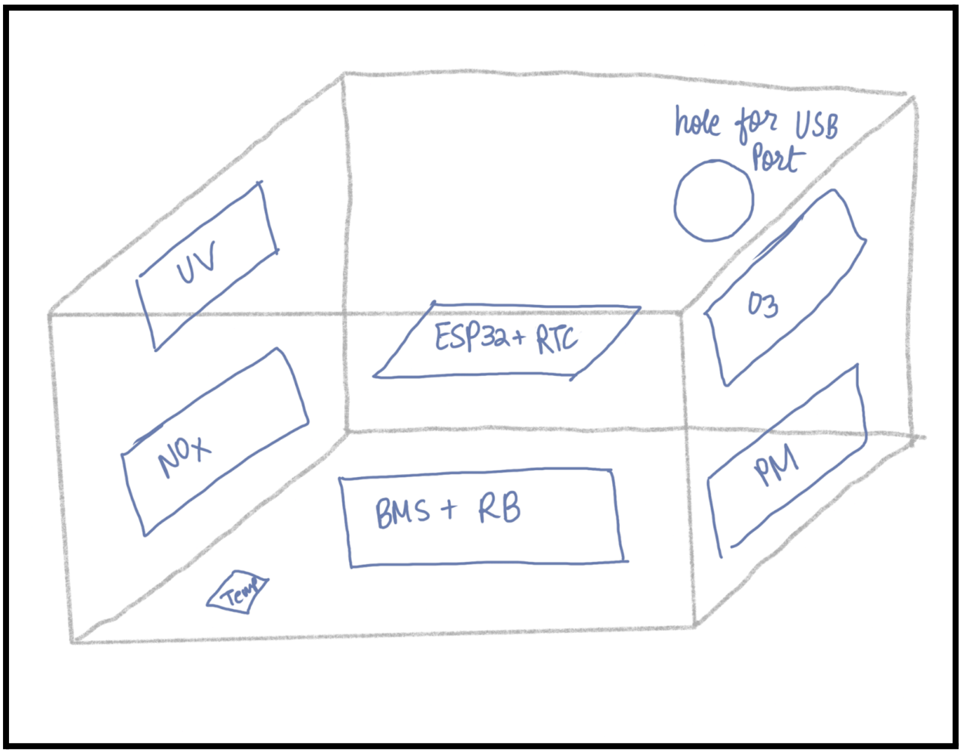

```
15:18:47.598 -> ----------------------
15:18:48.659 -> Temperature: 27.54 °C
15:18:48.659 -> Humidity: 72.17 %rH
15:18:48.659 -> TVOC: 7 ppb     eCO2: 425 ppm
15:18:48.659 -> ----------------------
15:18:49.690 -> Temperature: 27.54 °C
15:18:49.690 -> Humidity: 72.19 %rH
15:18:49.690 -> TVOC: 9 ppb     eCO2: 428 ppm
15:18:49.690 -> ----------------------
15:18:50.764 -> Temperature: 27.56 °C
15:18:50.764 -> Humidity: 72.20 %rH
15:18:50.764 -> TVOC: 3 ppb     eCO2: 413 ppm
15:18:50.764 -> ----------------------
15:18:51.802 -> Temperature: 27.54 °C
15:18:51.802 -> Humidity: 72.22 %rH
15:18:51.802 -> TVOC: 6 ppb     eCO2: 422 ppm
15:18:51.802 -> ----------------------
15:18:52.886 -> Temperature: 27.55 °C
15:18:52.886 -> Humidity: 72.22 %rH
15:18:52.886 -> TVOC: 7 ppb     eCO2: 420 ppm
15:18:52.886 -> ----------------------
15:18:53.937 -> Temperature: 27.55 °C
15:18:53.937 -> Humidity: 72.22 %rH
15:18:53.937 -> TVOC: 7 ppb     eCO2: 419 ppm
15:18:53.937 -> ----------------------
15:18:54.972 -> Temperature: 27.52 °C
15:18:54.972 -> Humidity: 72.23 %rH
15:18:54.972 -> TVOC: 9 ppb     eCO2: 411 ppm
15:18:54.972 -> ----------------------
15:18:56.025 -> Temperature: 27.53 °C
15:18:56.025 -> Humidity: 72.21 %rH
15:18:56.025 -> TVOC: 12 ppb    eCO2: 428 ppm
```

SDS011


Tools Help
ESP32 Dev Module
sketch_sep7a.ino
if (! aht.begin()) {
Serial.println("Could not find AHT? Check wiring");
while (1) delay(10);
}
Serial.println("AHT10 or AHT20 found");
}
void loop() {
sensors_event_t humidity, temp;
aht.getEvent(&humidity, &temp); // populate temp and humidity objects with fresh data
Serial.print("Humidity: ");
Serial.print(humidity.relative_humidity);
Serial.println("% rH");
Serial.println("");
delay(1000); // Wait 5 seconds before the next reading
REMOVE
INSTALL
Output
Serial Monitor
Humidity: 54.20% rH
Temperature: 30.19 degrees C
Humidity: 54.20% rH
Temperature: 30.15 degrees C
Humidity: 54.23% rH
Temperature: 30.08 degrees C
Humidity: 54.30% rH



Layout of the components



Key principles to consider while forming the layout

- **Thermal isolation** : Sensors which can get hot (NOx and Ozone) are placed on top, and sensors which are cooler are placed at the bottom of the box.
- **Airflow** : The gas sensors (SGP30, MQ131, MiCS-2714) and the particle sensor (SDS011) require free access to the ambient air being measure. The SDS011 has its own fan and needs clear intake and exhaust ports. Moreover, there will be holes at the bottom of the box to maintain ventilation.
- **Accessibility** : the ESP32's USB port (for programming/power) should be easily accessible from the outside.
- **Sensor Exposure** : The UV sensor must have a clear, direct line of sight to the outside of the box, preferably pointing upwards towards the sky.

Research on latitudes/ longitudes and how sensor placement changes in different geographies

Effects of Sunlight:

- At higher latitudes, the sun stays lower in the sky → lower solar intensity and different shadow angles.
- This affects solar-powered sensors, requiring larger panels or optimized tilt.
- UV exposure and day night cycle duration (e.g., polar day/night) can change battery charging patterns.
- Longitude mainly determines local solar time, so for distributed sensor networks, synchronization matters to align measurements.

Geopolitical/Regulatory factors:

- Longitude indirectly ties to country/region regulations:
  Wireless frequency bands (LoRa, WiFi, GSM) differ by region.
  Sensor calibration standards (e.g., air quality PM2.5 thresholds) vary.

Latitude determines tilt angle, intensity levels, and seasonal variation.

Longitude determines time alignment of measurements (solar noon vs clock time).

Since Hyderabad lies closer to the equator than poles , the sun is usually higher overhead, so our UV sensor orientation can remain nearly horizontal with minimal tilt adjustments compared to higher latitudes.

Some other work

Research and Relevant material: [Click here]
Presentation: ESW project-male and females : [Click here]

Work for the upcoming weeks :

- Connect all sensors together with the ESP32.
- Incorporate rechargeable battery system with the ESP32.
- Design a PCB before node deployment
- Do calibration and data analysis.