

Providing Technical Help in Modifying the Existing Online Continuous Effluent/Emission Monitoring Systems (OCEMS) of TNPCB

Background

The Tamil Nadu Pollution Control Board (TNPCB) operates Online Continuous Effluent/Emission Monitoring Systems (OCEMS) at the Care Air Centre, continuously monitoring effluent and emission quality in major industries to ensure compliance with discharge and flue gas emission standards. TNPCB officials visited IIT Madras and discussed the features of OCEMS and the data acquisition system. They requested IIT Madras to provide technical assistance to TNPCB for enhancing the existing system to improve its efficiency and reliability.

Objective

Provide technical help in modifying the existing online continuous effluent/emission monitoring systems (OCEMS) of TNPCB

Scope

- i) Developing onsite auditing protocol for OCEMS Analyzers of water and air to check
 - a) The suitability of the OCEMS analyzer and its measuring principles for a specific industrial process and the parameter to be measured as per CPCB guidelines
 - b) Whether the OCEMS analyzer is correctly calibrated and verification of the calibration records of the OCEMS analyzer maintained by the industry
 - c) Whether the OCEMS data measured by the analyzer is transmitted to the TNPCB/CPCB server without Tampering
- ii) Identification and customization of an IoT based data logger to ensure tamper-proof data acquisition from OCEMS analyzers and transmission of the real-time data to the TNPCB/CPCB/Servers
- iii) Logic for data interpretation and validation of OCEMS data to be evolved so that the portal can be developed through NIC. Chennai/NIC. Delhi. The portal should employ statistical methods to check for simulation/manipulation of OCEMS data and may check data authenticity by referring to energy meter & flow meter readings. Also, evolve data validation protocol

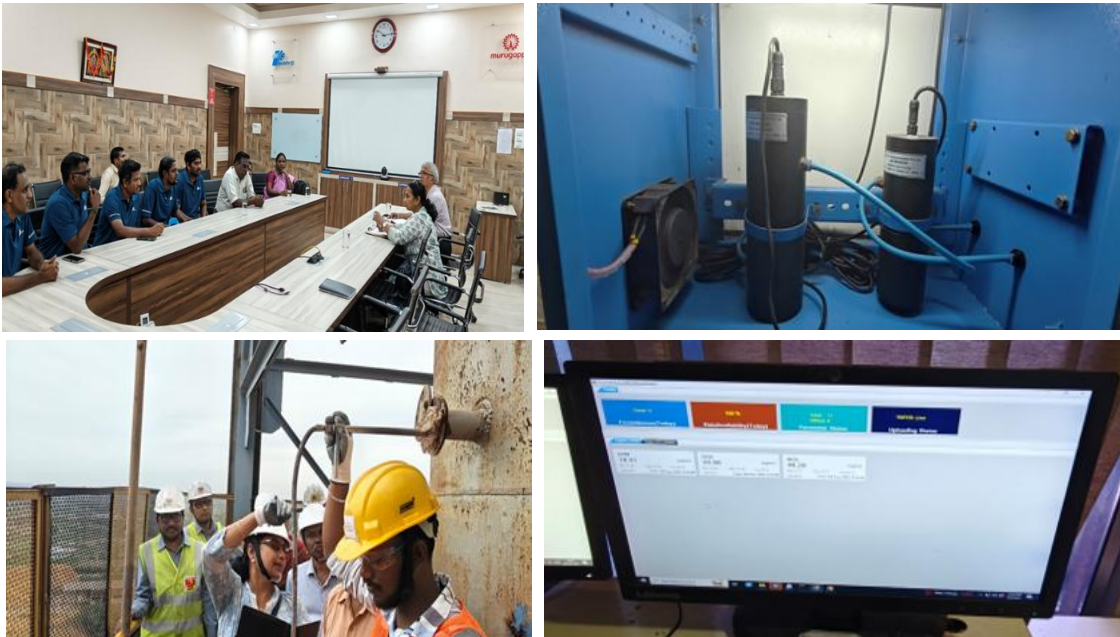
Deliverables

- i) An SOP for onsite auditing/inspection of OCEMS analyzers for water and air

- ii) An IOT data logger
- iii) A document detailing the Logic (Algorithm/flow chart) for data interpretation and validation portal

Work Carried Out

A. Field Visits: IIT Madras team visited eight industries across the state as identified by the TNPCB. These industries include automobile, pharmaceutical, chemicals, sugar, cement etc. Field visits were carried out in the presence of local TNPCB Officials. Prior to the field visit, company was requested to provide all the data in prescribed format. IIT Madras Team had in-person interaction with the company officials and the service providers. The service providers were asked to explain in detail the basis for sensors are working, the calibration procedure and operation and maintenance protocol.



- IIT Madras team inspected the OCEMS system for both flue gasses and effluent treatment
- IIT Madras Team took effluent samples from critical locations and analysed them in IIT Madras Lab. and the results are compared with the data obtained using sensors
- Company was requested to do stack monitoring in presence of IIT Madras team and the values are compared with those obtained using sensors
- IIT Madras visited the Data Logging (and Dashboard) facilities pertaining to OCEMS and asked the service provider to explain the data logging and transfer procedure.

B. Key Observations

- In majority of the companies having stacks, a purging system is installed in the stack. It is connected to a compressor. the dilution of flue gases is occurring through fresh air purging. No sensor or information is available when the purge is in operation. It is diluting the sample and giving a wrong value.



Compressors for Purging in the Tank

- Most of the service providers have only partial knowledge about sensor working, correct procedures for sensor calibration and validation and correct way to carry out stack monitoring. They are not even aware of iso-kinetic sampling of SPM from stack
- In some companies, although remote calibration facilities are available, they are not being used. Sensor calibration is carried out by service provider. It is not carried out frequently.
- Validation of sensor working is not carried out frequently
- In some companies, sensors are not standard sensors
- In some companies, willful tampering of calibration curve itself was evident.
- Calibration, PC shut down etc. are not communicated to TNPCB properly. Although some sensors are not functional during the visit, data was still being sent to TNPCB
- SoP should be strictly adhered to sensor cleaning, calibration and validation. In some companies, they are not even aware of SoPs.
- In many companies, although some units of ETP were not functioning, OCEMS sensors were showing less concentration values in the treated effluent, indicating dilution of clean water prior to the measurement by sensors.
- The sampling and analyzing ports for ETP are not sealed, allowing potential manipulation/dilution of samples.
- The samples are collected to a separate tank and analyses is done. It may not be giving the correct value due to long time retention. The container is not sealed. The sample can be manipulated
- It is advisable to have CCTV cameras in all sensor rooms. In some companies, although CCTV cameras are there, they are focusing somewhere else.
- The correlation coefficients used to estimate BOD and COD from sensor readings are fixed, which is scientifically incorrect.



Sensors Open to Tampering

Further Observations:

- Most industries follow a standard monitoring architecture:

Sensor → 4–20 mA signal → Local Control System → Cloud upload to TNPCB (every 15 minutes)

The architecture is generally reliable from an instrumentation perspective.

- Major areas of concern based on observations:
 - Sample collection practices
 - Sensor handling and calibration
 - Data transparency and access control
 - Cybersecurity measures

Some industries follow best practices; others show gaps that can affect data authenticity and reliability

On Data Integrity

Role-Based Access Control (RBAC)

- ☐ Ambiguous implementation: Roles, responsibilities, and change logs not well-defined.
- ☐ Lack of traceability for configuration or data access changes.

Data Security & Transmission

- ☐ Weak or missing encryption between local systems and cloud.
- ☐ Third-party vendors own the data but lack clear accountability for data privacy and protection.

Cybersecurity Framework

- ☐ No comprehensive policy for data protection.

- ☐ “Data at rest” and “data in motion” are not adequately secured.
- ☐ No evidence of regular security audits or cyber hygiene compliance checks.
- **Sensor failures**
 - a. Guideline for various sensor errors in the appropriate format with API modification (if required) to be developed
 - b. Guideline to include process to handle sensor failure and establish SLAs for downtime of sensors
- **Calibration of devices**
 - a. Determination of Calibration frequency based on types of sensors.
 - b. Development of Maintenance guideline/handbook/checklist that needs to be updated to reflect the calibration frequency
 - c. Inclusion of periodic Audit checks to validate the periodic calibration
- Development of **robust data logging mechanism** with encryption
- Enable **real-time validation** of sensor readings.
 - a. Development of real time validation process, procedure and SLA/timelines for validation/resolution
 - b. Inclusion of auto alerts for out of range process along with the established process for controlling the deviation

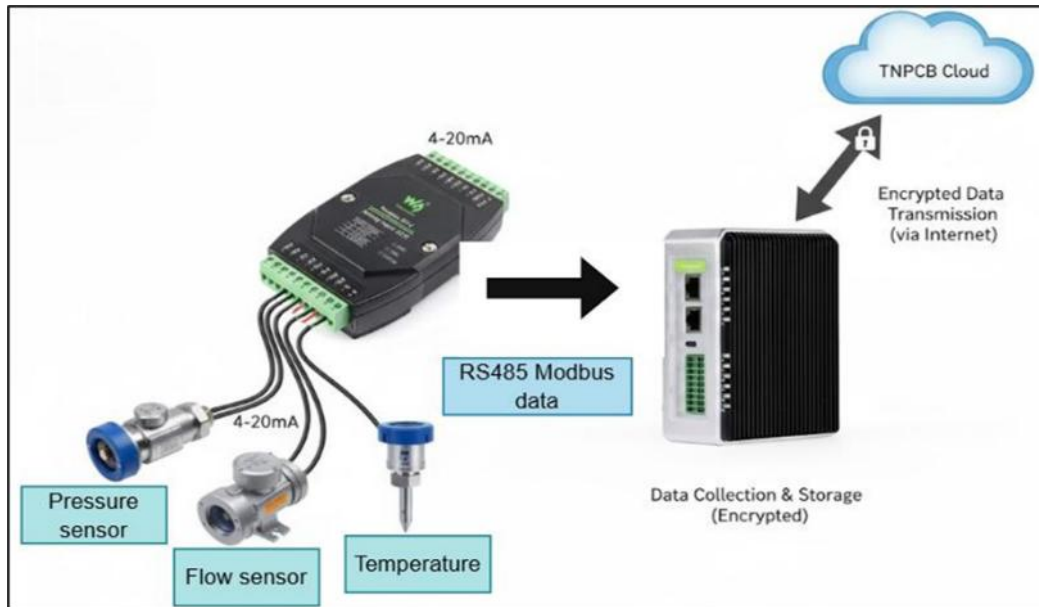
C. Standard Operating Procedure

IIT Madras prepared a standard Operating Procedure including: industry wise parameter definition, measurement principles and measurement technologies, calibration philosophy and procedures, references, standards and normative framework, advanced inspection check points, sensor and analyses certification, sensor citing and installation criteria. SOP for data logging system and for validation of data received by the Dash Board at TNPCB Head Quarters was also prepared and provided to TNPCB.

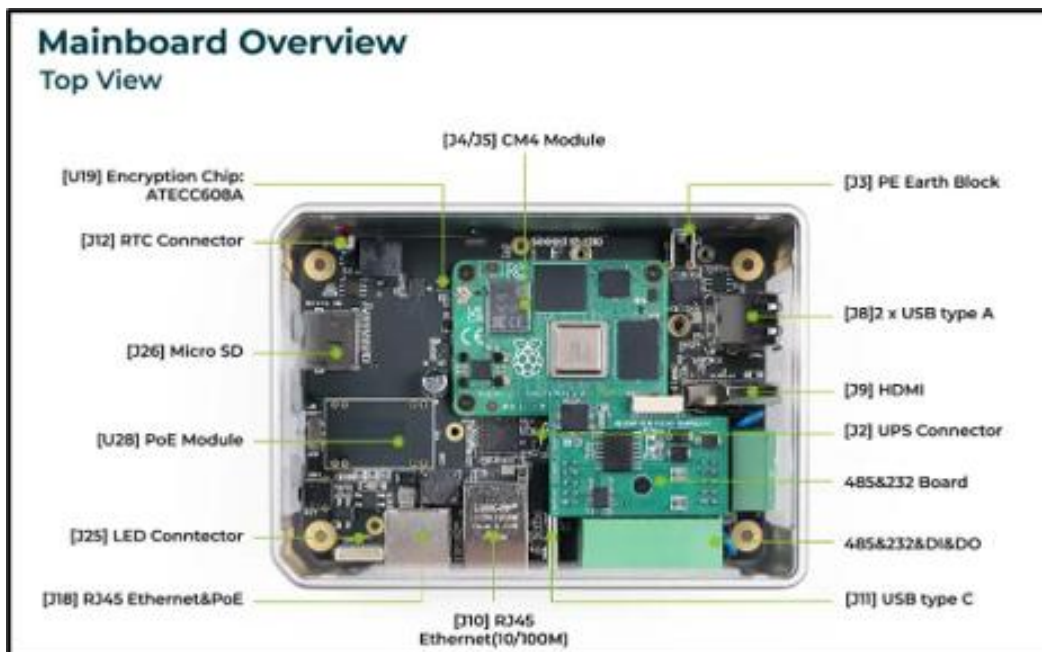
D. Industrial Data Logger

IIT Madras provided the technical solution for a secure, real time data acquisition and logging system designed to meet the mandatory compliance requirements of the Tamil Nadu Pollution Control Board (TNPCB). The core requirement is to securely and reliably transmit continuous effluent/emission monitoring data (from industrial sensors) directly to the designated TNPCB/CPCB cloud servers with mandated encryption.

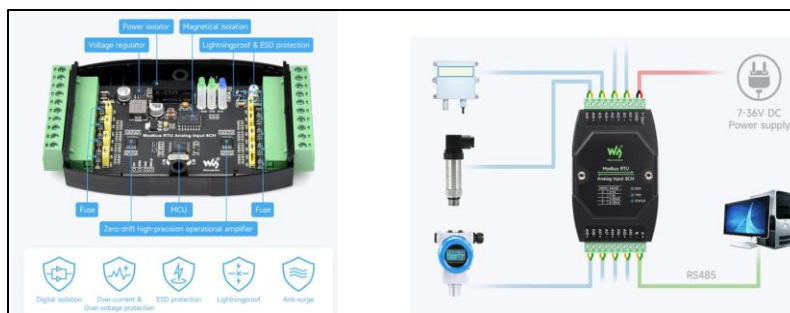
The solution leverages an Industrial Edge IoT Gateway, the re Computer R1100, connected using RS485 to Analyzers & Sensors through an 8 channel 4 to 20 mA analog input module and a high-speed 4G LTE communication module. This architecture ensures high-fidelity data acquisition from standard industrial sensors (4-20 mA and Analyzers through RS485), robust performance in harsh factory environments, hardware-based data security and redundant connectivity for uninterrupted compliance reporting.



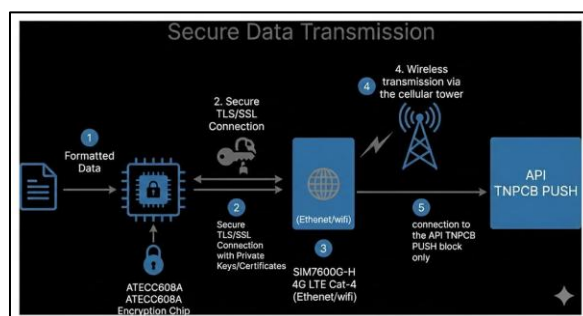
Data Logger Workflow and Architecture



RE Computer Device Overview



Industrial computing unit and data acquisition module



Process flow diagram for the securing data

E. Data Validation

The main objective of this part was to determine whether the data submitted by industries to the Tamil Nadu Pollution Control Board is genuine or manipulated.

To achieve this, a set of time-series validation checks and parameter relationship analyses have been performed. These checks help identify irregularities, inconsistencies, and anomalies in the submitted datasets. Time series validation includes: (i) time stamp validation checks, (ii) duplicate and monotonicity checks, (iii) cadence per parameter check, (iv) gap and burst detection, (v) Clock Synchronization Validation, (vi) required fields check and (vii) rolling null monitoring.

IIT Madras also provided methodology for relationship-based analysis.

- IIT Madras provided Software Requirements Specification for OCEMS Data Validation and Analytical Monitoring Platform.
- Soft Copies of Programs written in Python Programming Language are provided

Major Outcome

The project has resulted in practical tools and protocols that can support TNPCB in strengthening its OCEMS framework, improving confidence in real-time environmental data, enhancing regulatory oversight, and enabling more effective, transparent, and technology-driven environmental compliance.