ONLINE EFFLUENT MONITORING

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GUIDELINES OCEMS (EMISSION AND EFFLUENT) – REQUIREMENTS & REGULATORY

A good ENVIRONMENTAL GOVERNANCE regime paves the path for sustainable growth of a nation- assures quality environment, equitable growth, health & safety for its people while promoting growth.

It needs

- Suitable pollution norms
- Standardised pollution monitoring practices
- Credible Reporting (disclosure)
- Transparency
- Strong regulatory framework
- Self regulation- market oriented pollution control

REGULATORY REGIME

Consent orders of SPCBs/PCCs specify standards to be complied by industries

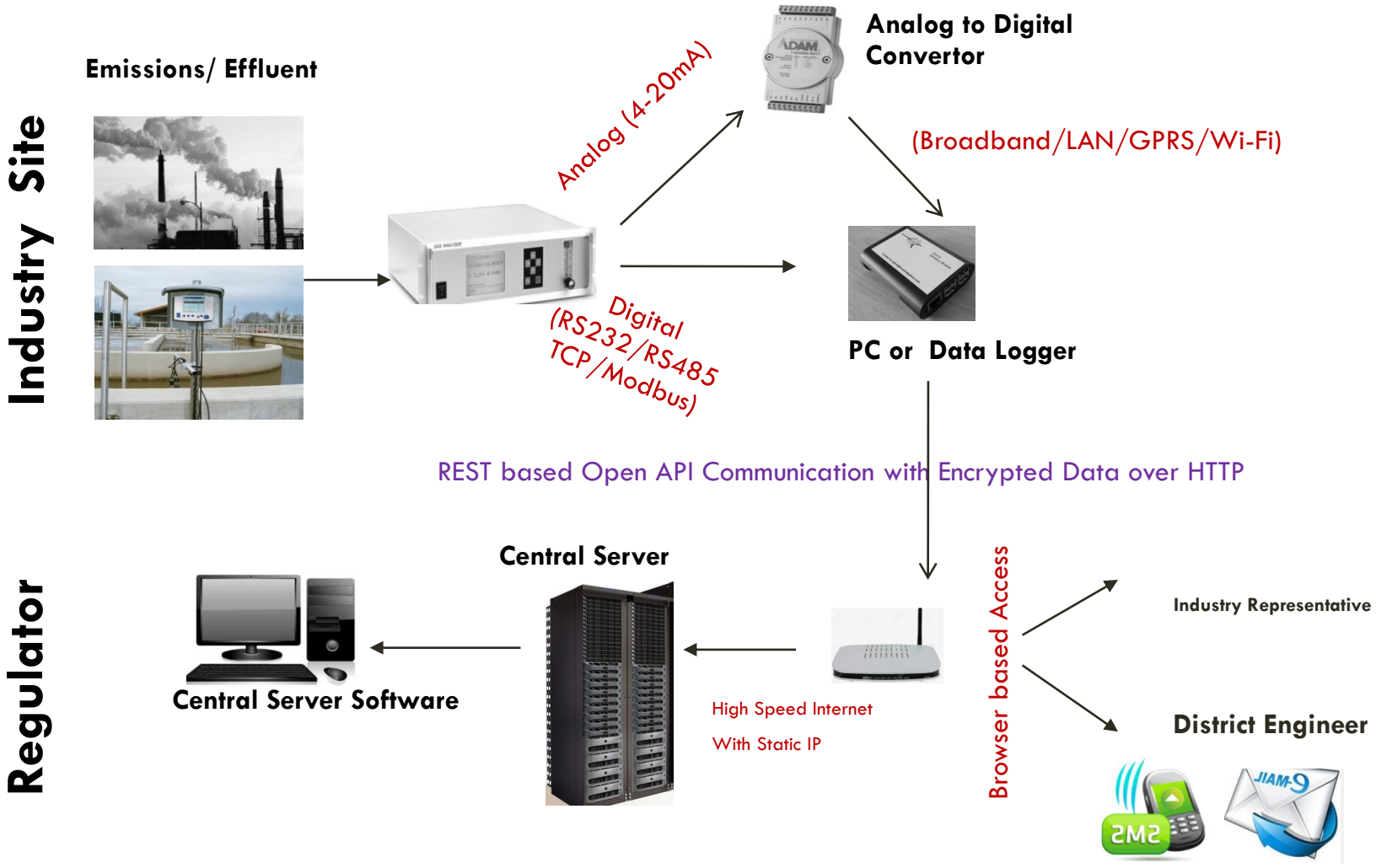
Industries submit analysis reports to SPCBs/PCCs and invariably copies are marked to CPCB

Reports submitted by industries largely comply with the consent standard limits in contrast to the samples collected by SPCBs/PCCs/CPCB that by and large remains non complying.

- Actions (based on manual monitoring methodology) against industries are not leading to improvement in treatment processes by the units besides the willingness of persistent defaulters remains non committal.

What real time monitoring brings ?

- Credible pollution monitoring- less manual intervention
- Transparency
- Better regulatory hand- continuous vigil
- Immediate corrective measures
- Process optimization
- Basic framework for market based pollution control
- Paves path for Self- monitoring regime



Conceptual view of online monitoring

HOW CEMS STARTED?

CPCB direction issued in Feb 2014

- 17 categories of industries, CETPs, common bio-medical treatment facility, Common hazardous waste treatment facilities, municipal solid waste treatment facilities.

Feb. 2014

Mar. 2014

CPCB direction under National Ganga River Basin Authority Mission (NGRBA), March 2014 for installation of real time effluent quality monitoring- nearly 800 industries to install.

CPCB Guidelines for CEMS- August 2017;

Guidelines Revised in Aug 2018- **Mandated for RED category industries in revised guidelines.**

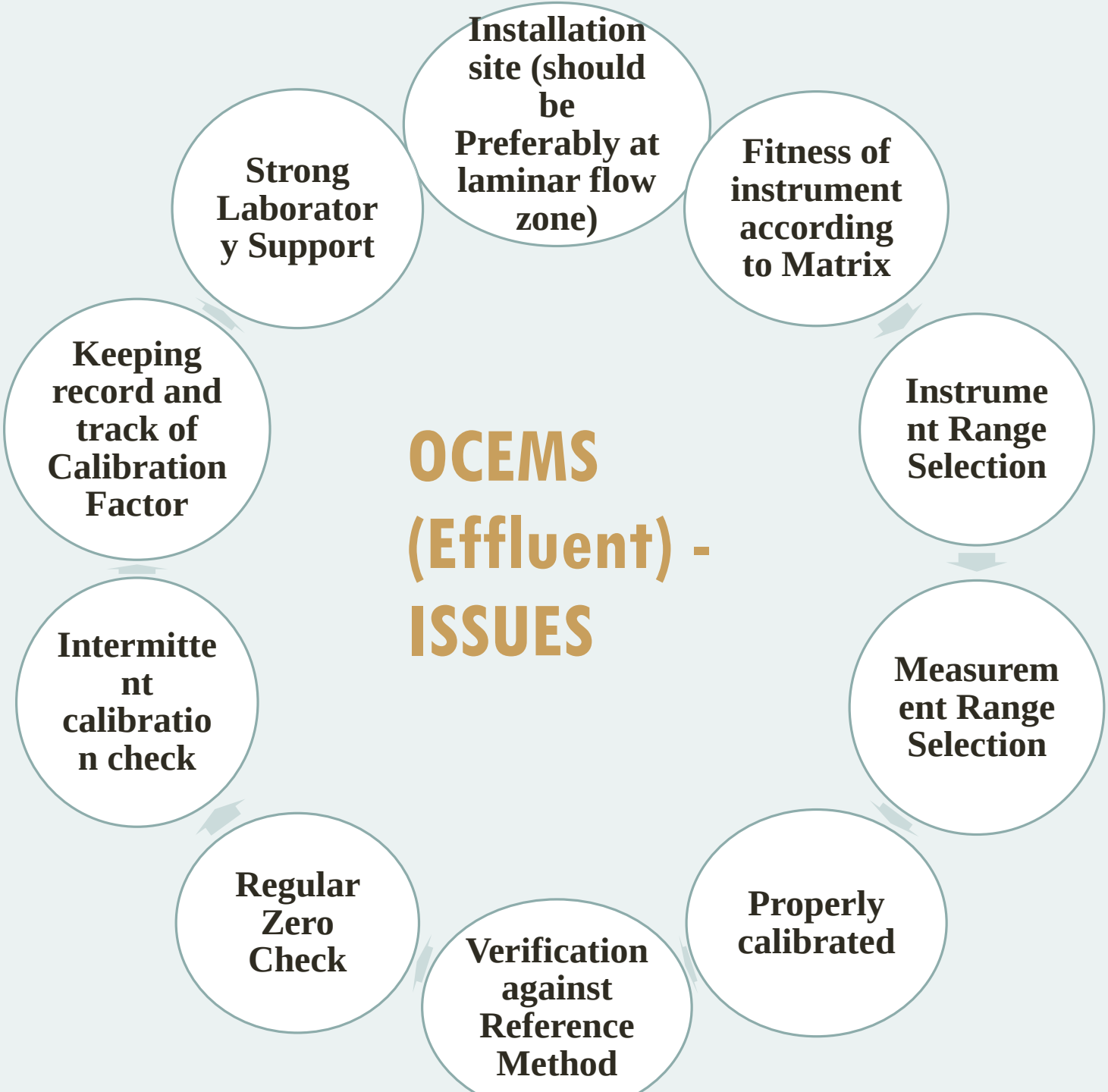
OCEMS (CONTINUOUS EMISSIONS / EFFLUENT MONITORING SYSTEM)

The system composed of Equipment, Instrument to draw, condition, analyze the flue gas sample and provide permanent record of emissions or process control parameters continuously at real time basis is called Continuous Emissions Monitoring System (CEMS)

Benefits of OCEMS

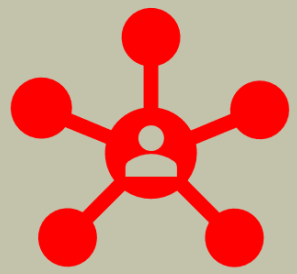
- Provides real time data.
- Time series analysis possible with continuous data.
- Reduction in regulatory cost as well as long term monitoring cost.
- Helps optimization in process control
- Continuous performance check of Pollution Control Devices and optimization of resources used.
- Expected better compliance through self regulation by industry hence lower emission.
- Remotely accessible to operator/regulator.
- Greater transparency in monitoring of performance.
- Can open market driven pollution control venture (ETS)

OCEMS (Effluent) - ISSUES



COMPONENTS OF A CEMS

- Sample Collection — sampling device
- Interface – Sample conditioning & transportation wherever required
- Analyzer — Specific to pollutants, generates an output signal proportional to the concentration
- Calibration devices – Analyzer control system, calibration gases, recording etc.
- Data Acquisition – Data logging system record electrical signals in defined number of channels
- Data Handling System— Pick, calculate, record, transfer the data in report form to desired destination
- Additional Devices: Flow Rate (Velocity Monitor, Temperature sensor, Moisture monitoring device, Diluent Gas monitoring Devices



1. Technology Selection
    2. Suitability / Fitness to specific emission
    3. Quality Certification (COP)
4. Installation
5. Calibration
6. Field Performance testing
7. Data Acquisition
8. Data Handling System
9. Data Robustness
10. Data Exceedance / Violation
11. Compliance

ISSUES WITH CEMS IMPLEMENTATION

MONITORING STATION

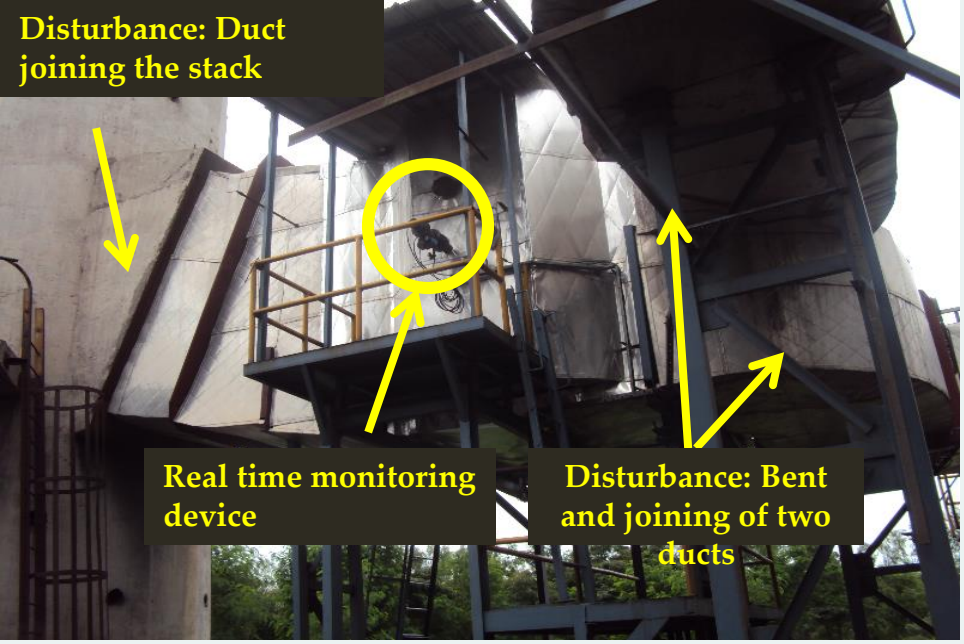
Jajmau Bridge Kanpur-Fixed

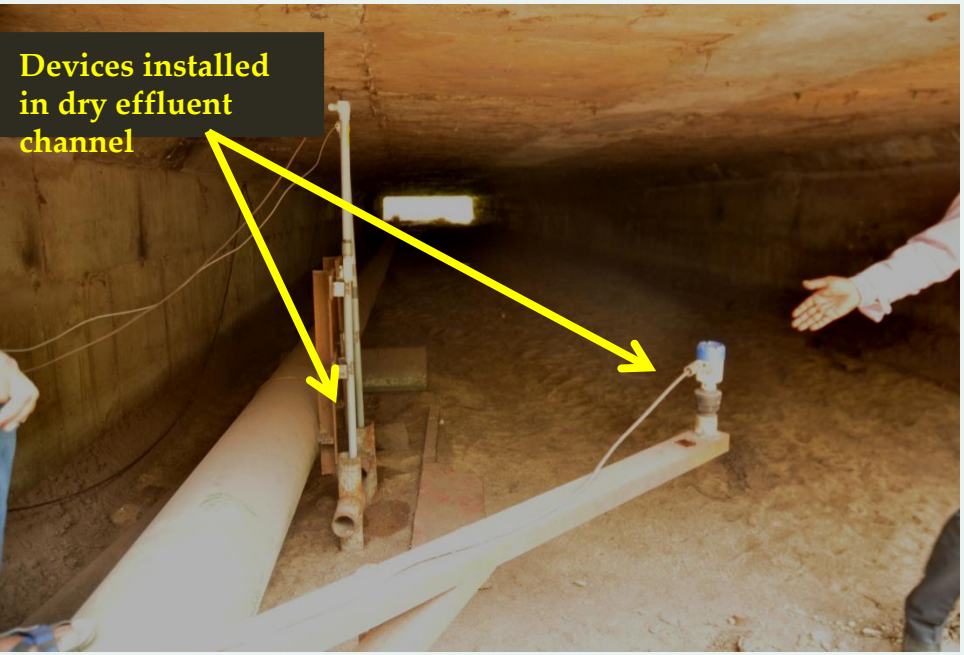
Varanasi Downstream-Floating

AUTOMATIC WATER QUALITY MONITORING OF RIVER GANGA

SENSOR CAGE WITH SENSORS

ONLINE TOC ANALYZER





- **Incomplete installation**
- **Wrong installations-** no clear idea on where to install CEMS- which stack ? Which location ?
- **Many non-functional- poor maintenance**
- **No clarity on suitable technology selection**. to comply the direction many industries installed cheaper devices irrespective to their suitability
- **Data supply to regulators was poor**
- **Data was not credible**

Issues identified in implementation

Parameter to be monitored (Online)

	Effluent Parameters(13)	**Emission Parameters(7)**
n	pH, BOD, COD, TSS, Flow	PM, Fluoride
	-	PM,NOx,SO_2
	pH, BOD,COD,TSS, Flow	PM
ye	pH, BOD,COD, TSS, Cr, Flow	-
li	pH, TSS, Flow	Cl_2,HCl
	pH, flow, Ammonical Nitrogen, F	PM, Fluoride, NH3
el	pH, Phenol, cyanide, flow	PM,SO_2
y	pH, BOD,COD,TSS, flow	PM,CO,NOx,SO_2
ical	pH, BOD,COD,TSS, flow	PM,CO,NOx,SO_2,
	pH, BOD, COD, TSS, Cr, As , flow	-
utical	pH, BOD, COD, TSS ,Cr ,As, flow	-
nts	pH, TSS, Temperature	PM,NOx,SO_2
per	pH, BOD, COD, TSS ,AOx, flow	-
	pH, BOD,COD,TSS, flow	

Effluent Monitoring Technologies Available

Available Technologies	Parameters Measured	Applications	Limitations
UV Spectrophotometry (Single/two/four wavelengths)	COD, BOD	Fresh Water & Waste water with constant matrix	Suitable for fresh water and not for waste water applications. Interference of colour &high turbidity. Operates on stable matrix.
UV-Vis Spectrophotometry 40 wavelength	COD, BOD, TSS	Fresh Water & Waste Water with constant matrix	Many organic compounds are unattended due to lesser scanning of UV spectra. Operates on stable matrix. Sample pumping limitation
UV-Visible Spectrophotometry (Single Beam)	COD, BOD, TSS	Fresh Water & Waste Water	Fresh Water & Waste Water Interference due to colour & high turbidity affects the analyzer operation. Reference beam compensation not available.
UV-Vis Spectrophotometry (Double Beam)	COD, BOD, TSS	Fresh water to Waste water	Fresh water to Waste water Interference of colour & turbidity is compensated in visible spectrum

Effluent Monitoring Technologies Available

Available Technologies	Parameters Measured	Applications	Limitations
Insitu UV spectrometry sensor technology	pH, TDS, COD, BOD, TOC, Turbidity	Waste water	Low measuring capacity of COD ((i.e. 5000 mg/l) and TSS (200 mg/l)
UV/Visible spectrometry, probe & by-pass style	Flow, pH, BOD, TSS, COD, NH_3, Cr, As, TOC, Nitrate, Nitrite	Waste water	The frequency of cleaning varies widely depending on the turbulence in the process
Wet chemical oxidation ($K_2Cr_2O_7$) method with colorimetric determination	COD	Waste water	Applicable only for COD
High temperature catalytic combustion oxidation	COD, BOD, TOC	Waste water	Fresh Water
IR light absorption at 880 nm	TSS	Waste water	Turbidity interference is there which can be overcome.
LAR Tech	High Temperatures Thermal Oxidation		

Effluent Monitoring Technologies Available

Available Technologies	Parameters Measured	Applications	Limitations
Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Calorimetric	COD	Fresh Water & Waste Water	Fresh Water & Waste Water Discharge of hazardous chemicals
Electrode /Electrochemical method	pH	Fresh water & Waste Water	Fresh water & Waste Water
Scattered Light Method (IR)	TSS	Fresh water & Waste Water	Fresh water & Waste Water
Nephelometry Method	TSS	Fresh Water & Less turbid water	Fresh Water with Low turbidity
Colorimetric (645-655nm)	NH_3	Fresh Water & Waste Water	Turbidity interference is there which can be overcome. 3-15 min cycle time
Ion Selective Electrode method With temp correction	NH_3	Fresh Water & Waste Water	Potassium interference Requires additional measurement of potassium for compensation
UV Absorbance or Multiple Wavelength UV Absorbance Spectrophotometers (200-450nm)	NH_3	Fresh Water & Waste Water	Turbidity interference is there which can be overcome.

Effluent Monitoring Technologies Available

Available Technologies	Parameters Measured	Applications	Limitations
Combines Combustion Catalytic Oxidation at 680°C and NDIR Method	TOC (Co-relation with BOD & COD)	Fresh Water and Waste Water	-Carrier gases required -Continuous High power requirement -Analyzer: Infrastructure required -More than 10-15 minutes sampling frequency -Only TOC can be measured -Any matrix change requires fresh correlation to COD & BOD
UV Persulfate NDIR Detector	TOC (Co-relation with BOD & COD)	Fresh Water & Waste Water	-Carrier gases required - Continuous High power requirement -Analyzer: Infrastructure required -More than 10-15 minutes sampling frequency -Only TOC can be measured Any matrix change requires fresh correlation to COD & BOD
Persulfate Oxidation at 116-130degC NDIR Detector	TOC (Co-relation with BOD & COD)	Fresh Water & Waste Water	-Fresh Water & Waste Water Applicable for moderate polluted effluent -Carrier gases required -Analyzer: Infrastructure required Any matrix change requires fresh correlation to COD & BOD

Effluent Monitoring Technologies Available

Available Technologies	Parameters Measured	Applications	Limitations
Colorimetric method Reaction of Cr-VI with diphenyl carbazide in acid solution	Chromium	Fresh Water & Waste Water	Fresh Water & Waste Water
Voltammetry (Anodic Stripping Voltammetry)	Chromium, Nickel	Fresh Water & Waste Water	Fresh Water
Dual Beam UV-Visible Spectrophotometry	Chromium Hexavalent and Trivalent in full spectrum	Fresh water & waste water	Experience in Indian condition is not available
Voltammetry (Anodic Stripping Voltammetry)	Arsenic	Fresh Water & Waste Water	Fresh Water
Colorimetric (SDDC) (Lab Method)	Arsenic	Waste Water Certain metals chromium, coboit, copper, mercury nichel, selemium, silver influence, generation of arsenic, H_2 sintufers	Turbidity interference is there which can be overcome. Chromium, Cobalt, Copper, mercury nickel, selenium, silver influence generation of arsenic. H_2S interfers in measurement

Effluent Monitoring Technologies Available

Available Technologies	Parameters Measured		Applications	Limitations
Two stage Advance Oxidation technology (biotector)	Total Nitrogen TOC, COD, BOD		Waste Water, fresh water	Fresh Water & Waste Water TOC< 6.5m, Time required for analse of TOC&TN 7 minutes, system concentrator required, Ambient Temperature 5-45 Z
Ammonium & Nitrogen Sensor Model I.Q. Verion	Ammonical-Nitrogen		Waste Water	Fresh Water
Low Temperature wet chemical oxidation (Applitech)	Total Phosphate & Total Nitrogen		Waste Water, fresh water	Fresh water
UV Fluorimetric	TOC, COD, BOD, TSS		Waste Water	Turbidity interference is there which can be overcome, Fresh Water
Photo flex system	Supercritical water oxidation (SCWO)	BOD, COD	Water & waste water	Sample temperature above 60^0C require the optional high temperature sampler

EFFLUENT MONITORING

Sampling

In-situ

extractive

B. Effluent Quality Monitoring

(i) The instruments/analysers for real time monitoring of effluent discharges/ shall be calibrated with respect to their functioning, drift, linearity detection limit, output, response time, repeatability of temperature and other relevant parameters before installation.

(ii) After six months of operation, the analysers/ instruments /sensors shall be checked for their health, data accuracy and reliability following multi point calibration (at least at 3 span concentrations) using standard laboratory methods and certified reference materials.

(iii) Comparison of the values of pH, COD, BOD, TSS and TOC as recorded by the analysers/instruments/sensors shall be done on a fortnightly basis i.e, second Friday of the monthly, at fixed time, starting 10.00 am., using standard reference materials.

(iv) In case deviation of the comparison values exceeds the target accuracy specified for the parameter, the analyser/instrument/sensor shall be rechecked for its accuracy again on the next day, following standard laboratory methods and standard reference materials.

(v) In case the deviation of the comparison values is beyond the target accuracy for the specified parameters for 2 consecutive days, the system shall be recalibrated in the laboratory following multi point calibration (at least 03 span concentration) using standard laboratory methods and certified reference material.

vi. In case of any change in effluent matrix, the correlation between TOC: COD & TOC: BOD with laboratory reference method in case of TOC analyser and for COD and BOD with laboratory reference method in case of UV-Visible Spectroscopy shall be rechecked.

(vii) The data capture rate shall be more than 85%.

(viii) The data comparison/calibration verification shall be done by laboratories empanelled by CPCB using standard reference methods and certified reference standard material as specified and at a frequency specified.

Criteria for Empanelment of Laboratories

(i) Laboratories recognised under the Environmental (Protection) Act, shall only be considered for empanelment.

(ii) The EPA recognised Laboratory having achieved robust statistical Z score more than 70% in the laboratory proficiency testing shall only qualify for empanelment.

(iii) The empanelled Laboratory shall participate in the proficiency testing programmes organised by CPCB twice a year.

(iv) The empanelment of Laboratories, failing to achieve the required Z score in the proficiency testing shall be kept in abeyance, till their performance in the next round of proficiency testing meets the prescribed score.

(v) Laboratories failing consecutively twice in achieving the desired Z score in proficiency testing shall not be considered for empanelment and/or their empanelment withdrawn

(vi) CPCB shall arrange for Analytical Quality Control Proficiency Testing programmes for Air Pollutants along with the Water Quality parameters.

(vii) The Head Quarter/ Zonal Office laboratories of CPCB shall verify performance of atleast 2% of the installed real time monitoring systems every year.

(viii) The data comparison/calibration shall be done by empanelled laboratories at frequency specified under para-“Calibration”.

- **Most of the issues are common in effluent and emission but the continuous effluent monitoring system is more challenging to satisfy the Data Quality Objectives**

Main issues

- Sampling location / plane
- Instrument calibration for few parameters are easy but data verification is difficult
- BOD COD are major challenging parameters
- Matrix plays important role in measurement technology
- TSS interference
- Overlapping optical band in various parameters in spectrometric methods

Performance Check Evaluation

- Correctness of Installation
- Calibration (Internal Electronic Calibration)
- External Calibration and Verification
- Comparison against Reference Methods in same matrix
- Analytical Range Selection (Minimum and Maximum)
- Thorough data base introspection with conventional methods to optimize selected range covering all operational events in Industrv
- Drift checks
- Audit (Composite sample monitoring)

Maintenance and Checking of Log Book

- Frequent changes of calibration Factor for indirect method may attract attention
- For photometric methods source lamp intensity, Wavelength calibration, stray light, linearity etc. are governing factors for instrument performance
- Filtration of Sample may be required to accurately eliminate the interferences; which invite clogging

Certification and approval

- Certified CEMS are available in market
- CWQMS Certification and approval is a big issue (Very few organization available worldwide)
- Presently India has allowed non certified instruments in real time industrial monitoring till Indian certification system is established

LEVEL (I) PERFORMANCE EVALUATION PROCESS

CRITERIA OF INSPECTION AND PERMISSION ON SAMPLING LOCATION

FOR ALL SENSORS / SAMPLING DEVICE

VERIFICATION OF FACTORY CALIBRATION CERTIFICATES

DEMONSTRATION AND VERIFICATION OF MANUFACTURER S CLAIM

BEFORE INSTALLATION

INSTALLATION (INCLUDING CALIBRATION) AND STABILIZATION OF ALL THE ANALYSER ON DIFFERENT LOAD CONDITION.

PRIMARY DATA COLLECTION AT 100% LOAD FOR 4 WEEKS

LEVEL (II) PERFORMANCE EVALUATION PROCESS

EVALUATION OF DATA DEPENDING ON CRITERIA SET FOR RANGE SELECTION, ZERO SPAN DRIFT, CALIBRATION, LINEARITY

IF IT MEETS THE CRITERIA SET THE OPERATOR IS ALLOWED TO RUN IT

FOR NEXT TWO MONTHS AND MAY BE ASKED TO PROVE ACCURACY AND PRECISION BY REPEATABILITY AND REPRODUCIBILTY TESTS AGAINST REFERENCE METHODS

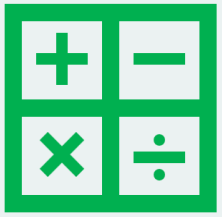
IN CASE OF FAILING TO MEET LEVEL (I) THE OPERATOR / VENDOR IS RESPONSIBLE TO REPEAT THE WHOLE PROCESS / A PART TO COMPLY WITH CRITERIA

ON COMPLIANCE TO THE LEVEL (I) & (II) PERFORMANCE

EVALUATION PROCESS THE ACCEPTANCE OF THE SPECIFIC SYSTEM INSTALLED IN RESPECTIVE PLANT MAY BE ISSUED BY REGULATOR

pH METER – FUNCTIONS

CALCULATION OF POTENTIALS



$U = U_0 + (\ln 10 * R * T) / (n * F) * \log (H^+_{media} / H^+_{internal})$

R	8.314	$J*K^{-1}*mol^{-1}$		
F	96487	$C*mol^{-1}$		
T	273.16	Kelvin	**0**	**°C**
n	1	electrons per ion		
ln10	2.303			
U_0	0	standard electrode potential		
H^+ media	1.E-07			
H^+ internal	1.E-07			
U	**0.00**	**in mvolts**		
s 0°C	**54.20**	**mV / pH**		

No pH theory without Nernst equation

COD, BOD AND TOC

- **COD** represents quantification of oxygen requires for oxidizing the carbon (Titrimetric / UV Spectrometry / TOC Relationship)
- **BOD** represents amount of dissolved O2 needed to degrade the organic compounds is effectively (UV Spectrometry / TOC Relationship
- **TOC** represents quantification of oxidizable carbon (TOC Analyzer)

COD MEASUREMENT RANGE - FLOW CELL

1

Low range with 10 mm flow cell

2

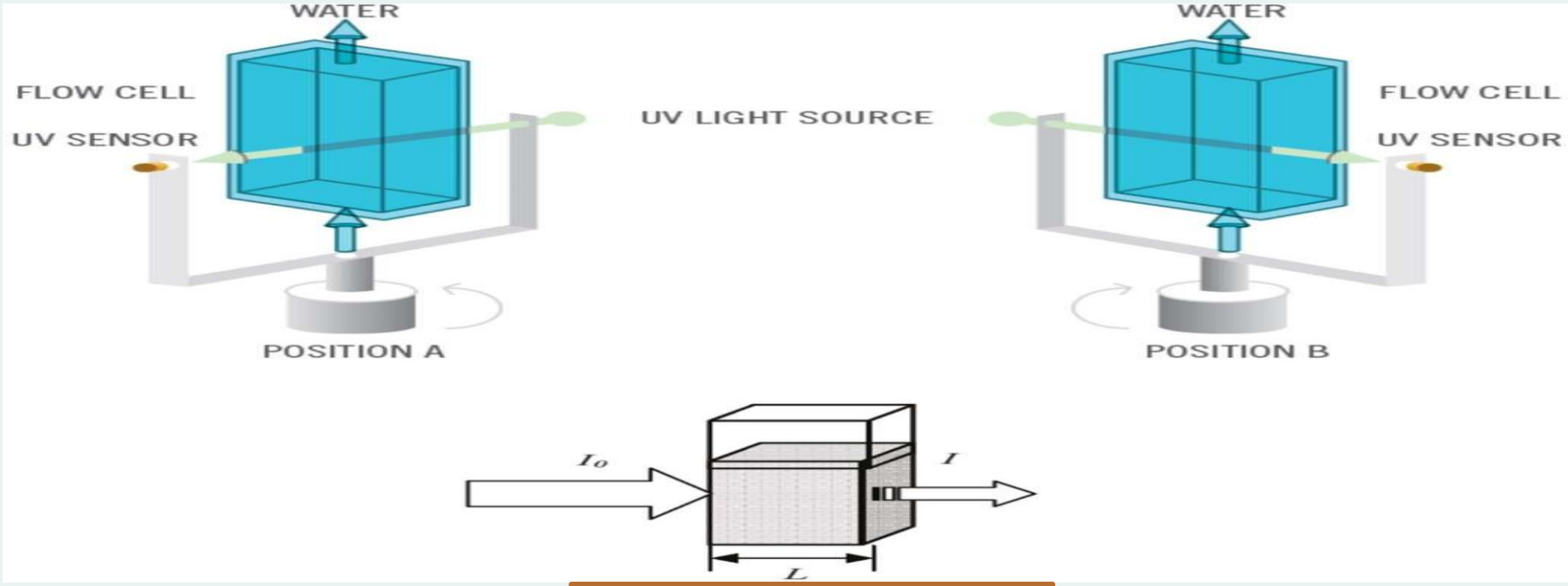
Range: 0 –100 mg/COD (Clear Water)

3

High range with 1 mm flow cell for

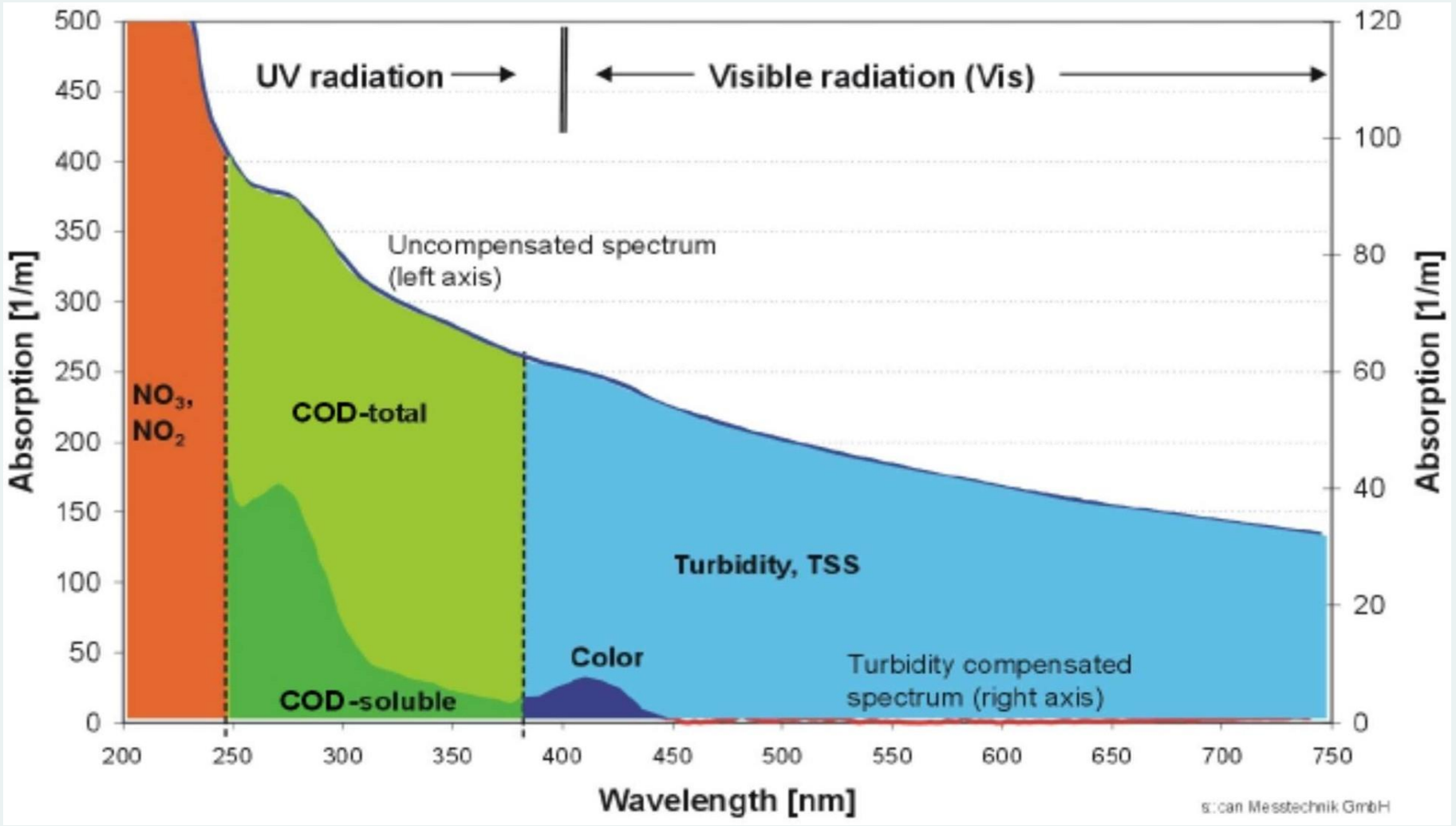
4

Range : 0 – 20,000 mg/l COD (Effluent)



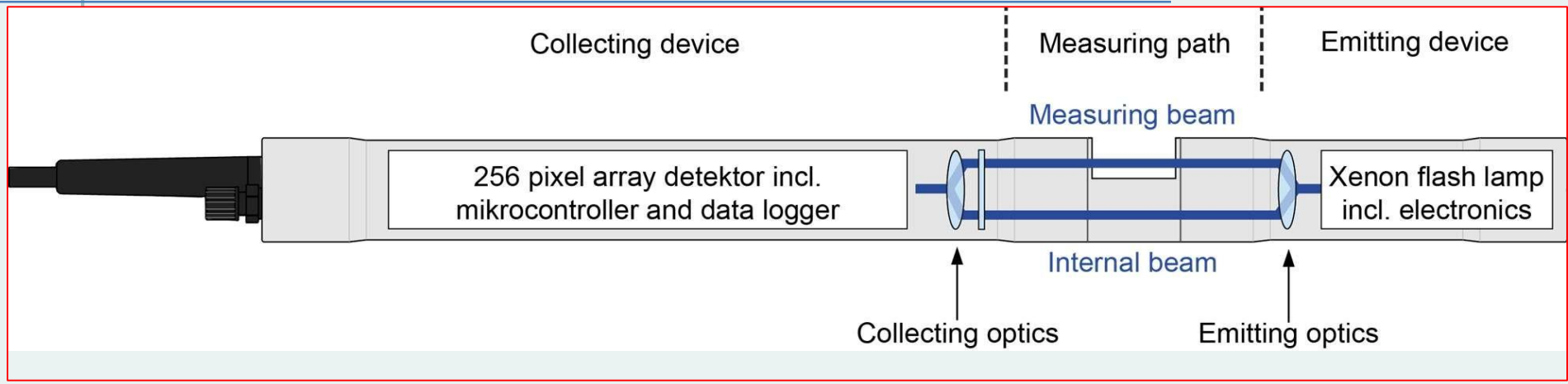
$$I = I_0 e^{-KCL}$$

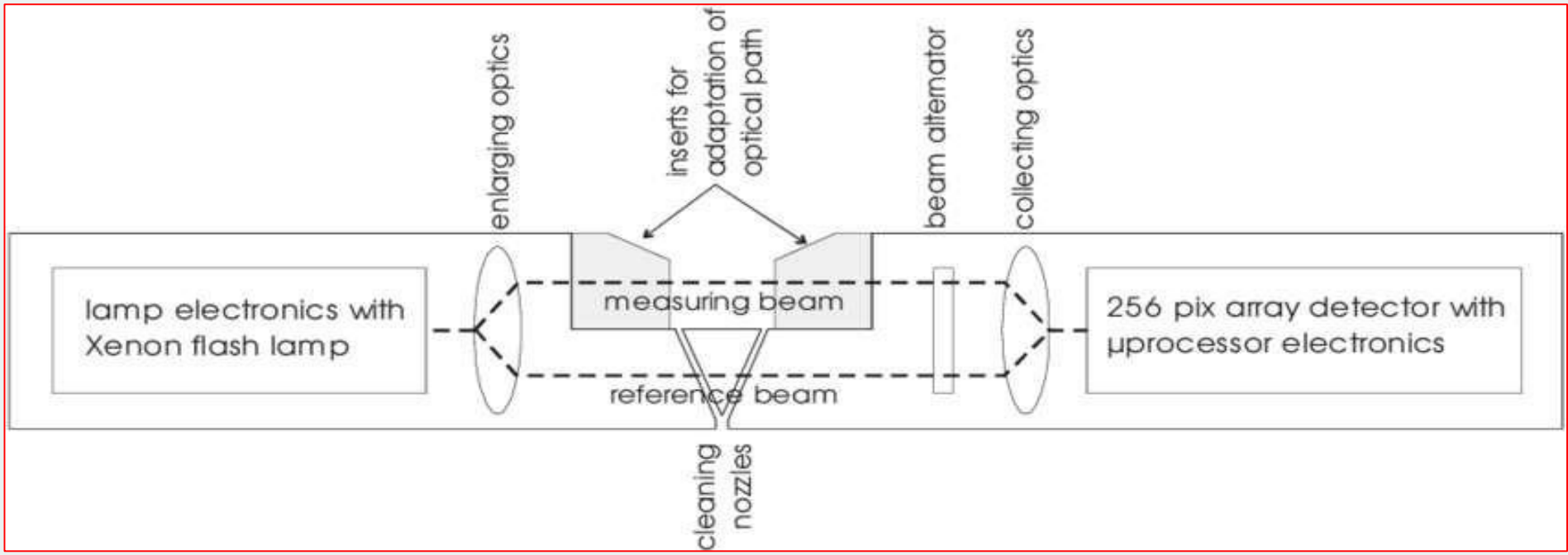
MEASURING PRINCIPLE = UV VIS SPECTROMETER



WHOLE RANGE SCANNING AND MATRIX MATCHING REQUIRED

ONLINE WATER QUALITY MONITORING & UV/VIS SPECTROMETRY



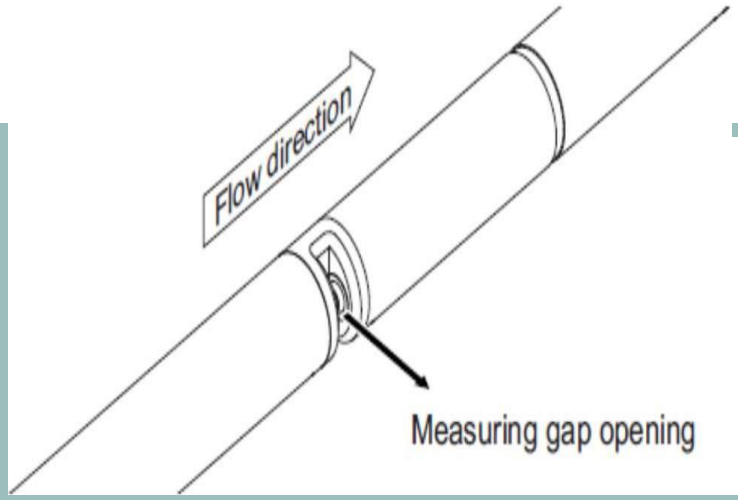


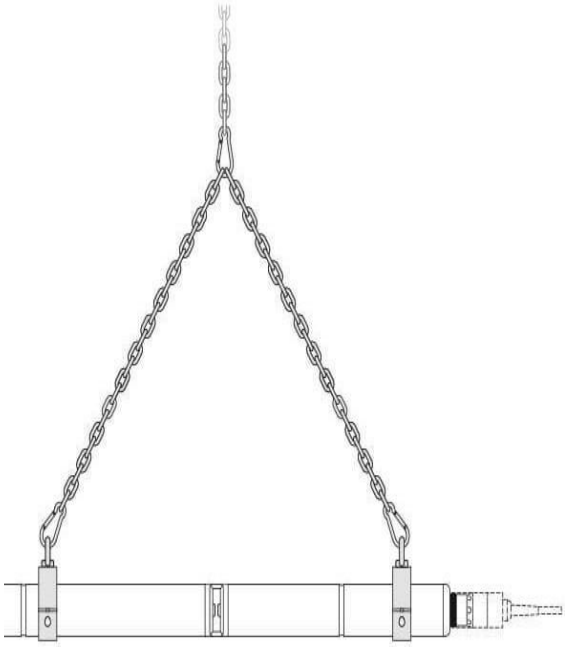
THE MEASURING GAP OPENING SHOULD BE ON THE SIDE.

ANY AIR BUBBLES CAN ESCAPE UPWARD AFTER CLEANING

NO SEDIMENT CAN COLLECT IN THE MEASURING GAP.

THE SENSOR SHOULD BE ALIGNED IN PARALLEL WITH THE FLOW DIRECTION.



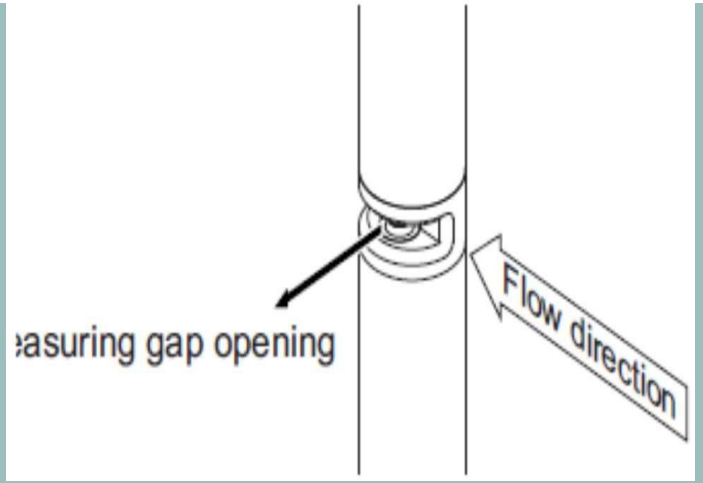


HORIZONTAL INSTALLATION

MOUNT THE SENSOR IN A POSITION THAT ALLOWS INTERFERING ELEMENTS IN THE MEASURING GAP TO ESCAPE WITH THE CURRENT.

THE MINIMUM FLOW RATE IS 0.2 M/S SO THE MEASURING GAP IS KEPT CLEAN OPTIMALLY..

VERTICAL INSTALLATION



Protocols for Online Continuous Effluent & Emission Monitoring Systems (OCEMS) 13.03.2018

✓ **Instructions for Industries to submit information**

The Industries are requested to submit information as per protocols mentioned in PART – I (Sections A, B, C, D, E) & PART – III (Section- H) **Only ONCE and information as per protocols mentioned in PART-II (Sections F & G) Every Quarter on 1st January, 1st April, 1st July and 1st October to CPCB.**

PART-I : Protocols for General Information and Technology Selection & Installation of OCEMS

- **Section A: General Information about Industry & its products**
- **Section B: General Information on Source Emission (B1) & Water Use & Effluent (B2) at discharge Locations**
- **Section C: Expected Flue Gas Stream Constituents at Sample Probe Locations**
- **Section D: Flue Gas Conditions at Sample Probe Location**
- **Section E: Selection and Installation of OCEMS at Emission & Effluent discharge points**

PART-II : Protocols for Operation & Calibration of OCEMS

Section F: Operation and Calibration procedures adopted by the Industries for Emission Monitoring

Section G: Operation and Calibration procedures adopted by Industries for Effluent Monitoring

PART-III : IT (Information Technology) Protocol for OCEMS Data Submission

Section H: IT Protocol for OCEMS Data Submission

PART-IV : Online Automated Alerts Generation Protocol

Section I: Online Automated Alerts Generation Protocol based on OCEMS Data Submission by Industries

Note 1: Any changes in industrial process, Air Pollution Control Devices, CEMS (even replacement with same technology) shall invite revised submission. Industry has to inform CPCB about the changes made and has to submit the information as per Section B (B1/B2) and other sections as applicable.

Online SMS Alerts Mechanism

- All Online effluent monitoring equipments are connected to Servers to transmit data through GPRS
- Server collect the analyzed data on every 1 minutes and generating files
- Server transmitting average of 15 min data to CPCB / SPCB on 15 min intervals through GPRS connectivity
- Server generates auto SMS Alerts to the registered mobile numbers for deviations, if any

Proposed Framework for Regulatory Controls through Real Time Effluent/ Emission Monitoring System

- Presently, SMS alerts are being sent to industries for deviations in the values (15 min avg of any parameter)
- Online data transmission are categorized as – live, delay (no data transmission since last four hours), and offline (no data transmission since last 48 hours or more)
- Considering the online monitoring data, a monitoring protocol is being devised to enhance compliance level;
  - Based on deviations, connectivity and frequency, following alerts shall be generated
  - These alerts are used for achieving compliance by industries with more focus on the proper operation & maintenance of ETP and calibration of sensors.

Alerts for Effluent Monitoring

Violation	Time weight	Alerts
Exceedence by > 40% from standards (pH, BOD, COD)	15 minutes average 8 times in 24 hours	
36 yellow alerts	During 30 days monitoring moving period	
72 Orange alerts	During 30 days monitoring moving period	
When instruments or data connectivity fails	Continuously for seven days	

Alerts for Emission Monitoring

Violation	Time weight	Alerts
Exceedence by > 25% from standards (PM, SO_2, NO_X, CO)	15 minutes average 8 times in 24 hours	
36 yellow alerts	During 30 days monitoring moving period	
72 Orange alerts	During 30 days monitoring moving period	
When instruments or data connectivity fails	More than one Red alerts during 30 days	

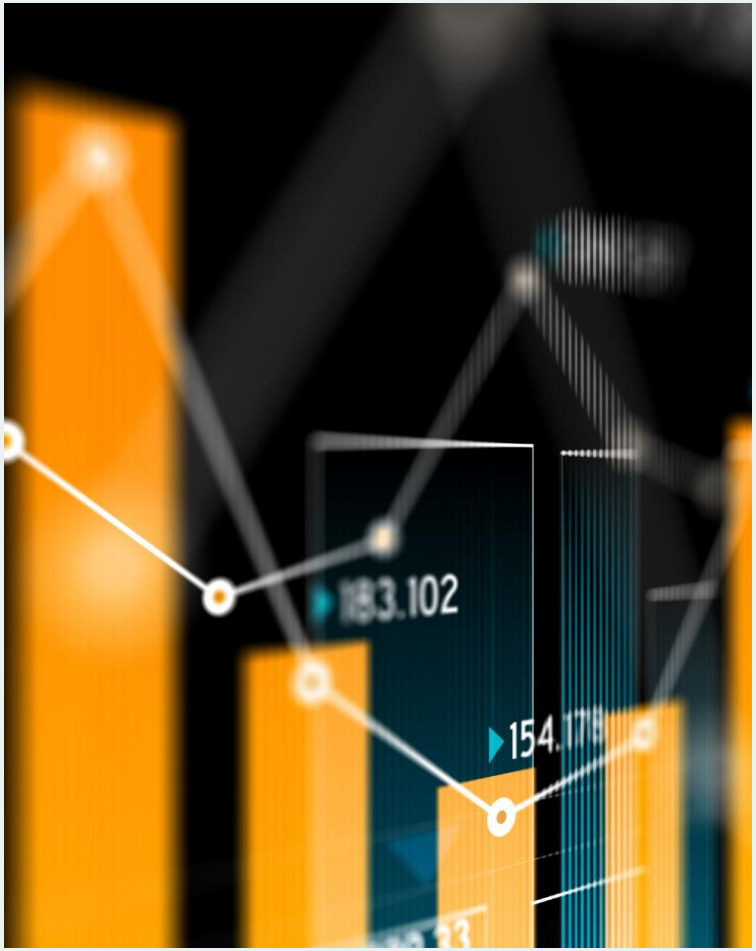
Data Validation

- **Data generated by an emission point (15 min Average)**
- **15*4*24*365=35040**
- **Valid data requirement = 29784**

- **Spike removal**

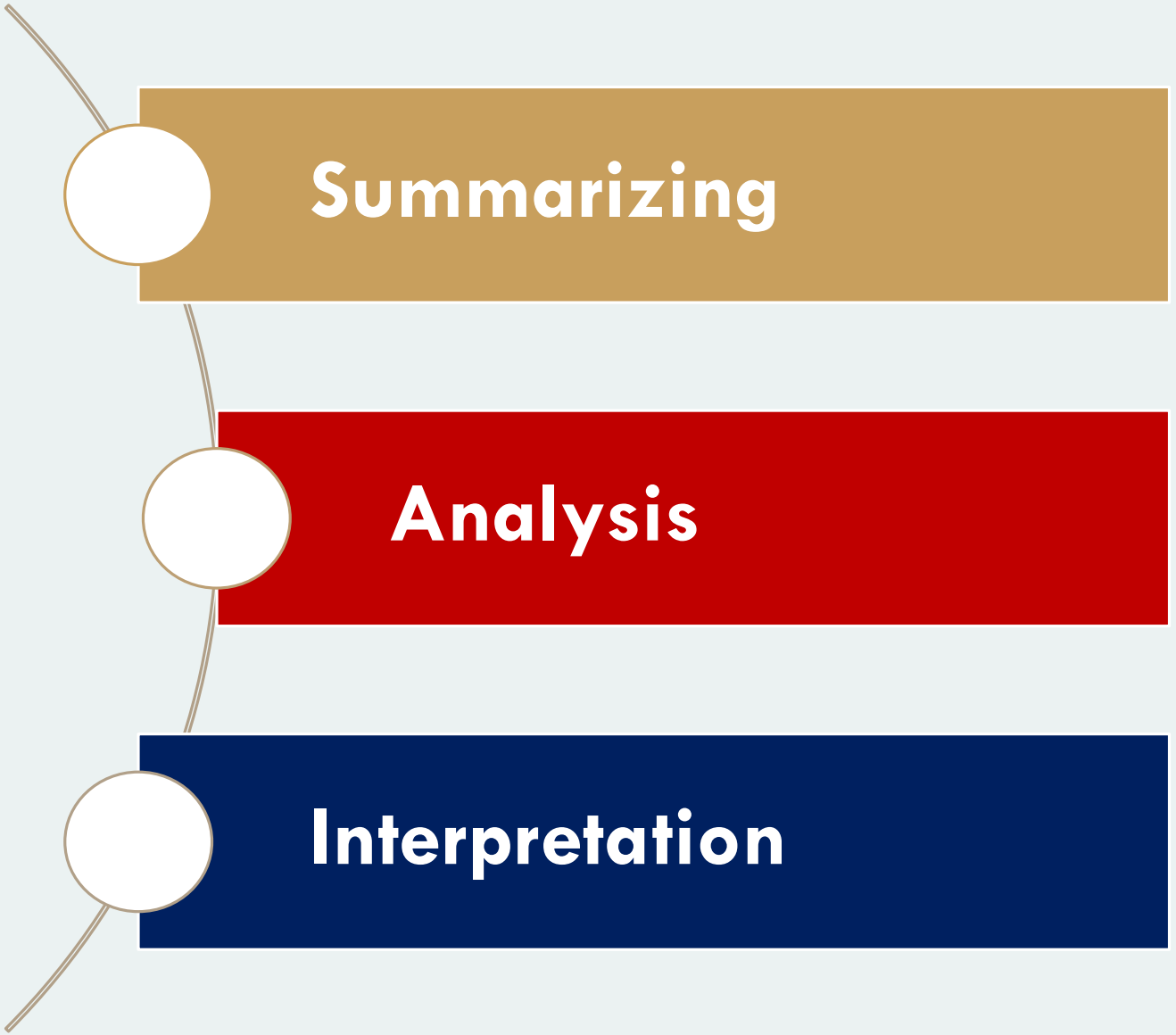
- **Spread of Data**

- **Min**
- **Max**
- **Avg**
- **SD**
- **NIQR**

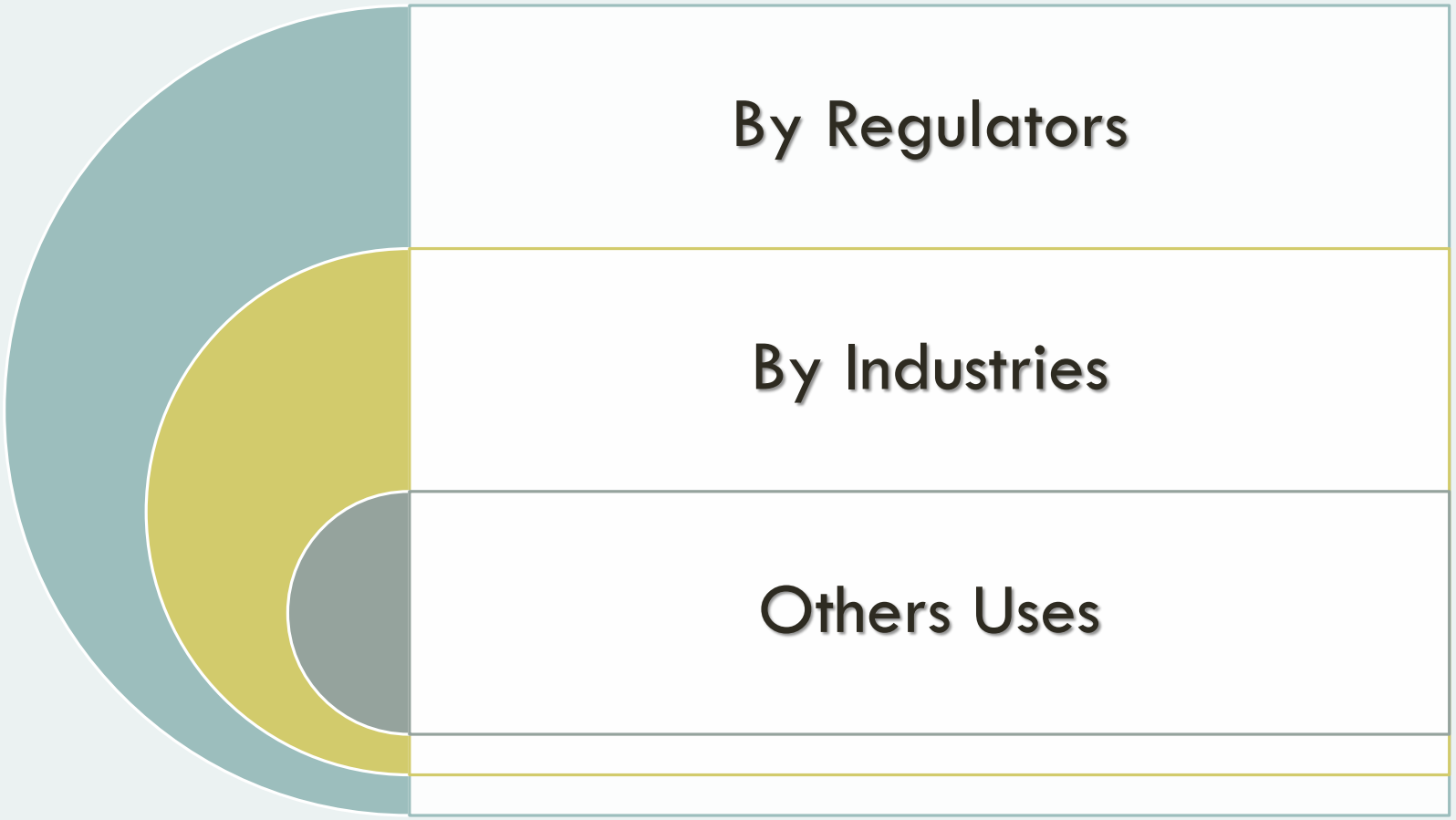


Progress Made So Far

- **Guideline for CEMS (Emission) finalized and published**
- **Guideline for OCEMS (Effluent) finalized and being published**
- **Compliance Monitoring Protocol Prepared circulated and information gathered**
- **Regulatory Alarm system established to trigger self regulatory and compliance regulatory inspections**
- **Remote calibration system has been rolled out**
- **Empanelment of Laboratory is in progress**
- **Data validation protocol is being prepared**
- **Indian Certification Agency Identified**


Summarizing
Analysis
Interpretation

Use of Real-time Environmental Data



“Thank You”