TAMIL NADU POLLUTION CONTROL BOARD

Circular Memo No.TNPCB / T6 / STP / 05656 / 2016 Dated. 02.02.2022

Sub: TNPCB – Monitoring of Sewage Treatment Plants – Certain instructions issued - Reg.

Ref:
1. Ministry of Environment, Forest and Climate Change Notification dt 13.10.2017.
2. National Green Tribunal(Principal Bench), New Delhi orders in OA No.1069/2018 DT.30.4.2019
3. CPCB File No.A-19014/43/06-UPC-I 4648 dated 7-8-2020 addressed to the Chairman, TNPCB, Chennai.
4. Chairman Procs. No.T1/ TNPCB/ F. 5656/STP/W/2021 dt.16.3.21 addressed to all Local Bodies.
5. T.O. memo No.TNPCB/DD(L)/F.No.6849/2018 dt:17.12.2021.

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All the District Environmental Engineers are informed that CPCB has emphasized that Continuous monitoring is essential to regulate and minimize the inspection of STPs on routine basis and also to ensure compliance of prescribed standards and transmit data to SPCB/PCCs and CPCB on continuous basis.

Accordingly, The CPCB has issued directions to the TNPCB among other things for the installation of Online Continuous Effluent Monitoring System (OCEMS) for self surveillance of STPs in the reference 3rd cited.

As per the CPCB's directions the Chairman, TNPCB has issued directions vide proceedings 4th Cited to the Heads of Local Bodies to provide OCEMS in the STPs for self surveillance of the STPs which are operated by them within the specified time prescribed by the CPCB (Copy marked to the field officers of TNPCB). Further, in the directions, the Urban Local bodies are instructed to use mobile application and upload the data on weekly basis to the CPCB. The above subject has been reminded to the DEEs / JCEEs (M), TNPCB for application in the field vide this office memo 5th cited.

Hence, in order to comply with the CPCB's directions all the local bodies have to install Online Continuous Effluent Monitoring System (OCEMS) for the parameters namely pH, TSS, COD, BOD and Flow to the STPs operated by them. In this regard, the guidelines issued by CPCB (in first revision July 2018) for the installation of OCEMS is enclosed in Annexure – I. (List of various technologies available for monitoring of the pollutants from page 23 to 27 of the said guidelines).

Hence, all the DEEs are directed to instruct all the Local bodies, Commercial Establishments, Residential Complexes, Educational Institutions and Industries that have provided STPs / proposed to provide STPs to install the OCEMS by following the procedure and guidelines for OCEMS – 2018 as recommended by CPCB and to carryout periodical calibrations of the existing / proposed OCEMS and shall submit the calibration certificate to respective District Office regularly..

In this regard, the Standard Operation Protocol for verification of installation and calibration of UV-Vis Dual Beam Scanning & Multipoint calibration mechanism technology based OCEMS used in STPs is also enclosed herewith in Annexure II.

In view of the above, all the DEEs, TNPC Board are hereby instructed to guide the entrepreneurs and to take appropriate necessary action to ensure the installation of OCEMS in all existing, under construction and proposed STPs in Government and Private sectors within the timelines of the CPCB and reports on the above may be furnished to this office on or before 01.03.2022 positively.

Encl: Annexure I and Annexure II.

03/02/22
For Chairman

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To

All District Environmental Engineers,
Tamil Nadu Pollution Control Board

Copy to

All Joint Chief Environmental Engineers (M) - for necessary follow up
Tamil Nadu Pollution Control Board

ANNEXURE-I

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Guidelines for Online Continuous Effluent Monitoring Systems (OCEMS)

CENTRAL POLLUTION CONTROL BOARD
PARIVESH BHAWAN, EAST ARJUN NAGAR
DELHI – 110 032

July, 2018

First Revision

Note: Efforts have been made to include all available monitoring technologies/instrumentation in the document. In case any high end technology/ instrumentation is not covered or is introduced subsequently the details be forwarded to CPCB, so that the same can be incorporated while reviewing this document subsequently.

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1.0 BACKGROUND

The concept of using CEMS as tool for ensuring compliance was imbibed in the regulatory regime way back in 2009 when the first Online Continuous Emission Monitoring System (CEMS) was installed at Indraprastha Power Plant, Delhi on directions from Central Pollution Control Board. Subsequently online effluent quality monitoring systems were installed at outlet of CETPs in Gujarat and Andhra Pradesh to monitor the effluent quality.

Central Pollution Control Board vide its letter No. B-29016/04/06PCI-1/5401 dated 05.02.2014 issued directions under section 18(1)b of the Water and Air Acts to the State Pollution Control Boards and Pollution Control Committees for directing the 17 categories of highly polluting industries such as Pulp & Paper, Distillery, Sugar, Tanneries, Power Plants, Cement, Oil Refineries, Fertilizer, Chloral Alkali Plants, Dye & Dye Intermediate Units, Pesticides and Pharma Sector, Common Effluent Treatment Plants (CETP) and STPs, Common Bio Medical Waste and Common Hazardous Waste Incinerators for installation of online effluent quality and common emission monitoring systems to help track the discharges of pollutants from these units.

Directions were also issued to 11 Ganga Basin State Pollution Control Boards/Pollution Control Committees vide letter No.B-190019/NGRBA/CPCB/2011-12 dated 05.02.2014 for directing grossly polluting industries i.e. the industries discharging effluents directly into River Ganga or its tributaries for installation of real time water quality monitoring systems to monitor parameters such as pH, TSS, COD, BOD, Chromium, Arsenic, AOx, Ammonia. The directions envisage:

- Installation of online effluent quality monitoring system at the outlet of the identified units for the measurement of the parameters, pH, COD, BOD and other sector specific parameters (Annexure-I) as per the guidelines provided and transmission of online data so generated to SPCB/PCCs and CPCB as well.
- Installation of surveillance system with industrial grade IP (Internet Protocol) cameras having PAN, Tilt Zoom (PTZ) with leased line real time connection for data streaming and transmission of the same.
- To ensure regular maintenance and operation of the online system with tamper proof mechanism having facilities for online calibration.

Subsequently, CPCB issued office circulars, guidance notes, orders and outcomes of discussions with various stakeholders including industries, which were also displayed on CPCB website http:// cpcb.nic.in/online-monitoring-clarification/. The important ones being:

- Installation of flow meters made mandatory for sectors like sugar and pulp & paper to monitor generation of total effluent.
- Compliance Reporting Protocol (CRP) to be used for submission of information on management of emission and effluent discharges.

2.0 GENESIS OF PROBLEM:

Chemicals (Pharmaceuticals, Organic/Inorganic, Fertilizers, Oil Refineries and Pesticides), Distilleries, Sugar, Pulp &Paper, Textile, Dying, Bleaching, Slaughter Houses, Tannery, Food & Dairy and other categories of industries located in states of Uttarakhand, Uttar Pradesh, Bihar and West Bengal have been discharging effluent directly or indirectly into the river Ganga and its tributaries (Ramganga & Kali-East) through drains, thereby causing deterioration of water quality of river Ganga and its tributaries.

The SPCBs and PCCs have prescribed standards for various pollutants emitted/ discharged by the industries as notified under the Environment (Protection) Act,1986. The compliance monitoring needs to be strengthened to ensure that treated industrial effluent complying with the stipulated norms is only discharged by the industries.

With rapid industrialisation, there is a need to regulate industries consistently and at the same time minimising inspections of industries. Therefore, efforts have been made through technological interventions to bring self-discipline in the industries to exercise self-monitoring & compliance and transmit data of effluent and emission to SPCBs/PCCs and to CPCB on continuous basis. This need for strategic shift in the method of enforcement of industrial pollution control was also necessitated by increasing demand for human/financial resources for many new activities.

For strengthening the monitoring and compliance through self-regulatory mechanism, online emission and effluent monitoring systems need to be installed in all the industries with high pollution potential and operated by the developers and industries. Since, it is expected to be a huge network, thereby as prescribed in Environment Policy 2006, 'Polluter Pays Principle' has been applied.

The initial stage of implementation of the concept was beset with many challenges such as selection of the right monitoring technology, proper installation of the monitoring system, as their proper calibration, data transfer, data interpretation etc. most of these challenges have been attended over the period.

CPCB published the first guidelines on continuous online effluent quality monitoring in November, 2014 to facilitate industries in selection of right monitoring system for their matrix of effluent, its installation and data management.

The experience gained with CEQMS over the last three years indicates enhanced compliance. The success of CEQMS/CEMS is recognised by SPCBs/PCCs as the system has helped in improving the compliance by the industries. The ground truthing of the values indicated by the online devices has to be done for proper interpretation of data, for which various measures need to be taken at SPCBs/PCCs level also.

However, for the regulatory purposes and for the purpose of legal action to be taken against non-compliant industries/facilities, the manual method of sampling, analysis and related procedures under the existing statutes need to be continued.

3.0 REAL TIME MONITORING

In recent years, online water quality monitoring technology has received attention and interest in context of providing accurate and continuous water/waste water quality information. There are already commercially available systems for monitoring parameters such as Turbidity, Colour, Fluoride, Sodium, Ammonia, Chlorides, Nitrates etc. Technological developments have been continuing for improving these systems. Developments of Indigenous systems have started in the country in view of continuous requirements and consistent policies of Government.

3.1 Merits of on-line Monitoring Techniques

The major advantages of on-line monitoring systems over traditional laboratory based and portable field methods are:

a. Online monitoring systems provide continuous measurement of data for long periods of time, at the monitoring site of interest.
b. All the major steps in traditional analysis like sample collection, preservation, transportation, sample pre-treatment, calibration, reagent addition and sample analysis procedures are usually automated in on-line analysers.
c. In case of sudden disturbance in the system, compared to conventional methods the on-line analysers provide timely information for taking immediate corrective/preventive steps.

3.2 Basic requirement of an efficient on line analyser

The major prerequisites of efficient online analysers are:

- Should be capable of operating un-attended over prolonged period of time.
- Should produce analytically valid results with precision and repeatability
- The instrument/analyser should be robust and rugged, for optimal operation under extreme environmental conditions, while maintaining its calibrated status.
- The analyser should have inbuilt features for automatic water matrix change adaption.
- The instrument / analyser should have onboard library of calibration spectras for different industrial matrices with provision of accumulating further calibration matrices.
- Should have data validation facility with features to transmit raw and validated data to central server.
- Should have Remote system access from central server provisioning log file access.
- Should have provision for Multi-server data transmission from each station without intermediate PC or plant server.
- Should have provision to send system alarm to central server in case any changes made in configuration or calibration.
- Should have provision to record all operation information in log file.
- Should have provision for independent analysis, validation, calibration & data transmission.

- ➢ Must have provision of a system memory (non-volatile) to record data for at-least one year of continuous operation.
- ➢ Should have provision of Plant level data viewing and retrieval with selection of ethernet, wireless, Modbus & USB.
- ➢ In case of TOC analyser, the empirical relationship between TOC to COD or BOD must be authenticated for all industrial applications and the correlation calculation (for factor) shall be provided.
- ➢ The correlation/interpretation factor for estimating COD and BOD using UV-Visible Absorption Technique shall be regularly authenticated/ validated and details should be transmitted online.
- ➢ That the Record of calibration and validation should be available on real time basis on central server from each analyser.
- ➢ Record of online diagnostic features including sensor status should be available in database for user friendly maintenance.
- ➢ Expandable program to calculate parameter load daily, weekly or monthly basis for future evaluation with flow rate signal input.
- ➢ Must have low operation and maintenance requirements with low chemical consumption and recurring cost of consumables and spares.

3.3 Techniques/ Instrumentation for online measurement

Real time continuous measurements can be made by two methods: -

- Online
- Inline or In situ

3.3.1 Online Analysers

In most cases online measurements are based on automated laboratory based measurement techniques. The sample is usually injected using rotation valves or peristaltic pumps to the instrument using flow injection analyses (FIA) or sequential flow injection techniques (SFI), via a separate analytical line which is connected to the main process stream. The sample is then extracted, pre-treated if required and presented to the analytical instruments for the required analysis. This system can be either calibrated online automatically, or offline by skilled operator. Online analysers usually require a suitable temperature, fixed background measurement conditions and frequent calibration to obtain analytically valid results.

3.3.1.1 Limitations of On-Line Analysers

In spite of the inherent advantages of on-line sensors/monitors, their wide application is still limited due to the following reasons:

- On-line monitoring suffers from more problems than laboratory-based methods as many on-line monitoring technologies developed are direct adaptation of traditional, laboratory-based analytical methods not originally designed for field applications, but required to operate in extreme and variable environments. Consequently, these methods require frequent calibration and maintenance.

- The analysers are often influenced from cross responses due to matrix variations between the standards and samples analysed, as the measurement conditions are not controlled.
- Changes in sample matrix affect on-line analysers making it difficult to obtain continuous, reliable measurement in the field.
- Significant economic and logistic costs are associated with maintaining remote equipment, as it is difficult for operators to detect problems, such as sensor fouling.
- The problems associated with conventional on-line analysers stems from the fact that univariate linear calibration models derived from Gauss's theory of least squares are employed to determine unknown concentrations. To obtain reproducible and accurate results, the samples and standards therefore must be analyzed, under the same measurement conditions. As consistent measurement conditions required for reliable performance are rarely available in the field, thereby affecting the performance of CEQMS/CEMS and can cause deviation in the data from online instrumentation.
- The users/regulatory authorities need to frequently validate their online results with laboratory based methods.

3.3.2 In line Analysers

Inline analysers are simpler in design and can measure directly in the process line, using a probe that is chemically insensitive. However, they are more susceptible to physical and chemical interference from the sample matrix as measurement backgrounds are more changeable and they usually require ex-situ calibration.

Despite their ability to acquire continuous real time data, their widespread application has been limited due to the inability to reliably obtain accurate, cost effective water quality data.

4.0 Available Technologies

4.1 Photometric Optical Technology

Photometric optical sensors are among the most commonly used measurement principles for online analysers. These methods are based on measuring the interaction of light with the sample and the measurement principle is usually based on Beer – Lambert Law which states about a linear relationship between absorbance and concentration of absorbing species. According to the law:

Absorbance $A = -\log(I/I_o) = \varepsilon * C * L$

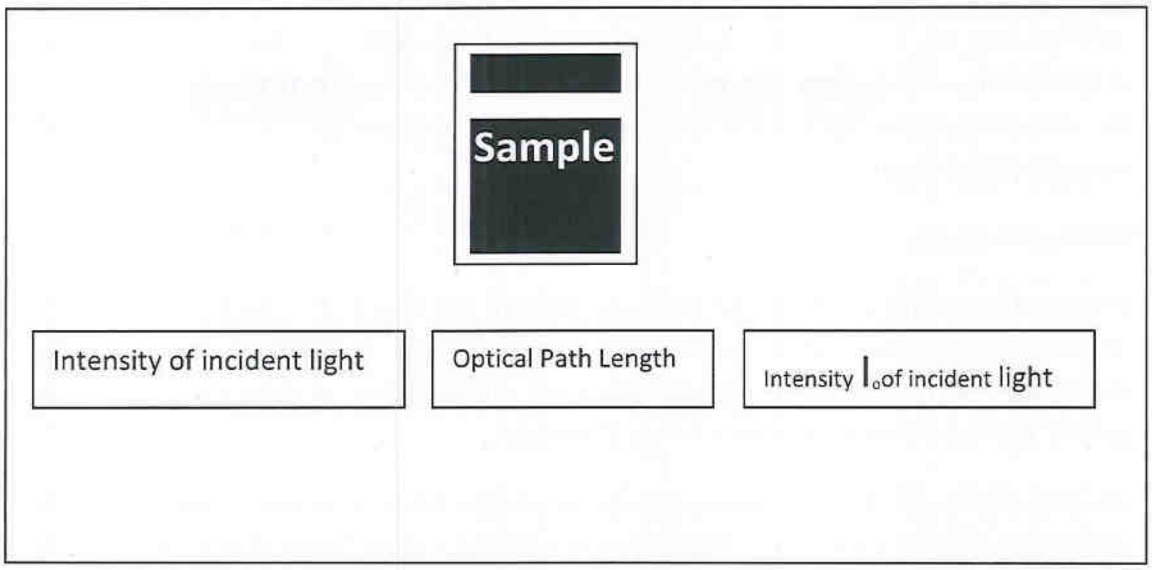
I = Intensity of incident light

I_o = Intensity of transmitted light

ε = Molar absorbtivity (L/mol/cm)

C = Concentration of solution (mol/l)

L = Optical path length (cm)



They are often employed for their simplicity and rapid response. The majority of commercially available photometric sensors fall into main three categories.

1. Colorimetric
2. UV Absorption and
3. UV Visible absorption

Optical sensors, such as non-destructive sensors arrays, have advantage over ISE (Ion Selective electrodes) for water quality monitoring as in these analysers gross fouling and potential problems or contamination can be detected by colour changes in the sample.

4.1.1 Colorimetric

These are largely based on direct adaptation of APHA standard methods, which use reagents to obtain desired complex ion formation to quantify the concentration at a specific wavelength. They require regular calibration with standard reagents using Beer's Law to maintain their calibrated online status.

4.1.2 UV Absorption

The measurement principle is based on specific absorption at a specified wavelength in the UV range. They require conventional calibration according to Beer's Law and standard reagents. The major application includes determination of parameters like DO and Turbidity.

4.1.3 UV Vis Absorption Spectroscopy

This spectrophotometer records light attenuation in the wavelength region between 200 and 750 nm. The measurement is performed in-situ, without sampling or sample pre-treatment, thus preventing errors due to sampling, sample transport and storage etc. A measurement cycle takes between 20 and 60 seconds, making possible a high measuring frequency and detection of rapid changes. In order to combine this high measurement frequency with high accuracy and sensitivity, the instrument is equipped with a Xenon flash lamp as a light source and a concave holographic grating matched with a 256-pixel diode array as detector. For long-term stability of the signal produced, a split light-beam design is used; one beam passes through the sample while the other travels along a parallel pathway inside the instrument and thus acts as an internal reference beam. This second beam is used to cancel out fluctuations and interferences. These instruments are available for wide range of applications, from ultra-pure water (dissolved organics in the µg/ltrange) up to concentrated wastewaters (organics and non-dissolved materials in tens of grams /ltrange).

The spectra, referred to as fingerprints obtained with such on-line spectrometers are used for the characterization of the sampled water. The fingerprints are used to monitor changes in the water composition through analysis of the general shape of the spectrum or absorption at a specific wavelength. Furthermore, they are also used to derive more specific parameters, such as turbidity, TSS, Color, Nitrate concentration and some parameters such as COD (chemical oxygen demand), BOD (biochemical oxygen demand), TOC (total organic carbon) and (dissolved organic carbon) DOC in water analysis.

Turbidity, due to suspended substances, causes light scattering and shading, thus influencing the absorption over the entire fingerprint. This is an important factor that influences in situ measurements and requires compensation in order to obtain reliable and reproducible readings. Furthermore, it is also used to estimate the concentration of single (groups of) substance, such as benzene, phenol, xylene and toluene. The wavelengths used for determining all these parameters have been selected using various analysis. The use of such multi-wavelength algorithms allows higher specificity than can be achieved with conventional single, dual wavelength, Eight wavelengths etc. in UV range photometry.

The methods usually employ Patterns Recognition Techniques (PRT) to quantify the absorption profile and convert it to an equivalent concentration for the particular water quality parameter of interest. Usually these methods do not require sample pre-treatment or daily calibration at the monitoring site of interest. They are employed mainly because samples can be analysed with very little or no sample preparation, no chemicals are required, and they have low operational costs. Such methods have been developed for monitoring Chemical Oxygen Demand (COD), Total Organic Carbons (TOC), Biochemical Oxygen Demand (BOD) and Nitrate.

4.2 Ion Selective Electrodes (ISE) Technology

ISEs are commonly employed as online sensors due to their speed and simplicity as well as low maintenance and purchase cost. With careful use, frequent calibration ideal measurement conditions being maintained, they can achieve higher accuracy and precision. Hence, in theory the configuration and embodiment of an ISE, makes it an ideal sensing probe for on-site, real time monitoring applications.

Data obtained from online ISE measurements, although continuous, is usually semi-quantitative in nature. This is because the analytical signal of the ISE is known to be affected by matrix interferences, drift, contamination (e.g. by organic molecules), non-linear responses at the lower end of the detection, temperature in the non-ideal measurement conditions. These factors in turn cause measurements errors. To improve its reliability, especially in the field, an ISE must be regularly calibrated with standards and samples should be analysed according to prescribed measurement conditions. However, the economic costs associated with calibration especially for instruments that require ex-situ calibration with skilled personnel, have greatly limited its adoption.

4.3 Potentiometric Technology

Potentiometric titration is a technique similar to direct titration of a redox reaction. It is a useful means of characterizing an acid. No indicator is used; instead the potential is measured across the analyte, typically an electrolyte solution. To do this, two electrodes are used, an indicator electrode (the glass electrode and metal ion indicator electrode) and a reference electrode. Reference electrodes generally used are hydrogen electrodes, calomel electrodes,

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and silver chloride electrodes. The indicator electrode forms an electrochemical half cell with the interested ions in the test solution. The reference electrode forms the other half cell.

The overall electric potential calculated is the potential drop over the test solution between the two electrodes. Ecell is recorded at intervals as the titrantis added. A graph of potential against volume added can be drawn and the end point of the reaction is halfway between the jump in voltage. Ecell depends on the concentration of the interested ions with which the indicator electrode is in contact. For example, the electrode reaction may be

Mn++ne------>M

As the concentration of Mn+ changes,the Ecell changes correspondingly. Thus the potentiometric titration involve measurement of Ecell with the addition of titrant.

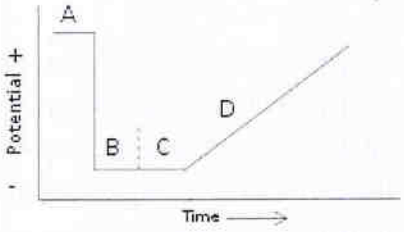
amounts of reducing agent are removed and the potential corresponds solely to the oxidizing agent. This large increase in potential difference signifies the endpoint of the reaction

4.4. Nephelometric Technology

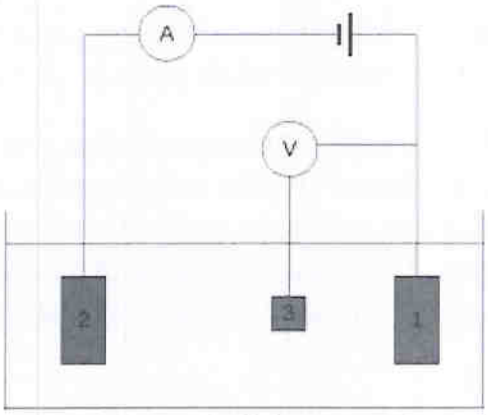
A nephelometer is an instrument for measuring concentration of suspended particulates in a liquid or gas colloid. A nephelometer measures suspended particulates by employing a light beam (source beam) and a light detectorset to one side (often 90°) of the source beam. Particle density is then a function of the light reflected into the detector from the particles. To some extent, how much light reflects for a given density of particles is dependent upon properties of the particles such as their shape, color, and reflectivity. Nephelometers are calibrated to a known particulate, then use environmental factors (k-factors) to compensate lighter or darker colored dusts accordingly. K-factor is determined by the user by running the nephelometer next to an air sampling pump and comparing results. There is a wide variety of research-grade nephelometers on the market as well as open source varieties.[2]

4.5 Voltametery

Voltammetry is a category of electroanalytical methods used in analytical chemistry and various industrial processes. In voltammetry, information about an analyte is obtained by measuring the current as the potential is varied. The analytical data for a voltammetric experiment comes in the form of a voltammagram which plots the current produced by the analyte versus the potential of the working electrode.



Potential as a function of time for anodic stripping voltammetry



Three-electrode setup: (1) working electrode; (2) counter electrode; (3) reference electrode

Voltammetry experiments investigate the half-cell reactivity of an analyse. Voltammetry is the study of current as a function of applied potential. These curves I = f(E) are called voltammograms. The potential is varied arbitrarily either step by step or continuously, and the actual current value is measured as the dependent variable. Most experiments control the potential (volts) of an electrode in contact with the analyse while measuring the resulting current (amperes).[4]

To conduct such an experiment one requires at least two electrodes. The working electrode, which makes contact with the analyse, must apply the desired potential in a controlled way and facilitate the transfer of charge to and from the analyse. A second electrode acts as the other half of the cell. This second electrode must have a known potential with which to gauge the potential of the working electrode, furthermore it must balance the charge added or removed by the working electrode. While this is a viable setup, it has a number of shortcomings. Most significantly, it is extremely difficult for an electrode to maintain a constant potential while passing current to counter redox events at the working electrode.

bulk electrolyte, but the added resistance greatly reduces the accuracy of the results.
With room temperature ionic liquids, the solvent can act as the electrolyte.

4.6 Total Organic Carbon (TOC) Based Technology

The organic carbon in water and wastewater is composed of a variety of organic compounds in various oxidation states. Some of these carbon compounds can be oxidized further by biological or chemical processes, and the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) may be used to characterise these fractions. The presence of organic carbon that does not respond to either the BOD or COD test makes them unsuitable for the measurement of total organic carbon.

Total organic carbon (TOC) is a more convenient and direct expression of total organic content than either BOD or COD, but does not provide the same kind of information. If a repeatable empirical relationship is established between TOC and BOD or COD, then TOC can be used to estimate the accompanying BOD or COD. This relationship must be established independently for each set of matrix conditions, such as various points in a treatment process.

Unlike BOD or COD, TOC is independent of the oxidation state of the organic matter and does not measure other organically bound elements, such as nitrogen and hydrogen, and inorganics that can contribute to the oxygen demand measured by BOD and COD. TOC measurement does not replace BOD and COD testing.

The organic and inorganic carbon present in the sample are being converted to CO2 either by thermal treatment(Combustion) or by chemical treatment (UV/persulphate digestion).

4.6.1 TOC Detection

For detection of TOC the converted CO2 proportional to the organic and inorganic carbon can be analysed using Conductivity or Non dispersive infrared (NDIR) methodology.

Thermal Treatment (Combustion Process)

The combustion process uses heat at 680°C or higher temperature in a stream of air, oxygen or nitrogen and usually in presence of a catalyst. Dissolved organics and particulate organics are expected to oxidise fully to carbon dioxide under these conditions. The catalysts vary from cupric oxide, cobalt oxide or platinum on an alumina support.

Chemical Treatment (UV/Persulphate)

The sample is treated with persulphate at 116 to 130 degree C in presence of UV to convert inorganic and organic carbon to CO2.

4.6.2 Non Dispersive Infrared (NDIR) based Analysers

The principal advantage of using NDIR is that it directly and specifically measures the CO_2 generated by oxidation of the organic carbon in the oxidation reactor, rather than relying on a measurement of a secondary, corrected effect, such as used in conductivity measurements.

Merits

- The low temperature techniques have the advantage of allowing a large volume of sample to be analysed thereby improving the low limit of detection.
- Also the blank value is very low as long as the reagents are pure, which makes the analysis more accurate

Limitations

- Usually the particulates are more difficult to oxidise by nature or organics escape exposure to the reagents by being within the interstitial spaces of the particles.
- High molecular weight compounds such as proteins may be slow to oxidise with the low temperature techniques.

4.6.2.1 Conductivity based Analysers

Direct conductivity provides an all encompassing approach of measuring CO_2. This detection method uses no carrier gas, is good at the parts per billion (ppb) ranges, but has a very limited analytical range.

Membrane conductivity relies upon the filtering of the CO_2 prior to measuring it with a conductivity cell. Both methods analyse sample conductivity before and after oxidization, attributing this differential measurement to the TOC of the sample.

Conductivity analysis assumes that only CO_2 is present within the solution. As long as this holds true, then the TOC calculation by this differential measurement is valid.

For UV persulphate method, conductivity detector is not recommended.

4.7 Flow Meters

A water flow meter is an instrument capable of measuring total water passing through a pipe. Several technologies are available for water measurement depending on the applications, cost factor, and maintenance requirements. Each water flow meter type has a unique principle of operation, overall cost-of-ownership, and specific application benefits.

Velocity/ Flow meters measure the water flow velocity and convert it into volume of water flow by multiplying the observed velocity with the known cross sectional area of the pipe/conduct through which water passes. They operate based on the principle that water passing through a known cross-sectional area having a measured velocity is proportional to the volume of water flow.

There are four major types of water flow meters: mechanical water flow meters, ultrasonic flow meters, vortex volumetric flow meters, and magnetic flow meters.

4.7.1 Mechanical Flow Meters

Mechanical flowmeters measure flow using an arrangement of moving parts, either by passing isolated, known volumes of a fluid through a series of gears or chambers (positive displacement, or PD) or by means of a spinning turbine or rotor.

All positive displacement flowmeters operate by isolating and counting known volumes of a fluid (gas or liquid) while feeding it through the meter. By counting the number of passed isolated volumes, a flow measurement is obtained. Each PD design uses a different means of isolating and counting these volumes. The frequency of the resulting pulse train is a measure of flow rate, while the total number of pulses gives the size of the batch. While PD meters are operated by the kinetic energy of the flowing fluid, metering pumps determine the flow rate while also adding kinetic energy to the fluid.

The turbine flowmeter consists of a multi-bladed rotor mounted at right angles to the flow, suspended in the fluid stream on a free-running bearing. The diameter of the rotor is very

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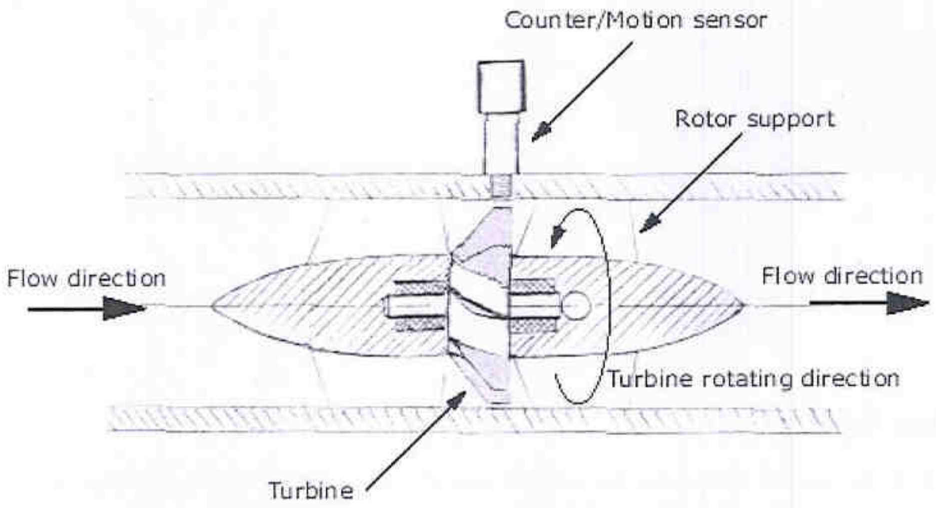
close to the inside diameter of the metering chamber, and its speed of rotation is proportional to the volumetric flow rate. Turbine rotation can be detected by solid state devices or by mechanical sensors. Other types of rotary element flowmeters include the propeller (impeller), shunt, and paddlewheel designs.



The other available mechanical flowmeters include: -

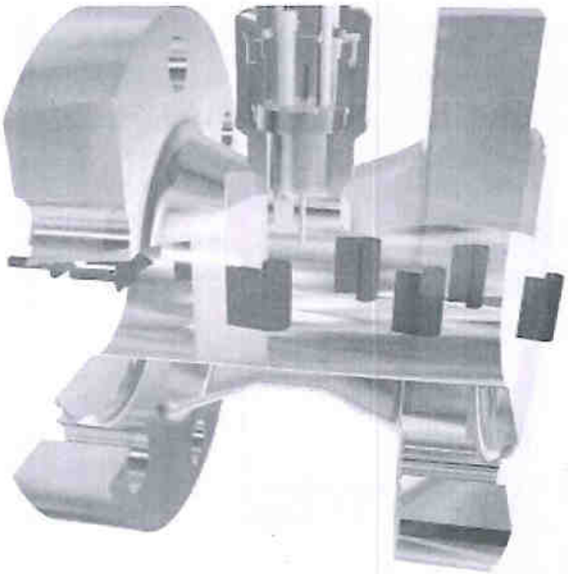
1. Positive Displacement Flowmeters
2. Liquid PD Meters
3. Piston Meters
4. Gear & Lobe Meters
5. Helix Meters
6. Metering Pumps

4.7.2 Vortex Flow Meters

Vortex flowmeter is a flowmeter for measuring fluid flow rates in an enclosed conduit.

A vortex flowmeter comprises of a flow sensor operable to sense pressure variations due to vortex-shedding of a fluid in a passage and to convert the pressure variations to a flow sensor signal, in the form of an electrical signal; and a signal processor operable to receive the flow sensor signal and to generate an output signal corresponding to the pressure variations due to vortex-shedding of the fluid in the passage.[2]

When the medium flows through the Bluff body at a certain speed, an alternately arranged vortex belt is generated behind the sides of the Bluff body, called the "von Karman vortex". Since both sides of the vortex generator alternately generate the vortex, the pressure pulsation is generated on both sides of the generator, which makes the detector produce alternating stress. The piezoelectric element encapsulated in the detection probe body generates an alternating charge signal with the same frequency as the vortex, under the action of alternating stress. The signal is sent to the intelligent flow totalizer to be processed after being amplified by the pre-amplifier, realizing displaying instantaneous flow and cumulative flow of fluid, communicating and controlling of flow data and the microcomputer system.

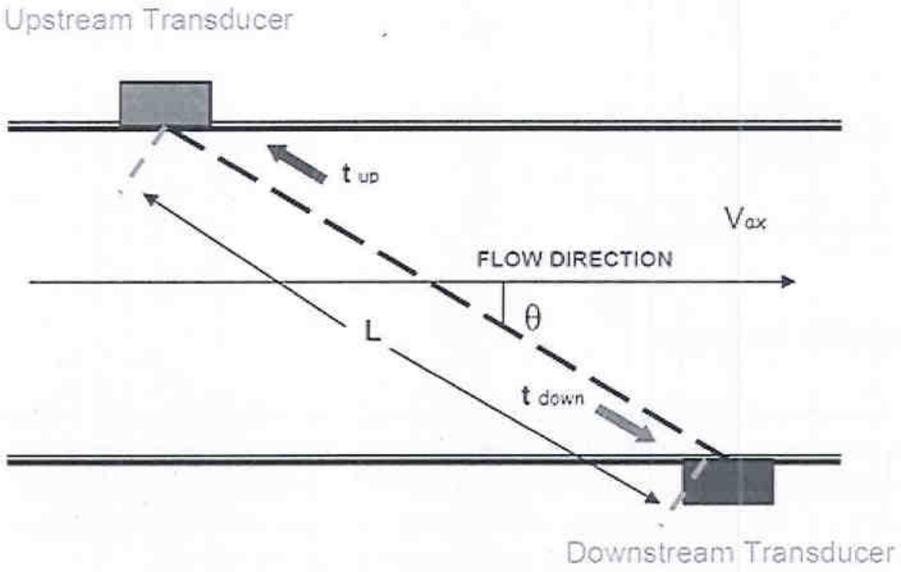


4.7.3 Ultrasonic Flow Meter

Ultrasonic flowmeters use sound waves to determine the velocity of a fluid flowing in a pipe. At no flow conditions, the frequencies of an ultrasonic wave transmitted into a pipe and its reflections from the fluid are the same. Under flowing conditions, the frequency of the reflected wave is different due to the Doppler effect. When the fluid moves faster, the frequency shift increases linearly. The transmitter processes signal from the transmitted wave and its reflections to determine the flow rate.

Transit time ultrasonic flowmeters send and receive ultrasonic waves between transducers in both the upstream and downstream directions in the pipe. At no flow conditions, it takes the same time to travel upstream and downstream between the transducers. Under flowing conditions, the upstream wave will travel slower and take more time than the (faster) downstream wave. When the fluid moves faster, the difference between the upstream and downstream times increases. The transmitter processes upstream and downstream times to determine the flow rate.

This technology can be very accurate and is used for custody transfer (meaning accounting accurately for an expensive fluid) of natural gas and petroleum liquids. High turndown (can read low as a percentage of the full scale or top reading), handles high pressures, is repeatable (consistent), handles extreme temperatures, can be used clamped to the outside of a pipe without penetration, is low maintenance, highly reliable and self –diagnosing. Ultrasonic flowmeters do not obstruct flow so they can be applied to sanitary, corrosive and abrasive liquids. Some ultrasonic flowmeters use clamp-on transducers that can be mounted external to the pipe and do not have any wetted parts Disadvantages can include high cost, sensitivity to stray process vibrations, problems with pipe diameter change due to build up and clamp-on units have lower accuracy.

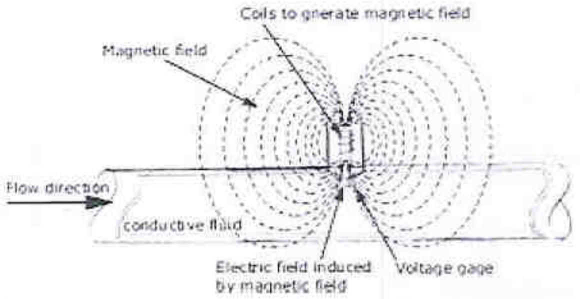


4.7.4 Magnetic Flow Meter

Magnetic flowmeters use Faraday's Law of Electromagnetic Induction to determine the flow of liquid in a pipeoils. Steam or gas flows don't register. Magnetic flowmeters measure the velocity of conductive liquids in pipes, such as water, acids, caustic, and slurries. Magnetic flowmeters can measure properly when the electrical conductivity of the liquid is greater than approximately 5µS/cm. In a magnetic flowmeter, a magnetic field is generated and channelled into the liquid flowing through the pipe. Following Faraday's Law, flow of a conductive liquid through the magnetic field will cause a voltage signal to be sensed by electrodes located on the flow tube walls. The signals produced are linear with the flow. When the fluid moves faster, more voltage is generated. Faraday's Law states that the voltage generated is proportional to the movement of the flowing liquid. The electronic transmitter processes the voltage signal to determine liquid flow.

Mags are intermediate in accuracy therefore not commonly used for commodity transfer except for some special cases where the fluid is not expensive like water. Can be adapted for sanitary uses. No pressure drop induced. Dirty liquids and even slurries OK. Very reliable. On the other hand, don't work on nonconductive /low conductivity fluids such as. such as deionized water, boiler feed water, or hydrocarbons, can cause the flowmeter to turn off and measure zero flow. This flowmeter does not obstruct flow, so it can be applied to clean, sanitary, dirty, corrosive and abrasive liquids. Applications for dirty liquids are found in the water, wastewater, mining, mineral processing, power, pulp and paper, and chemical industries. Magnetic flowmeters are used in water treatment plants to measure treated and untreated sewage, process water, water and chemicals.

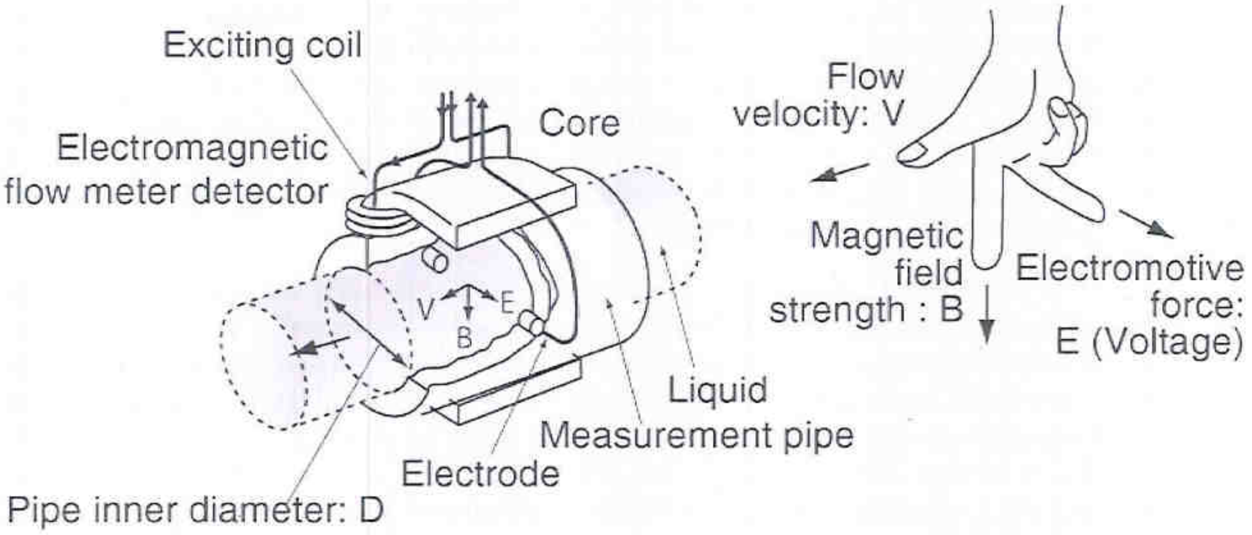
Magnetic flowmeters do not require much upstream and downstream straight run so they can be installed in relatively short meter runs. Magnetic flowmeters typically require 3-5 diameters of upstream straight run and 0-3 diameters of downstream straight run measured from the plane of the magnetic flowmeter electrodes



4.7.5 Electromagnetic Flowmeter

Electromagnetic flow meters detect flow by using Faraday's Law of induction. Under Faraday's law of induction, moving conductive liquids inside of a magnetic field generates an electromotive force (voltage) in which the pipe inner diameter, magnetic field strength, and average flow velocity are all proportional. In other words, the flow velocity of liquid moving in a magnetic field is converted into electricity. (E is proportional to V × B × D)

Inside an electromagnetic flow meter, there is an electromagnetic coil that generates a magnetic field, and electrodes that capture electromotive force(voltage). Due to this, although it may appear as if there is nothing inside the flow pipe of an electromagnetic flow meter, flow can be measured.



As the flow changes, the electromotive force (voltage) captured by the electrodes changes.

Electromagnetic flow meters generally have the following features.

PROS	·Unaffected by the temperature, pressure, density,or viscosity of the liquid. ·Able to detect liquids that include contaminants (solids, air bubbles)

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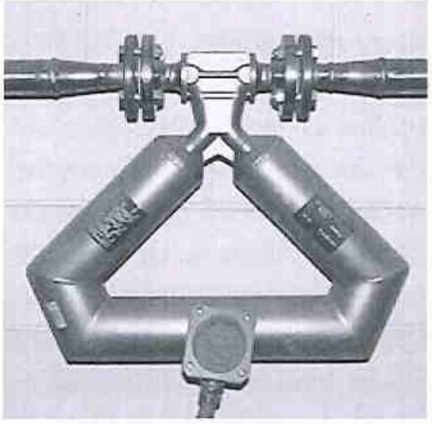
	· There is no pressure loss. · No moving parts (improves reliability)
CONS	· Cannot detect gases and liquids without electrical conductivity. · A short section of straight pipe is required.

As electromagnetic flow meters are based on the laws of electromagnetic induction, conductive liquids are the only liquids for which flow can be detected. Whether it is a conductive liquid or not is determined by the presence of electrical conductivity.

H_2O itself is a stable molecule, and will not conduct electricity The secret is that the absence or presence of impurities in the water determine its ability to conduct electricity.

Besides H_2O (water molecules), Ca_2+ (Calcium ions) and Mg_2+ (Magnesium ions) exist within water. Because these ions conduct electricity within water, tap water, groundwater and other ion rich waters possess a property that conducts electricity. Also, since pure water is only H_2O and does not contain any impurities, it cannot conduct electricity.

4.7.6 Mass Flowmeter



A **mass flow meter**, also known as an **inertial flow meter** is a device that measures mass flow rate of a fluid traveling through a tube. The mass flow rate is the mass of the fluid traveling past a fixed point per unit time.

The mass flow meter does not measure the volume per unit time (e.g., cubic meters per second) passing through the device; it measures the mass per unit time (e.g., kilograms per second) flowing through the device. Volumetric flow rate is the mass flow rate divided by the fluid density. If the density is constant, then the relationship is simple. If the fluid has varying density, then the relationship is not simple. The density of the fluid may change with temperature, pressure, or composition, for example. The fluid may also be a combination of phases such as a fluid with entrained bubbles. Actual density can be determined due to dependency of sound velocity on the controlled liquid concentration.[1]

5.0 Systems Available

The pH is monitored using electrochemical sensors. High Turbidity interferes in pH measurements besides the values are also impacted by variation in temperature.

The total suspended solids in the effluent are measured using various techniques including scattered light method, UV visible absorption, comparative techniques like Nephelometric, etc.

The standards for industrial discharges as notified in the EP(Act) 1986 and the water Act 1974 specify BOD and COD as the controlling parameter besides other specific parameters. Limited instrumentation for direct monitoring of these parameters i.e. BOD & COD on real time basis is available. The direct monitoring methods available require intensive infrastructure, besides using chemicals in the process which are released/discharged and can be a likely source of pollution. Besides the measurement is in batches, as it may take between 15 min to 02 hours to analyze one sample depending upon the concentration and methodology used.

These are indirect methods available for estimating BOD & COD. The 02 methods most commonly used for estimating BOD & COD in water and waste water samples are:

1) Deriving from TOC values and
2) Using UV Absorption spectrophotometry

In India TOC is not specified as a control parameter to industries or CETPs/STPs, therefore the values of BOD & COD have to be interpolated from TOC values.

In the first method TOC is measured and based on the laboratory validation as regards to the observed ratio of TOC: BOD & TOC: COD a correlation factor is established. The method of TOC measurement is approved. In the field TOC is monitored online using any of the approved principles i.e. persulfate or heated persulfate oxidation method, high temperature combustion method and assessment made through NDIR technique. Based on repeatable empirical relationship established between TOC, BOD or COD for a specific waste water source accompanying BOD or COD can be estimated from the recorded TOC values. This relationship between TOC: BOD &TOC: COD must be established for each set of matrix condition. Any change in waste water matrix impacts correlation between these pollutants and hence necessitates regular validation of the relationship between these pollutants.

Considering the need of skilled manpower, the requirement of gases and other peripheral requirements beside high O&M cost for operating TOC Analysers, need of an alternative method was felt.

The other method developed and deployed is based on UV-Visible Spectrophotometry. This UV-Vis spectral absorbance technology has been found to be less labour intensive in comparison. The tradeoffs in the ability to compensate for the various interferences should be taken into consideration. Some Instrument have incorporated features in their system to compensate for the interferences to improve their data quality.

Some of the systems based on UV-Vis spectrophotometry use single wavelength (i.e 254nm) or few wavelength bands to estimate COD/BOD values. These systems have measurement limitations. The method is suitable for fairly stable water matrix. Turbidity interferes in the measurements of COD and BOD. The measure is an indirect method as absorbance at specified wavelength is measured and correlated with COD & BOD.

Some other systems based on UV Visible Spectrometry use the full spectrum involving measurement of organics over the entire spectrum starting from 200 nm to 750 nm with adaptive ranging capabilities. The system takes care of single bond organics also. Any change in matrix needs recalibration of the system to assess the factor for determination of COD & BOD. Preferred tools such as multi-wavelength dual beam scanning in UV-Visible range with library of industrial matrices in analyser with multi-point local adaptive calibrations help to have matrix change adaption seems better for analyser. The measured values are determined from the spectral data. The calculation is based on methods and characteristics that were achieved from a multitude of measurement and longtime analysis and the observation from UV spectra. Thus, correlations vary with the change in waste matrix and these characteristics need to be frequently established in the beginning for better data quality vis-à-vis the actual values monitoring using laboratory technique. Any change in the waste matrix requires revalidation of the characteristics.

Some manufacturers have developed COD Analyser working on the same principle as the Laboratory technique for monitoring of COD. Many other technologies using direct/indirect methods have been introduced for monitoring of BOD & COD.

Based on the discussion held with the instrument manufacturers/their Indian counterparts and the information available in CPCB, list of various technologies available for monitoring of the pollutants as specified in the directions given by CPCB under Section 18(1) (b) of the Water & Air Acts has been compiled and detailed in the table below:

TABLE-1: TECHNOLOGIES AVAILABLE

Available Technologies	Parameters Measured	Applications
UV Spectrophotometry (Single wavelength)	**COD, BOD**	**Fresh Water analysis with constant matrix in water source**
UV-Vis Spectrophotometry 40 wavelength	**COD, BOD, TSS**	**Fresh Water & Waste Water analysis with Constant matrix in water source**
UV-Visible Spectrophotometry (Single Beam)	**COD, BOD, TSS**	**Fresh Water & Waste Water analysis without interference check and compensation**
UV-Vis Spectrophotometry (Double beam with entire spectrum scanning)	**COD, BOD, TSS**	**Fresh water to Waste water analysis Interference check for color and turbidity and compensation.**
Combines Combustion Catalytic Oxidation at 680°C and NDIR Method	**TOC (Co-relation with BOD & COD)**	**Fresh Water and Waste Water analysis**
UV Persulfate NDIR Detector	**TOC (Co-relation with BOD & COD)**	**Fresh Water & Waste Water analysis**

Persulfate Oxidation at 116-130degC NDIR Detector	TOC (Co-relation with BOD & COD)	Fresh Water & Waste Water analysis
Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Calorimetric	COD	Fresh Water & Waste Water analysis
Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Potentiometric Titration	COD	Fresh Water & Waste Water analysis
Electrode /Potentiometric method	pH	Fresh water & Waste Wateranalysis
Scattered Light Method (IR)	TSS	Fresh water & Waste Wateranalysis
Nephelometry Method	TSS	Fresh Water & Less turbid wateranalysis
Colorimetric (645-655nm)	NH3	Process stream & Waste Water analysis. Turbidity interference is there which can be overcome
Ion Selective Electrode method With temp correction	NH3	Process stream & Waste Water analysis. Turbidity interference is there which can be overcome.
UV Absorbance or Multiple Wavelength UV Absorbance Spectrophotometers (200-450nm)	NH3	Process stream & Waste Water analysis. Turbidity interference is there which can be overcome.
Colorimetric method Reaction of Cr-VI with diphenyl carbazide in acid solution	Chromium	Fresh Water & Waste Water analysis.
Voltammetry (Anodic Stripping Voltammetry)	Chromium	Fresh Water analysis.
Dual Beam UV-Visible Spectrophotometry	Chromium Hexavalent and Trivalent	Fresh water & waste water analysis.
Voltammetry (Anodic Stripping Voltammetry)	Arsenic	Fresh Water analysis.

5.1 Assessment of technology

The various Monitoring Technologies presented or informed by the Instrument Manufacturers/their Indian counterpart were recorded and based on the information available efforts made to assess the suitability of the technologies/instrumentations for monitoring the effluent quality in different matrices , keeping into considerations the limitations of the technologies, the varying Indian environmental conditions and also the chemical attributes in the effluent channels of the industries or the water bodies. Issues related to the use of reagents, maintenance required, operating costs, etc., wherever available were also considered. Table 2 compiled based on the information provided by vendors/ Indian counterpart, indicates the suitability of the available technologies/ instrumentation for monitoring different pollutants in varying matrices.

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TABLE 2: SUITABILITY OF TECHNOLOGIES FOR DIFFERENT MATRICES

Available Technologies	Parameters Measured	Applications	Limitations
UV Spectrophotometry (Single/two/four wavelengths)	**COD, BOD**	**Fresh Water analysis with constant matrix**	**Suitable for fresh water and not for waste water analysis. Interference of colour & high turbidity. Suitable for stable matrix. Single bond organic compounds are not measured.**
UV-Vis Spectrophotometry 40 wavelength	**COD, BOD, TSS**	**Fresh Water & Waste Water analysis with constant matrix**	**Many organic compounds are unattended due to lesser scanning of UV spectra. Suitable for stable matrix. Any matrix change would require revalidation of factor. Sample pumping limitation.**
UV-Visible Spectrophotometry (Single Beam)	**COD, BOD, TSS**	**Fresh Water & Waste Water analysis.**	**Interference due to colour & high turbidity affects the analysis. Reference beam compensation not available. Suitable for stable matrix. Any matrix change would require revalidation of factor.**
UV-Vis Spectrophotometry (Double beam with entire spectrum scanning)	**COD, BOD, TSS**	**Fresh water to Waste water analysis.**	**Interference of colour & turbidity is compensated in visible spectrum. Any matrix change would require revalidation of factor.**
Combines Combustion Catalytic Oxidation at 680°C and NDIR Method	**TOC (Co-relation with BOD & COD)**	**Fresh Water and Waste Water analysis.**	**-Carrier gases required -Continuous High power requirement -For Analyser: Infrastructure is 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 analysis.**	**-Carrier gases required - Continuous High power requirement -Analyser: 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 analysis.**	**Applicable for moderate polluted effluent. -Carrier gases required -Analyser: Infrastructure required Any matrix change requires fresh correlation to COD & BOD**
Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Calorimetric	**COD**	**Fresh Water & Waste Water analysis.**	**Discharge of hazardous chemicals.**
Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Potentiometric Titration	**COD**	**Fresh Water & Waste Water analysis.**	**-Auto feeding of reagents -Discharge of chemical --One sample takes about 30 min. -Sample measured during change of matrix**
Electrode /Potentiometric method	**pH**	**Fresh water & Waste Wateranalysis.**	**--Electrode life**
Scattered Light Method (IR)	**TSS**	**Fresh water & Waste Wateranalysis.**	**---**
Nephelometry Method	**TSS**	**Fresh Water & Less turbid water**	**Fresh Water analysis with Low turbidity**
Colorimetric (645-655nm)	**NH3**	**Fresh Water & Waste Water analysis.**	**Turbidity interference is there which can be overcome. 3-15 min cycle time**
Ion Selective Electrode methodWith temp correction	**NH3**	**Fresh Water & Waste Water analysis.**	**Interference from Potassium. Requires additional measurement of potassium for compensation.**
UV Absorbance or Multiple Wavelength UV Absorbance Spectrophotometers (200-450nm)	**NH3**	**Fresh Water & Waste Water analysis.**	**Turbidity interference is there which can be overcome.**
Colorimetric method Reaction of Cr-VI with diphenyl carbazide in acid solution	**Chromium**	**Fresh Water & Waste Water analysis.**	**Experience in Indian condition is not available.**
Voltammetry (Anodic Stripping Voltammetry)	**Chromium**	**Fresh Water analysis.**	**Experience in Indian condition is not available**

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Dual Beam UV-Visible Spectrophotometry	**Chromium Hexavalent and Trivalent in full spectrum**	**Fresh water & waste water analysis.**	**Experience in Indian condition is not available**
Voltammetry (Anodic Stripping Voltammetry)	**Arsenic**	**Fresh Water analysis.**	**Experience in Indian condition is not available**

5.2 Issues with real time monitoring systems

The initial Indian experience of real time monitoring systems was not very satisfactory as In most cases the data obtained is either not reliable or is non- existent, since the systems are neither operated optimally nor maintained properly. The operation of real time system needs dedication and initiation, both from both the Industry as well as the instrument supplier. It has been observed that due priority is not given by the industry to operation of real time monitoring system and at the same time the necessary support from the vendors is also not forthcoming. Effective operation of the real time systems requires appointment of a dedicated person by the industry with responsibility to maintain and operate the system by the Industry and the instrument supplier also considers its responsibility to ensure trouble free operation of the system. It is therefore essential that the responsibility of both the industry as well as the vendor needs to be clearly specified.

5.3 Site selection

For online RTEQMS, the location of the sensors is important and submersible In-situ sensors as preferred option. If site does not permit then system with flow cell or extraction may be opted, even though this would have been expected given the issues with sample conditioning which may affect the measurement accuracy sometimes with a significant degree of variability.

The discharge point from ETP has to be selected to fix the insitu sensors or pump to extract the sample for cabinet system. The insitu installation are preferred where sensor can be fixed directly in the treated effluent channel.

5.3.1 Installation CCTV Camera

This is a device required to be installed other than the PTZ cameras as directed earlier in the ZLD categories.

Industries installing devices for parameters measurements (pH, BOD, COD etc.) have to install day and night vision CCTV cameras for surveillance use. The CCTV cameras installed should focus on the sensors immersed in the channel/outlet. In case of extractive method used for the effluent collection, the inlet pipe through which sample is collected, should be focused by the camera, ensuring the visibility of the point from where sample is being sucked for measurements. The connectivity of the camera is to be provided to CPCB through the web portals on 24x7 basis.

This camera should operate continuously. The output of the CCTV camera should also be connected with the DVR/NVR and the data for one month should be kept as backup retrievable through the software provided to CPCB. The resolution of the camera should be kept as 352 x 240 pixel or above.

5.4 Quantification

5.4.1 Instrument Calibration: The following frequency has to be used for calibration of analyser. This calibration can be done in the laboratory of the industry and data should be submitted online to CPCB.

- pH – once every week or as specified by manufacturer whichever is earlier The industry chemist shall perform multi point calibration of pH meter using standard pH buffer with9.2, 4.0 and 7.0or as provided pH solutions by the instrument supplier. The pH values have to be reported at 25 Degree C.pH buffers have to be used to calculate a running variance of the measurements.
- Temperature (pH Meter correction) – validation is to be performed against traceable calibrated thermometer, once every month and data submitted online to CPCB.

5.4.2 Validation for COD, BOD, TOC & TSS: Online instrument operation will be evaluated using the known traceable standards using laboratory techniques. By validating sensors and probes with known standards such as KHP (potassium hydrogen phthalate) for COD & TOC, Formazin equivalent standard for TSS. If variation is out-side the set points of known standards, then system requires calibration. Frequency of the validation should be once in three Months or as specified by manufacturer, whichever is earlier

The data logger software must keep all calibration data points in memory for interpretation of matrix change adaption.

5.4.3 Field Comparison of BOD, COD, TOC

Methodologies adopted for these parameters mainly involve indirect principles. To establish a co-relation between reported data and laboratory analysed data field comparisons have to be performed.

Comparison Process:

Flow based composite sample from the discharge channel where OCEMS is installed shall be collected and analysed in EPA recognized laboratory till such time the list of empaneled laboratories for OCEMS is released.

Composite sample means: at least 06 hours (every 30 min) flow based composite for continuous process stream and batch process shall cover the whole duration of the batch.

Frequency: Initially Once in three months

Calibrating agencies: EPA recognized laboratories till laboratories empaneled for OCEMS.

Calibration Data Reporting

The laboratory generated data shall be compared with the OCEMS average data generated in the same time period.

The industry will have to mention the starting and end time of the calibration for each parameter.

5.4.4. Parameter Accuracy: Allowed Variability

There native difference between online and laboratory measurements has to be between

- **CODAccuracy ± 10%**
- **BOD Accuracy ±10%.**
- **pH Accuracy ±0.2 pH**
- **TSS Accuracy +/-10%**

5.4.5 Operation & maintenance

- Daily Check – Data Transmission, System Diagnostic alarms.
- Monthly Check – Sensors & system cleaning, data backup, Parameter Calibration as specified in calibration schedule.
- Periodic Check – System validation with known standards, Laboratory & Online parameters Comparative.

6.0 Reporting

The OCEMS suppliers have to provide central server at cloud operational on 24x7 basis and to provide online data connectivity with CPCB and SPCBs servers. Beside data connectivity they need to provide login credential to respective SPCBs/PCCs and CPCB to view the data in graphical/ tabular format and also to compare the data features. One-minute data averages must be transmitted/retrieved to servers on every 15 minutes. In the event of transmission loss, the time stamped data in the datalogger memory must be transmitted to fill from the last transmission break with a stamp of time delay. The software should have two-way communication, so that data from the system can be seen whenever desired and remote of controller/data logger can be taken to visualize the immediate status of the system. The data along with diagnostics and calibration details should be transmitted to CPCB and SPCBs servers.

6.1 Data Management

Considering the heterogeneity of real time monitoring systems industries are required to submit real time data through their respective instrument suppliers. This mechanism has helped in consolidating the data avoiding the complexity of different technologies and availability of monitored data in different data formats and at the same time involving the instrument suppliers in data transferring mechanism. The system enables two-way communication required to manage such real time systems.

The basic functional capabilities of such software systems shall include: -

- The system should be capable of collecting data on real time basis without any human intervention.
- The data generation, data pick up, data transmission; data integration at server end should be automatic.
- The submitted data shall be available to the Boards, SPCBs/PCCs and CPCB for immediate corrective action.
- Raw data should be transmitted simultaneously to SPCBs /PCCs and CPCB.
- In case of delay in collection of data due to any reason, the data transmission should be marked delayed data and reports of delayed data should by displayed on the portal
- At no point of time, manual data handling shall be permitted. Data validation should be permitted only through the administrator and data changes recorded with date and time stampings.
- Configurations of the systems once set up and verified, shall not be changed. In case any setting change is required it should be notified and recorded through the authorized representatives only.
- The data submitted electronically shall be available to the data generator through internet, so that corrective action if any required due to submission of non-validated data can be initiated by the industry.
- The software should be capable to verify the data correctness which means at any given point of time the regulatory authorities/data generator should be able to visualize the current data of any location's specific parameter.
- A system for data validation shall be incorporated in the software with two stage/three stage validation and fixed responsibilities of stakeholders as below;
    a. **Data Generator**:

    b. **SPCBs/PCCs**:

    c. **CPCB**:

  CPCB will help SPCBs/PCCs in data validation till such time, adequate expertise for data validation is developed by them.
- Change Request Management: window for requesting data changes due to actual field conditions shall be provided to the industry in line to SPCB for consideration.
- The site surrounding environmental conditions shall also be recorded along with other environmental parameters, as these have the potential to affect the system adversely and influence the data generated.
- System should have capability to depict data at the actual location of industry over the map. CPCB and or SPCBs shall develop a map based system for data integration at a single location.
- The software should be capable of analyzing the data with statistical tools and shall

  have the following capabilities:

  i) Statistical data analysis (customizable) for average, min., max., diurnal variation.

ii) Comparison of parameters of different locations in user selectable time formats i.e. in graphical and tabular formats compatible to MS Excel, MS Word, *.txt etc.
iii) Capability of comparison of data with respect to standards/threshold values.
iv) Auto report and, auto mail generation etc.
v) Providing calibration database for further validation/correction of data.
vi) Transmitting data to different locations as per EC, CTE/CTO, and other directives in force.
vii) Channel configuration for range, units etc.
viii) Providing data in export format on continuous basis through central/station computer system to other system.

- Data transmission through different media like phone line, Broadband, leased lines (at least any two media supported).
- Data Storage for next five years.
- System should be connected to a backup power source with adequate capacity to avoid any power disruption for atleast 2-3 hours.

CPCB has developed a software system to be collate, compile, process and interpret the large volume of data generated. The software system developed is being used as a common server where all technology providers are submitting the data collected from industries on continuous basis. The software is operational in NIC domain.

7.0 Available monitoring matrices Sector specific

Considering the technological limitations and issues related to installation, data management and operation of real time systems efforts have been made to prepare a compilation of technologies (Table-3) that can be considered by industries for installation.

TABLE-3: DETAILS OF PARAMETERS AND FEASIBLE TECHNOLOGIES REQUIRED TO BE INSTALLED FOR REAL TIME CONTINUOUS EFFLUENT MONITORING SYSTEMS IN DIFFERENT CATEGORIES OF INDUSTRIES IN INDIA.

Category No.	Category Name	Parameter to be monitored	Prescribed Standards	Available Technologies	Remarks
1	Aluminium	1. pH	5.5-9	1. Electrode Method	
		2. BOD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
2	Cement	Nil		--	No real time monitoring required for Effluent.
3	Distillery	1. pH	5.5-9.0	1. Electrode Method	In case of unit has achieved ZLD condition 1 & 2 of the notes after the table shall have to be complied.
		2. BOD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	

		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
4	Dye and dye intermediate	1. pH	6.0-8.5	1. Electrode Method	
		2. BOD	100	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method(TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				3. UV-Vis Spectro-photometry (Single wavelength)	
		5. Cr	2.0	1. Colorimetric method	Cr – Process Specific Experience in Indian conditions is not available.

				2. UV-Vis Spectroscopy (Entire spectrum scanning)	
		3. Flow		1. Magnetic /Ultrasonic	
5	Chlor Alkali	1. pH	5.5-9	1. Electrode method	
		2. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectrophotometry (Single Wavelength)	
6	Fertilizers Urea Plant	1. pH	6.5-8.0	1. Electrode Method	
		2. Ammonical Nitrogen	75	Ion Selective Electrode method with temp correction	
				UV Vis Spectrophotometers (Entire spectrum scanning)	
		3. TSS	100		
		4. Flow		1. Magnetic /Ultrasonic	
	Fertilizers (DAP)	1. pH	65.-8.5	1. Electrode Method	
		2. Flow		1. Magnetic /Ultrasonic	
		3. TSS	100	1.Scattered light IR Method	
				2.UV-Vis Spectrophotometry (Single Wavelength)	
	Fertilizers (Phospheric acid & SSP)	1. pH	6.5-8.5	1. Electrode Method	
		2. Fluoride		-	Fluoride -Since reliable real time monitoring systems are not available, manual monitoring system as practised shall be continued

		3. TSS	100	1.Scattered light IR Method	
				2.UV-Vis Spectrophotometry (Single Wavelength)	
		4. Flow			
7	Iron Et steel	1. pH	6.0-8.0	Electrode method	Cynide & Phenol -Since reliable real time monitoring systems are not available, manual monitoring system as practised shall be continued
		2. Phenol	1.0	-	
		3. Cynide	0.2	-	
		4. Flow		1. Magnetic /Ultrasonic	
8	Oil refinery	1. pH	6.0-8.5	1. Electrode Method	
		2. BOD	15	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	125	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Potentiometric Titration	
		4. TSS	20	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
9	Petro-chemicals	1. pH	6.5-8.5	1. Electrode Method	
		2. BOD	50	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	

				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
10	Pesticides	1. pH	6.5-8.5	1. Electrode Method	
		2. BOD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		6. Chromium		1. Colorimetric method	Chromium & Arsenic– Experience in Indian conditions is not available.
				2. UV-Vis Spectroscopy (Entire spectrum scanning)	
		5. Arsenic	0.2	1. Voltammetry	
		6. Flow		1. Magnetic /Ultrasonic	
11	Pharmaceuticals	1. pH	6.0-8.5	1. Electrode Method	
		2. BOD	100	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	

				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Chromium (6+)	0.1	2. Colorimetric method	Chromium & Arsenic– Experience in Indian Conditions is not available.
				2. UV-Vis Spectroscopy (Entire spectrum scanning)	
		6. Arsenic	0.2	1. Voltammetry	
		7.		1. Magnetic /Ultrasonic	
12	Power Plants	1. pH	6.5-8.5	1. Electrode Method	
		2. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		3. Tempe-rature	5^0C	1. Electrode Methods	
13	Pulp & Paper	1. pH	5.5-9.0	1. Electrode Method	
		2. BOD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	150-200	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	

				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate($K_2Cr_2O_7$) + Potentiometric Titration	
		4. AOx	5-8	1. UV-Vis Spectrophotometry	AOx – Process Specific. Some vendors claim that AOx can be monitored on real time basis. But there is no experience in Indian conditions.
		5. TSS	30	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		6. Mass Flow		1.Inertial flow measurement technology	
		7. Flow		1. Magnetic /Ultrasonic	
14	Sugar	1. pH	5.5-8.5	1. Electrode Method	
		2. BOD	100	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		4. Flow		1. Magnetic /Ultrasonic	
15	Tannery	1. pH	6.0-9.0	1. Electrode Method	
		2. BOD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	

		4. Cr	2.0	1. Colorimetric method	Cr – Process Specific Experience in Indian conditions is not available.
				2. UV-Vis Spectroscopy (Entire spectrum scanning)	
		5. Flow		1. Magnetic /Ultrasonic	
16	Zinc	1. pH	5.5-9	1. Electrode Method	
		2. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		3. Flow			
17	Copper	1. pH	5.5-9	1. Electrode Method	
		2. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		3. Flow		1. Magnetic /Ultrasonic	
18	Textile and Bleaching (GPI)	1. pH	5.5-9.0	1. Electrode Method	
		2. COD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		3. BOD	30		
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
19	Dairy (GPI)	1. pH	6.5-9.0	1. Electrode Method	
		2. BOD	100	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	

				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
20	Slaughter House (GPI)	1. pH	5.5-9	1. Electrode Method	
		2. BOD	100	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	
21	Other Engineering	1. pH	6.0-9.0	1. Electrode Method	
		2. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	

	units like Electroplating			2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		3. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		Ni	3.0	1. Voltametery	Ni, Cr – Process Specific Experience in Indian conditions is not available.
		Cr	2.0	1. Colorimetric method	
				2. UV-Vis Spectroscopy (Entire spectrum scanning)	
		3. Flow		1. Magnetic /Ultrasonic	
22	Other units of Soft Drinks and Food	1. pH	6.5-8.5	1. Electrode Method	
		2. BOD	30	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
		3. COD	250	1. UV-Vis Spectro-photometry (Entire spectrum scanning)	
				2. Combined Combustion Catalytic Oxidation at 680°C and NDIR Method (TOC)	
				3. Measuring COD using Potassium dichromate(K2Cr2O7) + Potentiometric Titration	
		4. TSS	100	1. Scattered light IR Method	
				2. UV-Vis Spectro-photometry (Single wavelength)	
		5. Flow		1. Magnetic /Ultrasonic	

Notes: -

1. Industries claiming Zero discharge and not discharging effluent outside the premises shall to install Camera and flow meter at the discharge point from the channel / drain provided for carrying the effluent within the industry.
2. Industries achieving Zero Liquid Discharge by utilizing effluent for irrigation/gardening will have to install Real time monitoring systems.
3. In case of parameters specified in Consent to Operate/Environmental Clearance and where real time monitoring technology is not well established, the parameters will be analysed using established laboratory methods atleast once in three months or as per the frequency specified in Consent to Operate/EC whichever is more.
4. The table/matrix will be updated, incorporating any new technology/instrumentation as and when need is felt.

Annexure-I

8. Parameters for online monitoring as per Guidelines

Sl. No	Category	Effluent Parameters	Emission Parameters
1	Aluminium	pH, BOD, COD, TSS, Flow	PM, Fluoride, Flow
2	Cement	-	PM,NOx,SO_2, Flow
3	Distillery	pH, BOD,COD,TSS, Flow	PM, Flow
4	Dye and dyeintermediate	pH, BOD,COD, TSS, Cr, Flow	-
5	Chlor Alkali	pH, TSS, Flow	Cl_2, HCl, Flow
6	Fertilizers	pH, flow, Ammonical Nitrogen, Fluoride	PM, Fluoride, Ammonia, Flow
7	Iron&steel	pH, Phenol, cyanide, flow	PM,SO_2, Flow
8	Oilrefinery	pH, BOD,COD,TSS, flow	PM,CO,NOx,SO_2, Flow
9	Petrochemical	pH, BOD,COD,TSS, flow	PM,CO,NOx,SO_2, Flow
10	Pesticides	pH, BOD, COD, TSS, Cr, As, flow	-
11	Pharmaceuticals	pH, BOD, COD, TSS ,Cr ,As, Flow	-
12	Power Plants	pH, TSS, Temperature	PM, NOx, SO_2, Flow
	Thermal Power Plants	pH, TSS, Temperature	PM, NOx, SO_2, Total Mercury(Gaseous), Flow
13	Pulp&paper	pH, BOD, COD,TSS ,AOx, Flow, Mass Flow	-
14	Sugar	pH, BOD,TSS, flow	-
15	Tannery	pH, BOD, TSS, Cr, Flow	-
16	Zinc	pH, TSS, flow	PM, SO_2, Flow
17	Copper	pH, TSS, flow	PM, SO_2, Flow
18	Textile(GPI)	pH, COD, TSS, flow	-
19	Dairy(GPI)	pH, BOD,COD,TSS, flow	-
20	Slaughter House	pH, BOD,COD,TSS, flow	-
21	Boiler	-	PM, SO_2, NOx, Flow

Notes:

(a) *CEM Systems must have Flow (Velocity) measurement device installed*

(b) *Direct measurement systems for O_2 or CO_2 as prescribed in respective standards shall be installed.*

(c) *For hazardous waste incinerator and Biomedical waste incinerator O_2, CO_2, and CO are important parameters to be monitored online.*

(d) *Any dilution extractive system must have CO_2 measurement facility at source and measuring point to prove the correctness of the selected dilution ratio.*

(e) *CCTV camera focusing sample inlet for effluent parameters monitoring to be installed with data storage in NVR for a month.*

9.0 Observations

Online analyzers area better tool to extend in-time information on compliance of ETP and CETP to the prescribed norms to regulator. The real time measurement for important parameters will give detailed information continuously, which laboratory instruments fail to give as random once in a month or quarter. The laboratory instruments information is too less to understand discharge compliance of industry.

10. Conclusions

1. The industries falling in 17 categories of highly polluting industries, the grossly polluting industries discharging directly/indirectly into river Ganga or its tributaries, Common Effluent Treatment Plants (CETP) and Sewage Treatment Plants (STPs), Common Bio Medical waste and Common Hazardous waste incinerators have to install real time effluent quality monitoring system. The installation of the system should be completed by March 31,2015.
2. The parameter i.e. Flow, pH, TSS, COD, BOD, and Ammonia will be monitored by installing Real Time Monitoring Systems. Other parameters specified in the consent to operate/Environmental Clearance will be monitored on quarterly basis using the established laboratory methods.
3. In case of industries having adopted Zero Liquid Discharge (ZLD) the units shall install IP camera with PAN, TILT Zoom, 5x or above focal length, with night vision capability and flow meters in the channel/drain provided for carrying the effluent from within the premises of the unit.
4. The industries meeting ZLD norms by utilizing the treated effluent for irrigation shall install real time monitoring system at the outlet of ETP, to monitor the quality of treated effluent.
5. As the data from real time systems is monitored at very short duration, regular fluctuation will be observed 10% exceedance of values over the prescribed norm shall not be considered for action presently. In case of regular noncompliance by the units the existing method of sampling, analysis and related procedure under the existing norms need to be continued for regulatory purpose and for purpose of actions against the unit.
6. The software will give alarm, in case of the concentration of parameter exceeds the prescribed norms by 10% continuously.
7. The responsibility of data submission lies with the Individual units. The instrument supplier will facilitate data transmission on behalf of industries. Industry will ensure at least 85% data availability from the system installed.
8. The vendors/instrument supplier shall install their server in SPCB/PCCs and CPCB for transferring data from the real time system.

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9. CPCB in consultation with SPCBs/PCCs shall explore the possibility to identify a common protocol, so that the data from the real time systems can be transferred directly to the server installed by SPCBs/PCCs and CPCB in a compatible form.
10. The vendor/instrument supplier shall make provisions to provide data continuously at least 04 locations in SPCBs/PCCs, RO/DO of CPCB, and industry directly from the analyzers.
11. In case of system requiring pumping of samples, the instrument supplier/vendors has to ensure that dilution of sample is not possible and in case of any dilution, the system gives alarm.
12. The SPCBs/PCCs will identify a team of officials for plausibility control of data received. The team members will be responsible for validating, interpreting and interpolation of data on daily basis.
13. The vendor /instrument supplier will regularly cross check the data obtained from real time system with that of the samples collected manually and analyzed using approved laboratory techniques and revalidate the factor for interpolation/extrapolation of COD/BOD values essential for generating better quality data. The industry will take responsibility of establishing co-relation factor.
14. The industries shall ensure that the monitoring systems are covered under Comprehensive Maintenance Contract with the vendors/ authorized Indian service partners of the instrument manufacturer for atleast during the next 05 years after the installation.
15. The authorized Indian service partner/instrument manufacturer shall ensure that any problem in monitoring system/data acquisition and transfer system does not persist beyond 72 hours.
16. The vendors/instrument manufacturers shall ensure availability of spare parts for at least 07 years after installation of the system.
17. The industry should take Bank Guaranty (BG) equivalent to 25% of the cost of the Real Time Monitoring Systems from the manufacturer of the system or its authorised Indian counterpart. The BG is taken to ensure optimal performance of the system including 85% data captive rates, providing reliable & accurate data.
18. As nearly all the RTEQMS are manufactured abroad, the Indian Bidder has to provide copy of the authorization from the original instrument manufacturer for bidding on his behalf
19. Role of manufacturers/supplier authorised Indian Service Partner:
    - Supply and install equipment suitable to monitor the effluent quality in the available matrix
    - Supply all the supporting equipment, analysers and software
    - Supply equipment/instruments capable of monitoring/measuring the parameters identified in the range of occurrence in the industrial unit
    - Supplied software should establish two-way communication sending diagnostics of instruments on demand, with central servers at SPCBs/PCCs and CPCB

- The software should be capable of transmitting the data along with diagnostics of the instrument

Note: Efforts have been made to include all available monitoring technologies /instrumentation in the document. In case any technology /instrumentation is not covered or is introduced subsequently the details be forwarded to CPCB, so that the same can be incorporated while reviewing this document after a few months.

ANNEXURE-II

Standard Operating Protocol for Verification of Installation and Calibration of UV-Vis Dual Beam Scanning & Multipoint calibration mechanism technology based OCEMS (Effluent) used in Sewage Treatment Plants (STPs)

Version 1.0

This protocol provides general guidance for verification of Online Continuous Effluent Monitoring System (OCEMS) installed at Sewage Treatment Plants (STPs) with step-wise approach for verification of installation and initial calibration by instrument installer, later validation of calibration by operator and performance check by the State Pollution Control Boards (SPCBs)/Pollution Control Committees (PCCs), so as to ensure that reliable data is generated by OCEMS.

1. Verification of OCEMS Installation

(i) **Pre-requisites**-OCEMS installation should be planned w.r.t. availability of location, uninterrupted stabilized power supply, protection from harsh environmental conditions, security, accessibility, safety of access to sensors and data display board, data transmission with remote or manual calibration procedure etc. These are pre-requisites before installation of OCEMS.

(ii) **Continuous Operation:** The purpose of installation of online analyser is to get continuous effluent monitoring data, hence, in no case the system shall be switched off without prior intimation to the concerned regulators.

(iii) **In-Situ location:** OCEMS must be installed at the Final Outlet/stable outlet channel with least water turbulence. It should always be placed at the treated water chamber overflowing in to final outlet.

(iv) The sensor must always remain submerged in effluent and whenever (during maintenance and calibration) sensor is taken out from the effluent, alarm should be generated and communicated to SPCB/CPCB server automatically.

(v) **Extractive location**: The sample must be drawn through a pump from the same location as mentioned above with little over pressure to maintain the sample supply continuously. In case the sample is not available, system should generate automated alarm communicated to CPCB/SPCB server.

2. Calibration of OCEMS:

STP Operators may deploy different makes of instruments based on different technologies measuring effluent quality in terms of pH, BOD, COD, and TSS, therefore, operation and calibration mechanism of such instruments will differ. This document covers calibration procedure for commonly used technologies for effluent monitoring, available as on date, that is UV-Vis principle based system for BOD, COD & TSS measurement having dual beam scanning and Multipoint calibration mechanism.

Complete calibration of OCEMS requires following checks, calibrations & validations:

(i) Function Check
(ii) Basic Installation & Calibration
(iii) Continuous Validation
(iv) Performance Check

The calibration shall be considered complete, when process no. (i), (ii), (iii) and (iv) have been completed successfully and all the conditions of protocol are found to be within permissible ranges/limits mentioned in this document.

Function checks, Installation & calibration check is the responsibility of the firm or its authorized representative installing OCEMS. Ensuring continuous validation of OCEMS is the responsibility of the operator of STPs (to be verified by SPCBs/PCCs). Performance check of OCEMS is the responsibility of SPCBs/PCCs to verify ~~the~~ performance of plants against stipulated standards.

2.1 OCEMS Function check

The purpose of this exercise is to cross verify the operation of basic electronics involved in the system. When required, this data should be shared through email to SPCBs/PCCs. Records of this function check should be available in the plant.

Parameter-wise function check process is below:

pH: Calibrate pH meter with Certified (having international traceability) Buffer solutions of pH 4, 7, 9.2 & 10. Perform at-least two point calibration within the expected range of the pH in the plant. For example, if pH is expected to be 7.8 then perform two points calibration with pH 7 and 9.2.

BOD: Not possible

COD: Use KHP Certified Reference Material (CRM)

Step 1: Prepare different dilutions using Potassium Hydrogen Phthalate (KHP) with stock solution 1000ppm and check performance of instrument in respective dilutions. Calibrate optics of the system with the procedure detailed below.

Step 2: Prepare stock standard (1000ppm equivalent COD) in laboratory and store it in refrigerator. Stock is stable upto six months, if stored in refrigerator. Hence, as a safety margin, do not use stock older than five months in calibration and also do not use stocks, if exposed in environment because of any reason.

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Step 3: Prepare working solution of nearly 1/3rd, 1/2, 2/3rd and 2 times of working range (i.e. COD levels expected in a plant) and perform the functional test on site within 24 hours.

Step 4: Verify the results and if not found within 5% of the range, perform functional check again

Step 5: Submit middle dilution (of the range in use at plant) as sample for parallel COD measurements in lab along-with the samples.

TSS: Use Formazine solution. Care to be taken in handling solution.

Frequency of function test is every 15 days. STPs may engage the firms providing services of O & M.

2.2 Basic Installation and Calibration of OCEMS

The purpose of this exercise is to ensure installation of the system in a plant and collect calibration data points for better matrix matching and to authenticate the range of measurement coverage. The data collected should be shared through email to SPCBs/PCCs or CPCB. Copy of this basic or initial calibration should be available at any point of time in the plant. If such exercise was not done earlier, the same should be completed and records be maintained. Basic calibration test should be repeated when two consecutive validation tests or performance tests fail and results fall beyond the "criteria of outliers" given in this document.

Step 1: Conduct Grab Sampling of effluent for 24 hours at an interval of 02 (Two) hours.

Step 2: Conduct flow based composite sampling for every 24 hours. All measurements shall be reported in metric SI units. For Example, the flow shall be reported in m3/hr after conversion factor of 4.546 is applied to the readings in MGD

Step 3: Follow standard sampling procedure for

- i. flow based composite preparation.
- ii. sample collection
- iii. sample preservation
- iv. sample storage with ice
- v. samples deposition

Step 4: Send samples for testing to a EPA recognized laboratory, which has participated in AQC, within last one year and has passed the AQC criteria successfully.

Step 5: Collect sample results within maximum seven days from the date of sampling.

Step 6: Collect copy of certificate of Lab's participation in AQC (as prescribed by CPCB) and its performance results in AQC, along-with the sample's results each time either physically or electronically (email etc.).

Step 7: Enter data of 12 (Twelve) Grab samples lab results of every parameter (pH, BOD, COD, TSS) into the OCEMS within seven days of sampling and maintain a record of calibration results entered in the OCEMS.

Step 8: Ensure that there are no previous calibration results entries in the system. If there are entries, remove all entries from the system. These entries have to be removed only at the first time calibration.

Step 9: While making calibration results entries, ensure that outliers (data points) as per given "Criteria of outliers" in this document, are not entered into the OCEMS.

Step 10: within next seven days from the first sampling date, Repeat the exercise again following steps 1 to 7 again.

Step 12: This time system should hold at-least total 15 valid calibration points (out of 24 data points) after calibration points entries.

Step 13: Compare results of composite sampling with average of continuous 15 minute values received through OCEMS for both days. The composite sample results should not be an outlier.

Step 14: If the system does not show Standard Error Mean (SEM) within prescribed criteria for any of the parameters, that particular parameter should be recalibrated, as per above procedure.

Step 15: As COD is the principal component of measurement of these instruments, cross check results of COD of the middle dilution, as sample. If not within 5% range of prepared working solution, perform function check again for COD parameter.

Step 16: Only (01) sample out of 24 samples (12 samples per day for two calibration days) shall be sent to SPCBs/PCCs or CPCB lab for cross check, while doing initial calibration of OCEMS in any industry. Sample should again be sent to SPCBs/PCCs or CPCB lab, when system fails in performance and is recommended for re-calibration. The SPCBs/PCCs or CPCB may accept sample only if it is preserved and transported following standard procedure. Report on basic installation and calibration of OCEMS at STPs should be sent to SPCBs/PCCs and CPCB.

Step 17: SPCBs/PCCs or CPCB will check the results of STPs sample received with online data and may ask for repeat of basic calibration, if found to be deviating more than acceptable error in standard laboratory method.

2.3 Continuous Validation of OCEMS

The purpose of this exercise is to check the validity of earlier calibration and collection of validated calibration data points for better matrix matching and to authenticate the range of measurement coverage. Frequency of continuous validation by plant operators should be once in 15 (Fifteen) days. The data collected should also be shared through email to CPCB, SPCB/PCCs.

Function 1: OCEMS Function check as above (as per technology used) to be performed once in fifteen days or fortnightly basis.

Function 2: OCEMS Validation through routine calibration library generation, to be performed once in fifteen days or fortnightly basis.

Process of Routine Calibration Library Generation

Step 1: Pick up one sample of effluent (treated water) from the OCEMS location.

Step 2: Create data entry point in OCEMS and note down exact date and time along-with Global calibration value at this point of time.

Step 3: Follow standard sampling procedure for:

  i. sample collection
  ii. sample preservation
  iii. sample storage with ice
  iv. samples deposition

Step 4: Sample should be given for testing to a EPA recognized laboratory only, which has participated in AQC - proficiency test, within last one year and has passed the criteria successfully.

Step 4: Collect result from laboratory within maximum seven days from the date of sampling.

Step 5: Collect copy of certificate of Lab's participation in AQC (as prescribed by CPCB) and its performance results in AQC, with the sample results each time either physically or electronically (email etc.).

Step 6: Visit OCEMS and enter data point in the library- ensuring that outliers are not entered into the system. Now the system will have one entry added to library. These data points of calibration along-with global calibration value should be available at central portals of respective SPCB/PCC and CPCB.

Step 7: If data point is an outlier, data entry should not be made in OCEMS, instead repeat the process from step 1 to step 7 again on the same day by picking up the sample again.

Step 8: If two consecutive validation check samples fall out of range and remains outliers, recommend basic OCEMS calibration again through the supplier.

2.4 OCEMS Performance Check by SPCBs/PCCs

The purpose of this exercise is to check the validity of earlier calibration and collection of validated calibration data points for better matrix matching and to authenticate the range of measurement coverage. OCEMS Performance check may be conducted by authorities like SPCBs/PCCs or by any authorized agency engaged by them once in 30 days or more depending on local requirement. Performance check data may be used to verify the performance of plants w.r.t. prescribed standards.

The data collected may be shared with plant operator. Data points within the ranges, should be made part of library of the OCEMS. More number of points shall provide better results. Efforts should be made to keep information available on web portals of CPCB and SPCB transparently, updated automatically.

Step 1: Perform function check as above, as per technology used, and routine calibration verification data Library.

Step 2: Pick up one sample of effluent from the OCEMS location.

Step 3: Create data entry point in OCEMS and note down exact date and time along-with Global calibration value at this point of time.

Step 4: Follow standard sampling procedure for

  i. sample collection
  ii. sample preservation
  iii. sample storage with ice
  iv. samples deposition

Step 5: Sample should be given for testing in own laboratory or a EPA recognized laboratory only, which has participated in AQC- Proficiency Test, within last one year and has passed the criteria successfully.

Step 6: Collect result within maximum seven days from the date of sampling.

Step 7: Collect copy of certificate of Lab's participation in AQC (as prescribed by CPCB) and its performance results in AQC, with the sample results each time either physically or electronically (email etc.).

Step 8: Visit OCEMS and enter data point in the library- ensuring that outliers are not entered into the system. Now the system will have more than 16 calibration points entries.

Step 9: If data point is an outlier data entry should not be made in OCEMS, instead repeat the process from step 1 to step 7 again on the same day by picking up the sample again.

Step 10: If two consecutive performance check samples fall out of range and remains outliers recommend basic OCEMS calibration again through the supplier.

3.0 Other Calibration Requirements

a. Sampling procedure
  - Precaution should be taken while taking the sample for OCEMS validation and performance verification. The water sample pick up point should be same, where OCEMS is operating.
  - Sample should be collected from the outlet of final treatment water storage tank from the instrument measuring-window location.

- Standard sampling procedure should be followed to pick up/storage/transport/preserve the samples. The samples collected should be submitted to the lab within maximum 24 hours.
- Since, exact sampling time plays significant role in the validation of data, sample pick up date and time should be endorsed in the instrument.
- Snapshot of the instrument at sample pick up time should be taken for results entry into the system later.
- Calibration status of OCEMS should be recorded by means of recording number of calibration data points available in the system. Here, data points means the results of lab against data of instrument and Global Calibration values entered in the system. Snapshot can be taken to collect these three data sets.

b. Calibration procedure:

To get better results through OCEMS, adaptation of water matrix/Pollution load is a key point which should be done through sampling as mentioned above and finally based on result multipoint Calibration should be done.

- Results of water samples given to a laboratory, during initial installation or validation or performance verification of OCEMS, for testing must be obtained within five days of sampling.
- Lab result entry must be made in the software of OCEMS within seven days against the same calibration point created at the time of sample pickup. date and time with the template snapshot taken during sampling should be used for data matching and records entry.
- Lab results can be entered in the system, only if results do not fall in criteria of outliers.
- In case results do not fall in the above criteria for two times consecutively, the system Basic installation calibration should be recommended.

4.0 Recommended Outliers:

Outliers have to be calculated on the basis of calculation of SEM (Standard error mean) in the lab results obtained during initial calibrations, continuous validation and performance verification. The SEM can be calculated through excel sheets as per formula applied: STDEV.S(G1:Gn)/SQRT(COUNT(G1:Gn))

The recommended **Criteria of outliers** derived from standard error mean limits for different parameters is as below:

- pH: SEM(Standard error mean) should not be more than 5
- BOD: SEM(Standard error mean) should not be more than 20
- COD: SEM(Standard error mean) should not be more than 10

- TSS: SEM(Standard error mean) should not be more than 10

Protocols of other technologies used in field will be developed in the next version of protocol.

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