



# INDIAN WATER QUALITY ASSOCIATION

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Proposed reference framework

**“for Improvement in waste water analysis  
through diagnostic laboratory practice  
for Improved STP performance  
and river rejuvenation.”**



Author:

**Sanjay Sharma**

Co-Authors:

**Amit Singh  
Anil Kumar  
Dr. Anil Mishra  
Dr. Manju Kajla**

Submitted by:

**INDIAN WATER  
QUALITY ASSOCIATION**



+91 97187 61234



info@iwqa.in



iwqa.in



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## Acronyms and abbreviations

The following abbreviations are used in this report. Where an abbreviation can have more than one meaning, the applicable meaning is determined by its technical or regulatory context.

| Acronym or abbreviation      | Meaning                                                                                |
|------------------------------|----------------------------------------------------------------------------------------|
| <b>AMR</b>                   | Antimicrobial resistance                                                               |
| <b>ARB</b>                   | Antimicrobial-resistant bacteria                                                       |
| <b>ARG</b>                   | Antimicrobial resistance gene                                                          |
| <b>BIS</b>                   | Bureau of Indian Standards                                                             |
| <b>BOD / BOD<sub>5</sub></b> | Biochemical oxygen demand / five-day biochemical oxygen demand                         |
| <b>CFR</b>                   | Code of Federal Regulations of the United States                                       |
| <b>COD</b>                   | Chemical oxygen demand                                                                 |
| <b>CPCB</b>                  | Central Pollution Control Board                                                        |
| <b>CST</b>                   | Capillary suction time                                                                 |
| <b>CWA</b>                   | Clean Water Act of the United States                                                   |
| <b>DAF</b>                   | Dissolved air flotation                                                                |
| <b>DO</b>                    | Dissolved oxygen                                                                       |
| <b>EC</b>                    | European Commission, or electrical conductivity where stated in the analytical context |
| <b>EN</b>                    | European Standard                                                                      |
| <b>EPA / US EPA</b>          | United States Environmental Protection Agency                                          |
| <b>ETP</b>                   | Effluent treatment plant                                                               |
| <b>EU</b>                    | European Union                                                                         |
| <b>F/M</b>                   | Food-to-microorganism ratio                                                            |
| <b>GIS</b>                   | Geographic information system                                                          |
| <b>HRT</b>                   | Hydraulic retention time                                                               |
| <b>HWW</b>                   | Hospital or healthcare wastewater                                                      |
| <b>IEC</b>                   | International Electrotechnical Commission                                              |
| <b>IFAS</b>                  | Integrated fixed-film activated sludge                                                 |
| <b>IS</b>                    | Indian Standard                                                                        |



| Acronym or abbreviation | Meaning                                                              |
|-------------------------|----------------------------------------------------------------------|
| <b>ISO</b>              | International Organization for Standardization                       |
| <b>IT</b>               | Information technology                                               |
| <b>IWQA</b>             | Indian Water Quality Association                                     |
| <b>LIMS</b>             | Laboratory information management system                             |
| <b>MBR</b>              | Membrane bioreactor                                                  |
| <b>MBBR</b>             | Moving bed biofilm reactor                                           |
| <b>MLSS</b>             | Mixed liquor suspended solids                                        |
| <b>MLVSS</b>            | Mixed liquor volatile suspended solids                               |
| <b>NPDES</b>            | National Pollutant Discharge Elimination System of the United States |
| <b>OLMS</b>             | Online monitoring system                                             |
| <b>ORP</b>              | Oxidation-reduction potential                                        |
| <b>OUR</b>              | Oxygen uptake rate                                                   |
| <b>PCC</b>              | Pollution Control Committee                                          |
| <b>PFAS</b>             | Per- and polyfluoroalkyl substances                                  |
| <b>QA</b>               | Quality assurance                                                    |
| <b>QC</b>               | Quality control                                                      |
| <b>RAS</b>              | Return activated sludge                                              |
| <b>SBR</b>              | Sequencing batch reactor                                             |
| <b>SCADA</b>            | Supervisory control and data acquisition                             |
| <b>SOP</b>              | Standard operating procedure                                         |
| <b>SOUR</b>             | Specific oxygen uptake rate                                          |
| <b>SPCB</b>             | State Pollution Control Board                                        |
| <b>SRT</b>              | Solids retention time or sludge retention time                       |
| <b>STP</b>              | Sewage treatment plant                                               |
| <b>SVI</b>              | Sludge volume index                                                  |
| <b>TDS</b>              | Total dissolved solids                                               |
| <b>TKN</b>              | Total Kjeldahl nitrogen                                              |
| <b>TMP</b>              | Transmembrane pressure                                               |
| <b>TN</b>               | Total nitrogen                                                       |
| <b>TOC</b>              | Total organic carbon                                                 |
| <b>TS</b>               | Total solids                                                         |
| <b>TSS</b>              | Total suspended solids                                               |
| <b>UV</b>               | Ultraviolet                                                          |
| <b>VFA</b>              | Volatile fatty acids                                                 |



| Acronym or abbreviation | Meaning                |
|-------------------------|------------------------|
| <b>VS</b>               | Volatile solids        |
| <b>WAS</b>              | Waste activated sludge |

## Introduction: From laboratory reporting to diagnostic decision support

Reliable water and wastewater analysis is the foundation of effective treatment, public-health protection and environmental restoration. A final-effluent result records the quality achieved at one sampling point, but a properly designed analytical programme explains how that result arose. By comparing influent, intermediate process streams, return liquors, sludge characteristics and final effluent over representative operating periods, a treatment facility can quantify pollutant loads and removal efficiencies, distinguish hydraulic overloading from organic or toxic shock loading, and assess each treatment unit rather than judge the entire STP from a single outlet sample.

The proposal therefore gives priority to diagnostics over the mere generation of laboratory reports. Diagnostics combines representative sampling, accurate analysis, quality assurance, process data, historical trends and technical interpretation to identify the probable cause and location of deterioration. Low removal efficiency may arise from inadequate aeration or oxygen transfer, unsuitable sludge age, abnormal MLSS, poor settleability, nutrient imbalance, industrial inhibition, short-circuiting, excessive return loads, equipment malfunction, inaccurate flow measurement, inappropriate chemical dosing, or sampling and analytical error. Because these causes require different remedies, a numerical report without diagnosis can result in delayed, ineffective or misdirected treatment action.

Adoption of this framework will convert the laboratory from a report-generating function into an active technical partner in plant operation. It will support early warning of process stress; protect biomass and equipment; improve process stability, pollutant removal and treated-effluent reliability; reduce avoidable chemical, energy and maintenance costs; strengthen preventive maintenance, compliance and data traceability; and require every material deviation to lead to a documented diagnosis, assigned corrective action and verification through follow-up testing. The result will be improved STP performance and process health, together with stronger protection of workers, downstream users and communities exposed to contaminated water.

The benefits extend beyond the treatment plant. Accurate load assessment, unit-wise diagnosis and reverse sewer monitoring help identify untreated, toxic or unauthorised discharges before they destabilise an STP or enter a drain, lake or river. More reliable treatment and source control reduce pollutant loads reaching receiving waters, provide defensible evidence for enforcement and investment decisions, and directly support river and water-body rejuvenation. Compliance decisions must, however, follow the applicable law, consent conditions and current regulator-approved analytical methods. BIS, CPCB, US EPA and European references in this document should be applied according to their legal status and checked for the latest edition, amendment and site-specific requirement.

### **Recommended adoption approach for laboratories and treatment organisations**

- Adopt the 39 recommendations as the policy basis for a Water and Wastewater Sampling, Analytical Quality Assurance and Treatment Process Diagnostic Manual applicable to the organisation's laboratories and associated treatment facilities.
- Maintain separate but traceable streams for statutory compliance data and diagnostic process data, ensuring that diagnostic interpretation supports operations without altering or substituting legally prescribed compliance results.
- Pilot the framework at representative drinking-water, sewage and effluent laboratories and at treatment plants using conventional activated sludge, SBR, MBBR, MBR or other relevant technologies before organisation-wide implementation.
- Use a controlled parameter-method-frequency-location-and-acceptance matrix approved jointly by laboratory management, plant operations, the quality function and the applicable regulatory authority where concurrence is required.

## Standards reference key

| Code    | Reference                                                                                                                                                     |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BIS-S1  | IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques                                              |
| BIS-S3  | IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples                                                                     |
| BIS-S10 | IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters                                                                         |
| BIS-A   | IS 3025 series, Methods of Sampling and Test Physical and Chemical for Water and Wastewater; use the current applicable part and amendment for each parameter |
| BIS-L   | IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories                                                                                     |
| CPCB-S  | CPCB Sampling Protocol for Water Wastewater and Soil                                                                                                          |
| CPCB-M  | CPCB Guide Manual Water and Wastewater Analysis                                                                                                               |
| CPCB-O  | CPCB Guidelines for Online Continuous Effluent Monitoring Systems and applicable directions or consent conditions                                             |
| CPCB-D  | Environment Protection Rules 1986 Schedule VI and the applicable SPCB, PCC or other regulator consent and discharge or reuse conditions                       |
| EPA-136 | US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control                                               |
| EPA-N   | US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance         |



|       |                                                                                                                                                                      |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| EPA-R | US EPA 40 CFR Parts 122 and 123, permit monitoring, records and reporting framework                                                                                  |
| EPA-Q | US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations                                                                 |
| EPA-B | US EPA 40 CFR Part 503 and approved methods guidance for sewage sludge and biosolids                                                                                 |
| EU-U  | Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements |
| EU-W  | Directive 2000 60 EC Water Framework Directive                                                                                                                       |
| EU-E  | Directive 2008 105 EC as amended by Directive 2013 39 EU on environmental quality standards and priority substances                                                  |
| EU-I  | Directive 2010 75 EU on industrial emissions and source-control principles                                                                                           |
| EU-L  | EN ISO 5667 series and EN ISO IEC 17025 as the European sampling and laboratory competence framework                                                                 |

## Detailed recommendations

### 1 Move from compliance testing to diagnostic analytics

Final-effluent compliance testing should remain mandatory, but it cannot by itself identify why an STP is underperforming. The responsible organisation should establish two linked data streams: a regulatory stream that follows the prescribed sampling point, frequency, method and limit; and a diagnostic stream that measures influent variability, unit-process performance, biological health, hydraulic conditions and pollutant loads. Diagnostic results should support operational decisions but must not replace or alter statutory compliance data.

The purpose of the laboratory must extend beyond generating a certificate or table of results. The laboratory in-charge should be made duty bound to review and sign an interpretive observation with every report. The observation should assess sampling adequacy and representativeness, identify exceedances and abnormal trends, compare the result with previous data and relevant design or consent criteria, comment on data quality and uncertainty, state likely process causes, specify additional checks where required and recommend time-bound operational or maintenance action. Where the available evidence is insufficient for a firm conclusion, the report should say so and prescribe the confirmatory sampling or analysis needed rather than leaving an unexplained abnormal value.

The laboratory in-charge should also review agreement between laboratory, field and OLMS results and escalate material discrepancies to the plant head. Reports should carry a clear status such as satisfactory, watch, action required or critical, with the reason and recommended response. The responsible operations officer should record action taken in the LIMS, and the laboratory should verify effectiveness through follow-up results. This joint accountability converts laboratory data into a management tool and ensures that recurring underperformance is not concealed within a series of unexamined reports.

All STP laboratory reports should be reviewed each working day, or at a risk-based frequency formally approved for the facility, by designated technical and quality-control reviewers through the LIMS dashboard or another controlled electronic workflow. The review should not be confined to checking



individual values against limits; it should examine influent and effluent loads, unit-wise removal, composite and grab results, sludge condition, operational parameters, mass-balance closure, online trends, instrument quality-control status and recent performance.

The reviewers should record signed observations on the laboratory report and communicate them without avoidable delay to the plant in-charge and designated senior technical and administrative authorities. The observation should assess data completeness and reliability, present treatment performance and unit efficiency, abnormal trends and probable causes, required confirmation, and any risk to compliance, process stability, public health, reuse or receiving-water quality.

The daily observation should also provide a reasoned forward assessment of likely efficiency over the next operating period. This anticipation should be based on the direction and rate of change in influent loading, effluent quality, ammonia conversion, sludge settleability, solids inventory, dissolved oxygen, equipment condition, chemical stock, energy interruptions, rainfall or industrial shock loads and other relevant evidence. The forecast should be expressed as stable, improving, deteriorating or at risk, with the basis, uncertainty and trigger values that would require escalation. It should not be presented as a guarantee where the available evidence is limited.

Every adverse observation must specify the action required, responsible operational or engineering role, priority, target completion time, confirmatory tests and closure criterion. The plant in-charge should record action taken and reasons for any deviation; designated technical and quality-control reviewers should verify the response; and unresolved, repeated or critical matters should remain under review by the designated senior authority until follow-up analysis confirms recovery.

Reference basis CPCB-D Environment Protection Rules 1986 Schedule VI and the applicable SPCB, PCC or other regulator consent and discharge or reuse conditions; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EPA-R US EPA 40 CFR Parts 122 and 123, permit monitoring, records and reporting framework; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## 2 Define the objective before sampling

A sampling programme must state the decision it is intended to support. Typical objectives include consent compliance, process control, performance verification, mass-balance assessment, shock-load investigation, reuse assurance or catchment enforcement. The same sample design is not suitable for every objective; for example, an instantaneous grab can confirm pH at a moment in time but cannot represent daily organic loading.

The responsible organisation should require a monitoring-plan sheet for each campaign stating the objective, locations, timing, sample type, parameters, analytical methods, detection limits, QA controls and decision rules. Changes in objective should require a documented revision rather than informal changes in the field.

**Reference basis** BIS-S1 IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques; BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-L EN ISO 5667 series and EN ISO IEC 17025 as the European sampling and laboratory competence framework

## 3 Obtain representative influent and effluent samples

Sampling points should contain a well-mixed flow and should avoid stagnant pockets, surface scum, settled deposits, recycle-stream interference and locations immediately downstream of chemical dosing unless that condition is the intended subject of testing. Influent sampling must represent the total sewage entering the works, including known return streams where relevant; final-effluent sampling must occur after the last treatment step and before dilution or mixing with another water.

Site-specific sampling-point validation should document access, safety, mixing, turbulence, pump cycles, backflow, bypasses and the effect of internal returns. Photographs, coordinates, a schematic and a unique point code should form part of the station record.

**Reference basis** BIS-S1 IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques; BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10,

guidance on sampling of waste waters; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-L EN ISO 5667 series and EN ISO IEC 17025 as the European sampling and laboratory competence framework

#### **4 Choose grab or composite samples correctly**

A single grab sample represents conditions only at the place and moment of collection and, by itself, generally cannot establish the average performance or treatment efficiency of an STP whose flow and pollutant strength vary hourly. Grab sampling remains essential for unstable or rapidly changing parameters such as temperature, pH, dissolved oxygen, residual disinfectant, sulphide and volatile compounds, and for confirming a short-duration upset or online alarm. For BOD, COD, TSS, nutrients and other sufficiently stable analytes used to assess average daily quality, load and removal efficiency, representative composite sampling should normally be used together with the required grab measurements.

Composite sampling should be treated as a core requirement for routine STP performance assessment, subject to parameter-specific method, preservation and holding-time requirements. Influent and corresponding effluent composites should cover comparable operating periods and account for hydraulic retention time; flow-proportional composites are preferred where flow varies materially. The responsible organisation should publish an analyte-by-analyte matrix specifying whether a grab, time-proportional composite or flow-proportional composite is required. A composite must not be used where mixing aliquots can cause volatilisation, reaction, biological transformation, adsorption or analyte loss. The report should present composite results alongside relevant grab and online readings so that average performance and short-term process excursions are both visible.

**Reference basis** BIS-S3 IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples; BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-N US EPA NPDES Compliance

Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance

### **5 Use time proportional and flow proportional composites deliberately**

A time-proportional composite gives equal weight to each sampling interval and is acceptable only when flow is reasonably stable. A flow-proportional composite, formed by sampling at fixed volume increments or varying aliquot volume with flow, better represents average concentration and daily load where diurnal or wet-weather flow varies materially.

Routine assessment of STP efficiency should be based on representative 24-hour sampling and testing rather than one sample collected once a day. Wastewater flow and pollutant concentration vary with domestic activity, industrial discharge, pumping cycles, rainfall and internal return streams; a single daily grab can coincide with a peak or low period and can materially overstate or understate the true daily influent load, effluent quality and removal efficiency. A 24-hour composite captures this diurnal variation and provides a defensible daily average for BOD, COD, TSS, nutrients and other stable parameters.

Automatic samplers should collect aliquots throughout the full 24-hour cycle and record aliquot time, associated flow signal, missed samples, bottle temperature, preservation, total composite volume and any interruption. Flow-proportional compositing should be preferred where flow varies materially; time-proportional sampling may be used only where flow is sufficiently stable or where the result is subsequently interpreted with the flow record. The corresponding influent and effluent sampling windows should account for effective hydraulic retention time so that removal calculations compare, as nearly as practicable, the same wastewater mass.

Twenty-four-hour composite sampling does not eliminate grab sampling. Grab measurements remain necessary for unstable parameters such as pH, temperature, dissolved oxygen, residual chlorine, sulphide and volatile compounds, and for investigating alarms, shock loads and short-duration process failures. The daily report should therefore combine the 24-hour composite result, the required grab measurements and the OLMS trend. Where operational constraints permit only one grab sample, the report must identify it as a spot result and must not present it as representative of the plant's daily efficiency without corroborating flow, online and historical data.

**Reference basis** BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EPA-R US EPA 40 CFR Parts 122 and 123, permit monitoring, records and reporting framework; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **6 Synchronise inlet and outlet sampling with hydraulic retention time**

Simultaneous inlet and outlet samples usually represent different wastewater parcels. Comparing them can produce false removal efficiencies when influent quality varies. The treatment organisation should determine the theoretical plant HRT from operating volume and actual flow, and periodically verify effective HRT or short-circuiting through tracer testing or hydraulic assessment where performance is disputed.

For a 24-hour influent composite, the corresponding downstream composite should normally be offset by the best estimate of effective travel time. For multi-stage diagnosis, the sampling window should be offset at each major unit. Reports should state the HRT basis, flow condition and uncertainty, particularly during monsoon or bypass conditions.

**Reference basis** BIS-S1 IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques; BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-L EN ISO 5667 series and EN ISO IEC 17025 as the European sampling and laboratory competence framework

## **7 Monitor each major unit process**

Monitoring only the inlet and final outlet identifies overall performance but not the failing unit. Permanent sampling provisions should be created after screening and grit removal, primary clarification where installed, biological reactors, secondary clarification or membrane separation,

tertiary filtration, disinfection and final discharge. Return liquors, recycle streams, bypasses and sludge lines should be included when they materially affect load.

Each unit should have a defined diagnostic question and a short parameter set. Unit-wise concentration and mass removal should be calculated only when hydraulically corresponding samples and validated flows are available.

**Reference basis** BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **8 Provide permanent safe and labelled sampling locations**

A technically correct programme fails if operators cannot obtain samples safely and consistently. The treatment organisation should provide platforms, guardrails, lighting, wash points, electrical supply for samplers where needed, sample taps of suitable material and clear labels linked to drawings and the laboratory information system.

A change in pipework, recycle routing or process configuration should trigger revalidation of the sampling point. Confined-space entry should not be required for routine sampling. The sampling-point register should identify hazards and required personal protective equipment.

**Reference basis** BIS-S1 IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques; BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance

## **9 Retain conventional parameters but improve their interpretation**

Flow, pH, temperature, BOD, COD, TSS, volatile suspended solids where relevant, conductivity and alkalinity remain the core indicators of municipal STP loading and performance. Results should be

reported with method, sample type, reporting limit, units and QA status. BOD and COD should be interpreted together to identify changes in biodegradability; TSS and volatile solids help distinguish solids loss from soluble organic breakthrough.

The applicable IS 3025 part or another method authorised by the regulator should be used. A result obtained by a rapid surrogate or online sensor should not be reported as the statutory method result unless the regulatory framework expressly permits it and equivalence has been demonstrated.

**Reference basis** BIS-A IS 3025 series, Methods of Sampling and Test Physical and Chemical for Water and Wastewater; use the current applicable part and amendment for each parameter; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; CPCB-D Environment Protection Rules 1986 Schedule VI and the applicable SPCB, PCC or other regulator consent and discharge or reuse conditions; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **10 Measure nitrogen and phosphorus species**

Ammonia, TKN or total nitrogen, nitrite, nitrate, orthophosphate and total phosphorus should be monitored according to process configuration and discharge or reuse requirements. Ammonia removal is a sensitive measure of nitrifier health; nitrite accumulation can indicate incomplete nitrification, toxicity or inadequate aeration; nitrate profiles support assessment of denitrification; phosphorus fractions help distinguish biological uptake from chemical precipitation.

Samples should be collected at locations that allow a nitrogen and phosphorus balance across anoxic, aerobic and clarification stages. Alkalinity consumption and recovery should be assessed with nitrogen transformation because inadequate alkalinity can limit nitrification.

**Reference basis** BIS-A IS 3025 series, Methods of Sampling and Test Physical and Chemical for Water and Wastewater; use the current applicable part and amendment for each parameter; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal,



micropollutants, energy and greenhouse-gas requirements; EU-W Directive 2000 60 EC Water Framework Directive

## **11 Monitor biological process health**

Activated-sludge control requires DO profiles, MLSS, MLVSS, SVI, settleability, microscopic observations where useful, RAS and WAS rates, sludge age or SRT, HRT, F to M ratio, pH, temperature and alkalinity. MBR plants also require transmembrane pressure, permeability, flux, backwash and chemical-cleaning records.

The responsible organisation should define technology-specific operating envelopes rather than one universal target. Results should be trended against effluent ammonia, TSS, BOD and energy consumption so that corrective action addresses the actual limiting condition rather than increasing aeration or wasting sludge by default.

**Reference basis** CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **12 Assess primary secondary tertiary and disinfection performance**

Primary treatment should be assessed through solids, settleable matter, organic fractions and sludge removal. Biological treatment should be assessed through soluble and particulate organic matter, nutrient conversion and biomass condition. Clarifiers or membranes should be assessed separately from biological conversion. Tertiary filters should be evaluated for headloss, solids breakthrough and backwash performance.

Disinfection assessment should combine dose or UV intensity, contact conditions, residual where applicable, turbidity or UV transmittance and microbiological results. A satisfactory final coliform result does not prove that disinfection is consistently controlled if contact time or UV performance is not recorded.

Reference basis CPCB-M CPCB Guide Manual Water and Wastewater Analysis; CPCB-D Environment Protection Rules 1986 Schedule VI and the applicable SPCB, PCC or other regulator consent and discharge or reuse conditions; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

### **13 Monitor sludge quality and solids inventory**

Sludge monitoring should cover production, concentration, volatile solids, dewaterability, moisture content, stabilisation, return liquors and final disposal or beneficial use. A plant mass balance should reconcile influent solids, effluent solids, biological conversion and sludge withdrawal. Unexplained solids loss often reveals inaccurate flow measurement, unrecorded wasting or clarifier carryover.

Where sludge is reused or land applied, pathogen, metal and other applicable quality requirements must be separately assessed under Indian authorisations. US EPA Part 503 is a useful comparative framework for biosolids, but it is not an Indian legal standard and should not replace applicable Indian rules or consent conditions.

**Reference basis** BIS-A IS 3025 series, Methods of Sampling and Test Physical and Chemical for Water and Wastewater; use the current applicable part and amendment for each parameter; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-B US EPA 40 CFR Part 503 and approved methods guidance for sewage sludge and biosolids; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

### **14 Measure oil grease surfactants and dissolved salts**

Oil and grease, anionic surfactants, conductivity, TDS, chloride and sulphate help identify commercial or industrial inputs that can impair oxygen transfer, biological activity, membranes and reuse suitability. These parameters should be added at influent and selected upstream sewer or drain locations where catchment risk justifies them.

Oil and grease sampling requires a dedicated container and method-specific handling; transferring the sample between containers can bias the result. Conductivity and TDS trends should be interpreted with flow to distinguish true saline loading from concentration during low-flow periods.

**Reference basis** BIS-A IS 3025 series, Methods of Sampling and Test Physical and Chemical for Water and Wastewater; use the current applicable part and amendment for each parameter; BIS-S3 IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EU-I Directive 2010 75 EU on industrial emissions and source-control principles

### **15 Establish a risk based metals and industrial toxicant programme**

Metals, cyanide, phenols, sulphide, solvents and other toxicants should be selected from the industrial and commercial profile of each sewer catchment. The first step is a baseline survey using methods with reporting limits below the relevant action level; routine monitoring can then focus on parameters and locations that present actual risk.

Total and dissolved metals must be distinguished where the decision requires it, with filtration performed at the prescribed stage before preservation. An exceedance should trigger confirmation, upstream step sampling, industrial-source review and examination of biological inhibition rather than relying on dilution at the STP.

**Reference basis** BIS-A IS 3025 series, Methods of Sampling and Test Physical and Chemical for Water and Wastewater; use the current applicable part and amendment for each parameter; BIS-S3 IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EU-E Directive 2008 105 EC as amended by Directive 2013 39 EU on environmental quality standards and priority substances; EU-I Directive 2010 75 EU on industrial emissions and source-control principles

## 16 Screen pharmaceuticals PFAS and other emerging contaminants on a risk basis

Emerging-contaminant monitoring should begin as a periodic diagnostic and source-characterisation programme, not as an unsupported claim of routine compliance. Target selection should consider hospitals, pharmaceutical activity, reuse objectives, receiving-water sensitivity and available validated methods. Samples require stringent blank control, suitable containers, low-contamination equipment and laboratories capable of trace analysis.

The EU recast directive establishes a policy direction toward quaternary treatment and micropollutant monitoring. EPA methods and research methods may support method selection, but only promulgated or regulator-approved methods should be used for enforceable decisions. The responsible laboratory or organisation should retain samples and metadata sufficient to evaluate future watch-list substances.

**Reference basis** BIS-S3 IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples; BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements; EU-E Directive 2008 105 EC as amended by Directive 2013 39 EU on environmental quality standards and priority substances

## 17 Include microbiology pathogens and antimicrobial resistance

Faecal indicators such as E coli or faecal coliforms should be measured at the final effluent and at intermediate points needed to evaluate disinfection. For high-risk reuse or public-health investigations, targeted pathogens may be added. Antibiotic-resistant bacteria and resistance genes can be included in periodic research or surveillance programmes, particularly where hospital discharges enter the catchment.

Microbiological samples require sterile containers, controlled temperature and short holding times. Molecular ARG results are not equivalent to viable pathogen counts and should be interpreted with

method controls and stated limitations. These measurements should inform risk management, not be treated as direct substitutes for statutory microbial indicators.

**Reference basis** BIS-S3 IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

### **18 Control sample containers preservation holding times and transport**

The monitoring plan should specify, for every analyte, container material, minimum volume, filtration requirement, preservative, temperature, maximum holding time and any special light or headspace condition. Field staff should receive pre-labelled bottle sets prepared by the laboratory, reducing the risk of incorrect preservation.

Compliance with preservation and holding time must be recorded from collection through analysis. A result from a nonconforming sample should be qualified or rejected under a documented rule; it should not silently enter the compliance database.

#### **Importance and significance of controlled transport**

Sampling does not end when a bottle is filled. Transport is part of the analytical process because temperature change, excessive delay, sunlight, contamination, volatilisation, adsorption, biological activity, oxidation-reduction reactions, settling and unnecessary agitation can alter the sample before it reaches the laboratory. Controlled transport preserves the condition of the sample as closely as practicable, improves the validity and comparability of results, and provides a defensible basis for compliance assessment, treatment-process diagnosis, pollutant-load estimation and enforcement action.

#### **Dedicated sampling vans**

Laboratories and treatment organisations carrying out regular field monitoring should deploy purpose-built sampling vans. Each van should include a validated temperature-controlled sample-storage compartment maintained at a target temperature of 4 degrees C, normally 4 plus or minus 2

degrees C unless the applicable analytical method specifies another condition. Temperature should be continuously recorded with a calibrated data logger. Samples should not be frozen unless the method expressly requires freezing. Bottles should be transported upright in secured, shock-absorbing racks or insulated carriers that minimise vibration, sudden movement, breakage, leakage, mixing and avoidable disturbance of settled or stratified material. Driving practices and route planning should minimise delay and mechanical shocks.

The van should carry programmable automatic samplers suitable for time-proportional and flow-proportional composite sampling, together with clean sampling lines, intake strainers, flow-interface connections, rechargeable power supply and refrigerated collection capability where required. Automatic samplers should be cleaned, blank-checked, programmed and verified under an approved SOP, and their settings, aliquot times, missed samples, power interruptions and deviations should be retained as part of the sampling record.

#### **Parameter-specific bottles and preservation**

The vehicle should carry adequate stocks of laboratory-issued, pre-cleaned and pre-labelled containers for the full analytical programme. These should include, as applicable, glass and plastic bottles, amber bottles, sterile microbiological containers, volatile-organic-compound vials without headspace, and pre-preserved containers for nutrients, metals and other analytes. Bottle material, volume, preservative and headspace should follow the approved method. Chemical preservatives and clean bottles should be segregated from collected sewage samples; all filled containers should have leak-proof closures, secondary containment and tamper-evident identification. Clean and contaminated equipment should be stored in physically separated zones.

#### **On-site testing GPS and LIMS connectivity**

The sampling van should support immediate field measurement of unstable parameters such as temperature, pH, dissolved oxygen, electrical conductivity, oxidation-reduction potential, turbidity and residual disinfectant, as relevant to the sampling objective. Field instruments should be calibrated or verified before use and protected against cross-contamination. A GPS-enabled device should record the sampling location, date, time and route. Barcode or QR-code identification should connect each bottle, field reading, photograph, automatic-sampler programme and chain-of-custody record to the LIMS in real time or through secure synchronisation after connectivity is restored.



### Operational safety and acceptance controls

The van should also carry calibrated thermometers, timers, sample seals, labels, field forms, personal protective equipment, first-aid and spill-response materials, hand-hygiene and decontamination supplies, fire protection, suitable lighting, ventilation and safe electrical power. The sampling SOP should define dispatch checks, cleaning and decontamination, route and holding-time control, custody transfer, receipt temperature, bottle condition, acceptance or rejection criteria and action when refrigeration, automatic sampling, GPS or LIMS functions fail. These controls ensure that improved transport facilities strengthen, rather than merely document, sample integrity.

**Reference basis** BIS-S3 IS 17614 Part 3 2021, identical to ISO 5667-3, preservation and handling of water samples; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance

### 19 Maintain chain of custody and traceability

Every sample should carry a unique identifier linked to plant, location, date and time, sampler, sample type, composite period, preservation, requested tests and field observations. Custody transfers, receipt condition, temperature, seal status and deviations should be recorded. Electronic records may be used if they preserve identity, access control and audit history.

Traceability should extend from field reading and sampler programme through raw instrument data, calculations, review, report approval and later correction. The original result must remain recoverable after any amendment.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-L EN ISO 5667 series and EN ISO IEC 17025 as the European sampling and laboratory competence framework



## 20 Apply field and laboratory quality control

The quality-control plan should include equipment blanks, trip blanks where relevant, field duplicates, laboratory blanks, duplicates, matrix spikes, laboratory control samples, calibration checks and control charts at frequencies appropriate to the method and risk. Acceptance criteria and action on failure must be defined before results are reviewed.

Quality-control results should accompany or be traceably linked to the reported data. A numerical result is not defensible merely because an instrument produced it; the batch must meet method and laboratory acceptance criteria.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance

## 21 Use blanks duplicates spikes and reference materials correctly

Each control answers a different question. Blanks identify contamination; duplicates assess precision; matrix spikes assess recovery in the wastewater matrix; and certified reference materials or independent control standards assess accuracy and traceability. One control cannot substitute for all the others.

The responsible organisation should define parameter-specific control frequencies, warning limits and rejection limits. Repeated matrix interference should lead to dilution, cleanup, standard addition or another validated corrective approach permitted by the method, with the qualification reported.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations

## 22 Estimate measurement uncertainty and adopt decision rules

Laboratories should identify significant uncertainty contributions from sampling, preservation, preparation, calibration, recovery, precision and calculation. The analytical laboratory should estimate measurement uncertainty for quantitative tests within its accredited quality system; The responsible organisation should separately recognise that field sampling can add substantial uncertainty.

A written decision rule is needed for results near a limit. The report should state whether uncertainty is considered in the conformity decision and should avoid implying greater precision than the method supports. The applicable regulator's decision rule remains controlling for statutory compliance.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EU-L EN ISO 5667 series and EN ISO IEC 17025 as the European sampling and laboratory competence framework

## 23 Specify laboratory water and reagent quality

Water used for blanks, standards, dilutions, BOD work, microbiology, metals and trace-organic analysis should be fit for its intended purpose. One generic label such as distilled water is insufficient. Suitability should be demonstrated through conductivity or resistivity, TOC where relevant, microbiological quality and method blanks.

Reagents and standards should have defined grade, traceability, lot number, preparation record, storage condition and expiry. Blank trends should be reviewed to detect deterioration of laboratory water or reagent contamination before it affects reported samples.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations

## 24 Control calibration and metrological traceability

Balances, volumetric equipment, thermometers, incubators, pH and DO meters, spectrophotometers, flow instruments and online analysers should be calibrated or verified on risk-based schedules.

Calibration ranges must bracket expected sample concentrations; continuing verification should demonstrate that calibration remained valid during the batch.

Each test result and its supporting measurement sequence should be retained in the native electronic data log of the analytical instrument wherever the technology permits. The record should include the sample identifier, parameter, date and time, analyst or user identification, method or programme, calibration status, blank and quality-control readings, replicate values, dilution or factor applied, raw response, calculated result, units, alarms, edits and audit-trail information. The instrument-generated record should be treated as the primary raw-data record and should not be overwritten by a manually entered final value.

The laboratory should implement a documented reconciliation plan for matching the signed laboratory report with instrument data logs. Each reported result should be traceable through a common sample and test identifier to the corresponding raw file or log entry. The LIMS should automatically import results where a validated interface is available; until then, an authorised reviewer should compare the report with the instrument record and document the verification. The plan should define the frequency and scope of reconciliation, treatment of rounding and dilution factors, review of altered or repeated results, investigation of mismatches, backup and retention periods, access control and approval of corrections. Material discrepancies should block release of the report or trigger withdrawal, correction and notification through the audit trail.

Future procurement of laboratory instruments should mandatorily specify adequate onboard memory for the expected test volume and retention period, non-volatile storage, date-and-time stamping, unique user access, protected audit trails, export of raw and processed data to a computer in an open or documented format, and secure integration with LIMS. Instruments should retain data during power interruption and prevent deletion or alteration without an attributable authorised event. Procurement evaluation should verify usable memory capacity, connectivity, software licences, interface compatibility, cybersecurity, backup, vendor support and availability of data throughout the instrument's service life rather than accept a generic statement that data logging is available.



Traceability should be established through competent calibration providers and certified or otherwise appropriate reference standards. Out-of-tolerance equipment should trigger an impact assessment on results issued since the last acceptable check.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times and quality control; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; CPCB-O CPCB Guidelines for Online Continuous Effluent Monitoring Systems and applicable directions or consent conditions

## 25 Validate flow and report pollutant loads

Concentration alone can mislead because dilution lowers mg per litre without reducing the mass discharged. The responsible organisation should report daily flow and calculate kg per day for BOD, COD, TSS, nitrogen, phosphorus and selected toxicants. Flow-proportional samples and validated flow data should be used where possible.

Flow meters should be checked for installation condition, zero, range, obstruction, calibration, data gaps and agreement with independent hydraulic or volumetric checks. Load calculations should show the flow period, concentration period and treatment of missing data.

**Reference basis** BIS-S10 IS 17614 Part 10 2021, identical to ISO 5667-10, guidance on sampling of waste waters; CPCB-O CPCB Guidelines for Online Continuous Effluent Monitoring Systems and applicable directions or consent conditions; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EPA-R US EPA 40 CFR Parts 122 and 123, permit monitoring, records and reporting framework; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## 26 Prepare water pollutant and solids mass balances

The laboratory should calculate and report plant-wide and unit-wise mass balances over defined and comparable periods. A mass balance converts concentration into load by combining validated analytical results with verified flow data, normally expressed as kg/day, and reconciles the pollutant

entering the STP with the quantities leaving in final effluent, removed in sludge, returned through recycle streams, discharged through bypasses or overflows, and accumulated within the process. At minimum, routine balances should cover flow, BOD or COD, TSS and key nitrogen species; phosphorus and other parameters should be added where relevant to the plant objective and available data.

Mass balance is important because concentration alone can be misleading. A lower effluent concentration may result from dilution rather than treatment, while a compliant outlet can conceal poor unit performance, solids accumulation, unmeasured return loads or loss of pollutants through an unrecorded stream. Mass balance calculation verifies whether reported removals are physically plausible, identifies sampling or flow-meter errors, quantifies actual unit loading and sludge production, and supports decisions on aeration, recycling, wasting, chemical dosing and capacity augmentation. It is also a strong quality-control check on the consistency of laboratory and operational data.

The laboratory in-charge should sign the balance sheet and provide a closure statement showing inputs, outputs, inventory change, calculated removal, unexplained residual and data-quality limitations. The responsible organisation should establish practical acceptance bands for balance closure according to parameter, plant configuration and data quality rather than expect perfect agreement. A material unexplained residual should trigger checks of sampling representativeness, 24-hour composite coverage, flow-meter accuracy and synchronization, sludge concentration and wasting volumes, internal recycles, bypasses, leakage and calculation units. The balance should not be accepted merely because the final effluent meets a limit; unresolved non-closure should remain open as a corrective-action item in the LIMS.

For performance reporting, removal efficiency should be calculated primarily on a load basis:  $\text{Removal efficiency (\%)} = [(\text{influent load} - \text{effluent load}) / \text{influent load}] \times 100$ , using comparable 24-hour flow and concentration data and, where necessary, an HRT-adjusted sampling window. Unit-process and solids balances should use the same principle while explicitly accounting for recycle and return streams. All assumptions, substituted values and excluded periods must be recorded so that the calculation can be reproduced and audited.

**Reference basis** BIS-S1 IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **27 Integrate online monitoring with laboratory verification**

Online monitoring systems (OLMS) for pH, dissolved oxygen, conductivity, turbidity, ammonia, nitrate, residual chlorine, UV intensity and other parameters provide high-frequency trends, alarms and immediate process-control information. Their principal strength is continuity: they can reveal diurnal variation, transient shock loads and gradual deterioration that periodic laboratory sampling may miss. However, reliable use requires representative installation, automatic cleaning where necessary, calibration and verification schedules, preventive maintenance, data-validation rules and alarms linked to defined operational responses.

Laboratory analysis remains indispensable and should take precedence for confirmation, compliance and detailed diagnosis where the prescribed approved method applies. OLMS readings may be affected by fouling, drift, cross-sensitivity, bubbles, temperature, sample conditioning, loss of reagents, calibration failure or an unrepresentative installation point. Accredited or quality-controlled laboratory methods can measure a wider range of parameters, provide method-specific quality control and confirm whether an apparent online excursion is real. OLMS should therefore supplement, not displace, laboratory analysis: every critical sensor should be checked against field or laboratory reference measurements at a defined frequency and whenever an alarm, drift or maintenance event occurs. Differences must be investigated and documented; data gaps, invalid values, maintenance periods and corrections must remain visible in the audit trail.

**Reference basis** CPCB-O CPCB Guidelines for Online Continuous Effluent Monitoring Systems and applicable directions or consent conditions; BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EPA-136 US EPA 40 CFR Part 136, approved wastewater analytical methods, preservation, holding times

and quality control; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **28 Use trend analysis and early warning limits**

Control charts and rolling trends can identify deterioration before a consent limit is exceeded. The responsible organisation should trend influent loads, unit removal, ammonia conversion, sludge settleability, membrane permeability, disinfectant control, energy use and QA failures. Warning and action limits should be based on plant history, design capacity, season and regulatory thresholds.

An alert should lead to a documented response and closure record. Statistical alarms must be reviewed with process context such as rainfall, maintenance, power failure or industrial discharge to avoid treating every outlier as an analytical error.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-O CPCB Guidelines for Online Continuous Effluent Monitoring Systems and applicable directions or consent conditions; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

## **29 Link water quality to energy and chemical efficiency**

Performance should be expressed not only as kWh per ML treated but also, where data permit, as kWh per kg of BOD, COD or nitrogen removed. Chemical use should be reported per ML and per unit pollutant removed. This prevents apparent efficiency gains caused by diluted influent or reduced treatment.

Energy optimisation must remain subordinate to effluent quality and process stability. Aeration, pumping, sludge handling, ozone or UV and chemical dosing should be evaluated separately so that a change can be linked to an operating cause. The EU recast directive provides a useful benchmark for energy-audit and neutrality planning.

**Reference basis** EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements;

EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance

### **30 Investigate shock loads and trace them upstream**

Rapid changes in ammonia, conductivity, COD fraction, colour, metals, cyanide, phenols, sulphide, oil and grease, oxygen uptake or biological activity should trigger a predefined incident protocol.

Immediate actions include confirmation, preservation of evidence, intensified inlet sampling, protection of the biological process and notification under applicable consent conditions.

Upstream tracing should use the sewer network, time of arrival, flow, conductivity or other tracers, industrial inventories and stepwise sampling. Enforcement samples must follow an appropriate chain of custody and regulator-approved methods. Source control is generally more effective than attempting to treat an unidentified toxic discharge at a municipal STP.

Reference basis CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-D Environment Protection Rules 1986 Schedule VI and the applicable SPCB, PCC or other regulator consent and discharge or reuse conditions; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EPA-R US EPA 40 CFR Parts 122 and 123, permit monitoring, records and reporting framework; EU-I Directive 2010 75 EU on industrial emissions and source-control principles

### **31 Implement LIMS dashboards and corrective action records**

A laboratory information management system (LIMS) should serve as the controlled data backbone connecting approved sampling plans, chain of custody, sample receipt, analytical methods, instrument output, raw data, quality-control results, validated results, flow records, plant-operation data, OLMS and SCADA time series, alerts, reports and corrective actions. Integration should use unique identifiers for the plant, sampling point, sample, instrument and parameter; synchronized timestamps; controlled units and method codes; and secure interfaces that prevent manual transcription errors. The LIMS should automatically align composite-sampling periods with corresponding flow and online data, calculate loads and unit-wise removal efficiencies, flag missing or implausible values, and retain the full provenance of every result.

Electronic burettes should be procured for titrimetric analyses so that delivered volume, endpoint or reading sequence, date and time, analyst, sample identifier, method, standardisation factor and calculation inputs are retained electronically and can be transferred to the laboratory computer and integrated with LIMS. Selection should favour e-burettes with sufficient non-volatile memory, user identification, calibration and verification records, protected data export and interfaces that avoid manual transcription. Where direct LIMS connectivity is not immediately available, the exported file should be securely imported or attached to the relevant test record with checksum or other integrity control and reviewer approval.

The instrument-to-LIMS architecture should preserve both the immutable raw record and the authorised reported result. The LIMS must show the source instrument, import time, software or interface version, transformations and calculations applied, reviewer approval and any subsequent amendment. Automated comparison rules should flag a missing raw record, duplicate result, result outside the calibrated range, failed quality-control check, unauthorised manual entry or mismatch between the laboratory report and the instrument data log. These controls should form part of method validation, internal audit and procurement acceptance testing.

LIMS dashboards should display laboratory and OLMS data on a common timeline while clearly distinguishing provisional sensor readings, quality-flagged values and authorised laboratory results. Configurable rules should identify exceedances, abnormal rates of change, disagreement between OLMS and laboratory measurements, instrument drift, missed sampling, failed quality-control checks and declining unit performance. Each alert should open a corrective-action record showing the observation, probable cause, confirmatory tests, required operational action, responsible officer, target date and evidence of closure. Role-based access, audit trails, backups, version control, cybersecurity controls and controlled master data are essential; corrections must preserve the original entry, reason, approver and date, and automated calculations and interfaces must be independently verified before use and after material change.

**Reference basis** BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EPA-R US EPA 40 CFR Parts 122 and 123, permit monitoring, records and reporting framework; CPCB-O CPCB Guidelines for Online Continuous Effluent Monitoring Systems and

applicable directions or consent conditions; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

### **32 Adopt a tiered programme manual pilot and multidisciplinary governance**

The responsible organisation should use three monitoring tiers. Tier I supports daily process control; Tier II provides representative compliance and performance assessment; Tier III provides periodic comprehensive diagnosis, including industrial toxicants and emerging contaminants. Frequencies should reflect plant risk, technology, receiving water, reuse and performance history.

An organisation-wide Water and Wastewater Sampling, Analytical Quality Assurance and Treatment Process Diagnostic Manual should define the programme. It should be piloted at representative plants of different sizes and technologies, independently reviewed, and then revised before system-wide adoption. Governance should include process engineers, operators, analytical chemists, microbiologists, instrumentation and metrology specialists, laboratory QA personnel, IT staff and catchment enforcement teams.

**Reference basis** BIS-S1 IS 17614 Part 1 2021, identical to ISO 5667-1, guidance on design of sampling programmes and sampling techniques; BIS-L IS/ISO/IEC 17025 2017, competence of testing and calibration laboratories; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-Q US EPA quality-system guidance for Quality Assurance Project Plans and environmental data operations; EPA-N US EPA NPDES Compliance Inspection Manual 2017, especially Chapters 4 to 7 on STP review, sampling, flow measurement and laboratory quality assurance; EU-U Directive EU 2024 3019 concerning urban wastewater treatment recast, including monitoring, nutrient removal, micropollutants, energy and greenhouse-gas requirements

### **33 Institute daily technical and quality-control review and escalation**

Designated technical and quality-control reviewers should review each STP laboratory report through the controlled LIMS workflow at a frequency appropriate to plant risk, with daily review for routine operational control wherever required. The review must cover sampling completeness and reliability, influent and effluent loads, unit-wise removal, sludge and operational parameters, mass-balance

closure, online trends, instrument quality-control status and comparison with recent plant history. A report is not complete merely because values have been entered or a limit has not been exceeded.

Signed observations should be forwarded to the plant in-charge and designated senior technical and administrative authorities through the approved reporting hierarchy. The note should classify the plant as satisfactory, watch, action required or critical; state present performance and efficiency; identify probable causes and confirmatory work; and highlight any risk to compliance, process stability, reuse, public health or the receiving environment. Repeated or critical observations must remain visible until formally closed.

Reference basis BIS-L IS/ISO/IEC 17025 2017; CPCB-M CPCB Guide Manual Water and Wastewater Analysis; EPA-N US EPA NPDES Compliance Inspection Manual 2017; EPA-Q US EPA quality-system guidance; CPCB-O CPCB Guidelines for Online Continuous Effluent Monitoring Systems

### **34 Require performance interpretation forecasting and corrective action**

Each reviewed report should contain an engineering interpretation of current STP performance, not only a recital of analytical values. It should calculate concentration- and load-based removal, compare actual performance with design and recent operating envelopes, identify the unit causing the limitation, and explain whether poor performance is likely due to loading, hydraulics, biomass condition, solids separation, chemical dosing, disinfection, equipment failure or data-quality weakness.

The observation should include a reasoned short-term outlook expressed as stable, improving, deteriorating or at risk. The forecast should use the direction and rate of change in influent load, ammonia conversion, BOD or COD removal, TSS, sludge settleability, solids inventory, DO, alkalinity, equipment availability, chemical stock, power interruptions, rainfall and industrial shock loads. The basis, uncertainty and escalation triggers must be stated so that the outlook is a documented technical assessment rather than an unsupported prediction.

Every adverse finding should generate a corrective-action record stating the action, responsible role, priority, completion time, confirmatory testing and closure criterion. The plant in-charge should record action taken or reasons for deviation; designated technical and quality-control reviewers

should verify the response; and the designated senior authority should monitor unresolved or recurring issues until follow-up data confirm improvement.

### **35 Preserve instrument data logs and reconcile every reported result**

Every analytical result should be traceable to the original instrument record. The native data log should retain sample and test identifiers, date and time, analyst, method, calibration state, blanks and quality controls, replicates, dilutions, raw response, calculated result, units, alarms, edits and audit trail. The laboratory report should not overwrite or substitute the raw record.

A controlled reconciliation plan should match each released laboratory result with the corresponding instrument file or log entry. Direct validated transfer to LIMS is preferred; otherwise, an authorised reviewer should document the comparison. Missing raw data, results outside the calibrated range, failed quality control, unexplained repetition, unauthorised manual entry or mismatch should block report release or trigger controlled correction and notification. Retention, backup, access control and restoration testing should be defined in the SOP.

### **36 Procure high memory connected instruments and electronic burettes**

All future analytical-instrument procurements should specify adequate non-volatile onboard memory, date-and-time stamping, unique user access, protected audit trails, export of raw and processed data in a documented format, computer connectivity and secure LIMS integration. Tender evaluation and acceptance testing should verify usable memory capacity at the expected workload, data retention during power failure, prevention of unattributed deletion or alteration, interface compatibility, software licences, cybersecurity, backup, vendor support and long-term data accessibility.

Electronic burettes should be mandatory for titrimetric methods where practicable. They should retain delivered volume, reading or endpoint sequence, sample identifier, analyst, date and time, method, standardisation factor, calibration or verification status and calculation inputs. Data should transfer directly to the laboratory computer or LIMS; where an interface is temporarily unavailable, the exported file should be securely attached to the test record with integrity verification and reviewer approval.

### **37 Establish reverse sewer monitoring to identify contaminant sources**

When abnormal ammonia, COD, conductivity, colour, oil and grease, sulphide, metals, cyanide, phenols, solvents, surfactants, toxicity, temperature or pH is detected at an STP inlet, The responsible organisation should activate a reverse sewer monitoring protocol. Investigation should begin at the STP inlet and move progressively upstream through trunk sewers, major interceptors, pumping stations, branch sewers, sub-drains and suspected industrial or institutional connections. At each branching point, samples and flow observations should be used to eliminate clean branches and concentrate the investigation on the contaminant pathway.

The monitoring design should combine time of arrival, sewer travel time, flow direction and pumping cycles with field screening and confirmatory laboratory analysis. Conductivity, pH, temperature, ammonia, oxidation-reduction potential, colour, fluorescence or other suitable tracers can support rapid screening; enforcement conclusions must rely on regulator-approved sampling, preservation, analysis and chain of custody. Automatic samplers may be deployed at strategic nodes to capture intermittent night-time or batch discharges that a daytime grab would miss. GIS sewer maps, catchment boundaries, industrial inventories, discharge permissions and historical complaints should be linked in LIMS or the incident platform.

Reverse monitoring is significant because protecting the biological process at source is usually faster, cheaper and more reliable than attempting to treat an unidentified toxic or high-strength discharge after it reaches the STP. It can prevent nitrifier inhibition, biomass collapse, foaming, odour, corrosion, unsafe working conditions, sludge contamination, membrane fouling and non-compliant effluent. It also provides defensible evidence for source control, cost recovery and enforcement, and creates a catchment risk map for preventive inspection and targeted monitoring.

Each incident report should identify the trigger, sampling route and times, hydraulic assumptions, field and laboratory results, suspected source, evidence strength, immediate plant-protection measures, notifications, enforcement handover and closure criteria. Where the source is not confirmed, uncertainty and the next monitoring step must be recorded rather than assigning responsibility without evidence.

Reference basis BIS-S1 and BIS-S10 IS 17614 sampling guidance; CPCB-S CPCB Sampling Protocol for Water Wastewater and Soil; CPCB-D applicable Environment Protection Rules and applicable SPCB, PCC or other regulator consent conditions; EPA-N US EPA NPDES Compliance Inspection Manual; EU-I industrial-emissions and source-control principles

### **38 Issue detailed SOPs for sampling analysis validation and reporting**

The responsible organisation should issue controlled, plant-applicable standard operating procedures covering the complete data chain. The sampling SOP should define objectives, locations and point codes; grab, time-proportional and flow-proportional composite selection; 24-hour sampling; HRT synchronization; automatic-sampler setup; bottle and preservative; field measurements; sample homogenisation and subsampling; holding time; transport; safety; chain of custody; field quality control; deviations; and actions for missed aliquots, power failure, rainfall, bypasses or abnormal events.

The analytical SOP for each parameter should state scope, principle, approved method, interferences, apparatus and instrument settings, reagent preparation and standardisation, calibration model and acceptance, blanks, duplicates, spikes and reference materials, detection and reporting limits, calculation, dilution, rounding, measurement uncertainty, quality-control acceptance, corrective action, raw-data retention, instrument-log reconciliation and result authorisation. Technology-specific operational tests and sludge tests should have separate SOPs with defined sampling locations and frequencies.

The reporting SOP should define report format, sample and result status, compliance and design comparisons, load and removal calculations, mass-balance closure, laboratory in-charge interpretation, daily review by designated technical and quality-control reviewers, performance forecast, action classification, escalation route, correction or withdrawal, LIMS workflow, response and closure. Every SOP should carry a unique number, revision, effective date, author, technical reviewer and approver; staff training and competency should be documented; obsolete versions should be withdrawn; and scheduled review should incorporate method, regulation, plant and instrument changes.

Reference basis BIS-L IS/ISO/IEC 17025 2017; BIS-S1, BIS-S3 and BIS-S10 IS 17614; BIS-A applicable IS 3025 parts; CPCB-M and CPCB-S; EPA-136 approved methods and quality control; EPA-Q quality-system guidance

### 39 Adopt a comprehensive inlet outlet and unit wise parameter programme

The parameter programme should distinguish compliance, performance assessment, process control, diagnostic investigation and reuse assurance. The matrix below is a technical minimum for programme design, not a universal legal frequency: the final plant-specific schedule must reflect treatment technology, capacity, consent conditions, influent risk, receiving water or reuse, seasonal variation and the current regulator-approved method. Stable load and removal parameters should normally use synchronized 24-hour composites; unstable parameters require grab or continuous measurement; and microbiological samples require aseptic collection and method-specific handling.

| Class    | Parameter group                                                            | Minimum locations and sample basis                                                                        | Main purpose                                                                 |
|----------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Physical | Flow and cumulative volume                                                 | Inlet and outlet continuously; major bypasses and internal returns                                        | Hydraulic loading, load calculation, mass balance and bypass detection       |
| Physical | Temperature, colour, odour, turbidity, conductivity and visible floatables | Inlet and outlet; selected unit outlets; grab or online as appropriate                                    | Shock-load warning, solids or colour breakthrough, sensor and reuse control  |
| Physical | Total suspended solids, settleable solids and volatile suspended solids    | Inlet and outlet by 24-hour composite; primary outlet, biological liquor and clarifier or membrane outlet | Solids removal, biomass inventory, clarifier carryover and mass balance      |
| Chemical | pH, alkalinity and acidity                                                 | Inlet, biological stages and outlet; grab or online                                                       | Biological suitability, nitrification capacity, corrosion and dosing control |

| Class    | Parameter group                                                                                           | Minimum locations and sample basis                                                                 | Main purpose                                                                      |
|----------|-----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Chemical | BOD5, COD and soluble COD or filtered COD                                                                 | Inlet and outlet by synchronized 24-hour composite; primary and biological outlets for diagnostics | Organic load, biodegradability, unit removal and load-based efficiency            |
| Chemical | TOC where justified                                                                                       | Inlet, outlet and advanced-treatment outlet                                                        | Rapid organic trend, reuse and advanced-treatment control                         |
| Chemical | Ammonia, TKN or total nitrogen, nitrite and nitrate                                                       | Inlet and outlet composite; anoxic and aerobic profiles; internal recycle                          | Nitrification, denitrification, nitrogen balance and toxicity diagnosis           |
| Chemical | Orthophosphate and total phosphorus                                                                       | Inlet and outlet composite; biological and chemical-treatment stages                               | Biological uptake, precipitation, nutrient balance and reuse or discharge control |
| Chemical | Chloride, sulphate, sulphide, TDS and salinity                                                            | Inlet and outlet; upstream sewer nodes during incidents                                            | Industrial intrusion, corrosion, odour, toxicity and reuse suitability            |
| Chemical | Oil and grease, surfactants and phenolic compounds                                                        | Inlet and outlet; pretreatment or DAF outlet; risk-based upstream locations                        | Foaming, oxygen-transfer inhibition, toxicity and source tracing                  |
| Chemical | Residual chlorine or disinfectant dose, UV transmittance or intensity and ozone residual where applicable | Disinfection inlet and outlet; online plus verified grab                                           | Dose, contact and disinfection-process verification                               |

| Class           | Parameter group                                                              | Minimum locations and sample basis                                           | Main purpose                                                       |
|-----------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Microbiological | E. coli, faecal coliform or regulator-specified indicator organisms          | Final outlet and reuse point; influent or unit points for validation studies | Disinfection efficacy, reuse safety and receiving-water protection |
| Microbiological | Total coliform, enterococci, bacteriophages or pathogens where risk requires | Outlet, reuse and targeted validation or outbreak investigation              | Broader pathogen control and treatment validation                  |
| Microbiological | Helminth eggs and protozoan indicators where reuse risk requires             | Final effluent and reclaimed-water point                                     | Agricultural or public-contact reuse protection                    |
| Emerging risk   | Antimicrobial-resistant bacteria and resistance genes                        | Periodic influent, biological stage, final effluent and sludge risk studies  | Assessment of HWW or high-risk catchments and treatment barriers   |

### Unit wise operational and sludge monitoring matrix

| Unit             | Parameters and records                                                                                                                                                         | Diagnostic significance                                                    |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Inlet works      | Flow, pH, temperature, conductivity, DO or ORP where useful, TSS, settleable solids, BOD, COD, ammonia, TKN or TN, phosphorus, oil and grease, sulphide and toxicity screening | Define load and variability; detect septage, industrial or shock discharge |
| Screens and grit | Screenings mass and moisture, grit volume and volatile content where needed, headloss and bypass records                                                                       | Assess preliminary-treatment performance and abnormal solids entry         |

| Unit                     | Parameters and records                                                                                                                                                       | Diagnostic significance                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Equalisation or pumping  | Level, flow, pH, conductivity, DO or ORP, mixing condition, pump starts and detention                                                                                        | Verify buffering, prevent septic conditions and explain load timing          |
| Primary clarifier or DAF | Influent and effluent TSS, settleable solids, BOD, COD, oil and grease; sludge blanket, sludge withdrawal and scum                                                           | Calculate primary removal and control solids carryover                       |
| Anoxic or anaerobic zone | DO, ORP, nitrate, nitrite, ammonia, alkalinity, orthophosphate, MLSS and mixing                                                                                              | Verify denitrification, biological phosphorus release and internal recycle   |
| Aeration basin           | DO profile, pH, temperature, alkalinity, MLSS, MLVSS, SVI, settleability, microscopy, OUR or SOUR, ammonia, nitrite, nitrate, soluble COD, SRT, F to M and air or energy use | Assess biomass health, nitrification, oxygen transfer and operating envelope |
| Secondary clarifier      | Influent and effluent TSS, turbidity, sludge blanket, solids loading, surface overflow, RAS and WAS flow and concentration                                                   | Distinguish biological conversion from separation failure                    |
| SBR                      | Cycle flow, fill, react and settle times, DO or ORP profiles, decant quality, MLSS, SVI, ammonia and nitrate by cycle stage                                                  | Verify cycle control and identify incomplete reaction or poor settling       |
| MBBR or IFAS             | DO, pH, alkalinity, ammonia, nitrate, carrier fill and movement, biofilm condition, media loss and screen headloss                                                           | Verify attached-growth activity and media retention                          |
| MBR                      | MLSS, DO, ammonia, nitrate, TMP, permeability, flux, recovery, aeration scour, backwash, integrity and cleaning records                                                      | Control fouling and verify membrane barrier performance                      |
| Tertiary filtration      | Influent and effluent turbidity and TSS, headloss, filtration rate, run time, backwash frequency and backwash-water quality                                                  | Detect breakthrough and optimise filter operation                            |

| Unit                             | Parameters and records                                                                                                                                          | Diagnostic significance                                      |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| Disinfection                     | Influent turbidity, disinfectant dose and residual or UV intensity and transmittance, flow, contact time and indicator organisms                                | Confirm dose-contact-response and microbiological outcome    |
| Sludge thickening and dewatering | Feed and cake solids, volatile solids, moisture, polymer dose, capture efficiency, filtrate or centrate TSS, COD, ammonia and phosphorus, CST or dewaterability | Control sludge processing and quantify return load           |
| Digestion                        | pH, temperature, TS and VS, VFA, alkalinity and ratio, gas quantity and methane where applicable, VS reduction and inhibition indicators                        | Verify stability, conversion, energy recovery and upset risk |
| Final sludge or biosolids        | Moisture, TS and VS, nutrients, metals, pathogens and other authorised end-use or disposal parameters                                                           | Demonstrate suitability for reuse, co-processing or disposal |

Risk-based additional parameters should include metals and metalloids, cyanide, fluoride, priority organic pollutants, pesticides, solvents, PFAS, pharmaceuticals, hormones, radiological parameters or specific industrial markers where the catchment inventory, incident history, hospital discharge, reuse objective or regulator requires them. These parameters should not be placed on an indiscriminate daily schedule; the SOP should define screening triggers, detection limits, confirmation, source tracing and escalation.

Frequency should be tiered. Continuous or high-frequency monitoring is appropriate for flow and selected process-control parameters; daily 24-hour composites should support routine load and efficiency assessment where practicable; daily or shift-wise operational tests should control biological and solids processes; microbiology should follow discharge or reuse requirements; and metals, toxics, emerging contaminants and detailed sludge characterisation should follow risk-based periodic or incident schedules. The laboratory, operations, the designated technical and quality-control reviewers should jointly approve a plant-specific parameter-method-frequency-location matrix and control it through LIMS.

Reference basis BIS-A IS 3025 series; BIS-S1, BIS-S3 and BIS-S10 IS 17614; BIS-L IS/ISO/IEC 17025; CPCB-M, CPCB-S, CPCB-D and CPCB-O; EPA-136 and EPA-N; applicable SPCB, PCC or other regulator consent and reuse conditions; EU-U and EU-L comparative frameworks

### Implementation sequence

| Period          | Principal actions                                                                                                                                                 |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| First 60 days   | Constitute the technical group; approve objectives and governance; inventory sampling points, flow meters, online analysers, methods and accreditation scope.     |
| Months 3 to 5   | Issue interim sampling and chain-of-custody instructions; validate priority flow and sampling points; select pilot STPs and baseline catchment risks.             |
| Months 6 to 9   | Run HRT-synchronised campaigns, unit-process profiles, QA audits and mass balances; configure the LIMS and corrective-action register.                            |
| Months 10 to 12 | Review pilot evidence; finalise the organisation-wide manual, parameter-frequency matrix, uncertainty and decision rules, training plan and phased capital works. |

### Primary online reference links

- [CPCB Sampling Protocol](#)
- [US EPA Approved CWA Methods](#)
- [US EPA NPDES Inspection Manual](#)
- [US EPA 40 CFR Part 136](#)
- [EU Directive 2024 3019](#)
- [EU Water Framework Directive](#)
- [EU Environmental Quality Standards Directive](#)
- [ISO 5667 10 catalogue](#)