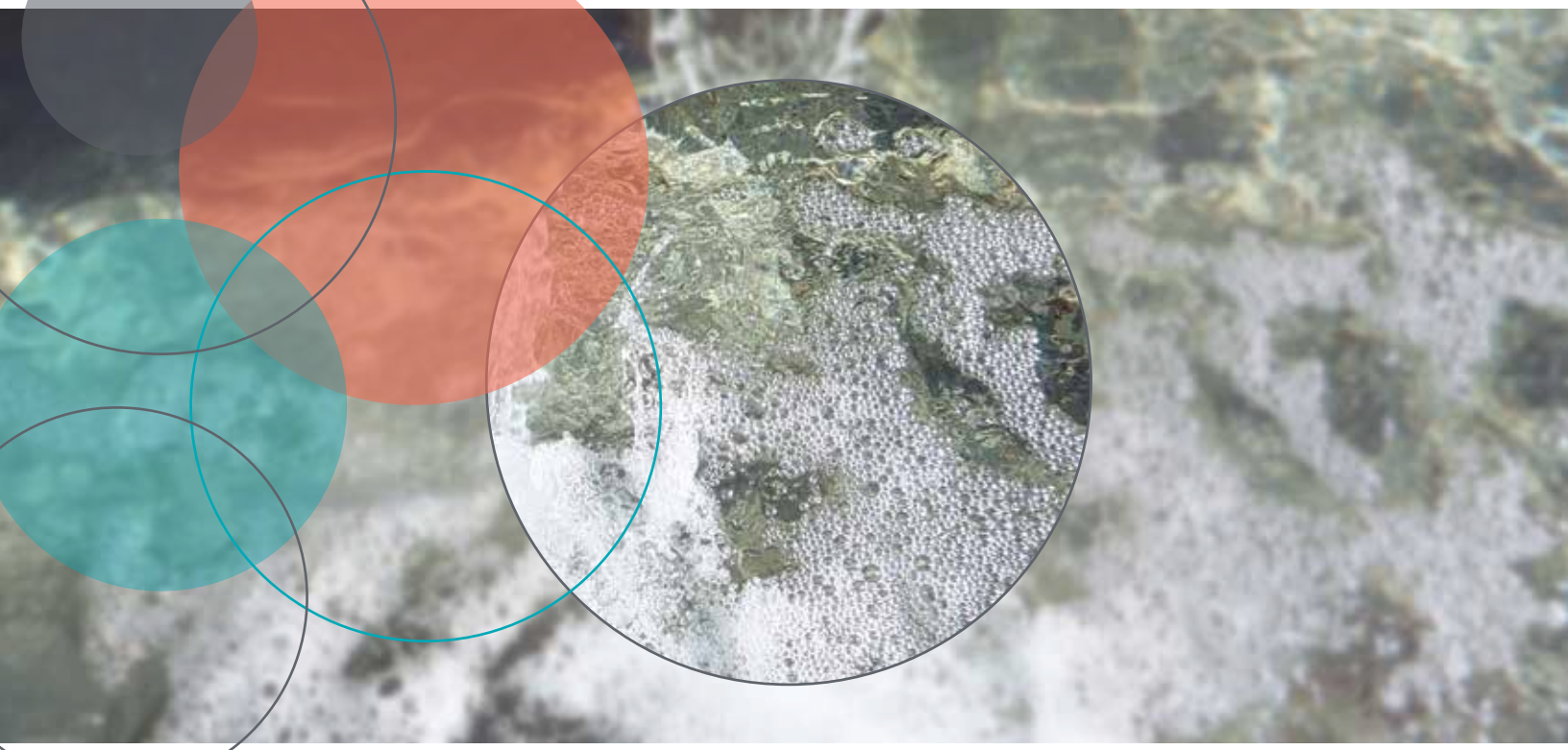

Nutrient Management Terminology Reference Guide

MARCH 2019

The purpose of this document is to offer definitions and clarification on commonly used nutrient management terms to practitioners working in wastewater treatment, nutrient removal, and nutrient recovery areas. An additional goal is to help move toward standardization of terminology. This document is not intended to cover similar terms used by water quality modeling practitioners.

THE Water Research FOUNDATION

ACKNOWLEDGMENTS

WRF thanks members of the Nutrient Removal Challenge team for their contributions to the research and to this guide.

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Figure 2 - Measured or Calculated Forms of Nitrogen

Filtration	Total N (TN)	Total Soluble N (TSN)	Total Particulate N (TpN)	
Ammonia	Total Ammonia N (TAN)	Total Ammonia N (TAN)	None	-
Nitrite	Nitrite (NO_2)	Nitrite (NO_2)	None	-
Nitrate	Nitrate (NO_3)	Nitrate (NO_3)	None	-
Oxidized N	Oxidized N (NOx)	Oxidized N (NOx)	None	-
Inorganic N	Total Inorganic N (TIN)	Total Inorganic N (TIN)	None	-
Total Kjeldahl Nitrogen	Total Kjeldahl N (TKN)	Soluble Total Kjeldahl N (STKN)	pTKN	TKN - pTKN
Organic N	Total Organic N (TON)	Soluble Organic N (SON)	Particulate Organic N (pON)	TON - SON

Oxidized N (NO_X) = NO_2 + NO_3
Total Inorganic N (TIN) = TAN + NO_2 + NO_3
Total Organic N (TON) = Total N (TN) - TAN - NO_2 - NO_3

Calculated Value
Measured Value

Figure 3 - Phosphorus Species in Wastewater Treatment

<table>
<tr><th colspan="4">Total P (TP)</th></tr>
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Figure 4 - Measured or Calculated Forms of Phosphorus

Filtration	Total P (TP)	Total Soluble P (TSP)	Total Particulate P (TpP)	
Reactive	Total Reactive P (TRP)	Soluble Reactive P (SRP)	Particulate Reactive P (pRP)	TRP - SRP
Acid Hydrolyzable	Total Acid-Hydrolyzable P (TAHP)	Soluble Acid-Hydrolyzable P (SAHP)	Particulate Acid-Hydrolyzable P (pAHP)	TAHP - SAHP
Organic	Total Organic P (TOP)	Soluble Organic P (SOP)	Particulate Organic P (pOP)	TOP - SOP

Total Organic P (TOP) = Total P (TP) - TRP - TAHP

Calculated Value

Measured Value

STAGES OF NUTRIENT REMOVAL

Three stages of nutrient removal are proposed. The Nutrient Removal Challenge focused on conventional nutrient removal and tertiary nutrient removal as defined below.

Conventional Nutrient Removal (CNR) – Nutrient removal achieved by conventional treatment processes. Biological nutrient removal (commonly referred to as BNR) achieved by modifying the aeration basin configuration for nitrogen and/or phosphorus removal without external carbon addition. Chemical addition to a primary clarifier or secondary process for phosphorus removal are examples of CNR processes.

Tertiary Nutrient Removal (TNR) – Nutrient removal with a combination of modified secondary and tertiary treatment processes. These processes include enhanced particle removal (using processes such as granular, media, or microfiltration) and chemical addition (such as carbon for denitrification or metal salts for phosphorus removal). TNR typically requires more than one anoxic zone for enhanced denitrification, either in the secondary treatment process or in a combined denitrification and tertiary filtration process.

Advanced Nutrient Removal (ANR) – Nutrient removal using advanced treatment processes. These processes are designed to eliminate specific molecules or ions and may generate a brine reject stream such as reverse osmosis concentrate.

A comparison of the three nutrient removal treatment stages, the processes that can be used, and expected performance from CNR, TNR, and ANR are shown in Table 1.

Table 1 - Nutrient Removal Treatment Processes and Performance

	CNR	TNR	ANR
		Processes	
Primary Treatment	Optional chemical addition for P removal	Optional chemical addition for P removal	Optional chemical addition for P removal
Secondary Treatment	BNR with suspended growth, biofilm, hybrid. Chemical addition generally not required	Multistage BNR Chemical addition generally required	Multistage BNR Chemical addition generally required
Tertiary Treatment	No	Filtration Chemical addition	Filtration Chemical addition
Advanced Treatment	No	No	Molecular separation, advanced oxidation, biofiltration
Other Features	No	Carbon supplement such as fermentation or chemical Side stream management	Carbon supplement such as fermentation or chemical Side stream management Brine disposal
		Performance Range	
Ammonia, mg N/L	2 - 5	0.5-2	<0.1
TN, mg N/L	8 - 15	3 – 8	<0.2
TP, mg P/L	0.5 - 2	0.03 – 0.1	<0.01

CNR = Conventional Nutrient Removal; TNR = Tertiary Nutrient Removal; ANR = Advanced Nutrient Removal

Note: Listed performance is based on best judgment for a typical range of effluent. Performance is highly dependent on site-specific conditions (temperature, weather, influent composition, influent strength, industrial contributions, and solids management practices.

NUTRIENT TERMS

Acid-Hydrolyzable Phosphorus (AHP)

This is the analytical method-based name for condensed phosphates, which are complex inorganic phosphate compounds. Acid hydrolysis is used to convert all dissolved and particulate condensed phosphates to dissolved orthophosphate so that they can be measured. Care must be used during the hydrolysis step to avoid releasing phosphate from organic compounds. Therefore, acid-hydrolyzable phosphorus (AHP) refers to the same P species as condensed phosphates; AHP is the preferred term.

Aerobic Ammonia-Oxidizing Bacteria (AerAOB)

Autotrophic bacteria capable of catabolic oxidation of ammonia to nitrite (nitritation) for energy production. Common AerAOBs in wastewater treatment are in the genus *Nitrosomonas* and *Nitrospira*.

Aerobic Process

An aqueous environment where dissolved oxygen is present. Conventional activated sludge treatment uses an aerobic process to support the growth of microorganisms that remove pollutants from wastewater. An aerobic environment is also needed to support the growth of nitrifying bacteria that convert ammonia to nitrite/nitrate in the nitritation/nitratation (or nitrification) processes.

Ammonia (NH_3)

The unionized form of the total ammonical nitrogen (TAN). Term is synonymous with free ammonia (FA) and unionized ammonia. This is often referred to as free ammonia as it can be stripped from the liquid to the gas phase by aeration or other gas/liquid mass transfer methods. At higher pH, more of the TAN is shifted to free ammonia versus ammonium ion. Ammonia exists in equilibrium in the liquid with ammonia in the gas phase according to Henry's Law and can be removed by stripping it from wastewater at elevated pH. Free ammonia is toxic to fish and other aquatic organisms.

Ammonia-Nitrogen

The term that is commonly used to describe the total ammonical nitrogen (TAN) in water, and includes the free ammonia (FA) and ammonium ions. It is often expressed as ammonia-N or NH_3-N.

Ammonia-Oxidizing Archaea (AOA)

Autotrophic archaea capable of catabolic oxidation of ammonia to nitrite (nitritation) for energy production. The nitritation ability of an archaea was first reported in 2005 followed by later reports on the presence of AOA in activated sludge. Compared to AOBs, the AOAs are slower growers but have a much higher affinity for ammonia and dissolved oxygen (DO) at very low concentrations, which suggests they can compete with AOBs at very low DO and/or low ammonia concentrations.

Ammonia-Oxidizing Bacteria (AOB)

Autotrophic bacteria capable of catabolic oxidation of ammonia. Two bacteria are commonly used in wastewater treatment: aerobic ammonia-oxidizing bacteria (AerAOBs) that convert ammonia to nitrite using oxygen and anaerobic ammonia-oxidizing bacteria (AnAOBs or anammox) that convert ammonia to nitrogen gas using nitrite.

Ammonia-Oxidizing Organisms (AOO)

Organisms capable of catabolic oxidation of ammonia to nitrite via nitritation; includes bacteria and archaea.

Ammonification

Term used to describe the conversion of organic nitrogen (such as proteins) to ammonia.

Ammonium (NH_4^+) Ion

The ionized and dominant ammonia species in wastewater under normal pH conditions. At pH 7.5 and lower, more than 99% of the total ammonical nitrogen (TAN) is present as ammonium ion.

Anaerobic Ammonia-Oxidizing Bacteria (AnAOB)

Autotrophic bacteria capable of catabolic oxidation of ammonia with nitrite to nitrogen gas. These bacteria are also called anammox bacteria. The term AnAOB is preferred.

Anaerobic Process

The classic definition of anaerobic by microbiologists is a condition for the growth of living organisms in the absence of oxygen. In mainstream wastewater treatment, the term has been expanded to include the absence of nitrate/nitrite as well as oxygen. The condition of having nitrate/nitrite present without oxygen is commonly referred to as anoxic. However, anaerobic had been used to describe the condition of the anammox process in which nitrite but no oxygen is present, with the primary purpose being ammonia removal without the use of oxygen. Enhanced biological phosphorus removal requires an anaerobic environment where phosphorous accumulating organisms (PAOs) convert acetate and propionate into polyhydroxyalkanoates (PHAs) storage products for later use under anoxic or aerobic conditions. Anaerobic processes are also used to stabilize waste sludge.

Anammox

This term is an abbreviation derived from "ANaerobic AMMonia OXidation," which is the process of biological oxidation of ammonia using nitrite as electron acceptor under anaerobic conditions by a specialized group of bacteria. In the anammox reaction, ammonium ions (NH_4^+) are oxidized to nitrogen gas and nitrite (NO_2) is reduced to nitrogen gas without the need for heterotrophic bacteria and without carbon addition. The bacteria that mediate this transformation are known as anammox bacteria and the conversion process commonly referenced to as the "Anammox Process." ANAMMOX is also the trade name for the process developed by the Delft Technical University of Technology. See also related terms for "anammox bacteria" and "deammonification."

Anammox Bacteria

Autotrophic bacteria that derive energy from the anammox reaction of ammonia oxidation by nitrite under anaerobic conditions. The bacteria discovery and identification, first reported in 1999, placed them under the order *Planctomycetales* in the phylogenetic tree for bacteria. The anammox bacteria found in wastewater treatment applications are species within *Candidatus "Kuenenia"* and *Candidatus "Brocadia"*. Anammox bacteria enrichments develop a deep red color and they can form dense granular flocs. The term anaerobic ammonia oxidizing bacteria (AnAOB) is preferred as a more generic term for anammox bacteria.

Anoxic Process

A term used in wastewater treatment to define a reactor condition in which no dissolved oxygen exists, but nitrate and/or nitrite are present to support biological activity. Biological denitrification occurs under anoxic conditions by heterotrophic bacteria when an organic electron donor source is available. Biological denitrification can also be carried out by autotrophic bacteria using hydrogen, reduced sulfur and reduced iron as electron donors.

Anthropogenic

Something that results from or is caused by human activities; the impact of human beings on nature. Anthropogenic water quality degradation can be traced back to point sources such as wastewater treatment plant discharges and non-point sources such as urban stormwater run-off and agricultural land run-off.

Archaea

Archaea and bacteria are prokaryotes that fall under distinct domains in the phylogenetic tree. Besides differences in 16S rRNA, other differences between the two types of prokaryotes are found in their cell wall, cell membrane, and ribosome composition. Archaea are also known for being able to tolerate extreme pH, dissolved solids, and temperature conditions.

Autotrophic Organisms

Organisms that use carbon dioxide as a source of carbon for cell synthesis. Nitrifying bacteria and algae are two examples of autotrophic organisms.

Bioavailable

In regards to nutrient management, this term refers to nutrients that are available to be used by bacteria, algae, and other organisms for growth. Also refer to related definitions for refractory and biodegradable.

Biochemical Oxidation

The decomposition of organic materials by microorganisms under aerobic conditions.

Biochemical Oxygen Demand (BOD)
An indirect measure of the amount of biodegradable organic pollution present in a water sample. The BOD test measures the quantity of oxygen used for the biochemical oxidation of organic matter over a specific period of time under specific conditions. The standard BOD_5 test measures the total oxygen used over five days at 20°C.

Biodegradable
In regard to nutrient management, this term refers to organic compounds and nutrients that are broken down and used by bacteria during biological treatment.

Catabolic Reaction
The metabolic breakdown of complex molecules into simpler ones, usually as energy yield reactions.

Chemical Oxygen Demand (COD)
A quantitative measure of the amount of oxygen required for chemical oxidation of carbonaceous (organic) material in wastewater using inorganic dichromate or permanganate salts as oxidants in a two-hour test.

Condensed Phosphates
One of the types of compounds measured as acid-hydrolyzable phosphorus (AHP).

Deammonification
Deammonification is the process that includes partial nitritation (carried out by AerAOB and AnAOB) that occurs in a single reactor or in two reactors in series.

Denitratation
The biological reduction of nitrate to nitrite, typically as the first step for denitrification. This reduction requires an electron acceptor such as organic compounds, reduced sulfur, and hydrogen.

Denitrification
Commonly used biological process to reduce nitrate to nitrogen gas. The biological reduction of nitrate to nitrogen gas occurs in a several steps: first the reduction of nitrate to nitrite, followed by a step-wise reduction of nitrite to nitric oxide, to nitrous oxide, and finally to nitrogen gas. This reduction requires an electron acceptor, such as organic compounds, reduced sulfur, and hydrogen. Denitrification is also referred to as denitratation-denitritation; denitrification is the preferred term.

Denitritation
The biological reduction of nitrite to nitrogen gas, typically as the second step for denitrification. This reduction requires an electron acceptor such as organic compounds, reduced sulfur, and hydrogen.

Dissolved Acid-Hydrolyzable Phosphorus (DAHP)

A synonym for soluble acid-hydrolyzable phosphorus (SAHP) or filterable acid-hydrolyzable phosphorus. See the definition for SAHP, which is the preferred term.

Dissolved Inorganic Phosphorus (DIP)

A synonym for soluble inorganic phosphorus (SIP). See the definition for SIP, which is the preferred term.

Dissolved Non-Reactive Phosphorus (DNRP)

A synonym for soluble non-reactive phosphorus (SNRP). See the definition for SNRP, which is the preferred term.

Dissolved Organic Nitrogen (DON)

A synonym for soluble organic nitrogen (SON). See the definition for SON, which is the preferred term.

Dissolved Organic Phosphorus (DOP)

A synonym for soluble organic phosphorus (SOP). See the definition for SOP, which is the preferred term.

Dissolved Reactive Phosphorus (DRP)

A synonym for soluble reactive phosphorus (SRP). See the definition for SRP, which is the preferred term.

Dissolved Total Phosphorus (DTP)

The total phosphorus measured in the filtrate of a sample. The total phosphorus analytical method involves a digestion step for the conversion of phosphorus to orthophosphorus. This is also referred to as total dissolved phosphorus (TDP) or total soluble phosphorus (TSP). TSP is the preferred term.

Filterable

Adjective used to describe compounds or species that will pass through a filter of a particular pore size. This definition follows ASTM D5907 - 18 "Standard Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water." It should be noted that some amount of colloidal solids will be present in the filtered sample. Synonyms such as "dissolved" or "soluble" also used. Soluble [soluble] is the preferred term. Used to characterize nutrient fractionations. Filter pore size of 0.45 um is commonly used but should be specified when presenting corresponding analytical results.

Filterable Acid-Hydrolyzable Phosphorus

Same as the dissolved acid-hydrolyzable phosphorus (DAHP) or the soluble acid-hydrolyzable phosphorus (SAHP). See definition for SAHP, which is the preferred term.

Filterable Non-Reactive Phosphorus

Same as the dissolved non-reactive phosphorus (DNRP) or the soluble non-reactive phosphorus (SNRP). See definition for SNRP, which is the preferred term.

Filterable Organic Phosphorus

Same as the dissolved organic phosphorus (DOP) or the soluble organic phosphorus (SOP). See definition for SOP, which is the preferred term.

Filterable Reactive Phosphorus

Same as the dissolved reactive phosphorus (DRP) or the soluble reactive phosphorus (SRP). See definition for SRP, which is the preferred term.

Free Ammonia (FA)

Free ammonia refers to unionized ammonia species and is synonymous with the term ammonia. The total ammonia nitrogen (as measured) includes free ammonia (unionized ammonia) and ammonium ions (NH_4+).

Free Nitrous Acid (FNA)

Nitrous acid (HNO_2) is produced as the hydrogenated weak acid form of nitrite. The concentration of nitrous acid increases with lower pH and higher nitrite concentrations. At a pH of 6.5 and nitrite-N concentration of about 200 mg/L, for example, enough free nitrous acid may be formed to inhibit NOBs.

Humic Substances

Relatively high molecular weight, polydisperse organic molecules derived from the microbial degradation of vegetation and complex organic substrates in wastewater. While many properties of humic substances are site specific, they tend to be enriched in aromatic and carboxylic functionalities and are more recalcitrant to microbial biodegradation compared to other organic substrates (e.g., carbohydrates, proteins, carboxylic acids) in wastewater systems.

Hydroxyapatite

A mineral made up of calcium, phosphate, and hydroxyl groups. Formation of this crystalline mineral, which is very similar to the material that makes up bone and teeth, provides a viable pathway to recover these minerals from wastewater for recycling as a fertilizer product.

Inert Dissolved Organic Nitrogen (IDON)

Term used to indicate soluble organic nitrogen (SON) that is highly stable and not decomposed with long-term exposure by bacteria or algae and thus is considered unavailable for algal growth. It is different than refractory DON (rDON) in that it is completely inert.

Kjeldahl Nitrogen

The sum of ammonical nitrogen plus organic nitrogen compounds that are converted to $(NH_4)_2SO_4$ during digestion as described in EPA Method #351.1. It includes ammonia-N (free ammonia plus ammonium ions) and soluble organic nitrogen and particulate organic nitrogen species. Also known as total Kjeldahl nitrogen (TKN).

Labile

Adjective used in relation to receiving water quality modeling to describe a substance, such as organic matter, that is readily transformed (hours to weeks) by physical, chemical, photo-chemical or biological processes to release its constituents, including nitrogen and phosphorus compounds. Also refer to the definition for the related term refractory.

Limit of Technology (LOT)

Loosely defined term used to describe the minimal effluent concentration of constituents under best achievable performance for a particular full-scale biological nutrient removal and tertiary treatment technology. Also refer to technology performance statistic (TPS).

Mixed Liquor Fermentation

A fermenter located within a BNR process where a portion of the mixed liquor suspended solids (MLSS) is retained under anaerobic conditions, often with addition of a carbon source and unmixed or partially mixed conditions, to generate VFA and support growth of phosphorous accumulating organisms (PAOs).

Nitratation

Biological oxidation of nitrite to nitrate using oxygen as the electron acceptor: $NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$. Organisms mediating this reaction are known as nitrite-oxidizing bacteria (NOB).

Nitrate (NO_3)

An oxygenated form of nitrogen with a nitrogen valence of +5.

Nitrification

The two-step biological conversion of ammonia to nitrate consisting of ammonia oxidation to nitrite (nitritation) followed by nitrite oxidation to nitrate (nitratation). Nitrogen removal by biological nitrification/denitrification cannot occur without first converting ammonia to nitrate by nitrification. This process can also be described as nitritation-nitratation. Since nitrification is the commonly accepted term for ammonia oxidation to nitrate, the term nitrification is preferred.

Nitrification-Denitrification

A process for biological nitrogen removal in which ammonia is oxidized to nitrate by biological nitrification followed by nitrate reduction to nitrogen gas by biological denitrification. A carbon source is required for denitrification.

Nitritation

Biological oxidation of ammonia to nitrite using oxygen as the electron acceptor: $NH_4^+ + 1.5\ O_2 \rightarrow NO_2^- + H_2O + 2H^+$. Organisms mediating this reaction are known as ammonia-oxidizing bacteria (AOB) and ammonia-oxidizing archaea (AOA), which collectively may be referred to as ammonia-oxidizing organisms (AOO).

Nitritation-Denitritation

A process to achieve biological nitrogen removal where biological oxidation of ammonia is only to nitrite, followed by biological reduction of nitrite to nitrogen gas. Nitritation-denitritation is a more accurate description of the biological processes to remove nitrogen without oxidation to nitrate. The term nitrite shunt is the preferred term for the process relying on the nitritation-denitritation sequence. Also refer to the related term shortcut nitrogen removal.

Nitritation-Nitratation

Sequential biological oxidation of ammonia to nitrite (nitritation) and biological oxidation of nitrite to nitrate (nitratation). This conversion is commonly referred to as nitrification. The term nitrification is the preferred term for the complete biological oxidation of ammonia to nitrate.

Nitrite (NO_2)

A less oxygenated form of nitrogen compared to nitrate, with a nitrogen valence of +3.

Nitrite-Oxidizing Bacteria (NOB)

Autotrophic bacteria capable of catabolic oxidation of nitrite to nitrate (nitratation) for energy production. Common NOBs in wastewater treatment are in the genus *Nitrobacter* and *Nitrospira*.

Nitrite Shunt

A process to achieve biological nitrogen removal where biological oxidation of ammonia is only to nitrite, followed by biological reduction of nitrite to nitrogen gas. The term nitrite shunt is typically applied for low DO or intermittently aerated activated sludge or fixed film reactors, where nitrite oxidation is minimized. Nitrite shunt is one of the shortcut nitrogen removal processes. Nitrite shunt is also called nitritation-denitritation; the term nitrite shunt is preferred when referring to nitrogen removal relying on the nitritation-denitritation sequence.

Nitrogen (N)

An essential macronutrient that is present in domestic wastewater as ammonia, nitrite, nitrate and organic nitrogen. The units for the concentration of each form of nitrogen and total nitrogen (sum of all of the forms) are expressed as milligrams per liter elemental nitrogen. Refer to the nitrogen species table.

Non-Filterable

Adjective used to describe compounds or species that will not pass through a filter of a particular pore size. This definition follows ASTM D5907 - 18 "Standard Test Methods for Filterable Matter (Total Dissolved Solids) and Nonfilterable Matter (Total Suspended Solids) in Water."
The synonym particulate is commonly used and is the preferred term. However, it should be noted that some amount of colloidal solids will be present in the filtered sample. Used to characterize nutrient fractionation. Filter pore size of 0.45 um is commonly used but should be specified when presenting corresponding analytical results.

Non-Filterable Phosphorus

Same as the particulate total phosphorus (pTP) or the phosphorus species that is retained/excluded when passing the sample through a 0.45 µm filter. Some colloidal particles will be lost in the filtration process and be measured instead as part of the dissolved fraction. See the definition for pTP, which is the preferred term.

Non-Reactive Phosphorus (NRP)

Defined as the difference between the total phosphorus (TP) and the reactive phosphorus (RP). The chemical species that make up NRP are not clearly defined. They may include polyphosphates, condensed phosphates and soluble organic phosphorus species. Removal processes for NRP are complex and not fully understood. The NRP accounts for a large fraction of the effluent P concentration following tertiary treatment designed to achieve a total P concentration of less than 0.10 mg/L.

Organic Compound

A combustible and sometimes biodegradable chemical compound containing carbon atoms bonded together with other elements. The principal groups of organic substances found in wastewater are proteins, carbohydrates, and fats and oils. Larger complex organics (which include humic substances) resist biological oxidation and persist in the environment.

Organic Nitrogen (ON)

Nitrogen contained in organic (carbon-based) compounds such as amino acids, peptides, humic substances and protein; may be in soluble form or contained within particulate material. This is also referred to as total organic nitrogen (TON) when it includes both soluble and particulate fractions.

Organic Phosphorus (OP)

Phosphate molecules associated with organic (carbon-based) substances such as amino acids, peptides, humic substances and protein; may be in soluble form or contained within particulate material. This is also referred to as total organic phosphorus (TOP). Organic phosphorus is not directly available to plants to be used as a nutrient.

Orthophosphate (OrthoP)

The orthophosphates include PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$, and H_3PO_4, which are readily available for consumption by bacteria, algae and plants as an essential nutrient for biomass growth. Orthophosphate is measured by colorimetric method. It is more accurately referred to as reactive phosphorus (RP) based on the test method.

Oxidized Nitrogen (NOx)

The sum of nitrite-N and nitrate-N concentrations.

Particulate

A descriptor used for the concentration of an inorganic or organic parameter of interest that will be retained by a 0.45 µm filter. It is synonymous with non-filterable. The term particulate is preferred over non-filterable.

Particulate Acid-Hydrolyzable Phosphorus (pAHP)

Acid-hydrolyzable phosphorus contained within the wastewater suspended and colloidal solids or biomass. The amount of pAHP in a sample can be calculated by subtracting the soluble acid-hydrolyzable phosphorus (SAHP) from the total acid-hydrolyzable phosphorus (TAHP). Acid hydrolyzable phosphorus compounds include condensed phosphates, polyphosphates, and polyphosphorus contained in bacteria storage granules.

Particulate Non-Reactive Phosphorus (pNRP)

Non-reactive phosphorus contained in particulate material captured on a 0. 45 µm filter following sample filtration. The pNRP is calculated by taking the difference between the total particulate phosphorus (TpP) and the soluble non-reactive phosphorus (SNRP).

Particulate Organic Nitrogen (pON)

Organic nitrogen contained within wastewater solids or biomass. The amount of pON can be calculated by subtracting the soluble organic nitrogen (SON) from the total organic nitrogen (TON). pON is the dominant particulate form of nitrogen in wastewater. Effluent pON is primarily associated with the biomass or total suspended solids (TSS) present in the effluent.

Particulate Organic Phosphorus (pOP)

Organic phosphorus contained within the wastewater solids or biomass. The amount of pOP in a sample can be calculated by subtracting the soluble organic phosphorus (SOP) from the total organic phosphorus (TOP).

Particulate Phosphorus (pP)

Same as particulate total phosphorus (pTP). See definition for pTP, which is the preferred term.

Particulate Reactive Phosphorus (pRP)

Reactive phosphorus contained in particulate material captured on a 0. 45 µm filter following sample filtration. The amount of pRP in a sample is calculated by subtracting the soluble reactive phosphorus (SRP) from the total reactive phosphorus (TRP). The SRP will include some colloidal particles containing RP that have passed through the filter.

Particulate Total Kjeldahl Nitrogen (pTKN)

The fraction of the total Kjeldahl nitrogen (TKN) that is contained in particulate material captured on a 0. 45 µm filter following sample filtration. The amount of pTKN in a sample is calculated by subtracting the soluble total Kjeldahl nitrogen (STKN) from the total Kjeldahl nitrogen (TKN). The pTKN calculated in this manner may not include some colloidal particles containing Kjeldahl nitrogen that have passed through the filter.

Particulate Total Phosphorus (pTP)

Also referred to as total particulate phosphorus (TpP); see definition for TpP, which is the preferred term.

Phosphorus (P)

An essential macronutrient that can be present in domestic wastewater as orthophosphate, pyrophosphate, tripolyphosphate and organic phosphate. The units for the concentration of each form of phosphorus and for total phosphorus (sum of all of the forms) are expressed as mg/L elemental phosphorus. Refer to the phosphorus species table.

RAS Fermentation

See Return Activated Sludge (RAS) Fermentation

Reactive Phosphorus (RP)

This is the portion of total phosphorus or dissolved phosphorus that is measured with a direct colorimetric test (no hydrolysis or digestion). The test commonly used for wastewater samples is the Ascorbic Acid Method, Standard Method 4500-P E-1999. It is mostly orthophosphate but due to the lab procedure, it can contain small amounts of other forms of phosphorus as well that react with a substance such as ammonium molybdate to form a color complex.

Recalcitrant

Adjective describing something that is stubbornly resistant; non-bioavailable; refractory; term commonly used to describe compounds that resist treatment or are not readily used for biological growth. In biological treatment, the term refractory is the preferred term.

Recalcitrant Soluble Organic Nitrogen

A synonym for refractory soluble organic nitrogen (rSON). See the definition for rSON, which is the preferred term.

Recalcitrant Soluble Organic Phosphorus

A synonym for refractory soluble organic phosphorus (rSOP). See the definition for rSOP, which is the preferred term.

Refractory

Adjective used to describe something that is very resistant to treatment or to being broken down. When used in relation to nutrient removal, refractory compounds are considered to pass through biological treatment processes unaffected and may increase as a byproduct of biological growth. Refractory is often used as a synonym of the term recalcitrant in this context. Refractory is preferred over recalcitrant for biological treatment usage. When used in relation to receiving water quality modeling, refractory is often used to describe an organic compound which breaks down at a slow rate (months to years) by a variety of mechanisms in the natural environment, including biological and chemical degradation, solar, wind, and physical mechanisms and is resistant to breakdown in processes with shorter detention time such as biological treatment in a wastewater treatment plant. Also refer to the definitions for related terms bioavailable and biodegradable.

Refractory Dissolved Organic Nitrogen (rDON)

A synonym for refractory soluble organic nitrogen (rSON), which is the preferred term. Refer to the definition for rSON.

Refractory Dissolved Organic Phosphorus (rDOP)

A synonym for refractory soluble organic phosphorus (rSOP), which is the preferred term. Refer to the definition for rSOP.

Refractory Soluble Organic Nitrogen (rSON)

It is the portion of SON present in a sample that is resistant to biological or chemical transformation. rSON is considered inert or only very slowly available for use by bacteria or algae. Analytical tests have shown that rSON, with regard to algal growth, is hydrophobic DON, extractable with XAD resin. The type of rSON is usually also described by whether the degradation is by bacteria in the wastewater treatment plant (WWTP) or by algae in surface waters. For the WWTP, the influent may contain SON that is resistant to biodegradation or the treated effluent may contain refractory SON received in the influent or produced from biological activity. The refractory SON in WWTP effluent that is resistant to algae uptake may be referred to as recalcitrant effluent SON. Bacterial or algal rSON is measured in specific bioassay tests that are complex and require related skill and experience. In water quality modeling, recalcitrant organic nitrogen compounds are differentiated as labile and refractory. Also referred to as rDON, rSON is the preferred term. Also refer to the definitions for related terms bioavailable and biodegradable.

Refractory Soluble Organic Phosphorus (rSOP)

This is the portion of SOP present in a sample that is resistant to biological or chemical breakdown. rSOP appears to become slowly available for use by bacteria in the wastewater treatment plant and by algae in surface waters. rSOP is often described by where the sample is taken in order to clearly describe whether the SOP is resistant to treatment in the biological treatment process or it is resistant to algae uptake in the surface water it is discharged to. rSOP is measured in complex bioassay tests that require related skill and experience. In water quality modeling, recalcitrant organic phosphorus compounds are differentiated as labile and refractory. Also referred to as rDOP, rSOP is the preferred term. Also refer to the definitions for the related terms bioavailable and biodegradable.

Return Activated Sludge (RAS) Fermentation

A fermenter located within a BNR process where a portion of Return Activated Sludge (RAS) solids is retained under anaerobic conditions, often with addition of a carbon source and unmixed or partially mixed conditions, to generate VFA and support growth of PAOs.

Shortcut Nitrogen Removal

This term is used to refer to both nitritation-denitritation (or nitrite shunt) and deammonification. See definitions for nitrite shunt and for deammonification.

Sidestream Enhanced Biological Phosphorus Removal (S2EBPR)

A biological phosphorus removal process where the anaerobic zone is located outside the main flow. The process often also includes mixed liquor fermentation or RAS fermentation.

Soluble

A descriptor used for the concentration of an inorganic or organic parameter of interest contained in the filtrate of a water sample after passing it through a 0.45 µm filter. Note that this may not represent a true dissolved concentration as some colloidal material can pass through the 0.45 µm filter. Examples of constituents of interest in nutrient removal systems are ammonia-nitrogen, nitrite, nitrate, organic nitrogen, Kjeldahl nitrogen, total phosphorus, reactive phosphorus, nonreactive phosphorus, biochemical oxygen demand (BOD), and chemical oxygen demand (COD). The term soluble is preferred over filterable or dissolved.

Soluble Acid-Hydrolyzable Phosphorus (SAHP)

The soluble or dissolved portion of the acid-hydrolyzable phosphorus (AHP) or the condensed phosphates. This is a synonym for dissolved acid-hydrolyzable phosphorus (DAHP) and filterable AHP. SAHP is the preferred term.

Soluble Inorganic Phosphorus (SIP)

In wastewater, SIP is the inorganic phosphorus in the filtrate of a sample. SIP would be calculated by adding the soluble reactive phosphorus (SRP) to the soluble acid-hydrolyzable phosphorus (SAHP). This is a synonym for dissolved inorganic phosphorus (DIP). SIP is the preferred term.

Soluble Non-Reactive Phosphorus (SNRP)

A synonym for dissolved non-reactive phosphorus (DNRP) or filterable non-reactive phosphorus. This phosphorus species is calculated as the difference between the total soluble phosphorus and the soluble reactive phosphorus (SRP). Non-reactive phosphorus includes the acid-hydrolyzable phosphorus (condensed phosphates), polyphosphates and organic phosphorus. SNRP is the preferred term.

Soluble Organic Nitrogen (SON)

In wastewater, it is the organic nitrogen measured in the filtrate of a sample. SON consists of combined amino acids, soluble microbial products, humic substances and other macromolecular nitrogen-containing organic compounds produced through the metabolism of low molecular weight proteins. The concentration of SON in a sample can be calculated as the difference between the total soluble nitrogen (TSN) and the total inorganic nitrogen (TIN) (i.e., NO_3^-, NH_4^+, and NO_2^-). SON is often the predominant nitrogen species in wastewater treatment plant effluent samples with a total nitrogen concentration below 2.0 mg/L. The term SON is preferred over DON.

Soluble Organic Phosphorus (SOP)

The fraction of the organic phosphorus in the filtrate of a sample. The SOP is calculated by taking the difference between the total soluble phosphorus and the total acid-hydrolyzable phosphorus (TAHP). Although it is referred to as "soluble" organic phosphorus, it may contain some colloidal organic phosphorus as well. The organic fraction is determined after the organic phosphorus is oxidized and converted to orthophosphate to be measured. Soluble organic phosphorus is also referred to as dissolved organic phosphorus (DOP) or filterable organic phosphorus; SOP is the preferred term.

Soluble Reactive Phosphorus (SRP)

The reactive phosphorus in the filtrate of a sample. Per Standard Methods and many EPA laboratory methods, the sample is filtered through a 0.45 µm filter prior to being analyzed. Although no claim is made that filtration through this size filter is a true separation of suspended and soluble forms of the nutrient, it defines a standard, convenient, and replicable analytical technique that separates all the suspended solids and the majority of the colloidal solids from the sample. It should be noted that some colloidal material will pass through a 0.45 µm filter. SRP is also referred to as dissolved reactive phosphorus (DRP) or filterable reactive phosphorus, but soluble reactive phosphorus (SRP) is the preferred term.

Soluble Total Kjeldahl Nitrogen (STKN)

The Kjeldahl nitrogen concentration in the filtrate after passing the sample through a 0.45 µm filter.

Struvite

Common name for magnesium ammonium phosphate hexahydrate; struvite forms as white or yellowish crystals. At some wastewater treatment facilities, particularly those that use anaerobic digestion, nuisance struvite forms in pipes and equipment causing pipe restrictions and blockages. Processes are available that produce struvite pellets in a controlled manner, allowing the minerals to be removed from the waste stream and recycled as a fertilizer product.

Technology Performance Statistic (TPS)

These performance measures were developed as a way to determine the real world variability in treatment performance of biological nutrient removal and tertiary treatment technologies designed to achieve low effluent nutrient concentrations. TPS is the preferred term over LOT. WERF study NUTR1R06k, entitled *Nutrient Management Volume 2: Removal Technology Performance and Reliability*, reported on TPS from a number of WWTPs. The statistics in this study were determined by analyzing three years worth of operating data from plants achieving low total nitrogen, total phosphorus and/or ammonia levels. Three separate TPS values were defined to represent ideal performance (14 day), median performance (50%) and reliably achievable performance for the various technologies analyzed. The reliable TPS varies from 80 to 99.9% depending on the permit requirements (max day, annual average, or other). A 95% TPS is often used to indicate the reliability achievable for monthly limits.

Total Acid Hydrolysable Phosphorus (TAHP)

Acid hydrolysis is used to convert all soluble and particulate condensed- and poly- phosphates to dissolved orthophosphate so that they can be measured as reactive phosphorus. The sample is not filtered prior to analysis. TAHP is calculated by subtracting the total reactive phosphorus (TRP) from the total phosphorus (TP) measured after acid hydrolysis.

Total Ammonical Nitrogen (TAN)

The sum of the unionized ammonia (NH_3) and the ammonium ions (NH_4^+). Ammonia/ammonium is a weak acid (pKa~9.5) and rapidly changes from one species to the other as pH change. At a pH of 9.5, approximately 50% of the TAN is present as ammonia and 50% as ammonium ion.

Total Dissolved Nitrogen (TDN)

A synonym for total soluble nitrogen (TSN); TDN includes both the organic and inorganic nitrogen present in the filtrate of a sample. The term total soluble nitrogen (TSN) is preferred.

Total Dissolved Phosphorus (TDP)

A synonym for total soluble phosphorus (TSP); TDP includes both the organic and inorganic phosphorus present in the filtrate of a sample. It is measured as reactive phosphorus after digestion of the sample filtrate. The term for total soluble phosphorus (TSP) is preferred.

Total Inorganic Nitrogen (TIN)
The sum of nitrite-N, nitrate-N, and ammonia-N in a sample.

Total Kjeldahl Nitrogen (TKN)
Also referred to as Kjeldahl nitrogen; see definition for Kjeldahl nitrogen.

Total Maximum Daily Load (TMDL)
A regulatory term from the United States Clean Water Act that is used to describe a calculated value that represents the largest amount of a certain pollutant that a body of water can receive and still meet water quality standards.

Total Nitrogen (TN)
The sum of total inorganic nitrogen (TIN) and total organic nitrogen (TON) in a sample. Total nitrogen can be determined as the sum of the total Kjeldahl nitrogen (TKN) plus nitrate-N and nitrite-N. TN can also be measured by a high temperature persulfate digestion step that converts all of the nitrogen to nitrate, which is then measured by colorimetric or other method. See the nitrogen species table.

Total Organic Nitrogen (TON)
A measure of the soluble and the particulate organic nitrogen in a sample. TON is calculated by subtracting the ammonia-N concentration from the TKN concentration or by subtracting the sum of the ammonia-N, nitrate-N and nitrite-N concentrations from the total nitrogen (TN) concentration.

Total Organic Phosphorus (TOP)
It is calculated by finding the difference between the total phosphorus (TP) and the sum of the total acid-hydrolyzable phosphorus (TAHP) and the total reactive phosphorus (TRP).

Total Oxidized Nitrogen (NOx)
The sum of nitrate-N and nitrite-N in a sample.

Total Particulate Nitrogen (TpN)
The total nitrogen contained in the solids that are filtered out of a sample. This is also referred to as total non-filterable nitrogen. TpN is the preferred term.

Total Particulate Phosphorus (TpP)
The total phosphorus contained in the solids that are filtered out of a sample. This is also referred to as total non-filterable phosphorus or particulate total phosphorus (pTP). TpP is the preferred term.

Total Phosphorus (TP)
All of the species of phosphorus in a sample. Total phosphorus is measured by a colorimetric test for reactive phosphorus according to Standard Methods 4500-P following acid and heat digestion. See the phosphorus species table.

Total Reactive Phosphorus (TRP)

This is the reactive phosphorus concentration in a sample without any prior digestion. It is a measure of orthophosphates plus other substances that may react with a reagent such as ammonia molybdate that forms a color complex.

Total Soluble Nitrogen (TSN)

The total nitrogen measured in the filtrate of a sample. This is also referred to as total filterable nitrogen or total dissolved nitrogen (TDN). TSN is the preferred term.

Total Soluble Phosphorus (TSP)

The total phosphorus measured in the filtrate of a sample. This is also referred to as total filterable phosphorus or total dissolved phosphorus (TDP). TSP is the preferred term.

Unionized Ammonia

Unionized ammonia is synonymous with ammonia. The total ammonia nitrogen (as measured) includes free ammonia (unionized ammonia) and ammonium ions (NH_4^+).

Vivianite

A hydrated iron phosphate crystalline mineral that provides a viable pathway to recover these minerals from wastewater for recycling as a fertilizer product.