Wisconsin Department of Natural Resources
Wastewater Operator Certification

Nutrient Removal - Total Nitrogen Study Guide

Subclass N

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Wisconsin Department of Natural Resources
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Preface

The Nutrient Removal-Total Nitrogen Study Guide is an important resource for preparing for the certification exam and is arranged by chapters and sections. Each section consists of key knowledges with important informational concepts needed to know for the certification exam. This study guide also serves as a wastewater treatment plant operations primer that can be used as a reference on the subject. Any diagrams, pictures, or references included in this study guide are included for informational/educational purposes and do not constitute endorsement of any sources by the Wisconsin Department of Natural Resources.

Preparing for the exams:
1. Study the material! Read every key knowledge until the concept is fully understood and known to memory.

2. Learn with others! Take classes in this type of wastewater operations to improve understanding and knowledge of the subject.

3. Learn even more! For an even greater understanding and knowledge of the subjects, read and review the references listed at the end of the study guide.

Knowledge of the study guide material will be tested using a multiple choice format. Every test question and answer comes directly from one of the key knowledges.

Choosing a test date:
Before choosing a test date, consider the time needed to thoroughly study the guides and the training opportunities available. A listing of wastewater training opportunities and exam dates is available at www.dnr.wi.gov by searching for the keywords “Operator Certification”.

Acknowledgements

The Nutrient Removal-Total Nitrogen Study Guide was the result of a collaborative effort of yearlong monthly meetings of wastewater operators, trainers, consultants, the Wisconsin Wastewater Operator Association (WWOA), and the Wisconsin Department of Natural Resources (WDNR). This study guide was developed as the result of the knowledge and collective work of following workgroup members:

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Chapter 1 - Theory and Principles

Section 1.1 - Definitions

1.1.1 Define aerobic (oxic) [O2].

Aerobic is a condition in which free and dissolved oxygen (DO) is available in an aqueous environment.

1.1.2 Define alkalinity.

Alkalinity is the ability of the wastewater to neutralize acid without effect on the pH and is measured as the calcium carbonate equivalent in mg/L.

1.1.3 Define the different forms of nitrogen in wastewater, their limits, and the reasons for their limits in Wisconsin Pollutant Discharge Elimination System (WPDES) permits.

A. Ammonia (NH3)
Ammonia is a form of nitrogen that exists in aquatic environments and is toxic to fish and other aquatic organisms. The WPDES Permit limits for ammonia are calculated based on: stream flow, stream temperature, stream pH, and the type of fishery classification. Ammonia is tested and reported as ammonia-nitrogen (mg/L).

B. Nitrate (NO3-)
Nitrate is the predominant form of nitrogen in groundwater. It has a Wisconsin Groundwater Enforcement Standard (ES) of 10 mg/L as nitrate-nitrogen (NO3-N). This standard is based on the risk of methemoglobinemia (blue-baby syndrome) in infants less than six months of age. Nitrate is tested and reported as nitrate-nitrogen (mg/L).

C. Nitrite (NO2-)
Nitrite is an intermediate product when ammonium is nitrified into nitrate and as nitrate denitrifies to nitrogen gas. Nitrite levels are higher in plant effluents with partial nitrification or denitrification occurring. Nitrite is tested and reported as nitrite-nitrogen (mg/L).

D. Organic nitrogen (Org-N)
Organic nitrogen is nitrogen bonded with carbon and is found in proteins, amino acids, urea, living or dead organisms, and decaying plant materials.

E. Total nitrogen (TN)
Total nitrogen is the sum of nitrate, nitrite, ammonia, and organic nitrogen. It is common practice to include a 10 mg/L of total nitrogen limitation in WPDES permits for groundwater discharges to ensure that drinking water standards are maintained in water supplies.

1.1.4 Define anaerobic [Ø].

Anaerobic is a condition in which free, dissolved, and combined oxygen is unavailable in an aqueous environment.

1.1.5 Define anoxic [NO2, NO3, SO4].

Anoxic is a condition in which oxygen is only available in combined form such as nitrate

(NO3-), nitrite (NO2-), or sulfate (SO4) in an aqueous environment.

1.1.6 Define biological nutrient removal (BNR).

BNR is the biological reduction of nitrogen and/or phosphorus in the final effluent using microorganisms.

1.1.7 Define carbonaceous biochemical oxygen demand (cBOD).

(Standard Method 5210B) The cBOD test is used to measure the oxygen demand of carbonaceous organic material in a wastewater sample as cBOD (mg/L). This test includes the use of a nitrogenous demand inhibitor to exclude the oxygen demand of ammonia and organic nitrogen.

1.1.8 Define denitrification.

Denitrification is a biological process where bacteria convert nitrate (NO3-) to nitrogen gas (N2) under anoxic conditions.

1.1.9 Define denitrifiers.

Denitrifiers are bacteria that convert nitrate to nitrogen gas in an anoxic environment.

1.1.10 Define eutrophication.

Eutrophication is the excessive growth of plant and algae in receiving waters due to dissolved nutrients and their decomposition.

1.1.11 Define hydraulic retention time (HRT).

HRT, also known as detention time, is the period of time that wastewater remains in a tank.

1.1.12 Define hypoxia.

Hypoxia is depressed oxygen levels below the 2.0 mg/L necessary to sustain most aquatic life. Hypoxia can result from eutrophication.

1.1.13 Define the Nitrate Groundwater Standard.

Nitrate is the most widespread groundwater contaminant in Wisconsin. It has a federal Maximum Contaminant Level (MCL) and Wisconsin Groundwater Enforcement Standard (ES) of 10 mg/L as nitrate-nitrogen. The standards are based on the risk of methemoglobinemia (Blue Baby Syndrome) in infants under six months of age.

1.1.14 Define nitrification.

Nitrification is a biological process where nitrifiers convert nitrogen in the form of ammonia (NH3) into nitrite (NO2-) and then nitrate (NO3-) under aerobic conditions.

1.1.15 Define nitrifiers.

Nitrifiers are bacteria that convert ammonia into nitrite then nitrate in an aerobic environment.

1.1.16 Define nitrogenous oxygen demand (NOD).

NOD is the amount of oxygen required to convert ammonia to nitrite then nitrate in a sample and is measured in mg/L.

1.1.17 Define selector.

A selector is part of the treatment system that selects for a specific type of microorganism by providing an environment (anaerobic, anoxic, aerobic) that favors its growth.

1.1.18 Define sludge age.

Sludge age is the theoretical length of time a particle of activated sludge stays in the treatment plant and is measured in days. In an activated sludge plant, sludge age is the amount (lbs) of mixed liquor suspended solids (MLSS) divided by the suspended solids, or excess cell mass, withdrawn from the system per day (lbs/day of waste activated sludge (WAS)).

1.1.19 Define substrate.

The food or chemical on which an organism depends for growth. The organic matter in wastewater (as measured by the BOD5 test) is a substrate for the microorganisms in activated sludge.

1.1.20 Define Total Kjeldahl Nitrogen.

Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and ammonia.

Section 1.2 - Wastewater Characteristics

1.2.1 Describe the sources of nitrogen.

Nitrogen is found in human waste, foods, certain soaps, and cleaning detergents and discharges from industrial and commercial sources. Urea/urine is the largest source of nitrogen in residential wastewater.

1.2.2 Discuss the environmental effects of high levels of effluent nitrogen.

A. Ammonia toxicity
Excessive ammonia in receiving waters is toxic to fish and some other aquatic life. Reactions in the water cause cell death in the nervous system leading to convulsions, coma, and death.

B. Hypoxia
Excessive nitrogen can lead to a spike in phytoplankton populations (such as algae). When these organisms die, they begin decomposing using up dissolved oxygen (DO), eventually dropping the DO level below 2 mg/L. This drop in DO is known as hypoxia.

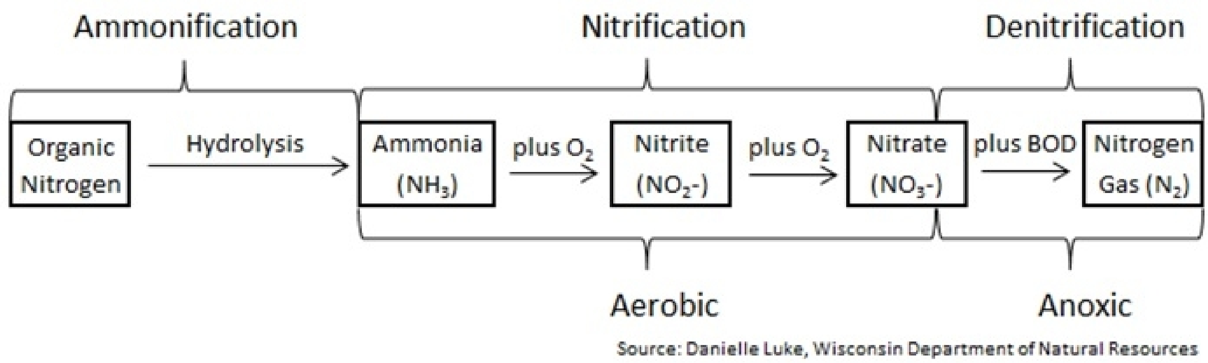
C. Blue Baby Syndrome (methemoglobinemia)
High levels of nitrate in drinking water become a public health hazard. For infants, the high levels of nitrate interfere with the blood's oxygen-carrying capacity causing the skin to take a bluish hue, a condition called Blue Baby Syndrome.

1.2.3 Discuss and show how nitrogen moves through the wastewater treatment plant.

Raw influent contains 20 to 85 mg/L of total nitrogen, roughly half organic nitrogen and half ammonia. In the secondary process most of the organic nitrogen will be converted to ammonia. If there is sufficient time, DO, microorganisms, and temperature, most of the ammonia will be converted to nitrite then nitrate (nitrification).

If there is an anoxic zone before or after aeration, some of the nitrate will be converted to nitrogen gas (denitrification) which then bubbles up out of the water.

Figure 1.2.3.1

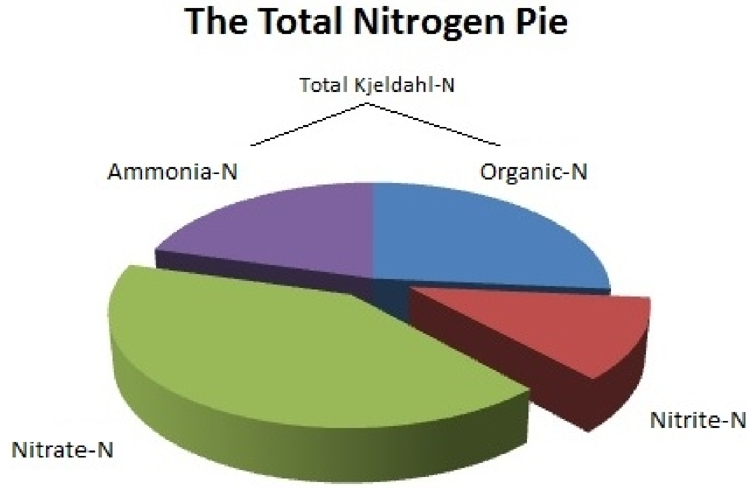


Section 1.3 - Biological Principles

1.3.1 Describe the different forms of nitrogen.

Wastewater and sludge contain nitrogen in the forms of organic nitrogen, ammonia (NH3) or ammonium (NH4+), nitrate (NO3-), and nitrite (NO2-).

Figure 1.3.1.1



1.3.2 Discuss the removal of the different forms of total nitrogen.

A. Total Kjeldahl Nitrogen (TKN)
TKN consists of ammonia and organic nitrogen. Ammonification converts organic nitrogen to ammonia through biological activity. Most of the organic nitrogen is converted to ammonia in the secondary treatment. Any remaining particulate organic nitrogen will settle in the final clarifier and be wasted with the sludge.

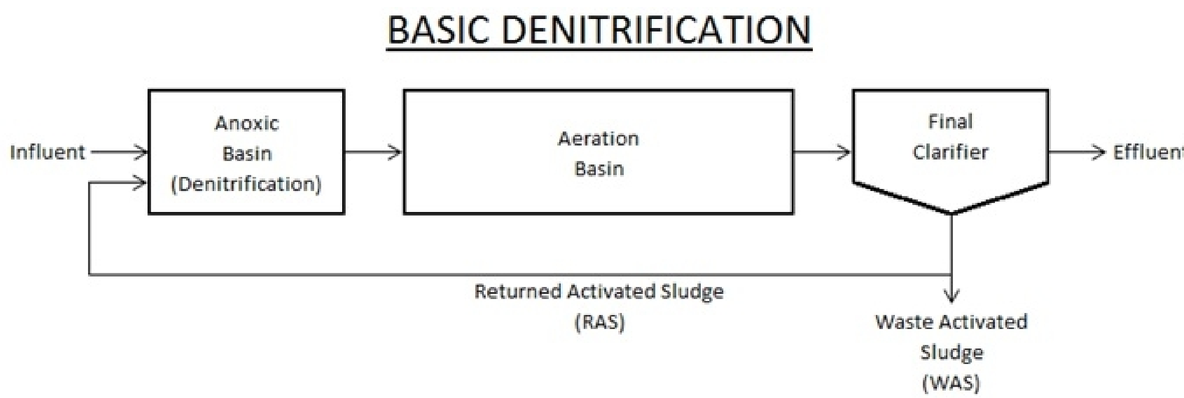
B. Nitrite and Nitrate
Nitrite and nitrate is removed using biological nitrogen removal, consisting of nitrification (converting ammonia to nitrite then nitrate), followed by denitrification (converting nitrate into nitrogen gas).

1.3.3 Describe the nitrification and denitrification processes in wastewater treatment.

A. Aerobic
Nitrification is a biological process where nitrifiers convert nitrogen in the form of ammonia to nitrite then nitrate under aerobic conditions.

B. Anoxic
Denitrification is a biological process where denitrifiers convert nitrate and nitrite to nitrogen gas under anoxic conditions.

Figure 1.3.3.1



1.3.4 Describe the environmental conditions needed to support the growth of nitrifiers.

Nitrifiers convert ammonia to nitrate. They work best under the following environmental conditions:

A. DO greater than 1.0 mg/L
B. pH between 7.0 and 8.5
C. Alkalinity greater than 50 mg/L
D. Temperatures between 50°F and 85°F (10°C to 30°C), nitrification can cease below 46°F (8°C)
E. Longer sludge ages (greater than 10 days) because of their slow growth

1.3.5 Describe the environmental conditions needed for the growth of denitrifiers.

Denitrifiers convert nitrate to nitrogen gas. They work best under the following environmental conditions:

A. DO less than 0.2 mg/L
B. pH between 7.0 and 8.5
C. Adequate organic matter (BOD)
D. Temperature between 50ºF and 85ºF (10ºC to 30ºC)

Chapter 2 - Operations and Maintenance

Section 2.1 - Reactors and Methods

2.1.1 Discuss the importance of sludge age in nitrification.

An older sludge age, generally greater than 10 days, is essential for nitrification due to the nitrifiers slow reproduction.

2.1.2 Discuss the importance of hydraulic residence time.

Hydraulic residence time (HRT), often called detention time, is the time it takes the flow to move through a basin.

A. Aerobic basin
The nitrifiers need sufficient time to convert ammonia into nitrite then nitrate in the aeration basin. A short detention time will not give the nitrifiers time to convert the ammonia. High flows from inflow and infiltration (I/I) can cause the nitrifiers to washout out of the aeration basin and final clarifier.

B. Anoxic basin
The denitrifiers need less time to convert the nitrate into nitrogen gas in the anoxic basin, generally 1 to 3 hours. The anoxic basin is much smaller than the aerobic basin to allow for a shorter detention time.

2.1.3 Discuss the importance of oxygen on nitrification and denitrification.

Nitrifiers need oxygen to convert ammonia to nitrite then nitrate (NH3 + O2 -> NO2 + O2 -> NO3 + H2O). If the dissolved oxygen (DO) drops too low, nitrification will not take place. Nitrification commonly takes place in the aeration basin, or other types of aerobic treatment.

Denitrifiers are able to strip oxygen off of the nitrate molecule (NO3 -> N2 (gas off) + O2) when no DO is available. In the anoxic zone they break down nitrate, absorb the oxygen, and release the nitrogen gas. If the anoxic selector becomes aerobic, denitrification will not occur.

2.1.4 Describe simultaneous nitrification and dentrification (SND).

SND is the phenomenon where ammonia and nitrate are biologically reduced within the same basin eliminating the need for two separate basins. SND will occur in a single activated sludge reactor or in a biofilm system when there is just enough DO supplied so only the floc's outer layer is aerobic and maintains nitrification. At the same time the interior of the floc is deprived of DO resulting in anoxic conditions and denitrification.

2.1.5 Describe anaerobic ammonium oxidation (Anammox®)

Anaerobic ammonium oxidation (Anammox®) is the transformation of ammonium and nitrite into nitrogen gas and water in a 1-stage process instead of passing through a 2-stage process of aerobic nitrification and anoxic denitrification. This process has limited application, and currently is used on wastewater high in nitrogen, such as digester decant.

2.1.6 Discuss the mixing requirement of the anoxic tanks.

The anoxic tank is mixed, not aerated, to keep the solids in suspension without adding DO. There are typically three types of mixers:

A. Floating mixer with blades suspended below the surface
B. Submersible mixers
C. Platform-mounted vertical-shaft mixers

Figure 2.1.6.1

FLOATING MIXER

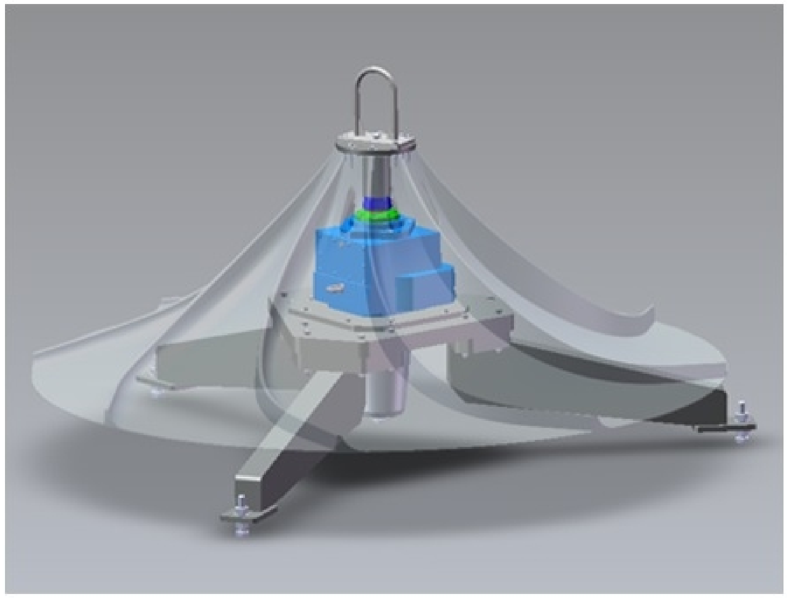


Figure 2.1.6.2

SUBMERSIBLE MIXER

Figure 2.1.6.3

Section 2.2 - Performance Limiting Factors

2.2.1 Discuss the effect nitrification and denitrification have on alkalinity.

The nitrification process will lower alkalinity (nitrifiers use alkalinity as one of their carbon sources) and in a plant with already low alkalinity, the pH will be affected. This then starts to negatively affect the nitrification process. Nitrification decreases alkalinity at a rate of 7.14 mg/L per 1 mg/L of ammonia converted to nitrite and nitrate. The process of denitrification will restore some of the alkalinity in the wastewater that was lost during nitrification at a rate of 3.57 mg/L per 1 mg/L of nitrate converted. If alkalinity is too low, it can be increased by the addition of sodium bicarbonate or caustic soda.

2.2.2 Discuss the significance of biochemical oxygen demand (BOD) removal prior to nitrification.

Nitrifiers growth depends upon the soluble BOD in the wastewater. Soluble BOD needs to be used up before nitrifiers will grow. Typically, nitrification will occur when the soluble BOD is the wastewater is reduced to less than 20 mg/L.

2.2.3 Describe carbon augmentation.

Biological nutrient removal requires sufficient BOD (carbon) for the process to work. Under certain conditions, it may be necessary to provide additional BOD. Carbon augmentation can come from an internal source, such as fermented sludge or from an external source, such as purchased chemical. Examples of external sources are: acetic acid, ethanol, glycerol, methanol, sugar, and other proprietary products designed specifically for this purpose.

2.2.4 Describe how cold temperatures can effect nitrification.

Nitrifiers are very sensitive to temperature, slowing down metabolism. Nitrification works best at temperatures between 10°C to 30°C (50°F to 85°F). At temperatures below 8°C (46°F), a loss in nitrification can occur. A higher mixed liquor suspended solids (MLSS) is necessary during the colder weather to maintain the same removal rate.

2.2.5 Discuss the BOD to nitrate ratio for denitrification.

Denitrifiers in an anoxic environment utilize BOD as their food source and oxygen from nitrate. The reaction results in the release of nitrogen gas to the atmosphere. Denitrifiers generally require 4 grams of BOD to remove 1 gram of nitrate-nitrogen.

2.2.6 List common sidestreams within a treatment plant.

The most common sidestreams are from:

A. Thickening and dewatering processes
1. Gravity belt thickening filtrate
2. Centrifuge centrate
3. Gravity thickening supernatant
4. Dissolved air flotation (DAF) subnatant
5. Rotary drum thickening filtrate
6. Belt filter press filtrate
7. Sludge drying bed underdrain
8. Plate and frame filtrate
9. Reed bed filtrate

B. Stabilization and storage
1. Aerobic digester decant
2. Anaerobic digestion supernatant
3. Biosolids storage decant
4. Effluent filter backwash

2.2.7 Discuss the possible impact of sidestreams or recycle flows back to the activated sludge process.

Sidestreams or recycle flows usually come from solids handling treatment or dewatering processes, such as decanting digesters, sludge dewatering, or sludge storage tanks. Sidestreams may be high in ammonia, BOD, and phosphorus. It is best to return sidestreams slowly and regularly, so microorganisms adjust and acclimate to this loading. The use of an equalization tank can assist in adding sidestreams slowly. The equalization tank can be aerated for a sufficient detention time, reducing the amount of ammonia in the sidestream.

Pretreatment of sidestreams may be necessary to meet ammonia permit limits.

2.2.8 Discuss the effect of excess oxygen on dentrification.

If the anoxic selector becomes aerobic, denitrification will not occur. Denitrifiers use organic carbon for cell growth with DO in an aerobic environment and is the preferred source of oxygen. In an anoxic zone, where DO is not available, they are forced to use nitrate for their source of oxygen, breaking the nitrogen and oxygen bound.

Chapter 3 - Monitoring, Process Control, and Troubleshooting

Section 3.1 - Sampling and Testing

3.1.1 Discuss inline monitoring of the biological nutrient process using oxidation reduction potential (ORP) and dissolved oxygen (DO) meters.

While DO is often used to monitor aerobic processes, it is limited in its accuracy in measuring very low levels to zero oxygen in solution, thus true and actual anaerobic or anoxic conditions cannot be measured with a DO meter. ORP is the best instrument to use when measuring these conditions.

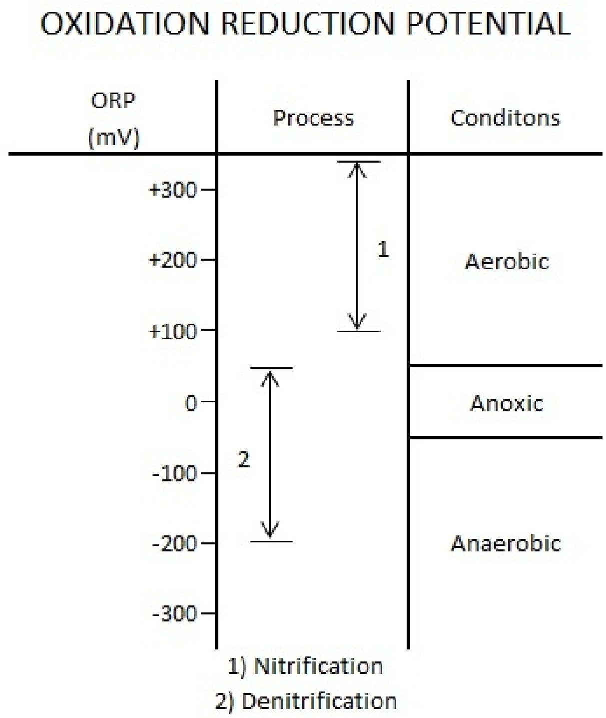
In wastewater, the ORP is the tendency of the solution to either gain or lose electrons. Oxidizing agents take on electrons while reducing agents give up electrons. Raw wastewater typically contains more reducing agents than oxidizing agents and in the biological treatment of wastewater bacteria, in the presence of oxygen, oxidizes these reducing agents.

ORP measures the movement of electrons in a wastewater solution. It is a measurement of the ratio of oxidizing and reducing agents in solution. ORP is measured in millivolts (mV). It is an excellent and preferred method for measuring anaerobic (a highly reducing environment), anoxic (a reducing environment), and aerobic (an oxidizing environment), all necessary and very important conditions needed in the successful biological removal of nutrients from wastewater. The optimal ORP operating range to create the anoxic biological environment is -200 to +50 mV.

The range of ORP readings for such environments can be found in Figure 3.1.1.1.

Graphic source: Gronsky, et al., 1992.

Figure 3.1.1.1



3.1.2 Describe the tests used to monitor nitrification and denitrification, where to sample, why they are used, and how often.

Figure 3.1.2.1

Parameter:	Sample Location:	Why Tested:	How Often:
Dissolved oxygen (DO)	Well-mixed area of aeration basin	Maintaining an aerobic zone is needed for nitrification	Daily or continuously
Oxygen reduction potential (ORP)	Well-mixed area of anoxic basin	Maintaining an anoxic zone (+50 mV to -200 mV) is needed for denitrification	Daily or continuously
Ammonia and total Kjeldahl nitrogen (TKN)	Plant influent and effluent	To determine the amount to be treated and removal efficiency	Daily
Alkalinity	Plant influent and effluent	To determine if additional alkalinity needs to be added for sucessful nitrification	As required
Nitrate	Plant effluent or return activated sludge (RAS) and anoxic zone effluent	To determine removal efficiency	Daily or continuously
Biochemical oxygen demand (BOD)	Plant influent	To ensure carbon is sufficient for denitrification	Daily

Section 3.2 - Data Understanding and Interpretation

3.2.1 Discuss in-plant nitrate testing for process control purposes.

A. Portable test kits
Portable test kits are inexpensive, simple to use, and give immediate results. The disadvantages of using portable test kits, include: difficulty of running calibrations, lack of accuracy, and outside interferences (wind, rain, temperature, etc.).

B. Inline sensors
Inline monitoring provides real-time information to operators, when making operational decisions. Inline sensors are more costly than portable test kits, and require routine calibration, maintenance, and cleaning. Inline sensor's can also be programmed into the facility's SCADA system and provide real-time control and record management.

Section 3.3 - Corrective Actions

3.3.1 Discuss the possible causes and corrective actions for pH and alkalinity concerns.

Figure 3.3.1.1

Problem	Cause	Corrective Action
Low influent alkalinity	Low alkalinity in public water supply	Add alkalinity to the influent
Normal influent pH, low effluent pH	Alkalinity consumption during nitrification, thus effecting pH	Chemically add alkalinity to the influent and/or regain some alkalinity through denitrification

3.3.2 Discuss the possible causes and corrective actions with denitrification issues.

3.3.2.1

Problem	Cause	Corrective Action
Very high influent nitrate	Sidestreams	Treat sidestreams seperately using air/stream stripping or ANAMMOX; blend the sidestream with the RAS
	Industrial sources	Preliminary treatment at the source; Update the Sewer Use Ordinance limiting the ammount of nitrate discharged
	High nitrate use in collection system (for hydrogen sulfide control)	Limit the need of nitrate use by adding ventilation to the collection system; use alternate chemicals, such as ferric chloride
Short denitrification selector detention times	Sediment build-up in the selector	Take selector offline and remove build-up
Lack of a carbon source (food)		Add carbon augmentation
High effluent total nitrogen	Low temperature	Increase DO and MLSS

Chapter 4 - Safety

Section 4.1 - Definitions

4.1.1 Define lock-out/tag-out.

Lock-out/tag-out is used to protect the operator from serious injury by ensuring that machinery remains completely off. The lock is placed on the power source in a way that prohibits the machinery from receiving the power necessary to run and includes a tag with the operator's name performing the maintenance. Without a lock-out/tag-out system, the possibility exists that a machine will unexpectedly start-up, either because of stored energy not correctly released, being triggered by the control system, or through someone starting it without realizing maintenance is being performed.

4.1.2 Define personal protective equipment (PPE).

PPE is the protective clothing and other devices designed to protect an individual while in potentially hazardous areas or performing potentially hazardous operations. Examples of PPE include gloves, hard hats, steel-toed boots, safety glasses, and appropriate clothing.

Section 4.2 - Safety

4.2.1 Discuss the importance of floatation devices at a wastewater treatment plant.

Sampling from basins, channels, and other treatment processes puts an operator at risk of falling into the wastewater. Basins that are aerated can be the most dangerous because the aeration process makes it extremely difficult, if not impossible, to stay afloat in waters saturated with high concentrations of air. For this reason, an operator should never extend beyond the protection of the guardrails. The Occupational Safety and Health Administration (OSHA) highly recommends ring buoys with at least 90 ft of line be provided and readily available for emergencies and strategically placed around all process basins. OSHA also recommends any operator working over or near water where a risk of drowning is present be provided with a life jacket or buoyant work vest.

4.2.2 List various safety considerations that are important when working in a wastewater treatment plant.

A. Falling into tanks where currents can pull an operator under the water surface
B. Noise
C. Exposure to waterborne and bloodborne pathogens
D. Rotating equipment
E. Electrical hazards
F. Slippery surfaces
G. Confined spaces
H. Compressed air
I. Chemicals and chemical equipment

Operators should follow all federal and state safety requirements. Safety programs and emergency procedures should be in place and followed at all times.

4.2.3 Discuss procedures for entering treatment tanks or vessels.

Owners of wastewater treatment facilities should clearly define all confined spaces. Operators should know them and follow all confined space entry procedures.

4.2.4 Describe the applicable safety program and requirements municipal wastewater treatment plants must follow.

The Wisconsin Department of Safety and Professional Services - SPS 332 Public Employee Safety and Health must be followed. Some of the important safety requirements are confined space, excavation, hearing conservation, bloodborne pathogens, CPR/First Aid, Safety Data Sheets (SDS), electrical, fall protection, hazardous materials, as well as others. Non-public entities follow the Occupational Safety & Health Administration (OSHA) CFR 29 part 1910.

4.2.5 Discuss the importance of maintaining chemical delivery, storage, and usage records.

Some chemicals used in an attached-growth treatment plant are hazardous materials and must be identified. SDS for each are required to be kept onsite and readily available. In the event of a spill, the Department of Natural Resources must be contacted.

4.2.6 Discuss preventative spill measures and procedures when handling hazardous chemicals.

Storage tanks must have secondary containment that equals the volume of the storage tank. Place containment pails under potential leaks points and when uncoupling fill lines during unloading of delivery vehicles. Inspect and maintain fill lines and valves. Inspect storage tanks and hardware for integrity. Pay attention to what is being done! Provide onsite containment equipment such as absorbent booms, sandbags, etc. and seal the yard and storm drains to prevent offsite loss of chemical.

In case of a spill:

A. Hazardous material spills should be reported to the Department of Natural Resources using the spill hotline at 1(800)943-0003 within 24 hours and the local emergency response agencies.

B. Contact CHEMTREC for further spill response and cleanup advice.

Chapter 5 - Calculations

Section 5.1 - Sludge Age

5.1.1 Given treatment plant data, calculate the sludge age (days).

GIVEN:

[MLSS = mixed liquor suspended solids]
[MG = million gallons]
[WAS = wasted activated sludge]
[MGD = million gallons per day]

MLSS = 2,300 mg/L
Aeration basin volume = 34,500 gals = 0.0345 MG
WAS concentration = 3,800 mg/L

WAS flow = 0.001 MGD

FORMULAS AND SOLUTION:

MLSS (lbs) = aeration basin vol. (MG) × MLSS (mg/L) × 8.34
= 0.0345 MG × 2,300 mg/L × 8.34
= 662 lbs of MLSS under aeration

WAS (lbs) = WAS flow (MGD) × WAS cons. (mg/L) × 8.34
= 0.001 MGD × 3,800 mg/L × 8.34
= 32 lbs of WAS/day

Sludge age (days) = MLSS (lbs under aeration) ÷ WAS (lbs/day)
= 662 lbs ÷ 32 lbs/day
= 21 days

Section 5.2 - Hydraulic Retention Time

5.2.1 Given treatment plant data, calculate the hydraulic retention time (HRT).

Influent flow = 1.2 MGD
Returned activated sludge (RAS) flow = 0.55 MGD
Anoxic selector volume = 150,000 gals

FORMULA AND SOLUTION:

HRT (hrs) = (tank vol. (MG) ÷ [influent flow (MGD) + RAS flow (MGD)]) × 24 hrs/day
= (0.150 MG ÷ [1.2 MGD + 0.55 MGD]) × 24 hrs/day
= (0.150 MG ÷ 1.75 MGD) × 24 hrs/day
= 2.1 hrs

References and Resources

1. UW WATER LIBRARY

Most of the resources listed on this page can be borrowed through the UW Water Library as part of a partnership between the UW Water Library, the Wisconsin Wastewater Operator Association (WWOA), Central States Water Environmental Association (CSWEA), and the Wisconsin Department of Natural Resources. Instructions for borrowing materials from the UW Water Library can be found by visiting the website provided below, clicking on 'WISCONSIN RESIDENTS', and then clicking on 'HOW TO BORROW MATERIALS'.

www.aqua.wisc.edu/waterlibrary

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