Registration form

NUTRIENTS AND MICROBES TRAINING COURSE $200.00

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Start and finish dates: ____

You will have 90 days from this date in order to complete this course

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Collection___ Wastewater Treatment ___ Pretreatment____ Other ___________________

Your certificate will be mailed to you in about two weeks unless you pay for the rush service.

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I understand that it is my responsibility to ensure that this CEU course is either approved or accepted in my State for CEU credit. I understand State laws and rules change on a frequent basis and I believe this course is currently accepted in my State for CEU or contact hour credit, if it is not, I will not hold Technical Learning College responsible. I also understand that this type of study program deals with dangerous conditions and that I will not hold Technical Learning College, Technical Learning Consultants, Inc. (TLC) liable for any errors or omissions or advice contained in this CEU education training course or for any violation or injury caused by this CEU education training course material. I will call or contact TLC if I need help or assistance and double-check to ensure my registration page and assignment has been received and graded.

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You can obtain a printed version of the course manual from TLC for an additional $79.95 plus shipping charges.

AFFIDAVIT OF EXAM COMPLETION

I affirm that I personally completed the entire text of the course. I also affirm that I completed the exam without assistance from any outside source. I understand that it is my responsibility to file or maintain my certificate of completion as required by the state or by the designation organization.

Grading Information

In order to maintain the integrity of our courses we do not distribute test scores, percentages or questions missed. Our exams are based upon pass/fail criteria with the benchmark for successful completion set at 70%. Once you pass the exam, your record will reflect a successful completion and a certificate will be issued to you.

For security purposes, please fax or e-mail a copy of your driver's license and always call us to confirm we've received your assignment and to confirm your identity.

Nutrients and Microbes Answer Key

Name____

Phone #__________________________________

Multiple Choice. Pick only one answer per question. Select answer according to text, exactly as in text. Circle, Mark off, underline or Bold the answer.

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Please fax or e-mail the answer key to TLC
Western Campus Fax (928) 272-0747.

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For security purposes, please fax or e-mail a copy of your driver's license and always call us to confirm we've received your assignment and to confirm your identity. Thank you…

Please e-mail or fax this survey with your final exam

NUTRIENTS AND MICROBES CEU COURSE
CUSTOMER SERVICE RESPONSE CARD

NAME: ________________________

E-MAIL________________________________PHONE____________________

PLEASE COMPLETE THIS FORM BY CIRCLING THE NUMBER OF THE APPROPRIATE ANSWER IN THE AREA BELOW.

1. Please rate the difficulty of your course.
   Very Easy 0 1 2 3 4 5 Very Difficult
2. Please rate the difficulty of the testing process.
   Very Easy 0 1 2 3 4 5 Very Difficult
3. Please rate the subject matter on the exam to your actual field or work.
   Very Similar 0 1 2 3 4 5 Very Different
4. How did you hear about this Course? ___________________________________
5. What would you do to improve the Course?

How about the price of the course-

Poor_____ Fair ____ Average ____ Good____ Great_____

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Poor___ Fair ____ Average ____ Good _____ Great_____

Any other concerns or comments.

Nutrients and Microbes Training Course Assignment

Your assignment is to correctly answer the following questions about the characteristic of the wastewater treatment system, nutrients and nutrient removal, filtration, microbes, bugs and the activated sludge process.

You will have 90 days in order to successfully complete this assignment with a score of 70% or better. If you need any assistance, please contact TLC's Student Services. Once you are finished, please, e-mail or fax or e-mail your answer sheet along with your registration form.

Please use the Answer Key and Registration form. Select the exact answer from text.

Photosynthetic Organisms

1. ________________ are environmentally sensitive and have a narrow pH range of 6.5-7.5 and require temperatures > 14^{o} C.
A. An anaerobic fermenter
B. Acid formers
C. Methane bacteria
D. General anaerobic degraders
E. Anaerobic methane formation
F. None of the Above

2. Note that the products of the _______________ (principally acetic acid) become the substrate for the methane producers.
A. An anaerobic fermenter
B. Acid formers
C. Methane bacteria
D. General anaerobic degraders
E. Anaerobic methane formation
F. None of the Above

3. A problem exists at times where the acid formers overproduce organic acids, lowering the pH below where the methane bacteria can function (a pH < 6.5). This can stop methane formation and lead to a buildup of sludge in a lagoon with a low pH. In an anaerobic fermenter, this is called a "___________________".
A. An anaerobic fermenter
B. Acid formers
C. Methane bacteria
D. General anaerobic degraders
E. Stuck digester
F. None of the Above

4. Methane fermentation ceases at cold temperature, probably not occurring in most lagoons in the wintertime in cold climates. A number of ________________(14 genera reported to date) called sulfate reducing bacteria can use sulfate as an electron acceptor, reducing sulfate to hydrogen sulfide.
A. Anaerobic sulfur bacteria
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Anaerobes or microaerophilic
E. Anaerobic bacteria
F. None of the Above

5. This occurs when BOD and sulfate are present and oxygen is absent. ________________is a major cause of odors in ponds.
A. Sulfate reduction
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Anaerobes or microaerophilic
E. Anaerobic conditions
F. None of the Above

6. Anaerobic, _________ occur in all lagoons and are the predominant photo-synthetic organisms in anaerobic lagoons.
A. Anaerobic sulfur bacteria
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Anaerobes or microaerophilic
E. Anaerobic conditions
F. None of the Above

7. The ______________, generally grouped into the red and green sulfur bacteria and represented by about 28 genera, oxidize reduced sulfur compounds (H2S) using light energy to produce sulfur and sulfate,

A. Anaerobic sulfur bacteria
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Anaerobes or microaerophilic
E. Anaerobic conditions
F. None of the Above

8. H2S is used in place of H2O as used by algae and green plants, producing S04- instead of O2. All are either strict anaerobes or_________________.

A. Anaerobic sulfur bacteria
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Microaerophilic
E. Anaerobic conditions
F. None of the Above

9. Most common are Chromatium, Thiocystis, and Thiopedia, which can grow in profusion and give a lagoon a pink or red color. Finding them is most often an indication of organic overloading and _________________ in an intended aerobic system.

A. Anaerobic sulfur bacteria
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Anaerobes or microaerophilic
E. Anaerobic conditions
F. None of the Above

10. Conversion of odorous sulfides to sulfur and sulfate by these sulfur bacteria is a significant odor control mechanism in facultative and____________, and can be desirable.

A. Anaerobic sulfur bacteria
B. Photosynthetic bacteria
C. Anaerobic bacteria
D. Anaerobes or microaerophilic
E. Anaerobic lagoons
F. None of the Above

Treatment Lagoon

11. The ______________ at a treatment lagoon is determined by the various chemical species of alkalinity that are present. The main species present are carbon dioxide (CO2, bicarbonate ion (HCO3), and carbonate ion (CO23).

A. Algae
B. pH
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

12. Alkalinity and pH can affect which species will be present. High amounts of _________yield a low lagoon pH, while high amounts of CO23 yield a high lagoon pH.

A. Algae
B. Alkalinity and pH
C. CO2
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

13. Bacterial growth on _____________releases CO2 which subsequently dissolves in water to yield carbonic acid (H2CO3). This rapidly dissociates to bicarbonate ion, increasing the lagoon alkalinity.

A. Algae
B. Alkalinity and pH
C. Bacterial oxidation
D. BOD
E. Rotifers and daphnia
F. None of the Above

14. ________________ of BOD causes a decrease in lagoon pH due to CO2 release.

A. Algae
B. Alkalinity and pH
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

15. Algal growth in lagoons has the opposite effect on lagoon pH, raising the pH due to algal use for growth of _______________(CO2 and HCO3).

A. Algae
B. Alkalinity and pH
C. Bacterial oxidation
D. Inorganic carbon
E. Rotifers and daphnia
F. None of the Above

16. Algal growth reduces the lagoon alkalinity which may cause the pH to increase if the lagoon alkalinity (_____________) is low.

A. Algae
B. pH buffer capacity
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

17. Algae can grow to such an extent in lagoons (a bloom) that they consume all of the CO2 and HCO3 present for photosynthesis, leaving only carbonate (CO23) as the______________.

A. Algae
B. pH buffering species
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

18. This causes the pH of the lagoon to become alkaline. pH values of 9.5 or greater are common in lagoons during_______________, which can lead to lagoon effluent pH violations (in most states this is pH = 9).

A. Algal blooms
B. Alkalinity and pH
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

19. It should be noted that an increase in the lagoon pH caused by algal growth can be beneficial. Natural disinfection of _______________ is enhanced at higher pH.

A. Algae
B. Alkalinity and pH
C. Bacterial oxidation
D. Pathogens
E. Rotifers and daphnia
F. None of the Above

20. ____________ removal by natural chemical precipitation is greatly enhanced at pH values greater than pH = 8.5. In addition, ammonia stripping to the atmosphere is enhanced at higher pH values (NH3 is strippable, not NH4+).

A. Algae
B. Alkalinity and pH
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

Protozoans and Microinvertebrates

21. Many higher life forms (animals) develop in lagoons. These include protozoans and microinvertebrates such as _______________, annelids, chironomids (midge larvae), and mosquito larvae (often termed the zooplankton).

A. Algae
B. Alkalinity and pH
C. Bacterial oxidation
D. Phosphorus
E. Rotifers and daphnia
F. None of the Above

22. These organisms play a role in waste purification by feeding on _____________ and algae and promoting flocculation and settling of particulate material.

A. Algae
B. Alkalinity and pH
C. Bacteria
D. Protozoans
E. Rotifers and daphnia
F. None of the Above

23. __________________ are the most common higher life forms in lagoons with about 250 species identified in lagoons to date.

A. Algae
B. Alkalinity and pH
C. Bacteria
D. Protozoans
E. Rotifers and daphnia
F. None of the Above

24. Rotifers and daphnia are particularly important in controlling algal overgrowth and these often "________________" when algal concentrations are high.

A. Algae
B. Alkalinity and pH
C. Bacteria
D. Protozoans
E. Bloom
F. None of the Above

Activated Sludge Methods

25. We have some wastewater treatment plants that grow the microorganisms (Bugs) in large tanks. To have enough oxygen in the tanks we add _____________by blowing air into the tank full of waste-water and microorganisms.

A. Mass of microbes
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen
F. None of the Above

26. The air is bubbled in the water and mixes “the bugs,” food and oxygen together. When we treat wastewater this way, we call it the activated sludge method. With all of this food and air, the _______________ grow and multiply very rapidly.

A. Microbes
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

27. Pretty soon the population of bugs gets too large and some of them need to be removed to make room for new bugs to grow. We remove the _______________ by sedimentation in the same kind of tanks used for primary treatment.

A. Excess bugs
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

28. In the tank, the bugs sink to the bottom and we remove them. The settled bugs are also called_______________. The waste sludge is treated separately, and the remaining wastewater is now much cleaner.

A. Mass of microbes
B. Organic load
C. Bacteria
D. Waste activated sludge
E. Oxygen demand
F. None of the Above

29. In fact, after primary and secondary treatment, about 85% or more of all pollutants in the wastewater has been removed and it goes on to Disinfection. These systems originated in England in the early 1900's and earned their name because a sludge (______________) is produced which aerobically degrades and stabilizes the organic load of a wastewater.

A. Mass of microbes
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

30. For larger systems, especially when high variability is expected, the design involves the use of multiple aeration tanks and multiple settling tanks. The number of units employed depends on the flow of ____________________being generated.

A. Mass of microbes
B. Organic load
C. Bacteria
D. Wastewater
E. Oxygen demand
F. None of the Above

Organic Load

31. The organic load (generally coming from primary treatment operations such as settling, screening or flotation) enters the reactor where the active microbial population (____________) is present. The reactor must be continuously aerated.
A. Mass of microbes
B. Organic load
C. Activated sludge
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

32. The mixture then passes to a secondary settling tank where the cells are settled. The treated wastewater is generally discharged after disinfection while the settled ____________is recycled in part to the aeration basin.
A. Mass of microbes
B. Biomass
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

33. The cells must be recycled in order to maintain sufficient biomass to degrade the _____________ as quickly as possible.
A. Mass of microbes
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

34. The amount that is recirculated depends on the need to obtain a high degradation rate and on the need for the __________to flocculate properly so that the secondary settling separates the cells satisfactorily.
A. Mass of microbes
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

35. As the cells are retained longer in the system, the ________________ of the cells improve since they start to produce extra cellular slime which favors flocculating.
A. Mass of microbes
B. Organic load
C. Bacteria
D. Flocculating characteristics
E. Oxygen demand
F. None of the Above

Common Types

36. The most common types of ___________ are the conventional and the continuous flow stiffed tank, in which the contents are completely mixed. In the conventional process, the wastewater is circulated along the aeration tank, with the flow being arranged by baffles in plug flow mode.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge
E. Suctoria
F. None of the Above

37. The _______________ for this arrangement is maximum at the inlet as is the organic load concentration.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Suctoria
F. None of the Above

38. In the completely mixed process the inflow streams are usually introduced at several points to facilitate the ________________of the mixing; if the mixing is complete, the properties are constant throughout the reactor.
A. Homogeneity
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Suctoria
F. None of the Above

39. This configuration is inherently more stable to perturbations because mixing causes the dilution of the incoming stream into the tank. In fisheries wastewaters the ___________ that may appear are peaks of concentration of organic load or flow peaks.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Suctoria
F. None of the Above

40. The flow peaks can be damped in the primary treatment tanks. The conventional configurations would require less reactor volume if _______________could be assured, which usually does not occur.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Smooth plug flow
F. None of the Above

41. Other versions of ________________ (e.g., extended aeration, contact stabilization, step aeration and pure oxygen processes) are used in other kinds of wastewaters but are not known to be applied to treat fisheries wastewaters.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Suctoria
F. None of the Above

42. In all ________________, the cells are separated from the liquid and partially returned to the system to have a relatively high concentration of cells that degrade the organic load in a relatively short time.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Suctoria
F. None of the Above

Bugs or MOs
43. Four groups of bugs do most of the “eating” in the _____________ process. The first group is the bacteria which eat the dissolved organic compounds.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge
E. Suctoria
F. None of the Above

44. The second and third groups of bugs are microorganisms known as the free-swimming and stalked ciliates. These larger bugs eat the bacteria and are heavy enough to______________.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Settle by gravity
F. None of the Above

45. The fourth group is a microorganism, known as ____________, which feeds on the larger bugs and assists with settling.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Activated sludge systems
E. Suctoria
F. None of the Above

46. The interesting thing about the bacteria that eat the _________________ is they have no mouths.
A. Perturbations
B. Oxygen demand
C. Flow peaks
D. Dissolved organics
E. Suctoria
F. None of the Above

47. The bacteria have an interesting property, their "_______________" are stored on the outside of their bodies. This fat layer is sticky and is what the organics adhere to.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

48. Once the bacteria have "___________" their food, they start the digestion process.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

49. A chemical enzyme is sent out through the cell wall to break up the __________.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

50. This enzyme, known as ______________, breaks the organic molecules into small units which are able to pass through the cell wall of the bacteria.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

51. In wastewater treatment, this process of using bacteria-eating bugs in the presence of oxygen to reduce the organics in water is called _______________.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

52. The first step in the process, the contact of the bacteria with the ____________, takes about 20 minutes.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

53. The second step is the breaking up, ingestion and________, which takes four to 24 hours.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Digestion processes
E. Hydrolytic enzyme
F. None of the Above

54. The fat storage property of the bacteria is also an asset in settling. As the bugs "_____" into each other, the fat on each of them sticks together and causes flocculation of the non-organic solids and biomass.
A. Bump
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

55. From the aeration tank, the wastewater, now called mixed liquor, flows to a secondary clarification basin to allow the _______________to settle out of the water.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Flocculated biomass of solids
F. None of the Above

56. The solids biomass, which is the _____________, contains millions of bacteria and other microorganisms, is used again by returning it to the influent of the aeration tank for mixing with the primary effluent and ample amounts of air.
A. Fat reserves
B. Contacted
C. Organic compounds
D. Activated sludge
E. Hydrolytic enzyme
F. None of the Above

Paramecium sp.
57. Paramecium is a medium to large size (100-300 -m) swimming ciliate, commonly observed in_______________, sometimes in abundant numbers.
A. Activated sludge
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Swarmer
F. None of the Above

58. The body is either foot-shaped or cigar-shaped, and somewhat flexible. Paramecium is uniformly ciliated over the entire body surface with____________.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Longer cilia tufts at the rear of the cell
F. None of the Above

59. Paramecium swims with a _____________. It may also be seen paired up with another Paramecium which makes a good diagnostic key.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Swarmer
F. None of the Above

60. The cell has either one or two large water cavities which are also identification tools. This swimmer moves freely in the water column as it ______________.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Swarmer
F. None of the Above

61. It has a _________________used to trap bacteria and form the food cavities that move throughout the body as digestion occurs.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Large feeding groove
D. Stalked ciliate
E. Swarmer
F. None of the Above

62. Paramecium is described as a _______________ because its cilia move and filter bacteria from the water.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Swarmer
F. None of the Above

Vorticella sp.
63. Vorticella is a ___________. There are at least a dozen species found in activated sludge ranging in length from about 30 to 150 -m.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Swarmer
F. None of the Above

64. These organisms are oval to round shaped, have a____________, a domed feeding zone, and a water vacuole located near the terminal end of the feeding cavity.
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Contractile stalk
F. None of the Above

65. One organism is found on each stalk except during cell division. After reproducing, the offspring develops a band of swimming cilia and goes off to form its own stalk. The evicted organism is called a "______________."
A. Smooth gliding motion
B. Engulfs suspended bacteria
C. Filter-feeding ciliate
D. Stalked ciliate
E. Swarmer
F. None of the Above

66. Vorticella feeds by producing a_____________with its feeding cilia.
A. Contracting stalk
B. Vortex
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

67. The _____________ into its gullet. Vorticella's principal food source is suspended bacteria.
A. Contracting stalk
B. Vortex draws bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

68. The ________________ provides some mobility to help the organism capture bacteria and avoid predators.
A. Contracting stalk
B. Vortex draws bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

69. The ___________ resembles a coiled spring after its rapid contraction. Indicator: If treatment conditions are bad, for example low DO or toxicity, Vorticella will leave their stalks.
A. Stalk
B. Vortex draws bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

70. A bunch of empty ____________ indicates poor conditions in an activated sludge system. Vorticella sp. are present when the plant effluent quality is high.
A. Stalks
B. Vortex draws bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

Euglypha sp.
71. Euglypha (70-100 -m) is a shelled (testate) amoeba. _______________have jelly-like bodies. Motion occurs by extending a portion of the body (pseudopodia) outward.
A. Contracting stalk
B. Vortex draws bacteria
C. 150 oval plates
D. Amoebas
E. Pseudopodia
F. None of the Above

72. ________________have a rigid covering which is either secreted or built from sand grains or other extraneous materials.
A. Contracting stalk
B. Vortex draws bacteria
C. Shelled amoebas
D. Shark teeth
E. Pseudopodia
F. None of the Above

73. The _____________of this Euglypha sp. consists of about 150 oval plates. Its spines project backward from the lower half of the shell.
A. Secreted shell
B. Vortex draws bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

74. Euglypha spines may be single or in groups of two or three. The shell has an opening surrounded by _________________that resemble shark teeth under very high magnification.
A. Contracting stalk
B. Vortex draws bacteria
C. 8-11 plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

75. The shell of Euglypha is often transparent, allowing the hyaline (watery) body to be seen inside the shell. The ____________extend outward in long, thin, rays when feeding or moving.
A. Contracting stalk
B. Vortex draws bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

76. Euglypha primarily eats ______________.
A. Contracting stalk
B. Bacteria
C. 150 oval plates
D. Shark teeth
E. Pseudopodia
F. None of the Above

77. Shelled amoebas are common in soil, treatment plants, and stream bottoms where decaying organic matter is present. They adapt to a wide range of conditions and therefore are not good ______________.
A. Rotifer
B. Bacteria
C. Shelled amoebas
D. Indicator organisms
E. Euchlanis
F. None of the Above

Euchlanis sp.
78. This microscopic animal is a typical ___________________.
A. Rotifer
B. Bacteria
C. Shelled amoebas
D. Corona
E. Euchlanis
F. None of the Above

79. ________________ is a swimmer, using its foot and cilia for locomotion. In common with other rotifers, it has a head rimmed with cilia, a transparent body, and a foot with two strong swimming toes.
A. Rotifer
B. Bacteria
C. Shelled amoebas
D. Corona
E. Euchlanis
F. None of the Above

80. The head area, called the "_________," has cilia that beat rhythmically, producing a strong current for feeding or swimming.
A. Rotifer
B. Bacteria
C. Shelled amoebas
D. Corona
E. Euchlanis
F. None of the Above

81. Euchlanis is an omnivore, meaning that its varied diet includes detritus, bacteria, and small ____________.
A. Rotifer
B. Bacteria
C. Shelled amoebas
D. Protozoa
E. Euchlanis
F. None of the Above

82. _____________ has a glassy shell secreted by its outer skin. The transparent body reveals the brain, stomach, intestines, bladder, and reproductive organs.
A. Rotifer
B. Bacteria
C. Shelled amoebas
D. Corona
E. Euchlanis
F. None of the Above

83. A characteristic of rotifers is their_________________, which is a jaw-like device that grinds food as it enters the stomach. At times the action of the mastax resembles the pulsing action of a heart.
Rotifers, however, have no circulatory system.

A. Rotifers D. Corona
B. Mastax E. Euchlanis
C. Shelled amoebas F. None of the Above

84. Rotifers, however, have no_________________.

A. Rotifers D. Corona
B. Bacteria E. Circulatory system
C. Shelled amoebas F. None of the Above

85. Euchlanis is commonly found in activated sludge when effluent quality is good. It requires a continual supply of dissolved oxygen, evidence that _______________have been sustained.

A. Rotifer D. Corona
B. Aerobic conditions E. Euchlanis
C. Shelled amoebas F. None of the Above

Bacteria Section

86. Some bacteria are basically rods but instead of being straight they are twisted, bent or curved, sometimes in a spiral. These bacteria are called spirilla (singular spirillum). _________ are tightly coiled up bacteria.

A. Rods D. Clumps, chains or planes
B. Bacteria E. Spirochaetes
C. Biofilm F. None of the Above

87. Bacteria are friendly creatures; you never find one bacteria on its own. They tend to live together in clumps, chains or planes. When they live in chains, one after the other, they are called ________________- these often have long thin cells.

A. Rods D. Clumps, chains or planes
B. Bacteria E. Filamentous bacteria
C. Biofilm F. None of the Above

88. When they tend to collect in a plane or a thin layer over the surface of an object, they are called a __________________.

A. Rods D. Clumps, chains or planes
B. Bacteria E. BOD
C. Biofilm F. None of the Above

89. Many bacteria exist as a ________________ and the study of biofilms is very important. Biofilm bacteria secrete sticky substances that form a sort of gel in which they live. The plaque on your teeth that causes tooth decay is a biofilm.

A. Rods D. Clumps, chains or planes
B. Bacteria E. BOD
C. Biofilm F. None of the Above

Filamentous Bacteria

90. Filamentous Bacteria are a type of ____________that can be found in a wastewater treatment system.

A. Facultative D. Long thread-like strands
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

91. They function similar to floc forming bacteria since they degrade ____________ quite well. In small amounts, they are quite good to a biomass.
A. Facultative D. Long thread-like strands
B. Bacteria E. BOD
C. Anaerobic bacteria F. None of the Above

92. They can add stability and a backbone to the _________________that keeps the floc from breaking up or shearing due to turbulence from pumps, aeration or transfer of the water. In large amounts they can cause many problems.
A. Facultative D. Long thread-like strands
B. Bacteria E. Floc structure
C. Anaerobic bacteria F. None of the Above

93. Filaments are bacteria and fungi that grow in _________________ or colonies.
A. Facultative D. Long thread-like strands
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

Site Specific Bacteria
94. Aeration and biofilm building are the key operational parameters that contribute to the efficient degradation of organic matter (________________).
A. Facultative D. Long thread-like strands
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

95. Over time, the application-specific _____________ become site-specific as the biofilm develops and matures and is even more efficient in treating the site-specific waste stream.
A. Facultative D. Long thread-like strands
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

Facultative Bacteria
96. Most of the bacteria absorbing the ______________in a wastewater treatment system are facultative in nature. This means they are adaptable to survive and multiply in either anaerobic or aerobic conditions.
A. Facultative D. Organic material
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

97. The nature of ____________is dependent upon the environment in which they live.
A. Facultative D. Long thread-like strands
B. Individual bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

98. Usually, _______________will be anaerobic unless there is some type of mechanical or biochemical process used to add oxygen to the wastewater.
A. Facultative bacteria D. Long thread-like strands
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above

99. When bacteria are in the process of being transferred from one environment to another, the metamorphosis from _________________(and vice versa) takes place within a couple of hours.
A. Facultative D. Anaerobic to aerobic state
B. Bacteria E. BOD/COD removal
C. Anaerobic bacteria F. None of the Above
Anaerobic Bacteria

100. __________________live and reproduce in the absence of free oxygen. They utilize compounds such as sulfates and nitrates for energy and their metabolism is substantially reduced.
A. Organic material
B. Bacteria
C. Anaerobic bacteria
D. Free oxygen
E. BOD/COD removal
F. None of the Above

101. In order to remove a given amount of __________________in an anaerobic treatment system, the organic material must be exposed to a significantly higher quantity of bacteria and/or detained for a much longer period of time.
A. Organic material
B. Bacteria
C. Anaerobic process
D. Free oxygen
E. BOD/COD removal
F. None of the Above

102. A typical use for anaerobic bacteria would be in a septic tank. The slower metabolism of the anaerobic bacteria dictates that the wastewater be held several days in order to achieve even a nominal 50% reduction in __________________.
A. Organic material
B. Bacteria
C. Anaerobic process
D. Free oxygen
E. BOD/COD removal
F. None of the Above

103. That is why septic tanks are always followed by some type of effluent treatment and disposal process. The advantage of using the __________________is that electromechanical equipment is not required.
A. Organic material
B. Bacteria
C. Anaerobic process
D. Free oxygen
E. BOD/COD removal
F. None of the Above

104. ______________________release hydrogen sulfide as well as methane gas, both of which can create hazardous conditions. Even as the anaerobic action begins in the collection lines of a sewer system, deadly hydrogen sulfide or explosive methane gas can accumulate and be life threatening.
A. Organic material
B. Anaerobic bacteria
C. Anaerobic process
D. Free oxygen
E. BOD/COD removal
F. None of the Above

Aerobic Bacteria
105. Aerobic bacteria live and multiply in the presence of free oxygen. _________________ always achieve an aerobic state when oxygen is present.
A. Organic material
B. Bacteria
C. Anaerobic process
D. Facultative bacteria
E. BOD/COD removal
F. None of the Above

106. While the name "_________________" implies breathing air, dissolved oxygen is the primary source of energy for aerobic bacteria. The metabolism of aerobes is much higher than for anaerobes. This increase means that 90% fewer organisms are needed compared to the anaerobic process, or that treatment is accomplished in 90% less time.
A. Aerobic
B. Aerobic digestion
C. Anaerobic process
D. Activated sludge process
E. BOD/COD removal
F. None of the Above

107. This provides a number of advantages including a higher percentage of organic removal. The by-products of _______________________ are carbon dioxide and water.
A. Aerobic bacteria
B. Aerobic digestion
C. Anaerobic process
D. Activated sludge process
E. BOD/COD removal
F. None of the Above

108. ______________________ live in colonial structures called floc and are kept in suspension by the mechanical action used to introduce oxygen into the wastewater. This mechanical action exposes the floc to the organic material while treatment takes place.
A. Aerobic bacteria
B. Aerobic digestion
C. Anaerobic process
D. Activated sludge process
E. BOD/COD removal
F. None of the Above

109. Following digestion, a gravity clarifier separates and settles out the floc. Because of the mechanical nature of the ____________________ process, maintenance and operator oversight are required.
A. Aerobic bacteria
B. Aerobic digestion
C. Anaerobic process
D. Activated sludge process
E. BOD/COD removal
F. None of the Above

Protozoans and Metazoans

110. In a wastewater treatment system, the next higher life form above bacteria is protozoans. These single-celled animals perform three significant roles in the ____________ process.
A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoans
E. BOD/COD removal
F. None of the Above

111. These include floc formation, cropping of __________ and the removal of suspended material.
A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoans
E. BOD/COD removal
F. None of the Above

112. _______________ are also indicators of biomass health and effluent quality. Because protozoans are much larger in size than individual bacteria, identification and characterization is readily performed.
A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoans
E. BOD/COD removal
F. None of the Above

113. ________ are very similar to protozoans except that they are usually multi-celled animals.
A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoans
E. BOD/COD removal
F. None of the Above

114. ________________, such as nematodes and rotifers, are typically found only in a well-developed biomass.
A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoans
E. Macroinvertebrates
F. None of the Above

115. The presence of __________________and metazoans and the relative abundance of certain species can be a predictor of operational changes within a treatment plant.
A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoans
E. BOD/COD removal
F. None of the Above

116. In this way, an operator is able to make adjustments and minimize negative operational effects simply by observing changes in the _____________ and metazoan population.

A. Bacteria
B. Metazoans
C. Activated sludge
D. Protozoan
E. BOD/COD removal
F. None of the Above

Dispersed Growth

117. ______________ is material suspended within the activated sludge process that has not been adsorbed into the floc particles.

A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Secondary clarifier
E. Organic and inorganic particulate material
F. None of the Above

118. This material consists of very small quantities of colloidal (too small to settle out) bacteria as well as _________________________.

A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Secondary clarifier
E. Organic and inorganic particulate material
F. None of the Above

119. While a small amount of dispersed growth between the floc particles is normal, excessive amounts can be carried through a _______________. When discharged from the treatment plant, dispersed growth results in higher effluent solids.

A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Secondary clarifier
E. Organic and inorganic particulate material
F. None of the Above

Process Indicators

120. Following taxonomic identification, enumeration and evaluation of the characteristics of the various _________________________present in a wastewater sample, the information can be used to draw conclusions regarding the treatment process.

A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Secondary clarifier
E. Organisms and structures
F. None of the Above

121. A _______________________indicates immature floc, as would be found during start-up or a process recovery.

A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Secondary clarifier
E. Spherical floc particle
F. None of the Above

122. A _______________of irregular shape indicates the presence of a beneficial quantity of filamentous organisms and good quality effluent.

A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Mature floc particle
E. Organic and inorganic particulate material
F. None of the Above

123. An excess of dispersed growth could indicate a very young sludge, the presence of toxic material, __________________or an extended period of time at low dissolved oxygen levels.

A. Effluent of high quality
B. Excess mechanical aeration
C. Dispersed growth
D. Secondary clarifier
E. Organic and inorganic particulate material
F. None of the Above

124. Certain protozoans, such as _______________dominate during a system start-up. Free swimming ciliates are indicative of a sludge of intermediate health and an effluent of acceptable or satisfactory quality.
A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Amoebae and flagellates
E. Organic and inorganic particulate material
F. None of the Above

125. A predominance of crawling ciliates, stalked ciliates and metazoans is an indicator of sludge with _________________.
A. Effluent of high quality
B. Spherical floc particle
C. Dispersed growth
D. Excellent health and an effluent of high quality
E. Organic and inorganic particulate material
F. None of the Above

Activated Sludge

126. Aerobic flocs in a healthy state are referred to as activated sludge. While aerobic floc has a metabolic rate approximately 10 times higher than anaerobic sludge, it can be increased even further by exposing the bacteria to ________________.
A. Sludge
B. Overall process efficiency
C. Organic material
D. An abundance of oxygen
E. Filamentous organisms or Bacteria
F. None of the Above

127. Compared to a septic tank, which takes several days to reduce the organic material, an activated _____________can reduce the same amount of organic material in approximately 4-6 hours.
A. Sludge tank
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Filamentous organisms
F. None of the Above

128. This allows a much higher degree of _____________. In most cases, treatment efficiencies and removal levels are so much improved that additional downstream treatment components are dramatically reduced or totally eliminated.
A. Sludge
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Filamentous organisms or Bacteria
F. None of the Above

129. Problems may appear during the operation of activated sludge systems, including:
High solids content in clarified effluent, which may be due to too high or too low solids retention time and to growth of__________________.
A. Sludge
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Filamentous microorganisms
F. None of the Above

130. Rising sludge, occurring when sludge that normally settles rises back to the surface after having settled. In most cases, this is caused by the denitrification process, where nitrate present in the effluent is reduced to nitrogen gas, which then becomes trapped in the ____________ causing this to float.
A. Sludge
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Filamentous organisms or Bacteria
F. None of the Above

131. This problem can be reduced by decreasing the flow from the aeration basin to the settling tank or reducing the sludge resident time in the settler, either by increasing the rate of recycle to the aeration basin, increasing the rate of sludge collection from the bottom, or increasing the _____________from the system.
A. Sludge wasting rate
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Filamentous organisms or Bacteria
F. None of the Above

132. Bulking sludge, that which settles too slowly and is not compactable, caused by the predominance of _______________________.
A. Sludge
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Filamentous organisms
F. None of the Above

133. This problem can be due to several factors of which the most common are nutrient balance, wide fluctuations in organic load, __________________(too low levels), and an improper sludge recycle rate.
A. Sludge
B. Oxygen limitation
C. Organic material
D. Aeration basin
E. Filamentous organisms or Bacteria
F. None of the Above

134. Insufficient reduction of organic load, probably caused by a low solids retention time, insufficient amount of nutrients such as _____________(rare in fisheries wastewaters), short-circuiting in the settling tank, poor mixing in the reactor and insufficient aeration or presence of toxic substances.
A. Sludge
B. Overall process efficiency
C. P or N
D. Aeration basin
E. Filamentous organisms or Bacteria
F. None of the Above

135. Odors, caused by ______________in the settling tanks or insufficient aeration in the reactor.
A. Sludge
B. Overall process efficiency
C. Organic material
D. Aeration basin
E. Anaerobic conditions
F. None of the Above

Filamentous Organisms
136. The majority of ______________ are bacteria, although some of them are classified as algae, fungi or other life forms. There are a number of types of filamentous bacteria which proliferate in the activated sludge process.
A. Sludge
B. Mass
C. Interfloc bridging
D. Larger floc particles
E. Filamentous organisms
F. None of the Above

137. Filamentous organisms perform several different roles in the process, some of which are beneficial and some of which are detrimental. When __________ are in low concentrations in the process, they serve to strengthen the floc particles.
A. Sludge
B. Mass
C. Interfloc bridging
D. Larger floc particles
E. Filamentous organisms
F. None of the Above

138. This effect reduces the amount of shearing in the mechanical action of the aeration tank and allows the ______________to increase in size.
A. Sludge
B. Mass
C. Interfloc bridging
D. Floc particles
E. Filamentous organisms or Bacteria
F. None of the Above

139. _______________ are more readily settled in a clarifier. Larger floc particles settling in the clarifier also tend to accumulate smaller particulates (surface adsorption) as they settle producing an even higher quality effluent.
A. Sludge
B. Mass
C. Interfloc bridging
D. Larger floc particles
E. Filamentous organisms or Bacteria
F. None of the Above

140. If the filamentous organisms reach too high a concentration, they can extend dramatically from the floc particles and tie one floc particle to another (_____________) or even form a filamentous mat of extra-large size.
A. Sludge
B. Mass
C. Interfloc bridging
D. Larger floc particles
E. Filamentous organisms or Bacteria
F. None of the Above

141. Due to the increased surface area without a corresponding increase in mass, the _____________will not settle well.
A. Activated sludge
B. Mass
C. Interfloc bridging
D. Larger floc particles
E. Filamentous organisms or Bacteria
F. None of the Above

142. This results in less solids separation and may cause a washout of solid material from the system. In addition, air bubbles can become trapped in the mat and cause it to float, resulting in a ______________________.
A. Floating scum mat
B. Mass
C. Interfloc bridging
D. Organic material
E. Filamentous organisms or Bacteria
F. None of the Above

143. Due to the high surface area of the _________________ once they reach an excess concentration, they can absorb a higher percentage of the organic material and inhibit the growth of more desirable organisms.
A. Floating scum mat
B. Mass
C. Interfloc bridging
D. Organic material
E. Filamentous Bacteria
F. None of the Above

Filamentous Bacteria Identification

144. Filamentous Identification should be used as a tool to monitor the health of the ____________when a filament problem is suspected.
A. Floating scum mat
B. Biomass
C. Interfloc bridging
D. Organic material
E. Filamentous organisms or Bacteria
F. None of the Above

145. Filamentous Identification is used to determine the type of ___________present so that a cause can be found and corrections can be made to the system to alleviate future problems.
A. Floating scum mat
B. Mass
C. Filaments
D. Organic material
E. Filamentous organisms or Bacteria
F. None of the Above

146. All ____________ usually have a process control variation associated with the type of filament present that can be implemented to change the environment present and select out for floc forming bacteria instead.
A. Floating scum mat
B. Mass
C. Interfloc bridging
D. Organic material
E. Filamentous Bacteria
F. None of the Above

147. Killing the filaments with chlorine or peroxide will temporarily remove the filaments, but technically it is a band-aid. A process change must be made or the __________will return with time eventually.

A. Floating scum mat D. BOD
B. Mass or Sponge E. Activated sludge process
C. Filaments F. None of the Above

Filamentous Identification

148. Filaments can be internal or external, and they can be free of the __________or found intertwined in the floc.

A. Floating scum mat D. Floc structures
B. Mass or Sponge E. Activated sludge process
C. Filaments F. None of the Above

149. Most labs think that filaments need to be extending from the floc in order to be a problem. This is not true. Internal filaments can cause more problems than____________.

A. Floating scum mat D. External filaments
B. Mass or Sponge E. Activated sludge process
C. Filaments F. None of the Above

150. Think of internal filaments causing a structure like a sponge. It will retain water easily and be harder to dewater, will be hard to compress and will take up more space, thereby increasing ________________.

A. Floating scum mat D. Solids handling costs
B. Mass or Sponge E. Activated sludge process
C. Filaments F. None of the Above

151. ______________ present in the system do not always mean there is a problem. Some filaments are good if they form a strong backbone and add a rigid network to the floc. They help give the floc more structure and settle faster.

A. Floating scum mat D. BOD
B. Mass E. Activated sludge process
C. Filaments F. None of the Above

152. Filaments are good ______________also. They are only a problem when they become dominant. If filament abundance is in the abundant or excessive range, having a Filamentous Identification performed is recommended.

A. Floating scum mat D. BOD degraders
B. Mass or Sponge E. Activated sludge process
C. Filaments F. None of the Above

153. The activated sludge process was invented around 1914 and is today still the most commonly used biological wastewater treatment process. This widespread use is due to the fact that ______________ can be a rather easy process to implement and one that can attain high treatment efficiency.

A. Floating scum mat D. BOD
B. Mass or Sponge E. Activated sludge
C. Filaments F. None of the Above

154. Nocardia amarae, a common cause of disruptive foaming in waste treatment plants, is a slow growing, usually gram-positive, chemoautotrophic, __________, strict aerobe that produces the biosurfactant trehalose.

A. Floating scum mat D. BOD
B. Mass or Sponge E. Activated sludge process
C. Filamentous F. None of the Above

155. ________________can be brown, pink, orange, red, purple, gray or white, so color alone is not a key to identifying this species. N. amarae, member of the Actinomycetes family, is not motile, so it relies on movement of the water to carry it through the system.
A. Floating scum mat
B. Mass or Sponge
C. Colonies
D. BOD
E. Activated sludge process
F. None of the Above

156. It produces_________________, urease and nitrate reductase enzymes, but not casease. The foam from Nocardia amarae is usually a viscous brown color unless algae are entrapped in it, in which case it appears green and brown.
A. Floating scum mat
B. Catalase
C. Filaments
D. BOD
E. Activated sludge process
F. None of the Above

157. ____________________is yet another common cause of disruptive foaming in waste treatment plants, motile in its Hormogonia and sometimes Trichome phases.
A. Mixotrophic
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Nostocoida limicola
F. None of the Above

158. This __________________________often forms a confluent gel encasing flattened discs or large sheets of cells, forming symbiotic relationships with other species.
A. Mixotrophic
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Oxygenic phototrophic species
F. None of the Above

159. Staining gram-positive, _____________ produces round cells within tight coil formations. Nostocoida can also be dentified by their starburst effect formations using phase contrast microscopy at 400 to 1000x magnification. After chlorination, a few dead cells sticking out identify stress to this species.
A. Mixotrophic
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Nostocoida
F. None of the Above

Thiothrix

160. Thiothrix spp., the second most common cause of disruptive foaming in wastewater treatment plants appears as straight to slightly curved cells with rectangular shape form filaments up to 500 microns in length, in multicellular rigid filaments, staining gram-negative, with obligately ____________.
A. Mixotrophic
B. Thiothrix
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Aerobic respiration
F. None of the Above

161. Thiothrix are _____________, using several small organic carbons and reduced inorganic sulfur sources for growth and energy.
A. Mixotrophic
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Obligately aerobic respiration
F. None of the Above

162. Thiothrix I is one of the _______________found using phase contrast microscopy at 400 to 1000x magnification.
A. Mixotrophic
B. Largest filament
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Obligately aerobic respiration
F. None of the Above

163. Thiothrix II produces rectangular filaments up to 200 microns in length and is easily identified by their ________________using phase contrast microscopy at 400 to 1000x magnification.
A. Mixotrophic D. Starburst effect formations
B. Thiothrix I E. Obligately aerobic respiration
C. Microthrix parvicella F. None of the Above

Microthrix parvicella
164. Microthrix parvicella is another common cause of ______________in waste treatment plants, producing filaments up to 400 microns in length, easily visualized by phase contrast microscopy at 400x magnification.
A. Mixotrophic D. Sphaeroliticus natans
B. Disruptive foaming E. Obligately aerobic respiration
C. Microthrix parvicella F. None of the Above

165. This species is usually found outside floc, ___________in the system, but can also be found hanging out of the floc.
A. Mixotrophic D. Tangling with structures
B. Thiothrix I E. Obligately aerobic respiration
C. Microthrix parvicella F. None of the Above

Sphaeroliticus natans
166. Sphaeroliticus natans is another filamentous species, and yet it is reputed to increase settleability by_________________, increasing surface area.
A. Mixotrophic D. Sphaeroliticus natans
B. Thiothrix I E. Obligately aerobic respiration
C. Branching between flocs F. None of the Above

167. Cells are straight to___________, up to 1000 microns in length and stain gram-negative. These large cells can be easily visualized by phase contrast microscopy at 100x magnification.
A. Mixotrophic D. Sphaeroliticus natans
B. Slightly curved E. Obligately aerobic respiration
C. Microthrix parvicella F. None of the Above

168. Certain conditions favor the proliferation of filamentous species. A _____________ratio favors filamentous organisms, because their higher ratio of surface area to volume provides them with a selective advantage for securing nutrients in nutrient limited environments.
A. Mixotrophic D. Sphaeroliticus natans
B. Thiothrix I E. Low F/M (food to mass)
C. Microthrix parvicella F. None of the Above

169. When a plant runs___________, the slower growing filaments have a better chance to establish a strong colony.
A. Mixotrophic D. Sphaeroliticus natans
B. Thiothrix I E. An extremely long sludge age
C. Microthrix parvicella F. None of the Above

170. As a strict aerobe, high levels of oxygen are necessary to sustain this species. __________ thrives in temperatures from 17 to 37 deg. C.
A. Mixotrophic D. Sphaeroliticus natans
B. Thiothrix I E. Mesophilic, Nocardia amarae
C. Microthrix parvicella F. None of the Above

171. The presence of high levels of fats, oils and greases or hydrocarbons and phenols, can encourage this species, particularly when insufficient levels of ____________are present to balance these carbon sources.
A. Mixotrophic
B. Thiothrix I
C. Microthrix parvicella
D. Nitrogen and phosphorus
E. Mesophilic, Nocardia amarae
F. None of the Above

Filamentous Bacteria

172. A problem that often frustrates the performance of __________ is bulking sludge due to the growth of filamentous bacteria.
A. Microthrix
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Activated sludge
F. None of the Above

173. Sludge bulking can often be solved by careful process modifications. However, different filamentous bacteria such as Microthrix, _____________, Nostocoida, Thiothrix or ”Type 021N” and others cause bulking for very different reasons.
A. Microthrix
B. Thiothrix I
C. Thiothrix II
D. Sphaerotilus
E. Mesophilic, Nocardia amarae
F. None of the Above

174. Many _________________have not even been given a scientific name yet. Consequently, in order to make the right kind of process modification, knowledge to identify them and experience with the process ecology are required.
A. Microthrix
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Filamentous species
F. None of the Above

175. The potential for instability with _________ is an acute problem when strict demands on treatment performance are in place.
A. Microthrix
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Activated sludge
F. None of the Above

PAX - finally, a Fix for Microthrix

176. If you ever experienced an overgrowth of ___________ in your activated sludge plant, you will be aware that it can be very difficult to either eradicate or control.
A. Thiothrix II
B. Thiothrix I
C. Microthrix parvicella
D. Sphaeroliticus natans
E. Activated sludge
F. None of the Above

177. ____________is the most common cause of bulking and foaming in activated sludge plants, and it appears either essentially alone or in the company of other filaments.
A. Microthrix
B. Thiothrix I
C. Thiothrix II
D. Sphaeroliticus natans
E. Activated sludge
F. None of the Above

178. Microthrix foams appear in many of the photographs of aeration basins and clarifiers I have collected all over the world, and many of the plant tours on the Internet show the same brown stable scums associated with this organism. Let's face it, _________is just about everywhere.
A. Microthrix
B. Thiothrix I
C. Thiothrix II
D. Sphaeroliticus natans
E. Activated sludge
F. None of the Above

Microthrix is your enemy - Get to know it!

179. Microthrix fits into the filamentous bacterial classification of___________, which means that it tends to appear in plants with long sludge ages.

A. D.O. levels D. MCRT
B. Thiothrix II E. Low F/M
C. Microthrix parvicella F. None of the Above

180. Lackay et al. (1999) suggested that M. parvicella and its low F/M compatriots ___________, and types 0092, 0041, 1851, 0803 were also encouraged to the point of maximum proliferation by alternating anoxic-aerobic conditions (particularly 30-40% aerobic and 60-70% anoxic).

A. Haliscomenobacter hydrossis D. MCRT
B. Thiothrix I E. Activated sludge
C. Microthrix parvicella (M. parvicella) F. None of the Above

181. Modern plants incorporating denitrification and/or phosphorus removal are obvious candidates for bulking and foaming due to_______________.

A. D.O. levels D. MCRT
B. Thiothrix I E. Activated sludge
C. Microthrix F. None of the Above

182. Of all the filaments creating difficulties in activated sludge plants, it is one of the most easily recognized, but there is a commercial test kit available which uses fluorescent situ hybridization (or "______________") to permit visual identification should one feel the need.

A. FISH D. MCRT
B. Thiothrix I E. Activated sludge
C. Microthrix parvicella (M. parvicella) F. None of the Above

183. The design of plants can play a significant part in the proliferation of scums and foams and there are many common mistakes in plant design which assist organisms like Microthrix by retaining floating masses in dead areas of the plant which have very high ___________values and continuously reseed the biomass.

A. D.O. levels D. MCRT
B. Thiothrix I E. Activated sludge
C. Microthrix parvicella (M. parvicella) F. None of the Above

184. Similarly poor mixing, poorly designed and inadequate aeration systems, cyclic overloading and low process __________ can contribute to the creation of anoxic and anaerobic zones in what are supposed to be aeration basins.

A. D.O. levels D. MCRT
B. Thiothrix I E. Activated sludge
C. Microthrix parvicella (M. parvicella) F. None of the Above

Current Remedial Techniques

185. Jenkins et al. (1993) presented sludge chlorination as a method of choice in the United States to combat filamentous bulking due to any organism. The success of treatment of Microthrix in mixed liquor or foams is poor, due it is believed to resistant filamentous bacteria with hydrophobic cell walls such as M. parvicella and_________________.

A. D.O. levels D. Nostocoida limicola
B. Thiothrix I E. Activated sludge
C. Microthrix parvicella (M. parvicella) F. None of the Above

186. Lakay et al. (1988) obtained only a partial elimination of _____________ bacteria at a high chlorine dose. Hwang and Tanaka found in batch tests that M. parvicella remained intact at very high chlorine doses, while the microbial flocs were completely destroyed.
A. D.O. levels D. MCRT
B. Thiothrix I E. Activated sludge
C. Microthrix parvicella (M. parvicella) F. None of the Above

187. Saayman et al. (1996) examined the use of non-specific chemical treatment in a _________ and assessed the effects of biomass settling characteristics and other operational parameters.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. BNR plant F. None of the Above

188. While chlorine use was the most effective, it was reported to damage the biomass and cause difficulties in the ____________when dosed at high levels, while ozone and peroxide were less effective in treating settling problems but less of a problem to the biomass.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. P removal process F. None of the Above

189. In recent times the introduction of selectors has been hailed as a major initiative in the control and elimination of filamentous bacteria (bulking and foaming) and the maintenance of ________________.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Moderate biomass SVIs
C. Microthrix parvicella (M. parvicella) F. None of the Above

190. Evidence on the performance of selectors in controlling low ________________ has been described as both controversial and ambiguous and, in the Netherlands, despite incorporating over 80 selectors in full-scale plants, the percentage of plants with bulking associated with Microthrix parvicella was unchanged.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Microthrix parvicella (M. parvicella) F. None of the Above

191. Other experiences with the aerobic selector showed only little success in controlling the growth of M. parvicella in the presence of________, and a comparison of anoxic selectors at five plants in the US has demonstrated that performance and effectiveness varied significantly.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Long chain fatty acids (LCFA) F. None of the Above

More on Microthrix
192. Mamais et al. 1998 examined the effect of factors such as temperature, substrate type (easily biodegradable in the form of acetate and slowly biodegradable in the form of oleic acid) on ______________ growth using complete mix with and without selectors (anoxic and anaerobic) and plug flow reactors.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Microthrix parvicella (M. parvicella) F. None of the Above

193. The results indicate that low temperatures and substrates in the form of long chain fatty acids favor the growth of ____________________.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Microthrix parvicella (M. parvicella) F. None of the Above

194. The plug flow configuration was shown to be quite effective in controlling the growth of M. parvicella and producing a sludge with good settling characteristics, while the presence of a selector, either_______________, had no significant effect on the growth of M. parvicella.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Microthrix parvicella (M. parvicella) F. None of the Above

195. Maintenance of low sludge ages (5) days has also been reported to eliminate ___________ because it is a slow growing organism, but this is not always operationally possible.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Microthrix parvicella (M. parvicella) F. None of the Above

196. While it is often convenient to group filaments together, it does appear the ___________ has received special attention because of its ability to proliferate.
A. Anoxic and anaerobic D. MCRT
B. F/M filaments E. Bulking and foaming
C. Microthrix F. None of the Above

197. More selective investigation of Microthrix has indicated that it has quite well defined requirements. The nature of Microthrix is such that it has the capability of using long chain fatty acids (oleic acid) and their esters (_____________) (fats and oils) as sources of carbon and energy.
A. Lipids and LCFA D. MCRT
B. Triglycerides of palmitic and stearic acid E. Polyphosphate for energy
C. Microthrix parvicella (M. parvicella) F. None of the Above

198. ____________ are present in all domestic wastewater streams and often constitute a significant part of it. Values of 25-35% of the incoming COD have been reported, and it can support a substantial biomass production in a treatment plant.
A. Lipids and LCFA D. MCRT
B. F/M filaments E. Polyphosphate for energy
C. Microthrix parvicella (M. parvicella) F. None of the Above

199. __________ are generally easily consumed in activated sludge, and the consumption rate of LCFA under aerobic or anoxic conditions has been found to be rapid.
A. LCFA D. MCRT
B. F/M filaments E. Polyphosphate for energy
C. Microthrix parvicella (M. parvicella) F. None of the Above

200. Studies indicate that ___________consumes exclusively long chain fatty acids (LCFA), and that it is able to take up LCFA not only under aerobic, but also under anaerobic and anoxic conditions.
A. Lipids and LCFA D. MCRT
B. F/M filaments E. Polyphosphate for energy
C. Microthrix parvicella (M. parvicella) F. None of the Above

201. It has been reported that M. parvicella is able to out-compete other bacteria particularly well in alternating anaerobic-aerobic and anoxic activated sludge systems. This ability is based on a high uptake and storage capacity for ________ under anaerobic conditions and a subsequent use of the stored substrate for growth with oxygen (or nitrate) as electron acceptor.
A. LCFA
B. F/M filaments
C. Microthrix parvicella (M. parvicella)
D. MCRT
E. Polyphosphate for energy
F. None of the Above

202. Rosetti et al. (2002) carried out an extensive examination of ___________ and found that it was a very versatile organism which could store organic carbon under anaerobic conditions using stored polyphosphate for energy (like the organisms responsible for phosphorus removal).
A. Lipids and LCFA
B. F/M filaments
C. Microthrix parvicella (M. parvicella)
D. MCRT
E. Polyphosphate for energy
F. None of the Above

203. Once exposed to aerobic conditions it would recover rapidly and resume growing. Microthrix has a high storage capacity under all operating conditions (anaerobic, anoxic and anaerobic). It has a high "______________" or low Ks, which means it competes well at low substrate concentration.
A. Lipids and LCFA
B. F/M filaments
C. Microthrix parvicella (M. parvicella)
D. MCRT
E. Substrate affinity
F. None of the Above

204. Most interestingly, __________ has a maximum growth rate near 22° C, zero growth rate at 30° C and is capable of quite reasonably large growth rates at as low as 7° C which gives it a significant advantage in the competition with floc formers during winter in cold climates.
A. Lipids and LCFA
B. F/M filaments
C. Microthrix parvicella (M. parvicella)
D. MCRT
E. Polyphosphate for energy
F. None of the Above

PAX vs. Microthrix parvicella
205. Microthrix parvicella is well-equipped to survive, compete and dominate in all kinds of activated sludge systems. With all of the above in mind, it is pleasing to find that _____________ does have a weakness.
A. PAX or Poly aluminum chloride
B. F/M filaments
C. Microthrix parvicella (M. parvicella)
D. MCRT
E. MLSS concentration
F. None of the Above

206. That weakness is its apparent sensitivity to _______________ dosing, which seems to attack the ability of Microthrix parvicella to use lipids by reducing the activity of extracellular enzymes (lipases) on the surface of the organism rendering the organism relatively uncompetitive
A. PAX or Poly aluminum chloride
B. F/M filaments
C. Microthrix parvicella (M. parvicella)
D. MCRT
E. MLSS concentration
F. None of the Above

207. They also recommended the removal of the ______________before dosing to allow the concentration and time of dosage to be kept at a minimum.
A. PAX or Poly aluminum chloride
B. Morphological modification
C. Scum layer
D. MCRT
E. MLSS concentration
F. None of the Above

208. Removal of the floating sludge layer from the surface before starting _______ application was necessary to ensure specific and rapid impact of Al-salts on M. parvicella.

A. PAX or Poly aluminum chloride	D. MCRT
B. Morphological modification	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

209. In fact, the _____________represents an independent microbial system, into which aluminum can penetrate only at a limited extent.

A. PAX or Poly aluminum chloride	D. Stable floating sludge
B. Morphological modification	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

210. Dosage should be combined with high oxygen concentration in the aeration (i.e. above 2.5 mg/L) and the MLSS concentration low (i.e. under 2.5 g/L) since ______________ competes well at low oxygen levels.

A. PAX or Poly aluminum chloride	D. MCRT
B. Morphological modification	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

211. Of note was that the morphological properties of only __________ changed, apparently leaving the other filaments remaining unaffected.

A. PAX or Poly aluminum chloride	D. MCRT
B. Morphological modification	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

212. It was observed that by adding __________ a morphological modification of the filamentous bacterium M. parvicella occurs. The morphological modification is probably the reason why the hydrophobic property of the filaments decreases.

A. PAX or Poly aluminum chloride	D. MCRT
B. Morphological modification	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

PAX

213. PAX (or PAX-14 or polyaluminium chloride) used for ____________ control is a flocculant or coagulant commonly used in water and wastewater treatment.

A. PAX-14 (PAX) or Polyaluminum chloride	D. Sphaerotilus natans
B. Biomass	E. MLSS concentration
C. Microthrix	F. None of the Above

Proposed Treatment Regime

214. In the fall, to prevent the normal appearance of M.parvicella during the coming winter and to control problems with ___________(winter, spring). Dosage: 0.5-1.5g Al/kgSS/day usually added to return sludge.

A. PAX-14 (PAX) or Polyaluminum chloride	D. Sphaerotilus natans
B. Biomass	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

215. __________should be dosed continuously over the treatment period at the chosen level. Removal of floating sludge before and during dosing is recommended. Microscopic examination of the biomass and regular testing of biomass settling is also a very good idea and the dosing at the chosen remedial rate until a target SVI or preferably DSVI is reached should be the rule.

A. PAX-14 (PAX) or Polyaluminum chloride	D. Sphaerotilus natans
B. Biomass	E. MLSS concentration
C. Microthrix parvicella (M. parvicella)	F. None of the Above

Sphaerotilus natans

Description and Significance

216. _________________ is a filamentous bacterium that is covered in a tubular sheath and can be found in flowing water and in sewage and wastewater treatment plants.
A. PAX-14 (PAX) or Polyaluminum chloride
B. Biomass
C. Microthrix parvicella (M. parvicella)
D. Sphaerotilus natans
E. MLSS concentration
F. None of the Above

217. While this _____________sometimes clogs pipes and causes other similar problems, it does not cause major threat to wastewater treatment plants nor is it known to be pathogentic.
A. PAX-14 (PAX) or Polyaluminum chloride
B. Bacterium
C. Microthrix parvicella (M. parvicella)
D. Sphaerotilus natans
E. MLSS concentration
F. None of the Above

218. They can be rectangular when the cells are tightly packed within the sheath. The _____ are clear and easily observable with indentations.
A. PAX-14 (PAX) or Polyaluminum chloride
B. Biomass
C. Microthrix parvicella (M. parvicella)
D. Cell septa
E. MLSS concentration
F. None of the Above

219. Filaments radiate outward from the floc surface into the bulk solution and can cause sludge settling interference by____________________.
A. PAX-14 (PAX) or Polyaluminum chloride
B. Biomass
C. Inter-floc bridging
D. Sphaerotilus natans
E. MLSS concentration
F. None of the Above

220. The filament is usually____________________. There are no sulfur granules. Poly-ß-hydroxybutric acid (PHB) is frequently observed as dark intracellular granules.
A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. Gram negative and Neisser negative
E. MLSS concentration
F. None of the Above

221. In wastewater that is____________________, an exocellular slime coat may be present. Attached growth is usually uncommon, but may occur when at low growth rate.
A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. Nutrient deficient
E. MLSS concentration
F. None of the Above

222. This filament is usually found in environments where there is low _________ or low nutrients (Nor P).
A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. DO
E. MLSS concentration
F. None of the Above

Control

223. RAS chlorination can be used to get rid of the filaments but process changes should also be made. ________________occurs readily on this type of filament, although the empty sheaths still remain. Sludge wasting is necessary to remove them entirely from the system.
A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. Cell lysis
E. MLSS concentration
F. None of the Above

224. Manipulation of ______________concentration can be used to control the filaments. Nutrient deficient wastes can be checked by effluent values of residual NH3 and o-PO4 and should be supplemented if necessary.

A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. F/M and DO
E. MLSS concentration
F. None of the Above

Rank

225. ___________________ ranks 6th in number of predominance. Typically not found in pulp-mills with activated sludge.

A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. DO
E. MLSS concentration
F. None of the Above

Nostocoida limicola II Identification

226. Medium length, non-motile filaments (100-200 µm). Bent and irregularly coiled filaments with incidental true branching. Knots sometimes seen. _____________________with indentations. Cells are oval or disc shaped (1.2-1.4 µm).

A. Cell septa are clear
B. Biomass
C. Neisser staining properties
D. DO
E. MLSS concentration
F. None of the Above

227. Filaments are found within the floc structure but may occur in the_______________. The filament staining is variable, it is usually Gram negative but sometimes positive and Neisser positive.

A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. Bulk solution
E. MLSS concentration
F. None of the Above

228. Usually easy to identify due to its ______________. Stains entirely purple and looks like stacked discs (or hockey pucks). In industrial wastes, an organism that is Gram negative and Neisser negative occurs.

A. Sphaerotilus natans
B. Biomass
C. Neisser staining properties
D. DO
E. MLSS concentration
F. None of the Above

229. There is no sheath and there are no sulfur granules. ________________ granules are frequently observed as dark intracellular granules. Attached growth is usually uncommon. Three subtypes are known. Resembles M. parvicella except in its Neisser staining properties.

A. Starburst effect
B. Gram negative
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

Environment

230. This filament is usually found in environments where there is ______________and the presence of organic wastes. Wastes containing starch seem more selective to this filament. Bulking is more common in industrial wastes. The filament appears to be facultative fermentative, which is unique for most filaments.

A. Low DO or low F/M
B. Gram negative
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

Control

231. Manipulation of F/M (usually an increase) and ___________can be used to control the filaments. A selector may be used and chlorination. System changes include changing from a complete mix to plug flow aeration basin configuration.
A. Starburst effect
B. Gram negative
C. DO concentration
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

232. ____________ranks 12th in number of predominance in industry. Typically not found in kraft mills. Common in municipalities.
A. Starburst effect
B. Gram negative
C. Rosettes
D. N. limicola
E. Thiothrix I or Thiothrix II
F. None of the Above

Thiothrix I & II

233. Thiothrix species consist of two types of Thiothrix and they are ____________. Thiothrix filaments are straight or slightly curved with Thiothrix I having an overall length of 100-500 µm and individual cells having a rectangular shape (1.4-2.5 x 3-5 µm).
A. Starburst effect
B. Gram negative
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

234. Both types of Thiothrix are found stretching from the floc surface, there is a noticeable septa between cells. Both species are Gram negative and Neisser negative with cells that on occasions have_____________.
A. Starburst effect
B. Sulfur granules
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

235. There are additional structures on __________and they include apical gonidia as well as rosettes and a sheath is present, incidental attached growth may be observed. A holdfast may add to the characteristic of radiating out from a common center, the "starburst effect".
A. Starburst effect
B. Thiothrix trichomes
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

236. The filament staining is _________ or Gram variable when sulfur granules are present and Neisser negative with Neisser positive granules observed frequently.
A. Starburst effect
B. Gram negative
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

237. Exhibits bright sulfur granules in the presence of sulfides under phase contrast (use the S-test). _____________ is frequently observed as dark intracellular granules. No attached growth when extending into the bulk solution.
A. Starburst effect
B. Gram negative
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

238. Can form rosettes and the filaments can have gonidia on the tips. ________ are when many filaments radiate outward from a common origin. Prominent heavy sheath. Easy to identify due to its large size.
A. Starburst effect
B. Gram negative
C. Rosettes
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

Similar Organisms

239. _____________is similar when in the bulk solution and with no attached growth, although Type 021N has no sheath.

A. Starburst effect
B. Gram negative
C. Type 021N
D. Poly-ß-hydroxybutric acid (PHB)
E. Thiothrix I or Thiothrix II
F. None of the Above

Environment

240. This filament is usually found in environments where there are limited nutrients (N or P). It can also be found in wastes containing specific compounds with sulfides and/or organic acids or environments with low _________. Sometimes found in plants with high pH in the aeration system.

A. BOD test
B. BOD5
C. DO
D. Microbial degradation
E. TOC
F. None of the Above

Other Wastewater Treatment Components

Biochemical Oxygen Demand

241. Biochemical Oxygen Demand (BOD or BOD5) is an indirect measure of biodegradable organic compounds in water, and is determined by measuring the __________decrease in a controlled water sample over a five-day period.

A. BOD test
B. BOD5
C. Dissolved oxygen
D. Microbial degradation
E. TOC
F. None of the Above

242. During this five-day period, aerobic (oxygen-consuming) bacteria decompose organic matter in the sample and consume dissolved oxygen in proportion to the amount of organic material that is present. In general, a high __________ reflects high concentrations of substances that can be biologically degraded, thereby consuming oxygen and potentially resulting in low dissolved oxygen in the receiving water.

A. BOD
B. BOD5
C. DO
D. Microbial degradation
E. TOC
F. None of the Above

243. The _______________ was developed for samples dominated by oxygen-demanding pollutants like sewage. While its merit as a pollution parameter continues to be debated, BOD has the advantage of a long period of record.

A. BOD test
B. BOD5
C. DO
D. Microbial degradation
E. TOC
F. None of the Above

Organic Carbon

244. Most _______________in water occurs as partly degraded plant and animal materials, some of which are resistant to microbial degradation.

A. BOD test
B. BOD5
C. DO
D. Microbial degradation
E. Organic carbon
F. None of the Above

245. ___________________ is important in the estuarine food web and is incorporated into the ecosystem by photosynthesis of green plants, then consumed as carbohydrates and other organic compounds by higher animals. In another process, formerly living tissue containing carbon is decomposed as detritus by bacteria and other microbes.

A. BOD test
B. Organic carbon
C. DO
D. Microbial degradation
E. TOC
F. None of the Above

Total Organic Carbon

246. (TOC) bears a direct relationship with biological and chemical oxygen demand; high levels of _____________ can result from human sources, the high oxygen demand being the main concern.

A. BOD test D. Microbial degradation
B. BOD5 E. TOC
C. DO F. None of the Above

Need for Nitrogen and Phosphorus Removal at Wastewater Treatment Plants

Nutrients

247. Nutrients are chemical elements or compounds essential for plant and animal growth. Nutrient parameters include ammonia, organic nitrogen, _____________, nitrate nitrogen (for water only) and total phosphorus.

A. BOD test D. Microbial degradation
B. Kjeldahl nitrogen E. Low levels of nutrients
C. DO F. None of the Above

248. High amounts of nutrients have been associated with eutrophication, or over-fertilization of a water body, while low levels of nutrients can reduce plant growth and (for example) starve higher level organisms that consume ___________________.

A. BOD test D. Microbial degradation
B. Kjeldahl nitrogen E. Phytoplankton
C. DO F. None of the Above

249. Wastewater treatment has generally been defined as containing one or more of the following four processes: (1) preliminary, (2) primary, (3) secondary, and (4) advanced - also known as _________________.

A. Preliminary treatment D. Effluent disinfection
B. Primary treatment E. Secondary treatment
C. Tertiary treatment F. None of the Above

250. _________________ consists of grit removal, which removes dense inert particles and screening to remove rags and other large debris.

A. Preliminary treatment D. Effluent disinfection
B. Primary treatment E. Secondary treatment
C. Tertiary treatment F. None of the Above

251. ____________ involves gravity settling tanks to remove settleable solids, including settleable organic solids.

A. Preliminary treatment D. Effluent disinfection
B. Primary treatment E. Secondary treatment
C. Tertiary treatment F. None of the Above

252. The performance of primary settling tanks can be enhanced by adding chemicals to capture and flocculate smaller solid particles for removal and to ______________.

A. Preliminary treatment D. Effluent disinfection
B. Primary treatment E. Precipitate phosphorus
C. Tertiary treatment F. None of the Above

253. Secondary treatment follows ______________ in most plants and employs biological processes to remove colloidal and soluble organic matter.

A. Preliminary treatment D. Effluent disinfection
B. Primary treatment E. Secondary treatment
C. Tertiary treatment F. None of the Above

254. Effluent disinfection is usually included in the definition of _______________.
A. Preliminary treatment
B. Primary treatment
C. Tertiary treatment
D. Effluent disinfection
E. Secondary treatment
F. None of the Above

255. EPA classifies _______________ as “a level of treatment that is more stringent than secondary or produces a significant reduction in conventional, non-conventional, or toxic pollutants present in the wastewater”.
A. Preliminary treatment
B. Primary treatment
C. Tertiary treatment
D. Advanced treatment
E. Secondary treatment
F. None of the Above

256. Other technical references subdivide advanced treatment, using the terms “secondary with nutrient removal” when nitrogen, phosphorus, or both are removed and “_____________” to refer to additional reduction in solids by filters or microfilters.
A. Preliminary treatment
B. Primary treatment
C. Tertiary treatment
D. Effluent disinfection
E. Secondary treatment
F. None of the Above

257. Effluent filtration and nutrient removal are the most common __________processes.
A. Preliminary treatment
B. Primary treatment
C. Tertiary treatment
D. Advanced treatment
E. Secondary treatment
F. None of the Above

Nutrient Impairment of U.S. Waterways

258. The harmful effects of _______________ due to excessive nitrogen and phosphorus concentrations in the aquatic environment have been well documented.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

259. Algae and phytoplankton growth can be accelerated by higher concentrations of nutrients as they can obtain sufficient carbon for growth from carbon dioxide. In addition to stimulating eutrophication, nitrogen in the _______________can exert a direct demand on dissolved oxygen (DO) and can be toxic to aquatic life.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Form of ammonia
E. Phytoplankton and macroalgae
F. None of the Above

260. Even if a treatment plant converts ammonia to nitrate by a biological nitrification process, the resultant nitrate can stimulate algae and phytoplankton growth. Phosphorus also contributes to the____________.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Growth of algae
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

261. Either _____________ can be the limiting nutrient depending on the characteristics of the receiving water.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

262. Nitrogen is typically limiting in estuarine and marine systems and ____________ in fresh water systems.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

263. According to the 2007 report Effects of Nutrient Enrichment in the Nation’s Estuaries: A Decade of Change, increased nutrient loadings promote a progression of symptoms beginning with excessive growth of ___________ to the point where grazers cannot control growth.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

264. These blooms may be problematic, potentially lasting for months at a time and blocking sunlight to light-dependent ______________.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

265. In addition to increased growth, changes in naturally occurring ratios of nutrients may also affect which species dominate, potentially leading to_________________.
A. Nuisance/toxic algal blooms
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

266. These blooms may also lead to other more serious symptoms that affect biota, such as low DO and loss of ___________.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

267. Once water column nutrients have been depleted by phytoplankton and macroalgae and these blooms die, the bacteria decomposing the algae then consume oxygen, making it less available to surrounding_______________.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Aerobic aquatic life
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

268. Consequently, fish and invertebrate kills may occur due to hypoxia and anoxia, conditions of ______________________.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Low to no DO
F. None of the Above

269. ______________ may also cause risks to human health, resulting from consumption of shellfish contaminated with algal toxins or direct exposure to waterborne toxins.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

270. ___________ can also create problems if the water is used as a source of drinking water.
A. Eutrophic conditions
B. Submerged aquatic vegetation or (SAV)
C. Eutrophication
D. Nitrogen or Phosphorus
E. Phytoplankton and macroalgae
F. None of the Above

271. Chemicals used to disinfect drinking water will react with organic compounds in source water to form____________, which are potential carcinogens and are regulated by EPA.
A. Eutrophic conditions D. Nitrogen or Phosphorus
B. Submerged aquatic vegetation or (SAV) E. Phytoplankton and macroalgae
C. Disinfection byproducts F. None of the Above

Nutrient Constituents in Wastewater and Measurement Methods
Nitrogen
272. ______________ is an essential nutrient for plants and animals. Approximately 80 percent of the earth's atmosphere is composed of nitrogen and it is a key element of proteins and cells.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Kjeldahl Nitrogen (TKN)
C. Ammonia-nitrogen F. None of the Above

273. The major contributors of _____________ to wastewater are human activities such as food preparation, showering, and waste excretion.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Kjeldahl Nitrogen (TKN)
C. Ammonia-nitrogen F. None of the Above

274. The per capita contribution of_____ in domestic wastewater is about 1/5th of that for BOD.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Kjeldahl Nitrogen (TKN)
C. Ammonia-nitrogen F. None of the Above

275. ______________ in domestic wastewater typically ranges from 20 to 70 mg/L for low to high strength wastewater.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Nitrogen (TN)
C. Ammonia-nitrogen F. None of the Above

276. Factors affecting concentration include the extent of infiltration and the presence of industries. Influent concentration varies during the day and can vary significantly during rainfall events, as a result of ________________to the collection system.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Kjeldahl Nitrogen (TKN)
C. Inflow and infiltration F. None of the Above

277. ____________ in domestic wastewater consists of approximately 60 to 70 percent ammonia-nitrogen and 30 to 40 percent organic nitrogen.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Kjeldahl Nitrogen (TKN)
C. Ammonia-nitrogen F. None of the Above

278. Most of the _______________ is derived from urea, which breaks down rapidly to ammonia in wastewater influent.
A. An essential nutrient D. Nitrogen
B. Per capita contribution E. Total Kjeldahl Nitrogen (TKN)
C. Ammonia-nitrogen F. None of the Above

279. EPA approved methods for measuring ammonia, nitrate, and nitrite concentration use colorimetric techniques. Organic nitrogen is approximated using the standard method for ______.
A. An essential nutrient
B. Per capita contribution
C. Ammonia-nitrogen
D. Nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

280. The TKN method has three major steps:
Digestion to convert_______________________;
A. An essential nutrient
B. Per capita contribution
C. Ammonia-nitrogen
D. Nitrogen
E. Organic nitrogen to ammonium sulfate
F. None of the Above

281. Conversion of _______________through addition of a strong base and boiling; and
A. An essential nutrient
B. Ammonium sulfate into condensed ammonia gas
C. Ammonia-nitrogen
D. Nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

282. Measurement using colorimetric or titration methods. Because the measured concentration includes ammonia, the ammonia-nitrogen concentration is subtracted from the TKN to determine __________.
A. “As nitrogen”
B. Aliphatic N compounds
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

283. Nitrogen components in wastewater are typically reported on an ________basis so that the total nitrogen concentration can be accounted for as the influent nitrogen components are converted to other nitrogen compounds in wastewater treatment.
A. “As nitrogen”
B. Aliphatic N compounds
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

284. WWTPs designed for nitrification and denitrification can remove 80 to 95 percent of__________, but the removal of organic nitrogen is typically much less efficient.
A. “As nitrogen”
B. Inorganic nitrogen
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

285. Domestic wastewater organic nitrogen may be present in particulate, colloidal or dissolved forms and consist of proteins, amino acids, aliphatic N compounds, refractory natural compounds in drinking water (e.g.__________), or synthetic compounds (e.g. ethylene Diamine tetraacetic acid (EDTA)).
A. Humic substances
B. Aliphatic N compounds
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

286. _____________ may be released in secondary treatment by microorganisms either through metabolism or upon death and lysis.
A. “As nitrogen”
B. Aliphatic N compounds
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

287. Some _______________ may be contained in recondensation products. Hydrolysis of particulate and colloidal material by microorganisms releases some organic nitrogen as dissolved, biodegradable compounds.
A. Nitrogen
B. Aliphatic N compounds
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

288. Amino acids are readily degraded during secondary biological treatment, with 90 to 98 percent removal in activated sludge systems and 76 to 96 percent removal in trickling filters. However, other forms of ______________ may be more persistent in wastewater treatment processes.
A. “As nitrogen”
B. Aliphatic N compounds
C. Ammonia-nitrogen
D. Organic nitrogen
E. Total Kjeldahl Nitrogen (TKN)
F. None of the Above

289. The importance of organic nitrogen has increased as effluent limits on nitrogen have become more stringent. With more impaired waterways from nutrient loads, effluent limits for _____________ concentrations of 3.0 mg/L or less are becoming more common.
A. “As nitrogen”
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Dissolved organic nitrogen or (DON)
F. None of the Above

290. The ______________ concentration in the effluent from biological nutrient removal treatment facilities was found to range from 0.50 to 1.50 mg/L in 80 percent of 188 plants reported by Pagilla and values as high as 2.5 mg/L were observed.
A. “As nitrogen”
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Dissolved organic nitrogen or (DON)
F. None of the Above

291. Thus, for systems without effluent filtration or membrane bioreactors (MBRs) that are trying to meet a ___________goal of 3.0 mg/L, the effluent DON contribution can easily be 20 to 50 percent of the total effluent nitrogen concentration, compared to only about 10 percent for conventional treatment.
A. “As nitrogen”
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. TN treatment
E. Dissolved organic nitrogen or (DON)
F. None of the Above

292. The chemical composition of DON in wastewater effluents is not completely understood. Sedlak has suggested that only about 20 percent of the _____________ has been identified as free and combined amino acids, EDTA, and other trace nitrogen compounds.
A. “As nitrogen”
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Dissolved organic nitrogen or (DON)
F. None of the Above

293. About 45 percent may be unidentified low molecular weight compounds and the other 35 percent as unidentified high molecular weight compounds containing________________. Similar results were found by Khan.
A. “As nitrogen”
B. Total phosphorus or (TP)
C. Humic acids and amides
D. Phosphorus
E. Dissolved organic nitrogen or (DON)
F. None of the Above

294. The non-bioavailable portion is also referred to as recalcitrant DON (_________________).
A. “As nitrogen” D. rDON
B. Total phosphorus or (TP) E. Dissolved organic nitrogen or (DON)
C. Humic acids and amides F. None of the Above

Phosphorus
295. Total phosphorus (TP) in domestic wastewater typically ranges between 4 and 8 mg/L but can be higher depending on industrial sources, water conservation, or whether a detergent ban is in place. Sources of _______________are varied.
A. Orthophosphate fraction D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Phosphorus
C. Ammonia-nitrogen F. None of the Above

296. Some _____________ is present in all biological material, as it is an essential nutrient and part of a cell’s energy cycle.
A. Orthophosphate fraction D. Phosphorus
B. Total phosphorus or (TP) E. Polyphosphate
C. Ammonia-nitrogen F. None of the Above

297. ____________ is used in fertilizers, detergents, and cleaning agents and is present in human and animal waste.
A. Orthophosphate fraction D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Polyphosphate
C. Phosphorus F. None of the Above

298. The ____________ is soluble and can be in one of several forms (e.g., phosphoric acid, phosphate ion) depending on the solution pH.
A. Orthophosphate fraction D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Polyphosphate
C. Ammonia-nitrogen F. None of the Above

299. ____________are high-energy, condensed phosphates such as pyrophosphate and trimetaphosphate.
A. Orthophosphate fraction D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Polyphosphates
C. Ammonia-nitrogen F. None of the Above

300. They are also soluble but will not be precipitated out of wastewater by metal salts or lime. They can be converted to ___________ through hydrolysis, which is very slow, or by biological activity.
A. Orthophosphate fraction D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Polyphosphate
C. Ammonia-nitrogen F. None of the Above

301. Organically bound _____________can either be in the form of soluble colloids or particulate. It can also be divided into biodegradable and non-biodegradable fractions.
A. Orthophosphate fraction D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Phosphorus
C. Ammonia-nitrogen F. None of the Above

302. Particulate organically bound _____________ is generally precipitated out and removed with the sludge.
A. Phosphorus D. Total nitrogen or TN
B. Total phosphorus or (TP) E. Polyphosphate
C. Ammonia-nitrogen F. None of the Above

303. Soluble organically bound biodegradable ____________ can be hydrolyzed into orthophosphate during the treatment process.
A. Orthophosphate fraction
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Phosphorus
F. None of the Above

304. Soluble organically bound non-biodegradable ____________ will pass through a wastewater treatment plant.
A. Orthophosphate fraction
B. Total phosphorus or (TP)
C. Phosphorus
D. Total nitrogen or TN
E. Polyphosphate
F. None of the Above

305. A typical wastewater contains 3 to 4 mg/L phosphorus as ____________, 2 to 3 mg/L as polyphosphate, and 1 mg/L as organically bound phosphorus.
A. Orthophosphate fraction
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Polyphosphate
F. None of the Above

306. EPA approved laboratory methods rely on colorimetric analysis. Colorimetric analysis measures orthophosphate only, so a digestion step is needed to convert ___________ and organic phosphorus to orthophosphate to measure TP.
A. Orthophosphate fraction
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Polyphosphate
F. None of the Above

307. The persulfate method is reported to be the most common and easiest method. To determine dissolved _________________ (either total dissolved phosphorus or total dissolved orthophosphate), the sample is first filtered through a 0.45 micron filter.
A. Phosphorus
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Polyphosphate
F. None of the Above

308. USEPA approved ______________are routinely used to measure phosphorus levels as low as 0.01 mg/L. On-line analyzers that use the colorimetric method are available from venders (e.g., the Hach PhosphaxTM SC phosphate analyzer).
A. Orthophosphate fraction
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Polyphosphate
F. None of the Above

309. Ion chromatography is a second common technique used to measure orthophosphate in waste-water. As with colorimetric methods, digestion is required for TP measurement, with _____________________recommended.
A. Orthophosphate fraction
B. Total phosphorus or (TP)
C. Ammonia-nitrogen
D. Total nitrogen or TN
E. Persulfate digestion
F. None of the Above

Phosphorus Removal by Chemical Addition

310. The purpose of this section is to describe techniques for ________________by chemical addition. It summarizes issues associated with chemical feed location, mixing, and sludge production.
A. Phosphorus removal
B. Chemical precipitation
C. Enhance floc formation
D. Sludge production
E. Soluble phosphates
F. None of the Above

Principles

311. Chemical precipitation for phosphorus removal is a reliable, time-tested, wastewater treatment method that has not drastically changed over the years. To achieve removal, various coagulant aids are added to wastewater where they react with ___________ to form precipitates.
A. Precipitates
B. Chemical precipitation
C. Enhance floc formation
D. Sludge production
E. Soluble phosphates
F. None of the Above

312. The _________ are removed using a solids separation process, most commonly settling (clarification).
A. Precipitates
B. Chemical precipitation
C. Enhance floc formation
D. Sludge production
E. Soluble phosphates
F. None of the Above

313. _____________ is typically accomplished using either lime or a metal salt such as aluminum sulfate (alum) or ferric chloride.
A. Precipitates
B. Chemical precipitation
C. Enhance floc formation
D. Sludge production
E. Soluble phosphates
F. None of the Above

314. The addition of __________________and other substances can further enhance floc formation and solids settling. Operators can use existing secondary clarifiers or retrofit primary clarifiers for their specific purposes.
A. Precipitates
B. Chemical precipitation
C. Enhance floc formation
D. Sludge production
E. Polymers
F. None of the Above

Aluminum and Iron Salts

315. Alum and ferric or _________________ are commonly used as coagulant and settling aids in both the water and wastewater industry.
A. Alum
B. Ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

316. They are less corrosive, create less sludge, and are more popular with operators compared to lime. ______________ is available in liquid or dry form, can be stored on site in steel or mild concrete, and has a near unlimited shelf life.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

317. Ferric chloride is similar although care is needed during handling because of corrosivity. If an industrial source is available such as waste pickle liquor, __________________or ferrous sulfate have been used for phosphorus removal.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Ferrous chloride
E. Bicarbonate alkalinity
F. None of the Above

318. Ferrous forms should be added directly to aerobic reactors rather than to anaerobic reactors such as primary settling basins because the ferrous iron needs to oxidize to ______________for best results.
A. Ferric iron
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

319. The molar ratio of _________________required for phosphorus removal ranges from about 1.38:1 for 75 percent removal, 1.72:1 for 85 percent removal, and 2.3:1 for 95 percent removal.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Aluminum to phosphorus
E. Bicarbonate alkalinity
F. None of the Above

320. For iron compounds, a ratio of about 1:1 is required, with a supplemental amount of iron (10 mg/L) added to satisfy the formation of__________________.
A. Hydroxide
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

321. For additional removal of phosphorus with aluminum and_________, a ratio of between 2 and 6 parts metal salt to 1 part phosphorus may be required for adequate phosphorus removal.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron salts
E. Bicarbonate alkalinity
F. None of the Above

322. To supplement stoichiometry calculations, designers should consider jar tests and, in some cases, full-scale pilot tests to gauge the effects on the required dose of competing reactions; the influence of______________, adsorption, and co-precipitation reactions; and the interaction with polymers that are added to increase coagulation and flocculation.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. pH and alkalinity
E. Bicarbonate alkalinity
F. None of the Above

323. Aluminum or ________can be added to the primary clarifier, secondary clarifier, tertiary clarifier, or directly into the activated sludge aeration tank.
A. Alum
B. Ferric iron salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

324. Multiple additions can increase phosphorus removal efficiency. Ferrous salts can only be added to the aeration basin since it needs to be oxidized to _____ to precipitate the phosphorus.
A. Alum
B. Ferric
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

325. The solubility of aluminum and _________is a function of pH. The optimum solubility for alum was previously reported to occur at a pH range of 5.5 to 6.5, significantly lower than most influent wastewater.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron salts
E. Bicarbonate alkalinity
F. None of the Above

326. Chemicals such as lime compounds, caustic soda, and _________can be used to raise the pH of the waste stream prior to biological treatment processes or discharge.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Soda ash
E. Bicarbonate alkalinity
F. None of the Above

327. It is important to understand that _________is consumed during the precipitation reactions, and precipitation will be incomplete if insufficient alkalinity is present.
A. Alkalinity
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

Lime
328. Although lime had lost favor due to issues associated with chemical handling, sludge production, and____________, it has recently been considered more often because of its ability to reduce phosphorus to very low levels when combined with effluent filtration and the microbial control properties associated with its high pH.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Re-carbonation
E. Bicarbonate alkalinity
F. None of the Above

329. When lime is added to wastewater, it first reacts with the ______ to form calcium carbonate (CaCO3).
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

330. As the pH increases to more than 10, excess ___________will react with phosphate to precipitate hydroxylapatite [CA5(OH)(PO4)3].
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Calcium ions
E. Bicarbonate alkalinity
F. None of the Above

331. Because it reacts first with____________, the lime dose is essentially independent of the influent phosphorus concentration. Tchobanoglous et al. (2003) estimates the lime dose to typically be 1.4 to 1.6 times the total alkalinity expressed as CaCO3.
A. Alum
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Alkalinity
F. None of the Above

332. Lime addition can raise the pH to greater than 11. Because activated sludge processes require ____________levels below 9, lime cannot be added directly to biological treatment processes or it will cause process upsets.
A. pH
B. Ferric or ferrous salts
C. Lime compounds or Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

333. ____________ can be added to primary sedimentation tanks and removed with the primary sludge or it can be added as a tertiary treatment process after biological treatment.
A. Alum
B. Ferric or ferrous salts
C. Lime
D. Iron compounds
E. Bicarbonate alkalinity
F. None of the Above

334. When added to primary tanks, it will also result in the removal of colloidal material through coagulation and settling, with a concomitant removal of ____________up to 80 percent and chemical oxygen demand (COD) up to 60 percent.
A. TSS
B. High pH
C. Lime compounds or Lime
D. Colloidal material
E. Bicarbonate alkalinity
F. None of the Above

335. In either case, pH adjustment is needed and typically accomplished by adding CO2 or a liquid acid such as sulfuric acid, nitric acid, or __________.
A. Hypochlorite
B. High pH
C. Lime compounds or Lime
D. Colloidal material
E. Bicarbonate alkalinity
F. None of the Above

336. Hortskotte et al. (1974) showed that when the primary effluent is discharged directly to a nitrifying activated sludge plant, the ___________produced may neutralize the high pH.
A. Hydrogen ions
B. High pH
C. Lime compounds or Lime
D. Colloidal material
E. Bicarbonate alkalinity
F. None of the Above

337. When denitrification is practiced and the operator wishes to make use of the soluble COD in the primary effluent, the effluent must be neutralized before discharging it to the_________.
A. Hypochlorite
B. Anoxic zone
C. Lime compounds or Lime
D. Colloidal material
E. Bicarbonate alkalinity
F. None of the Above

338. ________ requires special handling and operations practices that further set it apart from chemical precipitation by metal salts. Although the formation of carbonate scaling on equipment and pipes is a drawback of lime treatment, lime slaking, where quicklime (CaO) is reacted with water to form calcium hydroxide (Ca(OH)2), is the biggest operational disadvantage.
A. Hypochlorite
B. High pH
C. Lime
D. Colloidal material
E. Bicarbonate alkalinity
F. None of the Above

Location of Chemical Feed and Mixing

339. _______________or metal salts can be added at several locations throughout the treatment plant to remove phosphorus.
A. Hypochlorite
B. High pH
C. Lime
D. Colloidal material
E. Bicarbonate alkalinity
F. None of the Above

340. ________________is when chemicals are added to raw water to precipitate phosphorus in the primary sedimentation basins.
A. Single-point applications
B. Post-precipitation
C. Biological processes
D. Pre-precipitation
E. Co-precipitation
F. None of the Above

341. ________________ involves adding chemicals to form precipitates that can be removed with biological sludge.
A. Single-point applications
B. Post-precipitation
C. Biological processes
D. Pre-precipitation
E. Co-precipitation
F. None of the Above

342. ________________ is when chemicals are added after secondary sedimentation and precipitants are removed in a tertiary process such as sedimentation or filtration.
A. Single-point applications
B. Post-precipitation
C. Biological processes
D. Pre-precipitation
E. Co-precipitation
F. None of the Above

343. Because it requires a high pH to achieve a low phosphorus concentration, lime cannot be added directly to biological reactors or to the____________________.
A. Single-point applications
B. Post-precipitation
C. Biological processes
D. Pre-precipitation
E. Secondary clarifiers
F. None of the Above

344. Multipoint additions of iron or aluminum salts have been very effective and can typically remove more phosphorus than ________________.
A. Single-point applications D. Pre-precipitation
B. Post-precipitation E. Co-precipitation
C. Biological processes F. None of the Above

345. There are several advantages to post-precipitating phosphorous using a tertiary treatment technique (after biological processes in a separate reactor): Microorganisms rely on phosphorus as a food source. If too much phosphorus is removed prior to________________, biological processes may suffer.
A. Single-point applications D. Pre-precipitation
B. Post-precipitation E. Co-precipitation
C. Biological treatment F. None of the Above

346. For activated sludge, the minimum ratio of phosphorus to BOD5 for a rapidly growing (low solids retention time (______________)) system is typically about 1:100.
A. Single-point applications D. Denitrification filters
B. SRT E. Biological treatment
C. Biological processes F. None of the Above

347. Competing chemicals in the ________________can increase the required dose.
A. Single-point applications D. Denitrification filters
B. Competing chemicals E. Primary sedimentation basins
C. Biological processes F. None of the Above

348. Phosphorus enters the ___________________as soluble orthophosphate, soluble polyphosphates, and organically bound phosphorus.
A. Single-point applications D. Treatment plant
B. Competing chemicals E. Biological treatment
C. Biological processes F. None of the Above

349. Most of the polyphosphates and much of the organically bound phosphorus are converted to more simple orthophosphates during ___________________.
A. Single-point applications D. Denitrification filters
B. Competing chemicals E. Biological treatment
C. Biological processes F. None of the Above

350. If the influent contains significant polyphosphates and/or organically bound phosphorus, locating ___________________after biological processes would be more efficient and achieve lower effluent levels.
A. Single-point applications D. Denitrification filters
B. Chemical treatment E. Biological treatment
C. Biological processes F. None of the Above

351. The removal of carbonate alkalinity and phosphorus by lime prior to biological treatment can have a negative impact on nitrification processes. Also, removing phosphorus to very low concentrations upstream of __________can negatively affect the denitrification process.
A. Single-point applications D. Denitrification filters
B. Competing chemicals E. Biological treatment
C. Biological processes F. None of the Above

352. Previous studies showed that the ____________can be balanced by the hydrogen ions produced during nitrification.
A. Single-point applications D. Hydroxide alkalinity
B. Competing chemicals E. Biological treatment
C. Biological processes F. None of the Above

353. Sludge recalcification can be used to achieve high removal efficiencies using lime in _____.
A. BOD and TSS
B. Tertiary treatment
C. Formation of precipitates
D. Chemicals
E. Polymer
F. None of the Above

354. One potential advantage to adding chemicals during primary treatment instead of tertiary treatment is reduced capital costs and space requirements as a result of removing additional ________________ and reducing the load to downstream processes, thereby reducing the size of the subsequent activated sludge basins and the amount of oxygen transfer needed.
A. BOD and TSS
B. Tertiary treatment
C. Formation of precipitates
D. Chemicals
E. Polymer
F. None of the Above

355. Chemicals should be well mixed with the wastewater to ensure reaction with soluble phosphates and ____________.
A. BOD and TSS
B. Tertiary treatment
C. Formation of precipitates
D. Chemicals
E. Polymer
F. None of the Above

356. _______________ may either be mixed in separate tanks or can be added at a point in the process where mixing already occurs.
A. BOD and TSS
B. Tertiary treatment
C. Formation of precipitates
D. Chemicals
E. Polymer
F. None of the Above

357. Bench-scale and pilot scale tests are often used to determine the correct mixing rate for a given composition of wastewater and chemicals used, including ________________
A. BOD and TSS
B. Tertiary treatment
C. Formation of precipitates
D. Chemicals
E. Polymer
F. None of the Above

Advanced Solids Separation Processes

358. The effectiveness of phosphorus removal by chemical addition is highly dependent on the solids separation process following___________________.
A. Ballasted high-rate or (BHRC)
B. Tertiary processes
C. Chemical precipitation
D. Phosphorus removal or remove phosphorus
E. Metal salts
F. None of the Above

359. Direct addition of metal salts to activated sludge processes followed by conventional clarification can typically remove ___________to effluent levels between 0.5 and 1.0 mg/L.
A. Ballasted high-rate or (BHRC)
B. TP
C. Formation of precipitates
D. Phosphorus removal or remove phosphorus
E. Metal salts
F. None of the Above

360. Tertiary processes (post-secondary treatment) can be used to ____________ to very low (< 0.1 mg/L) concentrations. For example, Reardon (2005) reports that four WWTP with tertiary clarifiers achieved TP levels of between 0.032 and 0.62 mg/L.
A. Ballasted high-rate or (BHRC)
B. Tertiary processes
C. Formation of precipitates
D. Phosphorus removal or remove phosphorus
E. Metal salts
F. None of the Above

361. Two common tertiary processes are________________. These approaches can be used separately or in combination.
A. Ballasted high-rate or (BHRC)
B. Tertiary processes
C. Formation of precipitates
D. Clarification and effluent filtration
E. Metal salts
F. None of the Above

Advances in tertiary clarification processes are discussed below.
362. The types of clarifiers used for tertiary processes include conventional, one or two-stage lime, solids-contact, high-rate, and ___________. Several patented BHRC using different types of ballast such as recycled sludge, microsand, and magnetic ballast (USEPA, 2008a) have been developed in recent years.
A. Ballasted high-rate or (BHRC)
B. Tertiary processes
C. Formation of precipitates
D. Phosphorus removal or remove phosphorus
E. Metal salts
F. None of the Above

363. The advantages of high-rate clarification are that the clarifiers have a smaller footprint and are able to treat larger quantities of wastewater in a shorter period of time. In addition, as an add-on during wet weather, they can help prevent ________________and combined sewer overflows (CSOs).
A. Ballasted high-rate or (BHRC)
B. Tertiary processes
C. Formation of precipitates
D. Phosphorus removal or remove phosphorus
E. Sanitary sewer overflows (SSOs)
F. None of the Above

Other Design and Operational Issues
364. _________________by chemical addition is limited to the soluble phosphates in the waste stream.
A. pH, complexation, mixing
B. Suspended solids
C. Advanced on-line analyzers
D. Phosphorus removal
E. Phosphates by microorganisms
F. None of the Above

365. Organically bound ____________ will not be removed by chemical treatment unless they are coagulated with the chemicals and removed in the sludge.
A. pH, complexation, mixing
B. Suspended solids
C. Advanced on-line analyzers
D. Phosphorus and polyphosphates
E. Phosphates by microorganisms
F. None of the Above

366. Chemicals can be added after biological treatment to capitalize on the conversion of polyphosphates and organically bound _____________by microorganisms in activated sludge.
A. pH, complexation, mixing
B. Suspended solids
C. Advanced on-line analyzers
D. Phosphorus to phosphates
E. Phosphates by microorganisms
F. None of the Above

367. The success of _______________by chemical addition depends on proper instrumentation and control.
A. pH, complexation, mixing
B. Suspended solids
C. Advanced on-line analyzers
D. Phosphorus removal
E. Phosphates by microorganisms
F. None of the Above

368. ______________typically takes the form of manual operation (for small systems), adjustments based on automatic flow measurements, or the more advanced on-line analyzers with computer-assisted dosage control.
A. pH, complexation, mixing
B. Dosage control
C. Advanced on-line analyzers
D. Phosphorus and polyphosphates
E. Phosphates by microorganisms
F. None of the Above

369. Chemical properties of any water used for making solutions should be considered – tap water high in ____________ could cause sludge to form when mixed with coagulants and could lead to clogging of chemical feed lines.
A. pH, complexation, mixing D. Phosphorus and polyphosphates
B. Suspended solids E. Phosphates by microorganisms
C. Advanced on-line analyzers F. None of the Above

370. Smith et al. (2008) found that factors such as ________________, and the coagulant used can limit the removal of phosphorus, especially in the range of <0.1 mg/L.
A. pH, complexation, mixing D. Phosphorus and polyphosphates
B. Suspended solids E. Phosphates by microorganisms
C. Salinity F. None of the Above

Impacts on Sludge Handling and Production

371. ________________ and production is generally considered to be one of the main downsides of chemical addition.
A. Sludge handling D. Biological phosphorus removal
B. Chemically treated sludge E. High total salts
C. Advanced on-line analyzers F. None of the Above

372. __________________always produce additional solids due to generation of metal- or calcium- phosphate precipitates and additional suspended solids.
A. Sludge handling D. Biological phosphorus removal
B. Chemically treated sludge E. Chemical precipitation methods
C. Advanced on-line analyzers F. None of the Above

373. Chemically treated sludge has a higher inorganic content compared to primary and activated sludge and will increase the required size of__________________.
A. Sludge handling D. Biological phosphorus removal
B. Chemically treated sludge E. Aerobic and anaerobic digesters
C. Advanced on-line analyzers F. None of the Above

374. Additional sludge production can be estimated using reaction equations. The use of metal salts can result in increased __________in the sludge and in the effluent.
A. Inorganic salts (salinity) D. Biological phosphorus removal
B. Chemically treated sludge E. High total salts
C. Advanced on-line analyzers F. None of the Above

375. _________can create problems when biosolids are land applied or when the effluent is returned to existing water supply reservoirs.
A. Sludge handling D. Biological phosphorus removal
B. Chemically treated sludge E. Salinity
C. Advanced on-line analyzers F. None of the Above

376. Biological phosphorus removal was developed in South Africa due to the high rate of indirect recycling of wastewater effluent which led to excessive ________________during dry periods.
A. Sludge handling D. Biological phosphorus removal
B. Chemically treated sludge E. High total salts
C. Total dissolved solids (TDS) F. None of the Above

377. _________ can reduce germination rates for crops and negatively affect the soil structure.
A. Sludge handling D. Biological phosphorus removal
B. Chemically treated sludge E. High total salts
C. Advanced on-line analyzers F. None of the Above

378. ______________ traditionally produces a higher sludge volume compared to metal salts because of its reaction with natural alkalinity.

A. Lime
B. Sludge handling
C. Ferric sludge
D. Characteristics of sludge
E. Nitrification and denitrification
F. None of the Above

379. An advantage of ____________ is that some stabilization can occur due to the high pH levels required.

A. Lime sludge
B. Sludge handling
C. Ferric sludge
D. Characteristics of sludge
E. Nitrification and denitrification
F. None of the Above

380. One disadvantage is that lime can cause scaling in mechanical thickening and dewatering systems. There are also differences in the amount and characteristics of sludge generated by alum versus_______________.

A. Lime sludge
B. Sludge handling
C. Ferric salts
D. Characteristics of sludge
E. Nitrification and denitrification
F. None of the Above

381. Although alum tends to produce less sludge than do__________, alum sludge can be more difficult to concentrate and dewater compared to ferric sludge.

A. Ferric salts
B. Sludge handling
C. Ferric sludge
D. Characteristics of sludge
E. Nitrification and denitrification
F. None of the Above

Biological Nitrogen Removal

382. This section provides an overview of the principles behind biological nitrogen removal and describes the ____________ in use today. It identifies key operational and design issues (including impacts on sludge handling and production), provides general guidelines on process selection, and summarizes ongoing research efforts in this area.

A. Lime sludge
B. Sludge handling
C. Ferric sludge
D. Characteristics of sludge
E. Nitrification and denitrification
F. None of the Above

Principles

383. In wastewater treatment, ___________occurs in two sequential processes: nitrification and denitrification.

A. Lime sludge
B. Sludge handling
C. Ferric sludge
D. Nitrogen removal
E. Nitrification and denitrification
F. None of the Above

Nitrification

384. __________________is an aerobic process in which autotrophic bacteria oxidize ammonia or nitrite for energy production.

A. Lime sludge
B. Sludge handling
C. Ferric sludge
D. Characteristics of sludge
E. Nitrification
F. None of the Above

385. Nitrification is normally a two-step aerobic biological process for the ____________to nitrate. Ammonia-nitrogen (NH3-N) is first converted to nitrite (NO2 -) by ammonia oxidizing bacteria (AOB).

A. Lime sludge
B. Sludge handling
C. Ferric sludge
D. Oxidation of ammonia
E. Nitrification and denitrification
F. None of the Above

386. The nitrite produced is then converted to nitrate (NO3-) by nitrite oxidizing bacteria (NOB). Both reactions usually occur in the same process unit at a wastewater treatment plant (e.g. ___________mixed liquor or fixed film biofilm).
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge
E. SRT
F. None of the Above

387. The group of AOB most associated with nitrification is the Nitrosomonas genus, although other AOB such as _________________can contribute to the process.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process (es)
E. Nitrosococcus and Nitrosospira
F. None of the Above

388. Nitrobacter are the NOB most associated with the second step, although other bacteria including _________________have been found to also oxidize nitrite.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process (es)
E. Nitrospina, Nitrococcus, and Nitrospira
F. None of the Above

389. _____________are classified as autotrophic bacteria because they derive energy from the oxidation of reduced inorganic compounds (in this case, nitrogenous compounds) and use inorganic carbon (CO2) as a food source.
A. Nitrifying bacteria
B. AOB and NOB
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

390. ______________require a significant amount of oxygen to complete the reactions, produce a small amount of biomass, and cause destruction of alkalinity through the consumption of carbon dioxide and production of hydrogen ions.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

391. For each gram (g) of NH3-N converted to nitrate, 4.57 g of oxygen are used, 0.16 g of new cells are formed, 7.14 g of _________ are removed, and 0.08 g of inorganic carbon are utilized in formation of new cells.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

392. Nitrifying bacteria grow slower and have much lower yields as a function of substrate consumed, compared to the __________ in biological treatment processes.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

393. The maximum specific growth rate of the nitrifying bacteria is 10 to 20 times less than the maximum specific growth rate of ___________ responsible for oxidation of carbonaceous organic compounds in waste-water treatment.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

394. The nitrification process needs a significantly higher ___________ to work compared to conventional activated sludge processes.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

395. The __________needed for nitrification in an activated sludge process is a function of the maximum specific growth rate (which is related to temperature), the reactor dissolved oxygen concentration, and pH.
A. Nitrifying bacteria
B. Alkalinity
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

396. Nitrification rates decline as the _________ concentration decreases below 3.0 mg/L and the pH decreases below 7.0 mg/L. With sufficient DO and adequate pH, typical nitrification design SRTs range from 10 to 20 days at 10^{o}C and 4 to 7 days at 20^{o}C.
A. Nitrifying bacteria
B. DO
C. Heterotrophic bacteria
D. Activated sludge process(es)
E. SRT
F. None of the Above

Denitrification

397. In municipal and industrial wastewater treatment processes, denitrification is the biological reduction _______________
A. Acetate
B. Heterotrophic nitrifying bacteria
C. Facultative aerobic bacteria
D. Of nitrate or nitrite to nitrogen gas (N2).
E. Nitrogen gas (N2)
F. None of the Above

398. It is accomplished by a variety of common ___________that are normally present in aerobic biological processes.
A. Acetate
B. Heterotrophic microorganisms
C. Facultative aerobic bacteria
D. Aerobic biological processes
E. Nitrogen gas (N2)
F. None of the Above

399. Most are _______________ with the ability to use elemental oxygen, nitrate, or nitrite as their terminal electron acceptors for the oxidation of organic material.
A. Acetate
B. Heterotrophic nitrifying bacteria
C. Facultative aerobic bacteria
D. Aerobic biological processes
E. Nitrogen gas (N2)
F. None of the Above

400. Denitrification by heterotrophic nitrifying bacteria and by autotrophic bacteria has also been observed. An example of a _____________ that can denitrify is Parococcus pantotropha, which obtains energy by nitrate or nitrite reduction while oxidizing ammonia under aerobic conditions.
A. Acetate
B. Heterotrophic nitrifying bacteria
C. Facultative aerobic bacteria
D. Aerobic biological processes
E. Nitrogen gas (N2)
F. None of the Above