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EN2002

AY-22-23 S2

Q1

i. d
ii. c
iii. c
iv. c
v. c
vi. a
vii. a
viii. c
ix. d
x. c

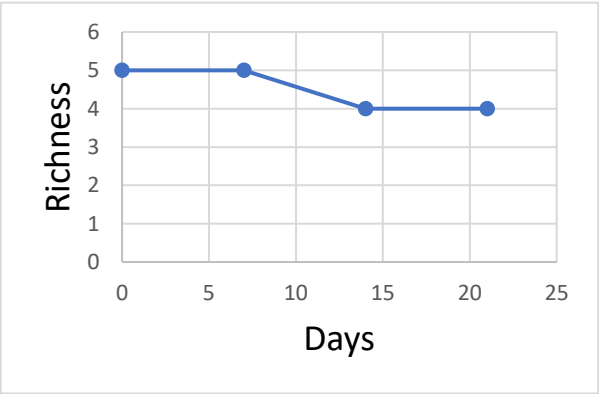
Q2(a)

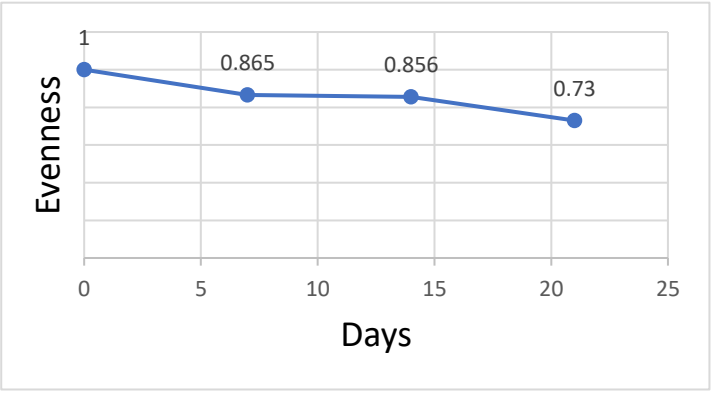
$at\ t = 0, \quad S = 5, \quad H = 1.609, \quad E_H = 1$

$at\ t = 7, \quad S = 5, \quad H = 1.392, \quad E_H = 0.865$

$at\ t = 14, \quad S = 4, \quad H = 1.187, \quad E_H = 0.856$

$at\ t = 21, \quad S = 4, \quad H = 1.012, \quad E_H = 0.730$





2(b)(i)

DNA	RNA
Doubled stranded	Single Stranded
Backbone sugar is deoxyribose	Backbone sugar is ribose
Bases are ATCG	Bases are AUCG
Exist as DNA only	Can exist as tRNA, mRNA and rRNA

2(b)(ii)

Polymerase chain reaction. Denaturation of double stranded DNA, annealing of primers and extension of primers.

2(b)(iii)

The viral RNA converted to DNA will be replicated too many times, allowing tiny quantities too small to cause disease to be detectable, giving a positive result even when viral RNA amount actually present is too little to be indicative of covid-19 infection.

2(c)

A : Nitrogen fixation

B : Nitrification

C : Nitrification

D : Denitrification

E : Anammox process

3(a)(i)

MCA has low reactivity, thus it has little reaction with microbial extracellular polymeric substances and natural organic matter present in water and biofilms. Thus, it can penetrate deep into the biofilms to inactivate hidden microorganisms, whereby a more reactive disinfectant would be completely consumed by reaction with organic matter before it can reach microorganisms hidden deep in the biofilms

3(a)(ii)

At the start, little or no organic matter is present in the water. Using MCA introduces ammonia into the water. Nitrifiers, which are autotrophic, do not require carbon in the form of organic matter to survive, and thus, make use of the ammonia for energy to replicate. As the population of nitrifiers increase, they also release more extracellular polymeric substance and natural organic matter, which act as organic carbon sources. Heterotrophic bacteria can then use these as their organic carbon source, allowing them to replicate and grow their population. Thus, growth of nitrifiers is followed by growth of heterotrophic bacteria.

3(b)(i)

We choose 10^{-4} dilution since CFUs count is within 20-80

Average CFU count = $\frac{64+56+62+58+52+68}{6} = 60\ CFUs/0.1$ ml $= 600\ CFU/$ ml

In original sample, CFU count = $600 \times 10^4 = 6 \times 10^6\ CFUs/ml$

3(b)(ii)

Yes, there is a discrepancy. More cells are counted using direct counting compared to methods using CFU count. This is due to the great plate count anomaly. Direct counting gives more cells as it includes cells that are dead, or cells that are viable but not culturable (VBNC). VBNC cells are alive, but have very low metabolic activity, and do not divide, due to reasons such as inappropriate temperature or lack of nutrients.

Q4(a)(i)

Oxygen is consumed by the biodegradation of organic matter by microorganisms. Microorganisms breakdown hydrocarbons using oxygen as the final electron acceptor, generating energy for production of more cells. The mechanisms can be described using the following equation :

$$O_2 + hydrocarbons \rightarrow CO_2 + H_2O + new\ cells$$

Q4(a)(ii)

Culture dependent methods would involve growing of sample on multiple selective cultures, each allowing for the growth of a specific type of microorganisms, then seeing if colonies form. (If colonies form, that type of bacteria that the culture selects for is present in the sample)

Culture independent method would involve metagenomics study, where we study the genome of the sample as a whole. First, we conduct high throughput sequencing of sample DNA. From the obtained results, we look out for specific genes coding for specific functions, which would indicate the potential presence of a specific type of microorganisms (for example, genes coding for enzyme involved in nitrification would indicate potential presence of nitrifiers)

Q4(b)

In anoxic conditions, bacteria carries out anaerobic respiration and fermentation, converting organic matter to carbon dioxide. Methanogens also carry out methanogenesis, converting organic matter to methane. This methane can also be converted by microorganisms to carbon dioxide once conditions become aerobic

In oxic conditions, bacteria carry out (aerobic) respiration, converting organic matter to carbon dioxide

Under anoxic conditions, denitrification occurs. Nitrous oxide is one of the intermediates formed when denitrifying bacteria convert nitrate to nitrogen gas. Some of these nitrous oxide escapes into the atmosphere before it can be converted into nitrogen gas.

Q4(c)

Sludge. It can be utilized through anaerobic sludge digestor process.

1. Hydrolysis of complex organic matter to soluble organic molecules by hydrolytic bacteria
2. Acidogenesis of soluble organic molecules to volatile fatty acids by Acidogens
3. Acetogenesis of volatile fatty acids to acetic acid and carbon dioxide by acetogenic bacteria
4. Methanogenesis of acetic acid to methane and carbon dioxide by methanogens.

This methane can then be used as an energy source

Q5(a)

i. 8
ii. 11
iii. 13
iv. 9
v. 4

Q5(b)

Antibiotics targeting peptidoglycan synthesis do not target archaea since the cell walls of archaea do not contain peptidoglycan. Thus, the antibiotic would only inhibit the growth of bacteria since they have peptidoglycan cell walls. Thus, less bacteria would be present to compete with the archaea for resources, allowing for the increased growth of archaea due to the increased availability of resources, thus enriching archaea.

Q5(c)

	Phosphorus	**Nitrogen**
Source	Abiotic reservoir of nitrogen gas in air/atmosphere	Abiotic reservoir of phosphorus in rocks/minerals
Biochemical transformation	Phosphorus can be used by organisms without having to undergo fixation first	Nitrogen gas needs to be fixed into forms like ammonium by microorganisms before it could be used by organisms
Human interference	Humans interfere with P cycle by harvesting P from rocks/minerals and concentration them in one location as fertiliser	Humans interfere with N cycle by fixing Nitrogen gas from atmosphere into fertiliser , and releasing them into the environment