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EN2002

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Q 1

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

Q2(a)

ARGs move from ARB to other bacteria via horizontal gene transfer.

Conjugation : transfer of plasmid DNA via physical contact

Transduction : transfer of DNA via bacteriophages (virus)

Transformation : one bacteria cell releases free DNA into the environment , which is then taken up by another bacteria cell

Q2(b)

$$5.815\ C_2O_4^{2-} + 0.2NH_4^+ + 1.86O_2 + 0.8H^+ + 5.41H_2O = 10.63\ HCO_3^- + CH_{1.8}O_{0.5}N_{0.2}$$

$$0.5C_2O_4^{2-} + 0.25\ O_2 + 0.5H_2O = HCO_3^-$$

- 1 mole of biomass requires 1.86 moles of O_2 for catabolism
- 1.85 moles of O_2 requires **3.72** moles of C_2O_4 for catabolism
- Hence moles of C_2O_4 for anabolism : 5.815 – 3.72 = **2.095** moles
- Ratio = $\frac{3.72}{2.095}$ = **1.78**

Q2(c)(i)

Oxidation : nitrification

Reduction : denitrification

Q2(c)(ii)

Microorganisms	Metabolic classification	Electron acceptor
X	Chemoautotroph	Oxygen
Y	Chemoheterotroph	Nitrogen

Q3(a)

For N, bacteria naturally fix nitrogen gas into usable forms like ammonium. Using technology, we can produce ammonia from hydrogen gas and nitrogen gas. If we were to apply those ammonia to soil as fertiliser, and they escape into water bodies, excess nutrients will lead to problems like algae bloom that kills fishes in lakes

For P, P is naturally obtained from phosphorus containing rocks, technology allows us to harvest and concentrate P in one location, excess P in one location may disrupt local ecosystem, runoff of P into water bodies can lead to algae blooms too, killing fishes.

Q3(b)(i)

We use 10^{-4} dilution since CFU count falls within 20-80 CFUs

Average = (64+56+62+58+52+68) / 6 = 60 CFUs/ 0.1 ml =600 CFUs/ml

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

Q3(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.

Q3(b)(iii)

$$\mu = \frac{\ln(20)}{6-1} = 0.6\ day^{-1}$$

$$t_d = \frac{\ln(2)}{0.6} = 1.16\ days$$

Q4(a)

Provide an environment with only nitrogen present as the electron acceptor, ensure no oxygen is present so that only floc forming bacteria can carry out metabolism for energy.

Provide a constantly high substrate concentration in the tank by keeping loading rate high, promoting growth of floc forming bacteria over filamentous bacteria

Q4(b)(i)

Disinfection by-products

Q4(b)(ii)

Microorganisms in the distribution form biofilms, which contain natural organic matter and microbial extracellular polymeric substances. These compounds react with disinfectants to form DBPs

Q4(c)(i)

Biochemical oxygen demand, the amount of dissolved oxygen used by microorganisms to oxidise organic compounds in water sample. It is quantified by measuring the change in dissolved oxygen levels of a water sample after 5 days of incubation at 20 °C in the dark

Q4(c)(ii)

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. 4,3,12
ii. 7
iii. 11
iv. 1,2

Q5(b)(i)

No, richness remains the same at 6

Q5(b)(ii)

Before exposure :

H=1.306

$E_H = 0.73$

After exposure to X

H = 1.135

$E_H = 0.634$

After exposure to Y :

H = 1.274

$E_H = 0.71$

Exposure to X and Y both decreases evenness. The magnitude of decrease is greater for exposure to X compared to exposure to Y