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EN2002 2019 - 2020 Sem 2

1i) d
1ii) b
1iii) c
1iv) d
1v) c
1vi) d
1vii) c
1viii) b
1ix) c
1x) b

2ai)

$$\ln\left[\frac{X}{X_0}\right] = \mu(t - t_0)$$

$$\ln\left[\frac{20}{1}\right] = \mu(6 - 1)$$

$$\mu = 0.59915$$

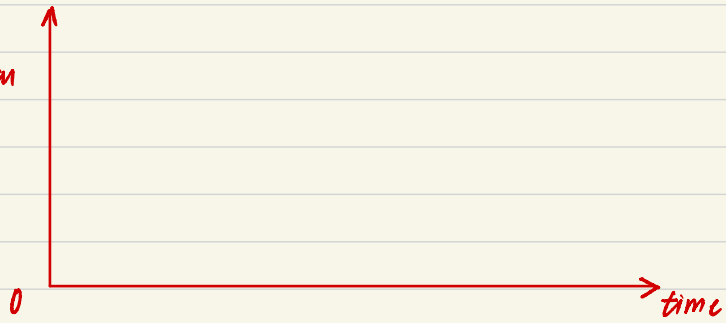
$$\ln\left[\frac{2X_0}{X_0}\right] = 0.59915\, t$$

$$t = 1.1569 \text{ days}$$

∴ Specific growth rate, $\mu = 0.599$
Doubling time = 1.16 days.

2aii)

2aiii)



2b) $X\,C_2O_4^{2-} + 0.2\,NH_4^+ + yO_2 + 0.8H^+ + 5.41H_2O$

$\rightarrow 10.63\,HCO_3^- + CH_{1.8}O_{0.5}N_{0.2}$ $\quad \therefore X = 5.815,\ y = 1.86$

$a\,C_2O_4^{2-} + bO_2 + cH_2O \rightarrow d\,HCO_3^-$

$\therefore a = 2,\ b = 1,\ C = 2,\ d = 4$

3ai) Chemotrophs

3aii) Phototrophs

3aiii) Chemoheterotroph

3aiv) Chemoautotrophs

3v) photoheterotrophs

3vi) photoautotrophs

3b)

	Metabolic group	Electron donor	Electron acceptor
AOB	chemoautotroph	NH_4^+	O_2
NOB	chemoheterotroph	External C source	NO_3^-
Anammox	chemoautotroph	NH_4^+	NO_2^-

3ci) 9

3cii) 8

3ciii) 6

3civ) 1 and 2

4a) Appropriate CFU range at 10^{-3} dilution

$$\text{Average CFU per plate} = \frac{54 + 56 + 64 + 58 + 62 + 66}{6}$$

$$= 60$$

$$\text{Bacterial concentration in CFU/ml} = \frac{60}{0.1} \times 10^3$$

$$= 6.0 \times 10^5$$

4b) There is a large discrepency of about 2 orders of magnitude whereby counting by observation had significantly larger numbers than cultivation. This discrepancy is known as the great plate count anomaly. This could be due to dead cells also being counted, cell being viable but not culturable which means that cells are in a state of very low metabolic activity and unable to divide. Some cells may also be symbiotic or parasitic, or simply not having the right nutrients/conditions for growth.

4ci) The bioremediation mechanism is Mineralization. Isolate X uptakes the toxin and uses it as a carbon and energy source and metabolizes it, thus removing and destroying it

4cii) The bioremediation mechanism is co-metabolization. Isolate Y uptakes the microcystins but instead uses glucose as the carbon and energy source. Microcystin is thus metabolized alongside glucose into something less or more hazardous and may be subsequently mineralized by other microbial species.

4ciii) The bioremediation mechanism is immobilization. Isolate Z is able to convert soluble Cr(VI) to insoluble Cr(III) by means of biosorption, bioaccumulation or biotransformation.

4d) I would use FISH (fluorescent in-situ hybridization) on the water sample. The FISH genetic stain is able to target specific rRNA sequences. They can be fluorescently labelled for visualization and can hybridize to its complement in a mixture.

5a) BOD is biochemical oxygen demand. It is the amount of dissolved oxygen consumed by micro-organisms with certain amount of organic matter. It is quantified by the BOD_5 test.
Dissolved oxygen (DO) of a sample of water is first measured. The sample is then sealed and left in the dark at 20°C for 5 days. The DO is then measured again at the end of the 5 days. The BOD_5 is then quantified by the difference between the initial and final DO.

5b) Profile A is for dissolved oxygen concentration.
Profile B is for viable bacterial cells.
When untreated water is first discharged into the water, microbes use the organic carbon in the water as carbon and energy sources. Thus aerobic metabolization occurs and O_2 is rapidly consumed. Micro-organisms also begin to grow rapidly. Therefore there is a sharp dip in DO conc. and a sharp increase in viable cells. Once organic matter is all consumed, DO starts to return back to normal and cells start to die off.

5c) Microbial metabolism of organic matter
Nitrification
Denitrification
Annamox
Enhanced Biological Phosphorus Removal (EBPR)

5d) The second most important end-product would be activated sludge. Activated sludge consists of micro-organisms, organics, inorganics and water. A portion of activated sludge is returned to the aeration tank so that micro-organisms like bacteria are able to break down organic material in the water to form CO_2, H_2O and new cells. DO levels have to be kept high in the tank through aeration as these micro-organisms require O_2 to break down the organic material.

$$\text{Organic Waste} + O_2 \xrightarrow[\text{cells}]{} CO_2 + H_2O + \text{New Cells}.$$