

i) Anthropocene is a new geologic epoch and was defined by mankind's massive impact on Earth. It is part of the Holocene epoch, the epoch that began with the end of the last ice age around 12 000 years ago.

The Anthropocene has been in existence for 200 000 years. (not sure)

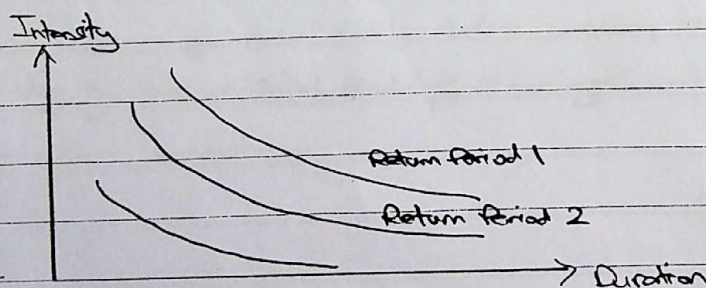
ii) The massive burning of fossil fuel has released high amount of carbon dioxide into the atmosphere. This resulted in problems such as rise in global temperature, rising sea levels, and climate change.

Human activity has resulted in the loss of biodiversity. There has been large destruction of tropical rainforests and habitats. The rainforests are estimated to contain 60% of Earth's plants and animal diversity. The loss of species since 1600 is 720, much higher than the natural loss rate of 1 plant and 1 animal every 100 to 1000 years.

Human activity has also caused widespread pollution. For example, excessive use of fertilizers, release of toxic chemicals into water bodies. These chemicals have negative impacts on the habitat.

(Can discuss the Industrial Revolution, Green Revolution, IT Revolution)

5) IDF curves are a family of curves that show the relationship between intensity, duration and frequency of occurrence of rainfall. They are used for the design of storm drainage systems and detention ponds.



FINISH STRONG!

(bii) In Singapore, for catchment areas of less than 100 ha, return period of 10 years is used. For catchment areas of 100 to 1000 ha, return period of 25 years is used. " " " more than 1000 ha or critical installations, return period of 50 to 1000 years is used.

IDF curves are used to plan for drainage systems. If the system has to stand for 10 years, return period of 10 years would be used. From the IDF curves, they would know the required capacity of the system to be able to withstand rainfall of the corresponding intensities and durations.

(iii) Due to increased impervious cover of urbanized watershed, drainage systems have to cater to increased runoff volume and peak flow rates. This is because rainfall is unable to infiltrate the ground and would be quickly channelled to drainage systems in a shorter amount of time.

Artificial channels and storm drainage collection systems also causes increased runoff rates and velocities due to its smooth surfaces. Hence, measures should be put in place to prevent erosion when the water is channelled to reservoirs.

(2ai) Brown agenda issues for an underdeveloped country refers to problems that affect basic human needs. For example, inadequate local safe water supplies, poor sanitation and inadequate or the lack of waste collection. These problems usually are local and require immediate attention.

Green agenda issues for a developed country are usually global and do not have geographical limitations. These problems include global warming, excessive usage of natural resources and pollution. They are only tackled after brown agenda issues have been solved.

2a.ii) Developed countries have already caused problems such as pollution to reach their current economic status. However, due to increasing attention to global sustainability issues, the economic development for the currently undeveloped nations may be limited or slowed down. In addition, since the problems caused are global, the undeveloped countries are affected as well. The undeveloped countries have to bear the burdens brought about by the rapid development of other countries.

bi) According to the logistic growth model, the growth rate will first increase proportionally to population. It will stabilize when it reaches a certain level. This is similar to how population first exponentially with abundant resources. When population approaches the carrying capacity, the limited resources available will restrict the rate of increase. Eventually the rate of increase becomes zero and population stagnates at the carrying capacity.

$$ii) P(t) = \frac{P_0 P_m}{P_0 + (P_m - P_0)e^{-rt}}$$

$$P_0 + (P_m - P_0)e^{-rt} = \frac{P_0 P_m}{P}$$

$$(P_m - P_0)e^{-rt} = \frac{P_0 P_m}{P} - P_0$$

$$(P_m - P_0)e^{-rt} = P_0 \left(\frac{P_m - P}{P} \right)$$

$$e^{-rt} = \frac{P_0 (P_m - P)}{P (P_m - P_0)}$$

$$\text{Taking ln, } -rt = \ln \left[\frac{P_0 (P_m - P)}{P (P_m - P_0)} \right]$$

$$-rt = \ln \left(\frac{P_m - P}{P} \right) + \ln \left(\frac{P_0}{P_m - P_0} \right)$$

$$\ln \left(\frac{P}{P_m - P} \right) = rt + \ln \left(\frac{P_0}{P_m - P_0} \right)$$

$$y = mx + c$$

Use the data collected to plot the above straight line curve. Then derive the missing parameters.

FINISH STRONG!

39i) P(at least twice) = $1 - P(\text{does not occur}) - P(\text{occurs once})$
 $= 1 - \left(\frac{99}{100}\right)^{10} - \binom{10}{1} \left(\frac{1}{100}\right) \left(\frac{99}{100}\right)^9$
 $= 0.0042662$
 $= 0.00427$

ii) Singapore is surrounded by the sea, consists of reclaimed land and is largely flat. This makes Singapore very vulnerable to rising sea level. Flooding of Singapore's coastal zones may occur. Buildings and homes may be flooded, causing destruction to lives and properties.

In addition, important installations like power plants and desalination may be located near the coast as sea water is required for their operation. Sea level rise will compromise these operations. This will also further affect other installations like wastewater treatment facilities. This results in hygiene and safety issues, as well as disruption of everyday life.

Most of Singapore's important business is located less than 2 metres above sea level. Sea level rise will severely impact Singapore's economy. Moreover, Singapore is heavily dependent on trading. If our container ports or the airport is affected, it would cause great disturbance to the economy.

New laws could be established to prevent buildings or installations being built near the coast. This will prevent future damage from incoming sea water.

Sea walls could be built at the coasts to keep the seawater beyond a certain boundary.

Early warning or prediction systems could be employed. This could allow advance planning to be conducted.

iii) IPCC refers to the Intergovernmental Panel on Climate Change. (Include briefly the roles of the three working groups). ~~WG I~~ collects the data required and uses it for downscaling. The results are provided to WG II and WG III. WG II and III then uses the results from downscaling for their respective planning.

FINISH STRONG!

- 3bi) Characteristics of EC: May be present in the environment but not routinely monitored
Concern about possible health and other effects to humans and ^{wildlives}
No standardized test data available
No approved methods to detect it
Lacking environment fate and transport information
Requires new tools to address this issue
Potential candidates for future regulation depending on their potential health effects and toxicity

Examples: Pharmaceutical and personal healthcare products like antibiotics, medicine
Endocrine disruptors
Disinfection by-products
Anti-bacterial nanomaterials

ii) Surface runoff: Antibiotics used on cattle
Sunscreen used by humans

Water treatment plant: Disinfection by-products

Wastewater: Improper disposal of unused or expired drugs in toilets

Via urine and faeces

Industrial, a hospital wastewater

Discharge of wastewater effluent ~~fact~~ releases the EC that were not removed.

In water treatment plants, alternative disinfection methods should be used so that it does not produce DBP.

In wastewater treatment plants, EC can be partially removed by existing methods. Additional measures like activated carbon can be used as well.

FINISH STRONG!

Aa) Recyclable: Metals

Non-recyclable: Plastics, glass, rubber, fluids

$$b) \text{ Net income per car} = \left(0.75 \times 1500 \times \frac{\$100}{1000} \right) - \left(0.25 \times 1500 \times \frac{\$200}{1000} \right) \\ = \$37.50$$

- c)
- Fire hazard. In addition, if combustion is incomplete or temperature is not high enough, harmful materials could be released into the environment
 - May trap water, resulting in breeding ground for mosquitoes. Mosquitoes are a known disease vector
 - Leakage of chemicals into the environment, eg groundwater

d) Advantages of electric vehicle: Subsidized/rebates available

More environmentally friendly as it does not contribute to non-point sources of pollution

Disadvantages: Fewer charging stations compared to petrol stations in Singapore
Takes a much longer time to recharge the battery compared to refuelling of a petrol car.

FINISH STRONG!

$$\begin{aligned} \text{5a) Total capital costs} &= 10 \text{ blocks} \times 1000 \text{ m}^2/\text{block} \times 0.15 \times 100 \text{ W/m}^2 \times \text{\$5/W} \\ &= \text{\$750 000} \end{aligned}$$

$$\begin{aligned} \text{Total annual revenue} &= 10 \times 1000 \times 0.15 \times 100 \times \frac{0.25}{1000} \times 24 \times 365 \\ &= \text{\$328 500} \end{aligned}$$

$$\begin{aligned} \text{Simple payback} &= \frac{\text{total capital cost}}{\text{total annual revenue}} = 2.2831 \\ &= 2.28 \text{ years} \end{aligned}$$

$$\begin{aligned} \text{b) Average annual power produced per household} \\ &= 1000 \text{ m}^2/\text{block} \times 100 \text{ W/m}^2 \times 0.15 \times \frac{1}{100} \\ &= 150 \text{ W} \end{aligned}$$

(?) c) Benefits: A cooler environment, since the solar radiation is intercepted by the solar panels. The apartment may heat up less

Reduced carbon footprint

Lower utility bills

Increased property value

d) Main concerns: Safety, especially since Singapore is a small island, any accident will affect more people within its disaster radius

Land space required to store the radioactive waste

Extremely long half life of radioactive waste \rightarrow more land space and requires long term monitoring

Sea water used to cool down the power plant leading to thermal pollution - disruption of marine ecosystem, eg coral bleaching