

Water Resources and Quality Assessment:

Question 1 -

Due in part to the growing climate crisis, water is becoming an increasingly valuable commodity globally (Ford et al, 2025). Spanning 2024, The House of Commons constituency data revealed 592,478 confirmed discharges across the UK, with 450,398 occurring in England, 118,276 in Wales, 24,398 in Scotland and 2,697 in Northern Ireland (Clark, 2025). A reported 1,502 sewage-related illnesses were recorded in 2025.

Brexit has shifted the legal stance on sewage spills in the UK, with discharges considered illegal under EU policy, becoming more common across Britain (Phillips, 2025). According to Ford et al (2025), the water / sewage industry discharged 12.7 million monitored hours of untreated wastewater and sewage into English waterways between 2019 and 2023. Limited monitoring has hidden the full extent of underperformance, but no river in England has a good overall health status (with only 15% having a good ecological status).

A study carried out by Rangel-Buitrago, Francois Galgani and Neal (2024) revealed that globally, over 80% of sewage is discharged into the environment without treatment. In addition to unwanted nutrient input (leading to eutrophication), sewage contains other, less innocuous chemicals which may remain in a watercourse for extended periods of time, causing disproportionate damage to water quality and the natural environment (Rajak et al, 2025). An example of this is pharmaceuticals, particularly antibiotics, which can spread antibiotic resistant bacteria into natural environments.

Another component of raw sewage is sewage litter, which is generally composed of wet wipes, sanitary products and cotton buds (although can contain a wide variety of inorganic materials) (Surfers Against Sewage, 2023). In 2025, a large quantity of plastic discs used in wastewater filtration were discovered around the coasts of Swansea and Neath Port Talbot (Youle, 2025).

Proliferation of sewage fungus, a polymicrobial bio film, poses long to threat to river health, resulting in reduced dissolved oxygen levels and subsequent fish kills (as well as general loss of aquatic life) (Hosea and Salvidge, 2024).

Because around 40% of the world's population lives within 100km of a coastline, protection of them for livelihoods is critical to modern society (Science Insights, 2025). Pollution from effluent in both coastal and freshwater environments can have adverse effects on tourism and fisheries, resulting in negative socio-economic implications for communities relying on these industries (Rangel-Buitrago, Francois Galgani and Neal, 2024)

Abundance of sensitive indicator species such as mayflies, stoneflies and caddisflies often reveal the ecological state of a river and therefore the extent to which they are polluted (Hosea and Salvidge, 2024). Given the lack of current monitoring in the UK, it would arguably be beneficial for a widespread start-up of grassroots initiatives aimed at monitoring river quality in each locality. This would provide a body of data to better inform management practices moving forward. Citizen science projects such as this were alluded to in the BBC 2 documentary, Thames Water: Inside the Crisis (2026), where independent groups gathered data on water quality along the Thames.

One of the commonly cited defences of water companies is that lack of funding has prevented them from being able to invest in the

facilities and staff to properly control sewage discharges, (The Rivers Trust, 2024). Despite this, part of the reason behind the lack of resources is the privatisation of water companies, which has resulted in funding being diverted to shareholders instead of infrastructure; an estimated £74.2 billion has been paid out in dividends to shareholders in England and Wales since privatisation (BBC, 2026; Clark, 2025). Given the negative overall effect this has had on sewage discharges and water quality in the UK, it would be beneficial from a management perspective to reinstate government control.

Question 2 -

$3.22\text{mg/L (concentration)} \times 2.18\text{m}^3/\text{s (flow rate)} \times 86.4 \text{ (constant)} = 606.49\text{kg/day (load)}$

606.49

614.87

606.01

638.51

682.21

670.73

670.73

690.34

690.92

742.48

749.09

771.22

777.99

801.84

841.88

872.47

935.97

1010.35

1057.54

897.03

759.95

625.97

589.68

625.19

Average load over 24hr period = 718.14 kg/day

Peak load = 1057.54 kg/day

The significance of calculating pollutant load in the management of water quality comes under two main categories. Firstly, in order to comply with EPA regulations, specified pollutants must be monitored and quantified to ensure they meet specific ecosystem and public health standards (UK Government, 2025). Secondly, understanding the typical composition of the river / basin is essential for gathering base data to be able to identify where pollutant events or other abnormalities have occurred. This is highlighted in the case of the River Towy, where nitrate and phosphate levels are abnormally high due largely to sewage spills and agricultural runoff (slurry) (NMB, 2026).

Question 3 -

- Nile River Delta (Africa)

The Nile is the longest river in the world, spanning across eleven countries (OWP, 2020). An estimated 250 million rely on it for daily water supply, with future predictions indicating this number could double by 2050, threatening to further stretch this limited freshwater resource. By 2040, around 80 million people (35% of the population living on the Nile) are estimated to be water-scarce according to OWP.

The rapidly increasing population alongside extreme weather events (exacerbated by climate change), are placing strain on the centuries-old colonial treaties formed to protect water rights along the Nile (OWP, 2020). This is largely evident between Egypt, Sudan and Ethiopia, where there is widespread dispute over how to equitably distribute resources (particularly as the Sudan War is indirectly stressed by these issues).

Egypt, a country with low annual rainfall, relies heavily on the Nile for agriculture (around 97% of freshwater) (Mustafa, El-Sherif and Nashat, 2026; OWP, 2020). Whilst population growth and climate change are the key drivers in this, inefficient irrigation is worsening the effects. In a review by Mustafa, El-Sherif and Nashat (2026), several mitigating practices are proposed, such as stricter regulations on toxic waste discharged into the Nile (from both industrial and domestic settings). In addition to this, scheduling land irrigation and improving technology (more effective leak detection) would also provide some relief to the diminishing supply. Although not mentioned in the review, further interaction between the different stakeholders of the Nile may be beneficial to avoid unnecessary conflict long-term.

- Java, Indonesia (SE Asia)

Despite Indonesia's overall water surplus, as a result of its unique geography, the vast majority is isolated to islands with lower populations such as Papua (Walton, 2019). The island of Java in Indonesia is the most densely populated island in the world, with over 1200 people per square kilometre. Fresh water resources in this region have always been limited, with only 10% of the nation's water supplies being located here. Indonesia's Ministry of Public Works and Housing has predicted "total scarcity" by 2040, with just 476m³ per person annually. Currently, only 10% of water usage in Indonesia is used in domestic or industrial settings. The remaining percentage is mainly rainwater used in agriculture (70%).

The cause of this shortage is largely rooted in anthropogenic climate change, which is extending dry seasons, and concentration rainfall into short, sharp periods (Walton, 2019). This has led to disarray in both urban and rural (agricultural) settings, reducing the quantity of

stored freshwater and increasing the incidence of flooding. Health impacts are widespread as a result of these changing patterns, with rates of dengue fever increasing year on year (Umami et al, 2022).

Various solutions have been proposed to resolve the issue, with reservoirs being a popular hard engineering option (Umami et al, 2022; Walton, 2019). Clean drinking water is the highest priority in this case, and meeting demand requires funding for sustainable infrastructure development. In recent times, institutional problems have blocked progression in this field.

- Iberian Peninsula (Europe)

Like many other cases, the reasons behind why the Iberian Peninsula is water scarce centres around climate change, and the increasingly erratic weather patterns this has created (Rouhani et al, 2025). In addition to this, over-extraction of water and deforestation (particularly for agriculture) have also put pressure on water security (Fonseca, Andrade and Santos, 2022). It is argued that, despite the inherent difficulty with predicting the impacts of climate change, there is an observable link between the timescale involved and the ability for the agriculture sector to effectively adapt.

One of the key proxies in assessing the extent to which climate change has impacted water scarcity is groundwater level change. According to Rouhani et al (2025), this has dropped significantly since 1986. Steady temperature increase was found to be the primary cause of this reduction, which, for future predictions, indicates that the issue will steadily worsen. Fonseca, Andrade and Santos (2022) reached similar conclusions studying normalised difference vegetation index (NDVI) across water-intense agricultural areas.

Rouhani et al (2025), have commented that, although human impacts were not the subject of their study, they could have implied even more severe consequences for groundwater. To this effect, they have suggested that effective management strategies must be implemented to optimise water consumption in the area. On the related article by Forseca, Andrade and Santos (2022), aquifer recharge techniques were highlighted (whilst largely concurring with Rouhani's findings). Also advocated was the creation of retention basins to enhance food security and climate resilience.

- Mexico City, USA (North America)

In Mexico City, excessive groundwater extraction and urban expansion as a result of population increase, has led to land subsidence (The Indian Express, 2026). Whilst this phenomenon was first recorded in the 1920s, the situation has gradually worsened over the last century, with visible disruptions to infrastructure. During recent years, the area has been forced to use external water sources to meet demand (Huerta-Vergara et al, 2022).

As the population has grown, lack of maintenance of water infrastructure has led to increased vulnerability in the area, with patches of high inefficiency across the system, and an overall low adaptive capacity (Huerta-Vergara et al, 2022). Water is lost from the system as a result of widespread paving of surfaces, creating an impermeable layer which increases surface runoff. Discharge of untreated wastewater into various waterways and rainfall stores has contaminated otherwise usable sources, reducing the overall capacity of drinking-quality water.

Huerta-Vergara et al (2022), cite that greater cooperation between the municipalities of Mexico City and the federal government would

increase the ability for the city to adapt and develop water-saving infrastructure. Alongside this, they also state that sustainable planning is crucial to the future of Mexico City; with no specific group responsible for water problems, the issue should be tackled at all scales (local, regional, and higher authority levels).

- Uruguay (South America)

Over the past six years, Uruguay has suffered a series of droughts caused by La Niña, resulting in billions in losses, mainly from the agricultural sector (Lucero-Méndez, 2023; Martinez, 2023). Whilst Uruguay has a relatively small population (around 3.5 million), 60% live in the metropolitan area of the capital, Montevideo, which has been put under increasing pressure from the droughts. With the threat of 1.9 million people losing access to safe drinking water, the government declared a water emergency on June 19th, 2023.

Further complicating the situation, is the country's current water supply, which is mixed with water from the Río de la Plata estuary (Kruk et al, 2025; Martinez, 2023). Because of the estuary's proximity to the Atlantic, tap water in Montevideo has reached twice the salinity recommended by the World Health Organisation, threatening public health. The issue has become highly political, with government discussion of privatisation and protests opposing the plans of large organisations such as Google, who announced plans to open a data centre which was estimated to consume 2 million gallons of water a day (the equivalent of the daily consumption of 55,000 people).

Whilst there is extensive debate over how to sustainably manage the water crisis, several suggestions have been made, including assessment of current laws, with a view to increasing the efficiency of water management (Kruk et al, 2025; Martinez, 2023). In order to

combat sanitation issues, Kruk et al (2025) suggested reviewing and creating a "plan of action" for the effects of resource extraction on ecosystems and public health. Monitoring physical health indicators may also provide insight quantifiable into the effect limited access to drinking-quality water is having.

Question 4 -

Find the dissolved oxygen concentration of a stream B (DO_B), given the following:

$$(DO_A \times Q_A) + (DO_B \times Q_B) = (DO_C \times Q_C)$$

$$DO_B = (DO_C \times Q_C) - (DO_A \times Q_A) / Q_B$$

$$Q_C(6.2) - Q_A(3.7) = Q_B(2.5)$$

Dissolved oxygen (DO) is function of temperature and chloride concentration. Given that the chloride concentration = 0 mg/L in this case, temperature is the only determining factor.

Values from table:

$$8.99 - 4.49 = 4.50 (DO_A)$$

$$9.28 - 3.58 = 5.70 (DO_C)$$

Input into original formula:

$$DO_B = (5.7 (DO_C) \times 6.2 (Q_C)) - (4.5 (DO_A) \times 3.7 (Q_A)) / 2.5 (Q_B) = 7.48 \text{mg} (DO_B)$$

Stream	Discharge (m ³ / s)	Temperature °C	DO Deficit	DO
A	3.7	21.0	4.49	4.50
B	2.5	—	—	7.48
C	6.2	19.4	3.58	5.70

Reference List -

- BBC. (2026). Thames Water: Inside the Crisis. Available at: <https://www.bbc.co.uk/programmes/m00284vn>. [Accessed 02.05.26].
- Clark, A. (2025). Constituency data: Sewage discharges in England. House of Commons Library. Available at: <https://commonslibrary.parliament.uk/constituency-data-sewage-discharges-in-england/>. [Accessed 03.05.26].
- Fonseca, A., Andrade, C. and Santos, J.A., 2022. Agricultural Water Security under Climate Change in the Iberian Peninsula. *Water*, 14(5), p.768.

- Ford, A.T., Singer, A.C., Hammond, P. and Woodward, J. (2025). Water Industry Strategies to Manufacture Doubt and Deflect Blame for Sewage Pollution in England. *Nature Water*, 3. doi: <https://doi.org/10.1038/s44221-024-00370-y>
- Hosea, L. and Salvidge, R. (2024). Everything you wish you never needed to know about sewage fungus. *The Guardian*. 17 Feb. Available at: <https://www.theguardian.com/environment/2024/feb/17/everything-you-wish-you-never-needed-to-know-about-sewage-fungus>. [Accessed 02.05.26].
- Huerta-Vergara, A.R., Arciniega-Esparza, S., Pedrozo-Acuña, A., Matus-Kramer, A. and Vega-López, E., 2022. Assessment of vulnerability to water shortage in the municipalities of Mexico City. *Boletín de la Sociedad Geológica Mexicana*, 74(1).
- Kruk, C., Cerruti, P., Piccini, C., Chalar, G., Áleman, A. and Segura, A.M., 2025. Health Implications and Socio-Environmental Drivers of Six Months of Drinking-Water Scarcity in the Capital City of Uruguay, South America.
- Lucero-Méndez, C., Ferrero, G., Szabo-Corbacho, M.A., Grattarola, A. and Garcia, H., Response to water scarcity for human consumption in Uruguay in 2023: Critical analysis & Technology validation.
- Martinez, B. (2023). Running Dry: The Battle for Water Security in Uruguay and Why It Foreshadows a Greater Issue. *Harvard International Review*. Available at: <https://hir.harvard.edu/running-dry-the-battle-for-water-security-in-uruguay-and-why-it-foreshadows-a-greater-issue/>. [Accessed 03.05.26].
- Mustafa, A.R.A.W., El-Sherif, H.A. and Nashat, M.H., 2026. The future of water conflict in the Nile Basin countries and their impact on Egyptian water security (A Review). *Journal of Sustainable Food, Water, Energy and Environment*, 2(1), pp.29-35.
- Nutrient Management Board (2026). What is a Nutrient Management Board? Available at: <https://experience.arcgis.com/experience/7dd8a5e2270449508501b744a643d778> [Accessed 13.05.26].
- Phillips, A. (2025). 'Our beaches are full of sewage, rubbish and sanitary products – Brexit is to blame'. *The i Paper*. Available at: <https://inews.co.uk/news/beaches-sewage-rubbish-sanitary-products-brexit-3407217> [Accessed 03.05.26].
- Rangel-Buitrago, N., Francois Galgani and Neal, W.J. (2024). Addressing the global challenge of coastal sewage pollution. *Marine Pollution Bulletin*, 201, pp.116232–116232. doi: <https://doi.org/10.1016/j.marpolbul.2024.116232>.
- Rajak, P., Ganguly, A., Dey, S. and Sen, K., 2025. Antibiotics in wastewater: Exploring the sources, links to antibiotic resistance, and strategies for their removal. *Cleaner Water*, p.100110.
- Rouhani, A., Ben-Salem, N., D'Oria, M., Silva, R.C.G., Viglione, A., Coptly, N.K., Rode, M., Barry, D.A., Gómez-Hernández, J.J. and Jomaa, S., 2025. Direct impact of climate change on groundwater levels in the Iberian Peninsula. *Science of The Total Environment*, 970, p.179009.

- Science Insights. (2025). What Percentage of People Live Within 100 km of a Coastline? Available at: <https://scienceinsights.org/what-percentage-of-people-live-within-100-km-of-a-coastline/>. [Accessed 03.05.26].
- Surfers Against Sewage (2023). Water Quality • Surfers Against Sewage. Surfers Against Sewage. Available at: <https://www.sas.org.uk/water-quality/>. [Accessed 03.05.26].
- The Indian Express (2026). Nasa's chilling space image: One of the world's largest cities is sinking almost 10 inches a year. The Indian Express. Available at: <https://indianexpress.com/article/trending/trending-globally/nasa-image-mexico-city-is-sinking-almost-10-inches-per-year-10675957/> [Accessed 03.05.26].
- The Organization for World Peace (2020). Nile River Conflicts. The Organization for World Peace. Available at: https://theowp.org/crisis_index/nile-river-conflicts/. [Accessed 03.05.26].
- The Rivers Trust (2024). State of Our Rivers. The Rivers Trust. Available at: <https://theriverstrust.org/key-issues/state-of-our-rivers>. [Accessed 03.05.26].
- UK Government (2025). Environmental Indicator Framework Theme B (Water). GOV.UK. Available at: <https://www.gov.uk/government/publications/environmental-indicator-framework-theme-b-water/environmental-indicator-framework-theme-b-water>. [Accessed 13.05.26].
- Umami, A., Sukmana, H., Wikurendra, E.A. and Paulik, E., 2022. A review on water management issues: potential and challenges in Indonesia. Sustainable Water Resources Management, 8(3), p.63.
- Walton, K (2019). The Lowy Institute. In Java, the water is running out. Available at: <https://www.loyyinstitute.org/the-interpreter/java-water-running-out>. [Accessed 03.05.26].
- Youle, R. (2025). Dozens of Swansea and Gower beaches 'plagued' by plastic discs. BBC News. 22 Oct. Available at: <https://www.bbc.co.uk/news/articles/c9d6e9l7jz3o> [Accessed 03.05.26].