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Faculté des sciences | Faculty of Science
Département de biologie | Department of Biology
Pavillon Gendron Hall – pièce/room 160
30 Marie-Curie Ottawa ON Canada K1N 6N5

EVS3120 Environmental Microbiology
Professor: Alexandre Poulain
Take Home Final Exam – Due December 16th 1:00pm

General Instructions:

1. This exam is worth 30% of your final mark.
2. This exam has 3 main questions plus one bonus question. You must answer all three main questions to reach the maximum mark of 30. The bonus question will allow you to get an additional 5 points.
3. This exam is open book.
4. Please write in complete sentences and pay attention to the quality of your writing.
5. You may decide the write your answers in French or English. Please maintain the same language throughout.
6. You are expected to answer each of the questions in **no more than 600 words** for each question (ca. one page font size 12 single space).
7. Do not forget to save your work regularly (or enable the autosave option).
8. You are responsible for the quality of your work. Learn more about academic integrity at uOttawa. This is an individual exam, you are not to complete it in groups. Should two or more students submit identical answers, all students with those answers will face allegations of academic fraud.
9. Should there be any suspicion of plagiarism, all students involved can expect a follow up oral examination to evaluate their knowledge level on the topic of the exam.
10. This exam was designed to be completed in **180 minutes**; however, do not worry, you have up until **December 16th at 1:00pm** to submit your completed exam. Furthermore, the exam will remain available until December 16th at 1:00pm once you open it.
11. Name the digital file (use .docx or .pdf format ONLY) containing your completed exam **student#_EVS3120F_surname.docx** or **student#_EVS3120F_surname.pdf**
12. You may **not** ask questions via email. If you notice any issues with the exam, please use the discussion forum and start a thread under "Questions about the final" topic using the anonymous option.
13. You must submit your completed exam by **1:00pm on December 16th** . **This is a hard deadline.**
    - Please use Arial or Times New Roman 12 point font and 2.54 cm margins (top, bottom, left and right).
    - Make sure to write your full name and student number in the header of your document.
    - Upload **a single file** (.docx or .pdf) with your entire completed exam to the 'MIDTERM assignment' on Brightspace by **1:00pm on December 16th** .
    - You will receive an email confirmation of the receipt of your submission.

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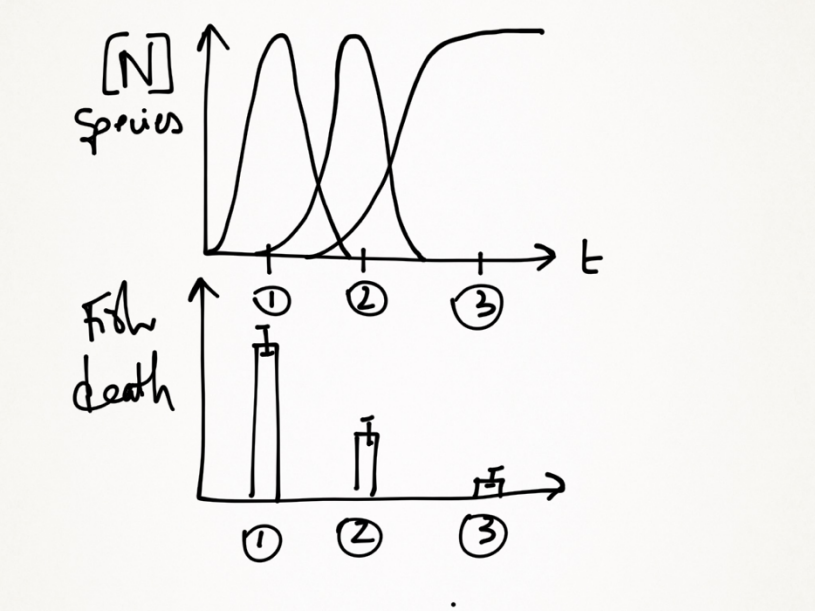
QUESTION #1: The Fish Tank (/10)

You have recently acquired an aquarium. You also purchased many beautiful cichlids. Unfortunately they all rapidly died. Your tank smelled a bit like an old camembert or brie and the pH was between 8.5 and 9.

Your friend Jessica advises you to not add too many fish at once otherwise they will all perish rapidly. She also suggests that you do not overfeed your fish. In fact, this friend suggests that you let your aquarium run for 6 to 8 weeks with only 2 to 3 hardy fish. Indeed, if too many fish are added, it is typical to observe mortality events depending on the sensitivity of the fish species. For the fish species of interest, you are given the following ecotoxicological data: The median lethal concentration (LC50) values for ammonia (NH3-N), nitrite (NO2-N) and nitrate (NO3-N) were 0.045 mg/l, 120.84 mg/l and 1565.43 mg/l.



[N] species: refers to the chemical species of nitrogen.

What does LC_{50} mean? (*source is Canadian Centre for Occupational Health and Safety*)

LC stands for "Lethal Concentration". LC values usually refer to the concentration of a chemical in air but in environmental studies it can also mean the concentration of a chemical in water. It is the concentration of the chemical in water that kills 50% of the test animals during the observation period is the LC_{50} value.

Using your knowledge of the nitrogen cycle, you are asked to explain why one should wait 6 to 8 weeks before increasing the number of fish in the tank. To structure your answer please identify and explain the microbially-catalyzed reactions that dominate the nitrogen cycle in this system. Identify the nitrogen species responsible for events 1, 2 and 3 in the figure above. Note that event 3 also corresponds to an important growth of plants in your aquarium.

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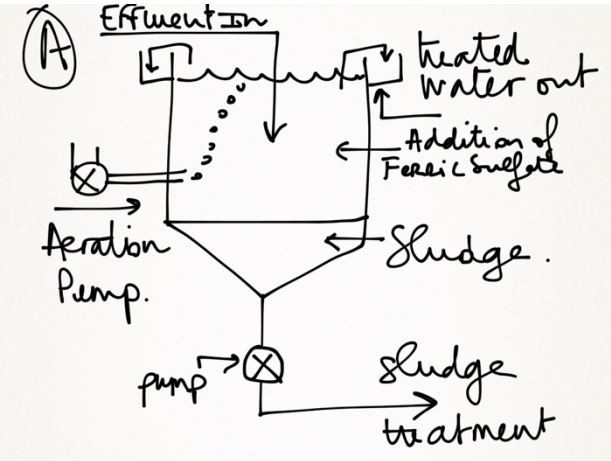
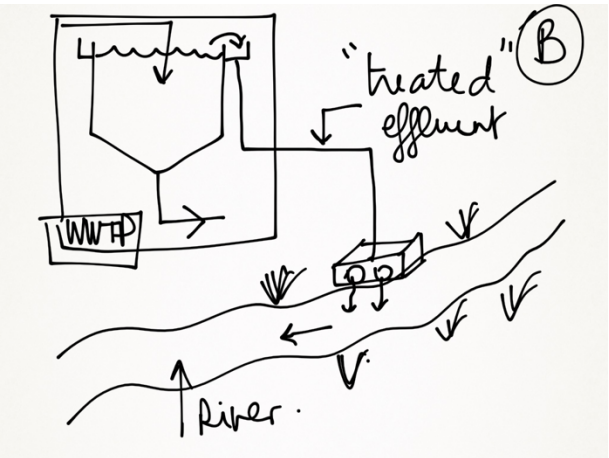
QUESTION #2: Mike's wastewater treatment plant (/10).

You are newly hired and in charge of the wastewater treatment plant (WWTP) of a small city. The city's system is a combined sewer system (e.g., combining storm drains and sanitary sewers). After removal of large particles and grit (sand, stone), microbes are used to treat dissolved and suspended organic matter. Iron sulfate is also added to facilitate the precipitation of nutrients (e.g., phosphate) and of toxic metals; an aeration pump provides oxygen to a well-mixed environment. Excess "sludge" or microbial aggregates are removed by a pump (see figure A). Treated effluent is released into a nearby river (see figure B).





In the middle of the night, you are informed that the pumps at the WWTP stopped working. You cannot repair the pump because important parts are missing. Very early in the morning, the mayor asks that you explain the possible long-term consequences of this situation should the pumps be not repaired rapidly. Using your knowledge of the carbon, oxygen and iron cycles, the concept of biological oxygen demand and the diversity of microbial metabolisms, please describe a possible catastrophe scenario and its impact on the river receiving the effluent.

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QUESTION #3: Pamukkale (/10)

The ancient Greco-Roman Byzantine city of Hierapolis was built on top of the **"White Castle"**. It is located in Southwestern Turkey and is referred to as "Pamukkale". It is a UNESCO World Heritage Site. The "White Castle" is made of several terraces of carbonate minerals fed by flowing waters originating from warm springs. These terraces host numerous pools that are very popular with tourists. Tourists can freely bathe in the pools. The site is such a spectacular attraction that numerous hotels have developed on site; unfortunately, these hotels are releasing part of their "greywater" in the springs that feed the pools. As the touristic season progresses, some pools develop a slimy coating and are smelly and some other pools develop a greenish color.

> => **Greywater**: Greywater or sullage is defined as wastewater generated from plates and wash-hand basins, showers and baths. Greywater often also includes wastewater from clothes washing machines and sometimes include discharge from dishwashers and kitchen sinks. Greywater contains organic matter.

Being a UNESCO World Heritage Site, Pamukkale is closely monitored. A recent study claimed that the site is threatened because the pools are rapidly filling up with carbonates. The study claims that the high tourist density is responsible for the pools filling up with carbonates. Please explain what you suspect are the mechanisms behind the degradation of this historical site.

BONUS QUESTION: Corrosion (/5).

You are an engineer hired by the city of Ottawa to investigate issues associated with the degradation of underground wastewater pipelines. Using your knowledge of the microbial sulfur cycle, please explain what is causing the degradation of the pipelines. A clearly annotated figure is encouraged to support your explanation.