Examination Sustainable Urban Water Engineering (ACE090)

Tuesday 11th January 2022
14:00 – 18:00 at Lindholmensalar

Examiner: Ann-Margret Strömvall, Water Environment Technology, 772 8600.
Ann-Margret is visiting the exam room ~15:30

The exam gives maximum 32p, 16p – grade 3, 21p – grade 4, 26p – grade 5

ANSWERS TO THE MULTIPLE-CHOICE QUESTIONS Q1 – Q7 SHOULD BE ANSWERED ON ONE AND THE SAME SHEET. QUESTIONS 8 – 10 SHOULD BE ANSWERED ON SEPARATE SHEETS!

Preliminary correction protocol is scheduled for 12th January 2022 in Canvas

Inspection of the exam takes place on Thursday 27th January 2022 at 12:00 – 13:00 in room 426 at Water Environment Technology

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Q1. You want to assess the impact of two effluents transporting urban runoff discharging into a river classified as a sensitive recipient water body. When and where do you take your water samples? Only one of the statements below is correct. 2p

a) In dry weather conditions, upstream and downstream of discharge points.
b) In wet weather conditions, upstream of discharge points.
c) In wet weather conditions, upstream and downstream of discharge points.
d) In dry weather conditions, downstream of discharge points.

Q2. What information can you get from a so-called Pourbaix diagram? Only one of the statements below is correct. 2p

a) The amount of oxygen that can be dissolved in water at a certain temperature and salinity.
b) Dose-response from a toxic substance on a biological system.
c) The metal speciation depending on oxidation-reductions potential and pH value.
d) Best practice solutions for pollution source control.

Q3. What is the main purpose for doing field measurements of parameters such as pH, ORP, DO, conductivity, turbidity, and temperature? Only one of the statements below is correct. 2p

a) These analyses are expensive to perform at a commercial laboratory, therefore it is cheaper to measure these parameters directly in-situ and with your own equipment.

b) The analyses are time-consuming to do at a commercial laboratory or on your own in a laboratory. To save time, it is better to do the measurements in-situ.

c) It is better to measure these parameters in the field to avoid possible cross-contamination from the transportation and storage of the samples.

d) These parameters are sensitive and can change over time through chemical reactions in a sample and are not representative if the analyses are delayed.

Q4. K_{OW} can be used to predict whether chemical compounds can potentially be environmental pollutants. Only one of the statements below is correct. 2p

a) Chemical compounds have the potential to bioaccumulate if $K_{OW} > 1000$.
b) Chemical compounds are hydrophilic if $\log K_{OW} > 3$.
c) Chemical compounds have the potential to bioaccumulate if $K_{OW} > 10$.
d) Chemical compounds tend to be persistent if $K_{OW} < 10$.

Q5. What is the meaning of the term SUDS? Only one of the statements below is correct. 2p

a) A water management practice that aims to collect as much of the stormwater as possible in urban environments for further transport and treatment in the sewage treatment plant.
b) A water management practice that includes techniques such as road sweeping, weed control, limitation of the use of fertilisers.
c) A water management practice that aims to adapt modern drainage systems with natural water processes such as soil percolation and bioretention.
d) A water management practice that aims to control traffic by reducing taxes, speed control, etc.

Q6. ISCO is a method used for treatment of contaminated groundwater. Only one of the statements below is correct. 2p

a) ISCO is a commonly used treatment technique for ex-situ treatment of groundwater where pollutants are destroyed ex-situ.
b) Chemical oxidants such as permanganate and Fenton reagents are often used in ISCO with good results for the degradation of organic pollutants.
c) The ISCO technique is particularly effective if groundwater contains high concentrations of TOC/DOC.
d) The ISCO method has limitation and can only degrade LNAPL.

Q7. Which of the following treatment trains can be the most effective solution for the treatment and removal of all the different pollutants and nutrients that occur in leachates from an old landfill? Only one of the statements below is correct. 2p

a) Chemical precipitation → nitrification and denitrification in a sequencing batch reactor (SBR) → peat filters → GAC filters.
b) Sedimentation in a pond→ chemical precipitation→ sand filters → GAC filters.
c) Sedimentation pond → wetland area.
d) Aerated lagoons and sedimentation in a pond.

Q8. Figure 1 presents a sketch of an urban area (not made to scale) with:

1. **A covered landfill that now serves as a recreational area.**
2. **Fields where crops are grown.**
3. **A residential area where people live.**
4. **Parking lot belonging to the residential area.**
5. **Recycling station where you can recycle metals, plastics, and glass. Unfortunately, it is not very well kept and there is often thrash on the ground.**
6. **A petrol station with an old, not well-functioning oil separator for stormwater.**

No number: A road that runs through the area.

No number: A bridge across the stream. However, it is made for bicycles and pedestrians and is not accessible by car.

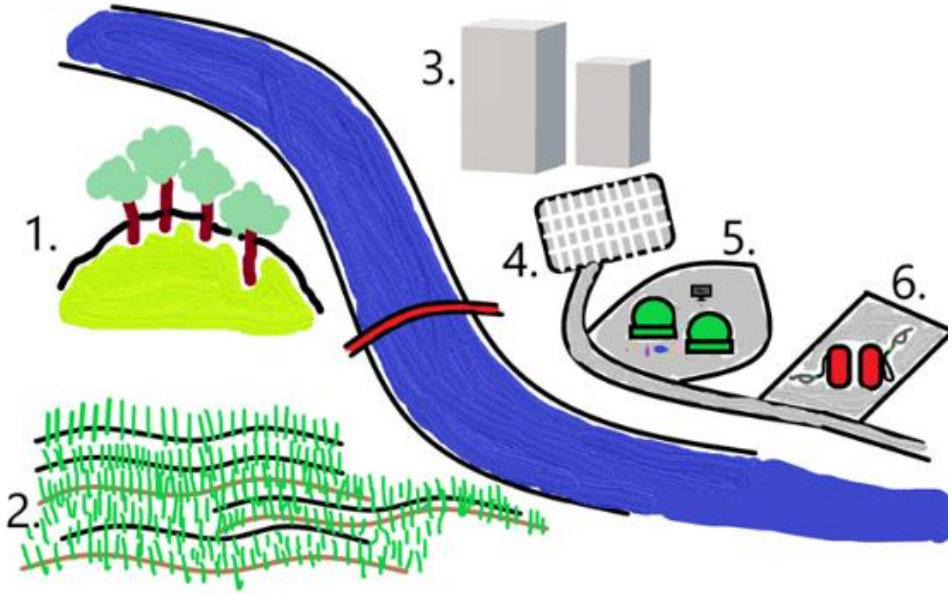

Figure 1. Sources of pollutants on a stream in an urban area.

The water quality of the stream flowing through this catchment area (Figure 1) is very poor and of concern as it has been classified as a very sensitive recipient. You have been asked to make a first inventory and assessment of possible negative impacts the urbanised area may have on the water body, regarding the stormwater and groundwater inflow entering the stream from the area. Except for the old, not so efficient, oil separator below the petrol station, there are no applied treatment methods for stormwater in this area and the degree of impervious surfaces is high on the right side of the stream. Most of the precipitation that falls on the right (residential) side of the river is expected to reach the water body untreated.

Draw a conceptual model of the area with a focus on the recipient and possible sources of pollutions. Write a short summary of the possible sources of pollution and the major pollutants and/or nutrients that you think are connected to each source. 6p

Below is an example of how you could answer question 8. Note that there are several different ways to illustrate a conceptual model.

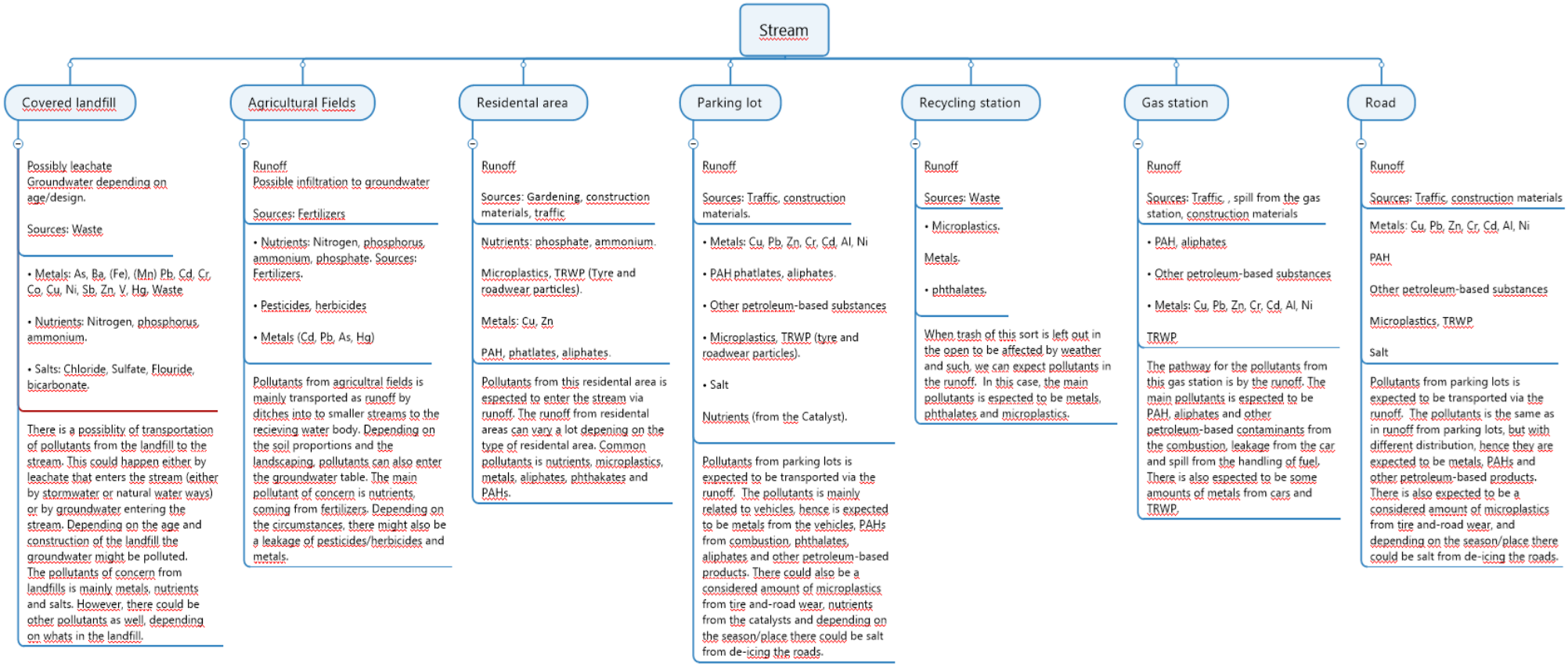

Figure 2. A stormwater sedimentation pond.

Q9. In Figure 2 you can see an example of a stormwater sedimentation pond. Describe in detail the processes for transport and removal of suspended solids/materials in the pond and explain the factors that affect the processes. Also, describe in detail the different processes for transport and removal in the pond of a toxic trace metal such as copper and explain the factors that affect the processes. 6p

Below is an example of how you could answer question 9

See Chapter 3 Stormwater treatment processes in Erickson et al 2013 + Lecture 11 on Stormwater treatment processes and techniques

*Suspended solids are particles **>1 µm** and that can settle fairly easily in a sedimentation pond and the sedimentation velocity follows the formula of **Ferguson and Church**. The sedimentation velocity depends on the **particle densities** and particles with a density of >2 g/cm^3 settle fairly easily. There is also a dependence with **temperature** and particles at 25^{o}C settle more easily than particles in a cold water around 4^{o}C. The **mixing conditions** also affect the removal efficiency, and the removal is more effective under plug flow than during totally mixed conditions.*

See Lecture 7 on Metals in the environment + Chapter 7. Heavy metals. Van der Perk, Soil and Water Contamination

Copper (Cu) is often sorbed to the surface on particles, especially if they contain a high organic content containing, for examples humic acids. But Cu can also be bound to dissolved organic carbon (DOC) and if the concentrations of DOC is high, Cu can be easily transported through the pond without sedimentation. The ability of Cu to settle as precipitation is also depends on the pH and redox potential that can be seen in the Pourbaix diagram in the figure below. In a pond with pH > than 4 and a high redox = oxid conditions dissolved copper can precipitate and settle as $Cu(OH)_2$

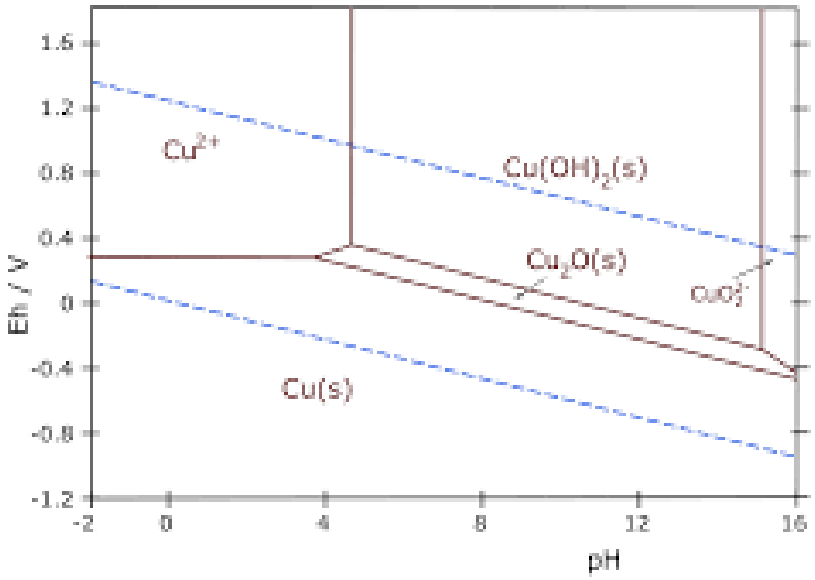

Figure 3. The effluent of landfill leachates.

Q10. In Figure 3 you can see an example of a pipe with an outflow/effluent of leachates from a landfill. In the leachate treatment of landfills, biological processes are used to remove iron, nutrients, and organic matter. Describe in detail these removal processes for each of iron, ammonium, and organic matter. Also, describe how this is done in practice with engineering solutions. 6p

Below is an example of how you could answer question 10

See Chapter 3 Stormwater treatment processes in Erickson et al 2013 + Lecture 10 Landfill leachates and treatment techniques and study visit Kikås.

1. Iron is removed by addition of oxygen and precipitates as iron oxides and hydroxides as for examples

$Fe^{2+} + O_2 \rightarrow\rightarrow 5Fe_2O_3x9H_20$

2a. Ammonium is removed by nitrification by addition of oxygen following the formulas

$2NH_4^+ + 3O_2 \rightarrow NO_3^- + 4H^+ + 4H_2O + 2NO_2^-$ *(Nitrosomonas)*

$2NO_2^- + O_2 \rightarrow 2NO_3^-$ *(Nitrobacter)*

Sum: $2NH_4^+ + 3O_2 \rightarrow 4H^+ + 4H_2O + 2NO_3^-$

2b. Nitrate can be further degraded under anoxic conditions to nitrogen gas in the denitrification process

[CH2O] (Organic matter) + $NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow (N_2O) \rightarrow N_2$ *(gas)*

3. Organic matter can be removed addition of air by microbial respiration

[CH_2O] (Org mat) + O_2 → CO_2 + H_2O

Depends on temperature could be limited during winter

1, 2a, and 3 could be done in an aerated pond by using a simple artificial pond provided with aeration. Oxygenation is carried out by mechanical aeration units as bottom aerators for deeper ponds or by induced surface aeration for faster aeration or shallower water. The biological processes that take place in an aerated pond are determined by temperature (air and water), pH, oxygenation level, flow regime, mixing regime and organic load, and the leachtes characteristics.

In order to receive denitrification (2b), the aerated pond could end with a part of the pond without aeration and with the goal to reach anaerobic conditions. Another possibility to achieve denitrification is to transfer the leachates after aeration to a wetland area. The third option is to combine the aerated pond with the sequencing batch reactor (SBR) process (DOI: 10.12983/ijsrk-2013-p034-043) + https://doi.org/10.1016/j.desal.2011.04.046

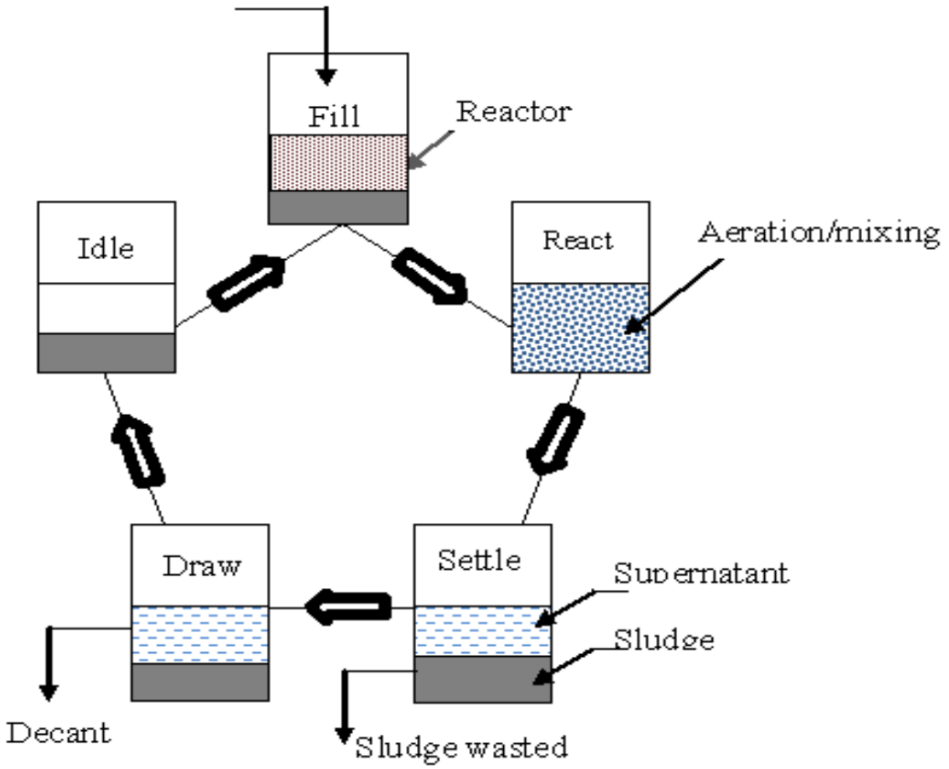

Fig. 1: SBR operation for one cycle (Aziz et al., 2011a)