# Experiment N° 13

## Requirements

1. Sewage and their types

   a) industrial wastewater
   b) municipal sewage
   c) waste from farms and livestock farms

2. Methods of wastewater treatment and disposal of products

   a) Primary treatment - purification of the trellises and screens
   b) Secondary treatment - biological treatment
   c) Tertiary treatment - chemical treatment

3. Analytical methods used in sewage treatment plants

   a) BOD, COD, DO
   b) pH, conductometry, colorimetry,
   c) determination of nitrates, nitrite, phosphates

4. Course of the experiment

# Wastewater treatment - Overview of issues

**Wastewater treatment plant** also called **wastewater treatment works** can mean one of the following:

- Sewage treatment – treatment and disposal of human waste.
- Industrial wastewater treatment – the treatment of wet wastes from manufacturing industry and commerce including mining, quarrying and heavy industries.
- Agricultural wastewater treatment – treatment and disposal of liquid animal waste, pesticide residues etc. from agriculture.[1]

**Sewage treatment**, or **domestic wastewater treatment**, is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce an environmentally-safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer). Using advanced technology it is now possible to re-use sewage effluent for drinking water, although Singapore is the only country to implement such technology on a production scale in its production of NEWater[2]

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[1] http://en.wikipedia.org/wiki/Wastewater_treatment_plant

[2] http://www.pub.gov.sg/about/historyfuture/Pages/NEWater.aspx

**Industrial wastewater treatment** covers the mechanisms and processes used to treat waters that have been contaminated in some way by anthropogenic industrial or commercial activities prior to its release into the environment or its re-use.

Most industries produce some wet waste although recent trends in the developed world have been to minimize such production or recycle such waste within the production process. However, many industries remain dependent on processes that produce wastewaters.[3]
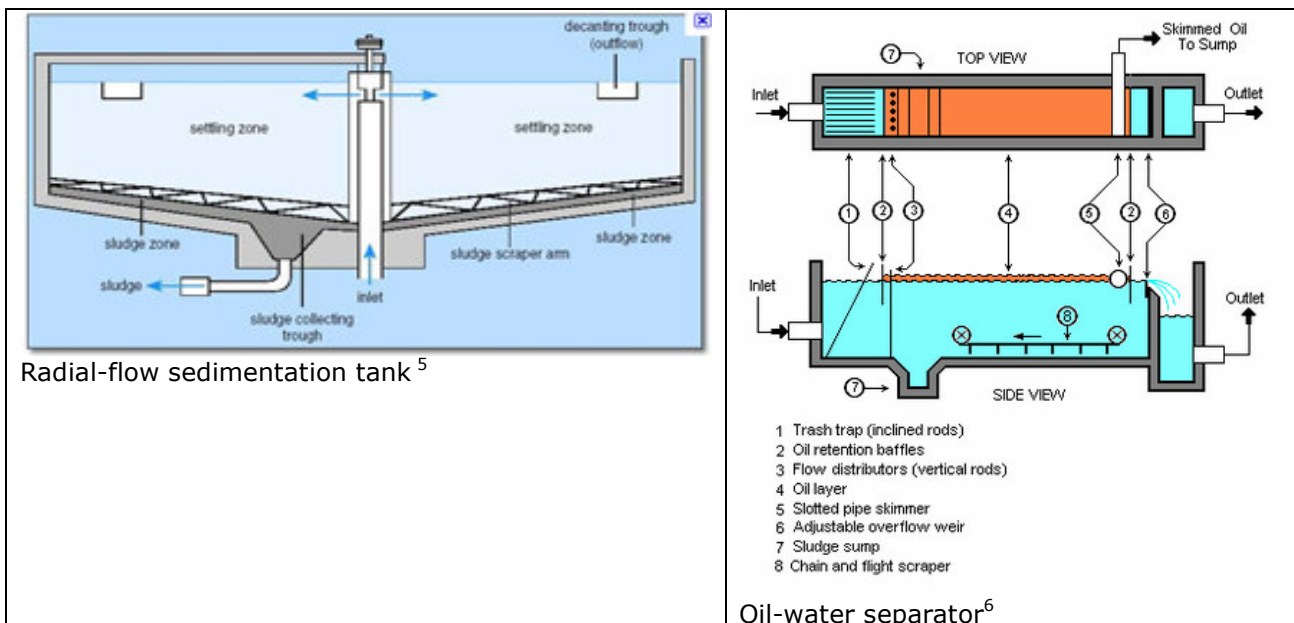
**Agricultural wastewater treatment** relates to the treatment of wastewaters produced in the course of agricultural activities. Agriculture is a highly intensified industry in many parts of the world, producing a range of wastewaters requiring a variety of treatment technologies and management practices.

Nonpoint source pollution from farms is caused by surface runoff from fields during rain storms. Agricultural runoff is a major source of pollution, in some cases the only source, in many watersheds.[4]

# Methods of treatment

### Preliminary & Primary treatment

This includes simple processes such as screening and grit removal (through constant velocity channels) to remove the gross solid pollution. Afterwards usually plain sedimentation, simple settlement of the solid material in sewage can reduce the polluting load by significant amounts.



Radial-flow sedimentation tank [5]



1 Trash trap (inclined rods)
2 Oil retention baffles
3 Flow distributors (vertical rods)
4 Oil layer
5 Slotted pipe skimmer
6 Adjustable overflow weir
7 Sludge sump
8 Chain and flight scraper

Oil-water separator[6]

3 http://en.wikipedia.org/wiki/Industrial_wastewater_treatment

4 http://www.epa.gov/owow/NPS/Ag_Runoff_Fact_Sheet.pdf

5 http://open.jorum.ac.uk/

6 http://en.wikipedia.org/wiki/Industrial_wastewater_treatment

### Secondary treatment

Further treatment and removal of common pollutants, usually by a biological process.



A generalized, schematic diagram of an activated sludge process.[7],[8]



A typical complete trickling filter system[9]
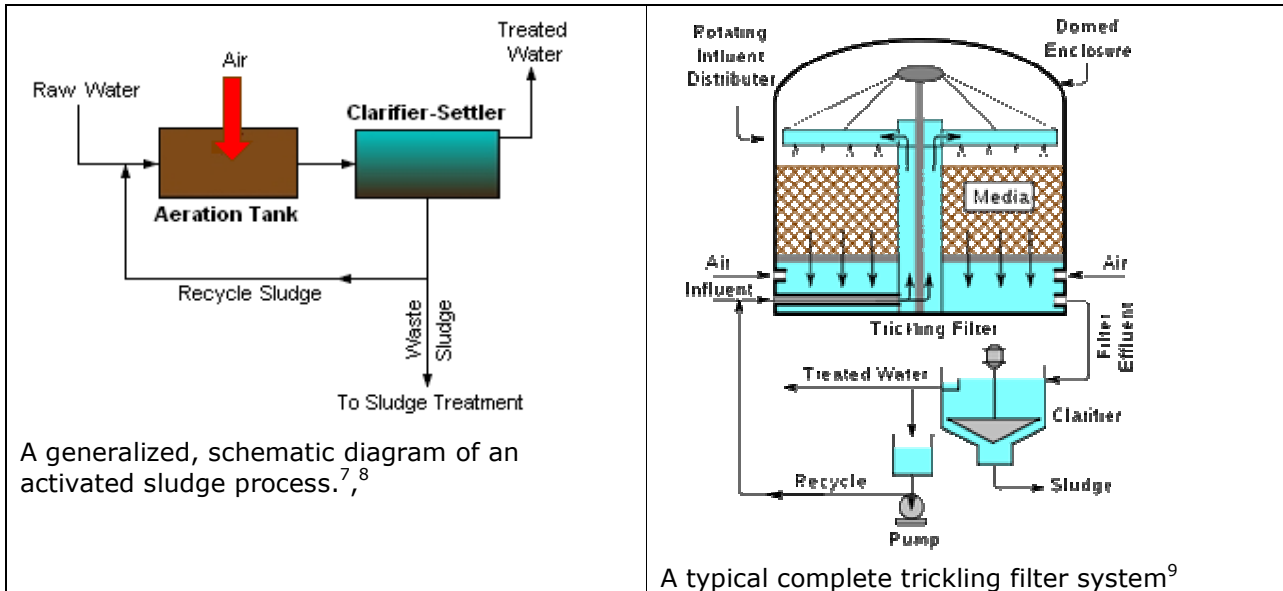
### Tertiary treatment

Usually for removal of specific pollutants e.g. nitrogen or phosphorous, or specific industrial pollutants.[10]



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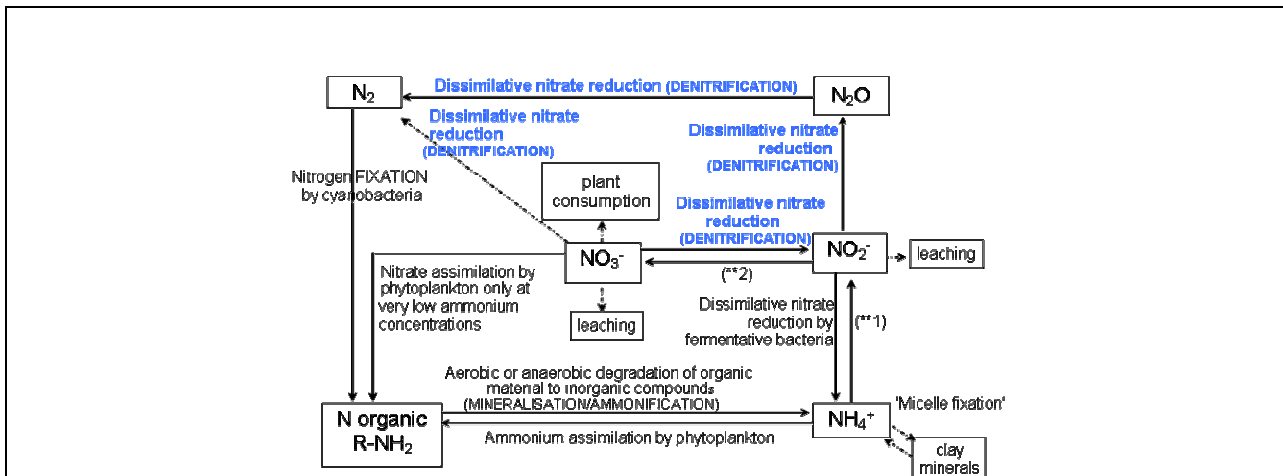
[7] http://en.wikipedia.org/wiki/Activated_sludge#cite_note-Beychok-0

[8] http://en.wikipedia.org/wiki/Activated_sludge

[9] http://en.wikipedia.org/wiki/File:Trickle_Filter.svg

[10] http://www.lut.ac.uk/well/resources/technical-briefs/64-wastewater-treatment-options.pdf

Denitrification is the process in which nitrates are reduced to gaseous nitrogen

$$NO_3^- \rightarrow N_2 \text{ or } N_2O.$$

This process is used by facultative anaerobes. These organisms flourish in an aerobic environment but are also capable of breaking down oxygen-containing compounds (e.g $NO_3^-$) to obtain oxygen in an anoxic environment. The bacteria mediating this change are referred to as 'denitrifying bacteria'
(Smith, 1990) [11].

**Phosphate precipitation**

Chemical precipitation is used to remove the inorganic forms of phosphate by the addition of a coagulant and a mixing of wastewater and coagulant. The multivalent metal ions most commonly used are calcium, aluminium and iron. [12]
Read more:[13]

# Analytical methods

**Biochemical oxygen demand** or **B.O.D.** is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.[14]

**BOD Measurement** – more:[15]

**Chemical oxygen demand** (**COD**) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. Older references may express the units as parts per million (ppm).[16]

**COD Measurement** – more:[17]

**Dissolved oxygen** (DO) is a relative measure of the amount of oxygen that is dissolved or carried in a given medium. It can be measured with a dissolved oxygen probe such as an oxygen sensor or an optode in liquid media, usually water.[18]

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11 http://www.chemgapedia.de/vsengine/vlu/vsc/en/ch/16/uc/vlus/nitrogenmarine.vlu/Page/vsc/en/ch/16/uc/chemicalcycles/nitrogen/denitrification.vscml.html

12 http://www.lenntech.com/phosphorous-removal.htm

13 http://www.lenntech.com/phosphorous-removal.htm#ixzz1i7M9zfO8

14 http://en.wikipedia.org/wiki/Biochemical_oxygen_demand

15 http://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/4oxygen.html

16 http://en.wikipedia.org/wiki/Chemical_oxygen_demand

17 http://en.wikipedia.org/wiki/Chemical_oxygen_demand

18 http://en.wikipedia.org/wiki/Oxygen_saturation

### DO Measurement – more:[19]

An oxygen meter has two components — the sensor (sometimes called the probe) and the meter. Various types of sensors are available, but they all operate in basically the same way: the sensor reacts with oxygen and an electrical signal is produced In proportion to the oxygen concentration. More: [20]

### pH Measurement

In chemistry, **pH** is a measure of the acidity or basicity of an aqueous solution. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C (77 °F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. pH measurements are important in medicine, biology, chemistry, agriculture, forestry, food science, environmental science, oceanography, civil engineering and many other applications.[21] More: [22]

### Electrolytic Conductance

An electrolytic solution contains free ions in addition to other kinetically identifiable species. When electrical potential is applied across the solution the macroscopic observations are, the flow of current through the solution and the chemical changes generally resulting in the liberation or dissolution of the electrode material at the points where the current enters or leaves the solution. This phenomenon of decomposition of the solutions by electrical current is termed as electrolysis.[23]

#### Basic principle of conductometry in solution

A conductance measuring cell consists of two inert electrodes that face each other and immerse in measuring solution. The inert electrode is generally platinum or stainless steel.[24]

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[19] http://www2.emersonprocess.com/siteadmincenter/PM%20Rosemount%20Analytical%20Documents/Liq_ADS_43-003.pdf

[20] https://srac.tamu.edu/index.cfm/event/getFactSheet/whichfactsheet/167/

[21] http://en.wikipedia.org/wiki/PH

[22] http://www.iupac.org/publications/pac/2002/pdf/7411x2169.pdf

[23] http://vedyadhara.ignou.ac.in/wiki/images/e/ed/Unit_4_Conductometric_Titrations.pdf

[24] http://archive.lib.cmu.ac.th/full/T/2007/chem1207tk_app.pdf
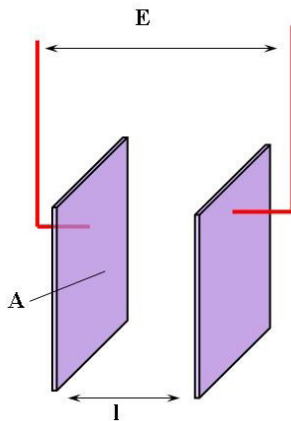
$$\sigma = (1/R) \times (l/A) = K_{cell} \times G$$

Where

$\sigma$ = conductivity, Scm-1
$R$ = resistance, $\Omega$
$G$ = conductance, S ( Siemens)
*cell K* = cell constant
$l$ = electrode length, cm
$A$ = electrode area, cm2

## Colorimetry

For a given compound, the intensity of absorption depends on the amount of the sample. If a particular frequency of radiation is being absorbed by a molecule, then more molecules there are, the more radiation of that frequency will be absorbed and less transmitted.
More:[25]

**Determination of nitrates & nitrite**

**QUANTOFIX® Nitrate/Nitrite**
**MACHEREY-NAGEL GmbH & Co. KG** ·

**Pack content:**
1 aluminium container with 100 test strips
**General indications:**
Remove only as many test strips as are required. Close the container immediately after removing a strip. Do not touch the test fields.
**Instructions for use:**
1. Dip the test strip with both fields into the test solution (pH 1–9) for 1 second.
2. Shake off excess liquid.
3. Wait 60 seconds.
4. Compare with the colour scale. If nitrate ions are present, the lower test field (at the end of the strip) will turn red-violet. The upper test field will show the nitrite concentration.
**Interferences (Nitrate):**
If the nitrite test field turns red-violet, the nitrate determination will be affected. To eliminate the interference due to nitrite, add 1 spoon sulphamic acid (REF 918 973) to 10 mL of the sample, shake again and repeat the test after 2 minutes. This allows the determination of 10 mg/L nitrate and 1000 mg/L nitrite simultaneously.
**Interferences (Nitrite):**
Strongly acid solutions (pH < 1) have to be buffered with sodium acetate; alkaline solutions have to be set to a pH value of 3–5 using citric acid. The following ions interfere with the determination in higher concentrations:

1000 mg/L $Br^-$, $BrO_3^-$, $Cl^-$, $ClO_3^-$, $ClO_4^-$, $F^-$, $J^-$, $Mo_7O_{24}^{6-}$, $NO_3^-$, $OCN^-$, $PO_4^{3-}$, $SO_3^{2-}$, $SO_4^{2-}$, $SeO_3^{2}$, $WO_4^{2-}$, acetate, oxalate, tartrate, citrate, succinate, $Ag^+$, $Al^{3+}$, $As^{3+}$, $Ba^{2+}$, $Be^{2+}$, $Co^{2+}$, $Cd^{2+}$,

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[25] http://books.google.pl/books?id=IW6gn7-ayoUC&pg=RA13-PA349&dq=colorimetry&redir_esc=y#v=onepage&q=colorimetry&f=false

$Cr^{3+}$, $Cu^{2+}$, $Hg^{2+}$, $K^+$, $Li^+$, $Mg^{2+}$, $Mn^{2+}$, $Na^+$, $Ni^{2+}$, $Pb^{2+}$, $Sb^{3+}$, $Tl^+$, $Zn^{2+}$, > 250 mg/L $S_2O_3^{2-}$, $S_2O_5^{2-}$, > 100 mg/L $[Fe(CN)_6]^{4-}$, $S_2O^{2-}$, $SCN^-$, ascorbate.

**Storage:**
Avoid exposing the strips to sunlight and moisture. Keep container cool and dry (storage temperature not above +30 °C). If correctly stored, the test strips may be used until the use-by-date printed on the packaging.

More:[26], [27]

### Determination of phosphates

Modern colorimetric method[28]

### More:[29]

### Further Reading

Article on biological methods of wastewater treatment in the petrochemical industry [30]

Article about the anaerobic treatment of dairy wastewater [31]

Article about the methods of coagulation and separation of solids from dairy wastewater [32]

Overview developed by - Adam Myśliński

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[26] http://www.dec.state.ak.us/eh/docs/lab/dw/Chem/inorganics/353.2.pdf

[27] http://www.eurasianjournals.com/index.php/ejac/article/viewFile/138/pdf_75

[28] http://www.amco-instruments.com/index_files/pdf/picco-espectro.pdf

[29] http://www.fsis.usda.gov/PDF/CLG_PHS_1_01.pdf

[30] http://www.water.siemens.com/SiteCollectionDocuments/Industries/Hydrocarbon_Processing/Brochures/CE_10-05_biological_trt.pdf

[31] http://www.mrec.org/pubs/Dairy%20Waste%20Handbook.pdf

[32] http://www.hydroflotech.com/Typical%20Applications/Dairy%20Products%20Wastewater/Dairy%20Products%20Wastewater.htm