The Islamic University of Gaza
Faculty of Engineering
Civil Engineering Department

Sanitary Engineering
(ECIV 4325)

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Lect. W1

Introduction to Sanitary Engineering and Wastewater Collection
Sanitary engineering:
A branch of engineering concerned with the design, construction, and maintenance of environmental facilities conducive to public health, such as water supply and waste disposal.

The Sanitary Engineer provides safe water and sewer services for the residents in order to protect both our environment and our standard of living.
The sanitary engineer job became essential with the rapid increase of cities and other rural population concentrations.

**Sanitary Engineering Fields**

- **Water supply**
  - Water collection
  - Ground water
  - Surface water
  - Water treatment
  - Water Distribution

- **Waste water Management**
  - Collection systems
  - Treatment
  - Reuse (and/or) disposal

- **Storm water Management**
  - Storm water collection
  - Storm water reuse (and/or) disposal
  - Storm water treatment (if needed)

- **Solid waste Management**
  - Collection systems
  - Treatment methods
  - Reuse (and/or) disposal
WASTE WATER COLLECTION SYSTEM

DEFINITIONS

**Sewer:** Sewers are underground pipes or conduits which carry sewage to points of disposal.

**Sewage:** The liquid waste from a community is called sewage. Sewage is classified into **domestic** and **non-domestic** sewage. The non-domestic sewage is classified into industrial, commercial, institutional and any other sewage that is not domestic.

**Sewerage:** The entire system used for collection, treatment and disposal of liquid waste. This includes pipes, manholes, and all structures used for the above mentioned purposes.

**Infiltration:** It is the water which enters the sewers from ground water through leaks from loose joints or cracks.

**Inflow:** It is the water which enters the sewers from the manholes during rainfall events.
<table>
<thead>
<tr>
<th>Type of Wastewater</th>
<th>Source of wastewater</th>
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<tbody>
<tr>
<td>Gray water</td>
<td>Washing water from the kitchen, bathroom, laundry (without faeces and urine)</td>
</tr>
<tr>
<td>Black water</td>
<td>Water from flush toilet (faeces and urine with flush water)</td>
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WASTEWATER COLLECTION SYSTEMS

Wastewater collection systems are used to collect and transmit liquid wastes to a central treatment facility. Like a distribution system for water supply, the collection system resembles a tree that branches out from the treatment plant to collect the wastewater from across the system. Wastewater from individual homes enters the collection system through a service line.
Types of collection systems

- **Separate system**
  - Sanitary system
  - Storm water
  1. Used for domestic and industrial wastes in addition to inflow and infiltration. Storm water is not considered.
  2. It is preferred for the following:
     The size of pipes is much smaller than the combined system sewers. This gives the advantage of good hydraulics in the pipe (the pipe is designed to have a minimum velocity to prevent sedimentation of sand).
     Separation of wastewater from storm water minimize the total quantity of sewage which has the following advantages:
        1. Smaller pumping stations are needed.
        2. Smaller and more efficient treatment plants are needed.
        3. Overflow of combined sewers in the storm events produces pollution to the environment which is not the case in separate sewer.
     Only unavoidable storm water enters the system which protects the system from the accumulation of sand in the sewers in the non-paved areas.

- **Combined system**
  - Both sanitary & storm water
  1. It is used for both storm water and wastewater.
  2. It is preferred for the following cases:
     - For areas of long rainy seasons.
     - For areas where it is difficult to construct two pipelines in the streets crowded with other services (electricity, telephone, gas, etc...).
     - It’s not preferred for areas of short rainy season, and for areas poorly paved which leads to the accumulation of sand in the system.
  3. Combined system is 40% lower in cost than separate system.

Generally, most of the countries recently preferring separate systems.
Wastewater Collection System
Lift Station and Force Main

- Lift Station
- Force Main
- Manholes
- Flow
- Gravity Sewer
Preliminary studies are needed for the design of sewage collection systems

1. Contour maps, and longitudinal profiles.
2. Geotechnical investigation (type of soil).
3. Hydrological investigation (water table).
4. Metrological data (rain, ...).
5. Detailed map of the area showing streets, buildings, levels of buildings entrance ... etc
6. Detailed cross section for the streets showing the underground service (water pipes, electricity cables, gas pipes, telephone, ...).
7. Water supply and consumption study.
8. Identification of industrial, commercial institutional and domestic areas.
9. Identification of collection points of sewage and possible locations of pumping stations and point of final collection.
11. Expected Development of the area (Master planning).
Population change

• 4 basic components of population change:
  – *Births*
  – *Deaths*
  – *Immigration*
  – *Outmigration*

• Excess of births over deaths results in natural increase

• Excess of deaths over births results in natural decrease

• The difference between inmigration and outmigration is net migration
Population change

• Closed population
  – A population for which immigration and out migration are nil, e.g., the population of the world as a whole
  – Population growth depends entirely on the difference between births and deaths

• Open population
  – A population in which there may be migration (international)
  – The growth of an open population consists of natural increase and net migration
Demographic Balancing Equation

• The principle of the balancing equation:
  – **In any time interval, the pop. of a country can increase or decrease only as a result of births, deaths and movements across the country's boundaries**
  – **Births & immigration add to the pop., & deaths and emigration subtract from it**
  – **If data are available from 2 censuses, and the numbers of births, deaths and in- and out-migrants are known, then the equation must balance exactly, if all the data are perfectly accurate**
**Demographic Balancing Equation**

- Pop. change = (Births - Deaths) + (Immigrants - Emigrants)

- \( P_t = P_0 + (B - D) + (I - E) \)
  
  *where: \( P_0 \) = initial population
  
  \( P_t \) = population after time \( t \)

- Worldwide, natural increase is the most important component of overall population change over time
**Projection - Definition**

- A population projection is:
  - An extrapolation of historical data into the future
  - An attempt to describe what is likely to happen under certain explicit assumptions about the future as related to the immediate past
  - A set of calculations, which show the future course of fertility, mortality and migration depending on the assumptions used
Projection – Linear growth

• Implies that there is a constant amount of increase per unit of time
• A straight line is used to project population growth
• It is expressed as $P_t = P_0 + bt$
  
  where $P_0 = \text{initial population}$

  $P_t = \text{population } t \text{ years later}$

  $b = \text{annual amount of population change}$
Projection – Linear growth

• Assumptions:
  – *Growth rate is constant*
  – *Change is only experienced at the end of unit time*
  – *Resultant change (i.e. interest) does not yield any change*
Projection – Geometric growth

• The growth assumes a geometric series

• It is expressed as

\[ P_t = P_0 \cdot (1 + r)^t \]

where \( P_0 \) = initial population

\( P_t \) = population \( t \) years later
Projection – Linear growth

- **Assumptions:**
  - *Growth rate is constant*
  - *Change is only experienced at the end of unit time*
  - *Compounding takes place at specified intervals*
Projection - Definition

- A population projection is:
  - An extrapolation of historical data into the future
  - An attempt to describe what is likely to happen under certain explicit assumptions about the future as related to the immediate past
  - A set of calculations, which show the future course of fertility, mortality and migration depending on the assumptions used
Population estimation

Many methods are used to forecast the population in the future. Each method has its own assumptions.

1. Arithmetic increases method: Assumption: The rate of change is constant

\[
\frac{dp}{dt} = K
\]

\( P_t = P_0 + Kt \)

\( P_0 = \) present or initial population

Validity: valid only if the curve is close to the real growth of the population in previous years.
Example 1:

The recent population of a city is 30000 inhabitant. What is the predicted population after 30 years if the population increases 4000 in 5 years.

Solution: The arithmetic increase method

\[
K = \frac{dp}{dt} = \frac{\Delta P}{\Delta t} = \frac{4000}{5} = 800
\]

\[
P_t = P_0 + Kt = 30000 + 800 \times 30 = 54000 \text{ inh}
\]
Example 2:

The recent population of a city is 30000 inhabitant. What is the predicted population after 30 years if the growth rate $R = 3.5\%$.

Solution: Uniform percentage of increase (Geometric Increase)

\[
P_t = P_0 (1+k)^n
\]

\[
P_{30} = 30000 \times (1+0.035)^{30} = 84204 \text{ inh}
\]
3. Curvilinear method:
It is a method of comparison of the city under consideration with similar cities larger in size.

4. Saturation method:
In this method, the maximum possible density of population is estimated according to the number of apartments and stories per unit area and the maximum family members.