

**The Islamic University of Gaza- Civil Engineering Department**  
**Advanced Sanitary Engineering- ECIV 5325**

## **Unit 6. The current wastewater treatment systems in Gaza Strip**

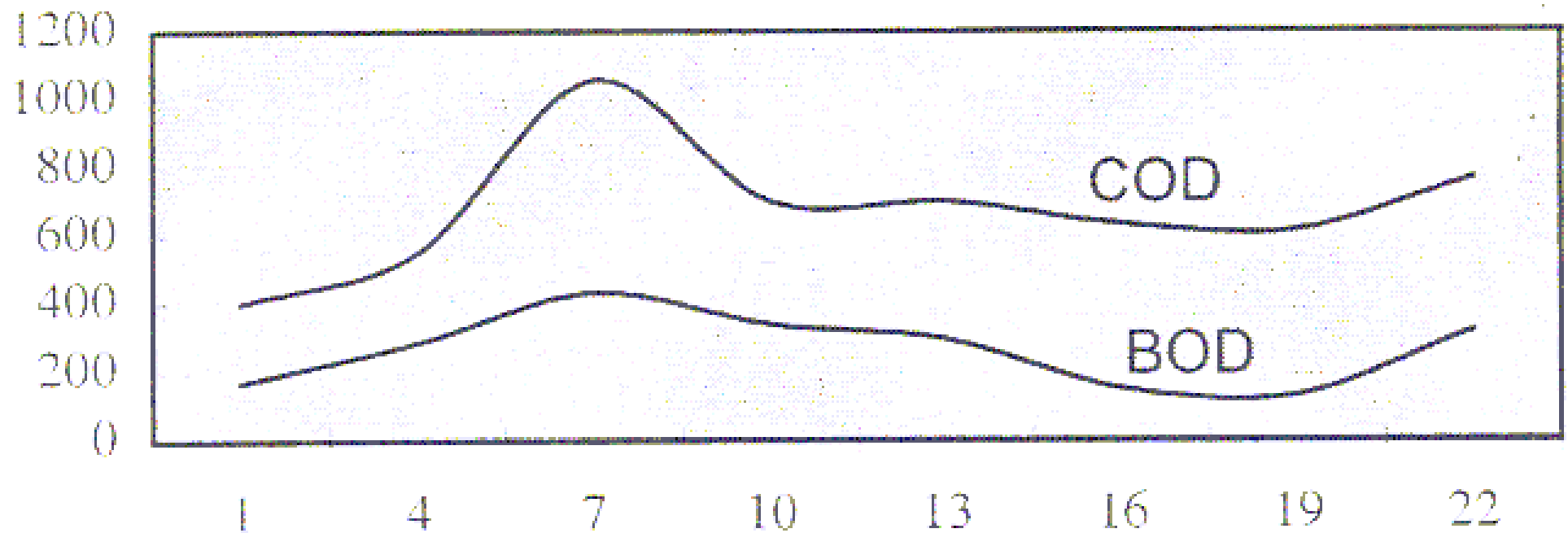
Prepared by  
Husam Al-Najar



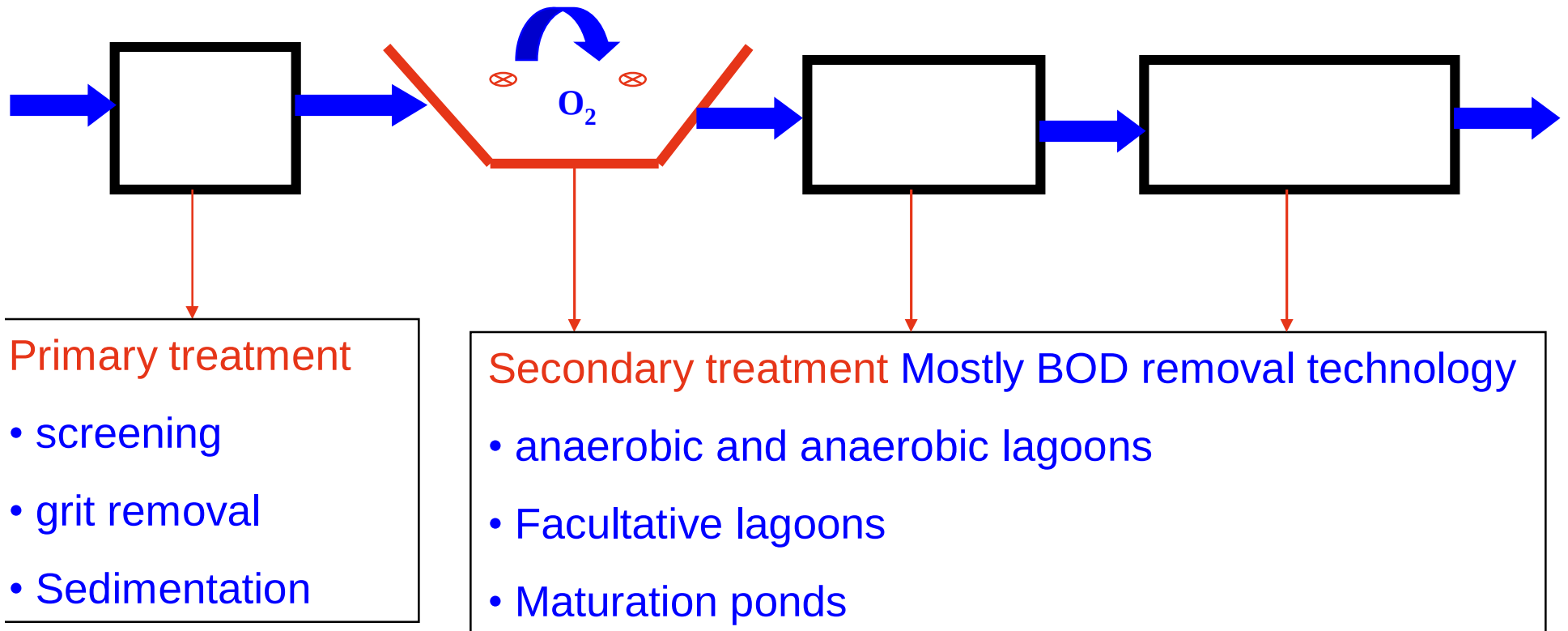
## Wastewater characteristics in Gaza Strip (PWA, 2003)

| Parameter<br>(mg/l) | Wastewater characteristics |      |       |
|---------------------|----------------------------|------|-------|
|                     | North area                 | Gaza | Rafah |
| BOD                 | 728                        | 667  | 777   |
| COD                 | 1385                       | 1306 | 1399  |
| SS                  | 663                        | 617  | 540   |

## BOD and COD concentration in the influent of Gaza Wastewater treatment plant with day time



# Treatment Process in Gaza Strip



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Anaerobic lagoon- Aerated lagoon- Facultative lagoon- Maturation pond

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## Anaerobic lagoon

### Design Criteria:

- Depth 2.5 to 5m
- Hydraulic retention time 1-20 days
- Design Loading for BOD removals in anaerobic lagoon (Horan, 1990)

| Design Temperature (°C) | Volumetric Loading ( $V_L$ )<br>(g BOD/m <sup>3</sup> /day) | BOD Removal (%) |
|-------------------------|-------------------------------------------------------------|-----------------|
| < 10                    | 100                                                         | 40              |
| 10-20                   | 20T-100                                                     | 2T+20           |
| > 20                    | 300                                                         | 60              |

$$Area = \frac{\text{BOD influent} * \text{Flow}}{V_L * \text{Depth}}$$

## Aerobic lagoon

### Design Criteria:

- Depth 2 to 5m
- the European standard is considered ( $>5\text{KW}/10^3\text{m}^3$ )
- Hydraulic retention time  $R = 3\text{-}5$  days
- Considering the kinetic and rate of cell synthesis equation:

$$L_e = \frac{L_i}{(1 + K_T R)}$$

$L_e$  and  $L_i$  are the effluent and influent BOD respectively.

$K_T$  reaction rate where  $K_T = K_{20} O_T^{T-20}$  where  $K_{20} = 1.4/\text{day}$

$O_T = 1.056$  when  $T$  ranges between  $20\text{-}30^\circ\text{C}$   
 $1.135$  when  $T$  ranges between  $4\text{-}20^\circ\text{C}$

## Facultative lagoon

### Design Criteria:

- Depth 1 to 2 m
- Hydraulic retention time 4-6 days
- The maximum allowable surface load for facultative lagoons  
= $11.2(1.054)^F$  where F is the water Fahrenheit temperature.

For Example  $14^{\circ}\text{C} = 1.8(14) + 32 = 57.2^{\circ}\text{F}$

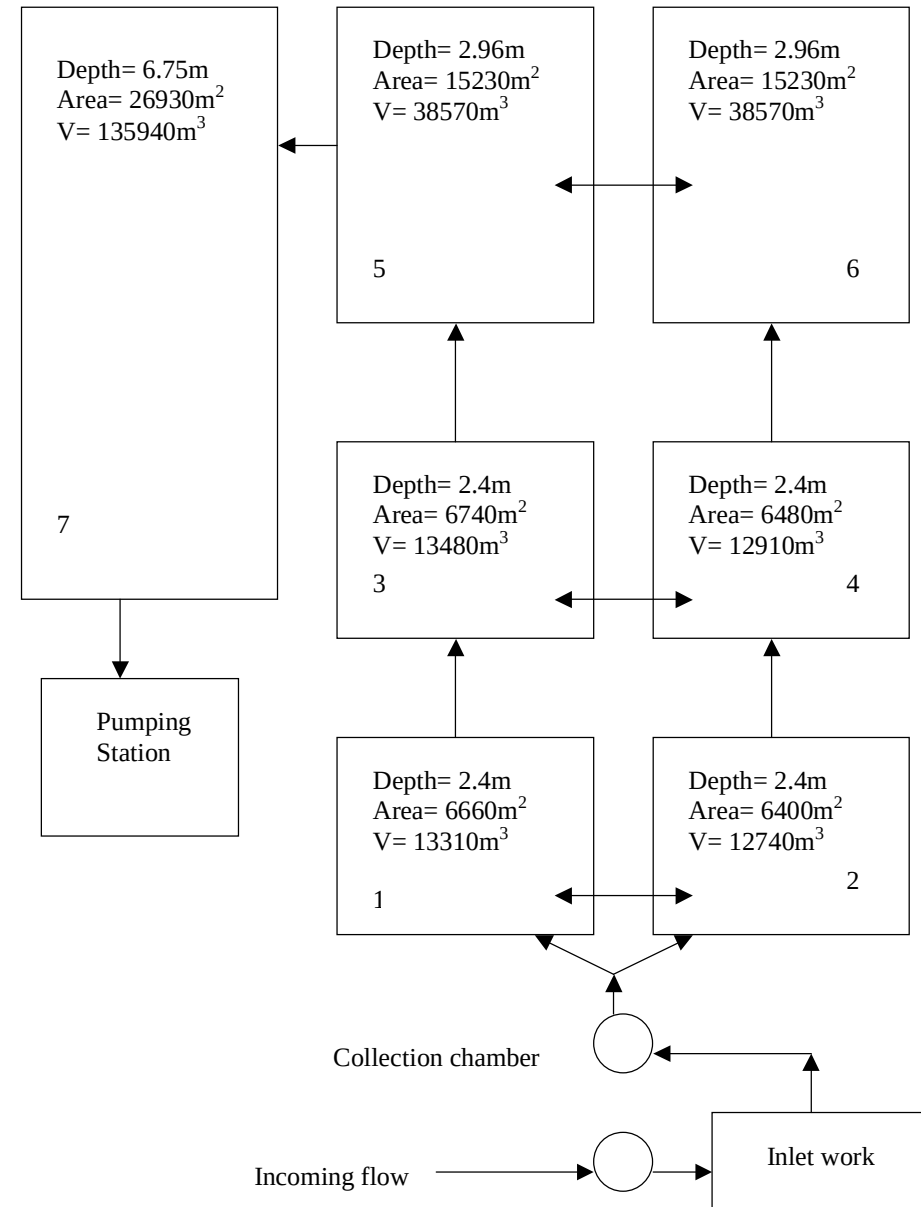
Maximum surface load =  $11.2 (1.054)^{57.2} = 227 \text{ kg/ha.d}$

- The efficiency of BOD removal  $\lambda_e = 0.725 \lambda_s + 10.75$   
where  $\lambda_e$  = BOD removal, (kg/ha.d)



## Beitlahya wastewater Treatment Plant as example

- Influent BOD= 600 mg/l
- Average flow rate= 11500 m<sup>3</sup>/day.
- Temperatures are 14 and 23°C.
- Regular operation route.



## Anaerobic lagoon

- The size of the anaerobic lagoon equals to 26000m<sup>3</sup>
- The hydraulic retention time equals 2.3 days.
- The BOD concentration in the influent ranges from 400 to 650 mg/l.
- For the assessment purposes BOD of 600 mg/l will be considered.
- Based on water temperature in winter 14°C and summer 23°C the treatment efficiency estimated to be 48 and 60% (Horan, 1991) respectively.
- The effluent from the anaerobic lagoons has 312 and 240 mg soluble BOD/l in winter and summer, respectively.

## Aerated lagoons

- Two aerated lagoons with total volume 26300m<sup>3</sup>.
- The estimated retention time equals to 2.3 days
- The two aerated lagoons have eight floating aerators each rated at 11KW (15hp) in addition to 4 jet-mixing aerators. This provides sufficient aeration for the lagoon if the European standard is considered (>5KW/10<sup>3</sup>m<sup>3</sup>).
- Considering the kinetic and rate of cell synthesis equation:

$$L_e = L_i / (1 + K_T R) \text{ where}$$

- The effluent from the aerobic treatment at wintertime equals  $312 / (1 + 0.67 \times 2.3) = 123 \text{ mg BOD/l}$ .
- While at summer time =  $240 / (1 + 0.69 \times 2.3) = 50 \text{ mg BOD/l}$ .  
considering the aeration system and complete mixing of 5KW/10<sup>3</sup>m<sup>3</sup>

## Facultative lagoons

- The volume of the facultative lagoons equals to 84000 m<sup>3</sup>
- Retention time 7.3 days.
- Surface area 30500 m<sup>2</sup>
- BOD load=49x11500= 564 kg/day

**BOD load /surface area=564x10000/30500= 185 kg/ha.d**

The maximum allowable surface load for facultative lagoons =11.2(1.054)<sup>F</sup>.

At winter : 14°C=1.8(14)+32=57.2<sup>F</sup>

**Maximum surface load= 11.2 (1.054)<sup>57.2</sup>=227 kg/ha.d**

The actual surface load is less than the permissible load, therefore it is expected that the facultative lagoon is functioning as proposed.

The efficiency of BOD removal at the facultative lagoons could be calculated as the following:

$$\lambda_e = 0.725 \lambda_s + 10.75 \quad \text{where } \lambda_e = \text{BOD removal, (kg/ha.d)}$$

$$\lambda_e = 0.725 (185) + 10.75 = 145 \text{ kg/ha.d}$$

$$\text{Removal efficiency} = 145/185 = 78\%$$

At winter temperature, the effluent BOD is estimated to be  $123 \times 0.22 = 27 \text{ mg BOD/l}$

At summer temperature  $23^\circ\text{C}$ , this value reach to  $50 \times 0.22 = 11 \text{ mg BOD/l}$ .

# **Wastewater Disposal/ Reuse**

## Palestinian Standards for irrigation and groundwater recharge

| Parameter               | Palestinian Standards |          |
|-------------------------|-----------------------|----------|
|                         | Irrigation            | Recharge |
| BOD (mg/l)              | 20-60                 | 20       |
| TSS (mg/l)              | 30-90                 | 30       |
| TDS (mg/l)              | 1500                  | 1500     |
| EC (ms/cm)              | -                     | -        |
| T-N (mg/l)              | 45                    | 100      |
| Na (mg/l)               | 200                   | 230      |
| Cl (mg/l)               | 500                   | 600      |
| SAR                     | 9                     | -        |
| B (mg/l)                | 0.7                   | 1        |
| F. Coliform (MPN/100ml) | 200-1000              | 200-1000 |
| Nematodes (ovum/l)      | <1                    | <1       |

## The Guidelines for the use of effluent waste water quality in irrigation (Takashi, 1990)

| Potential irrigation problem                                                                                                                                 | unit                            | Degree of restriction                                      |                                                     |                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------------------|-----------------------------------------------------|-------------------------------------------|
|                                                                                                                                                              |                                 | None                                                       | Slight to moderate                                  | Sever                                     |
| <b>Salinity</b><br>EC<br>TDS                                                                                                                                 | ds/m<br>mg/l                    | < 0.7<br>< 450                                             | 0.7-3<br>450-2000                                   | > 3.0<br>> 2000                           |
| <b>Permeability</b><br>SAR= 0-3 and EC =<br>3-6<br>6-12<br>12-20<br>20-40                                                                                    | ds/m                            | > 0.7<br>> 1.2<br>> 1.9<br>> 2.9<br>> 5.0                  | 0.7-0.2<br>1.2-0.3<br>1.9-0.5<br>2.9-1.3<br>5.0-2.9 | < 0.2<br>< 0.3<br>< 0.5<br>< 1.3<br>< 2.9 |
| <b>Specific Ion toxicity</b><br><b>Sodium</b><br>Surface irrigation<br>Sprinkler irrigation<br><b>Chloride</b><br>Surface irrigation<br>Sprinkler irrigation | SAR<br>mg/l<br><br>mg/l<br>mg/l | < 3<br>< 70<br><br>< 140<br>< 100                          | 3-9<br>> 70<br><br>140-350<br>> 100                 | > 9<br><br><br>> 350                      |
| <b>Miscellaneous effects</b><br>pH<br>Residual chlorine (overhead<br>sprinkler only)                                                                         | mg/l                            | Normal range 6.5-8.4<br><br>< 1.0                      1-5 |                                                     | <br><br>> 5.0                             |



## Recommended microbiological quality guidelines for wastewater use in agriculture

| Category | Reuse condition                                                                                 | Exposed group             | Intestinal nematodes<br>(arithmetic mean no. of eggs per litre) | Fecal coliform<br>(geometric mean no. per 100 ml) |
|----------|-------------------------------------------------------------------------------------------------|---------------------------|-----------------------------------------------------------------|---------------------------------------------------|
| A        | Irrigation of crops likely to be eaten uncooked, sports fields, public parks                    | Workers, consumers public | < 1                                                             | < 1000                                            |
| B        | Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees                   | Workers                   | < 1                                                             | No standard recommended                           |
| C        | Localize irrigation of crops in category B if exposure of workers and the public does not occur | None                      | Not applicable                                                  | Not applicable                                    |



**The potential land for wastewater reuse**