The Structural Standard of Waste Water Treatment Plant

30-Dec-05

Kitakyusyu City Environment Preservation Association

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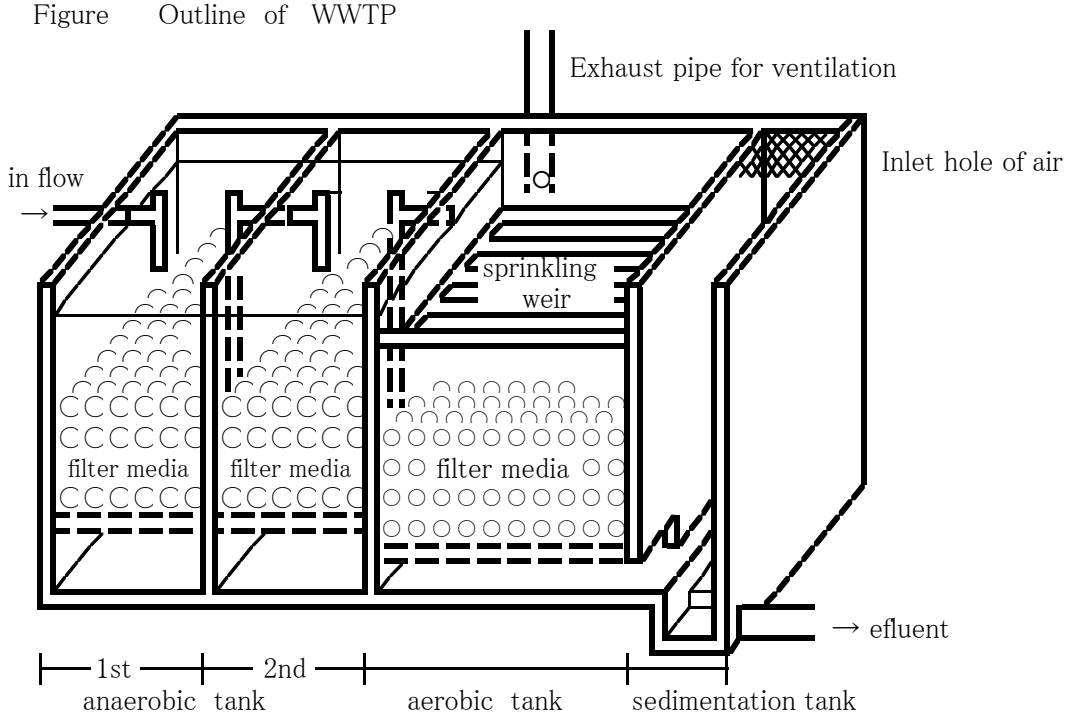
The Structure of Waste Water Treatment Plant

1. The applications
   This structure is applied to treat all waste water discharged by residence in Cebu City. And, I removed 「the Structual Standard of the sprinkling filter bed in Japan 」 for WWTP.
   This WWTP treats all domestic wastewater. I name this type「Anaerobic- sprinkling filter bed type 」.

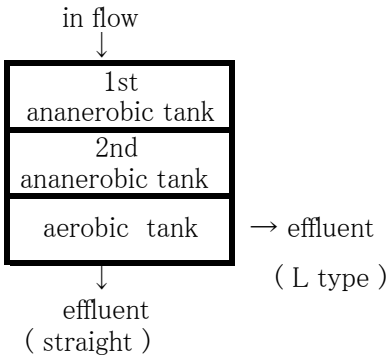
2. The definitions
   WWTP has the following three tanks.
   1) Anaerobic tank
   2) Aerobic tank
   3) Sedimentation tank
   Each tank is connected in the order above in series. (see figure)

Figure Outline of WWTP

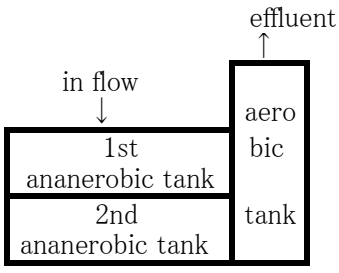


Construction example

case 1 (straight or L type)



case 2 (reverse)



3. The structure of each tank

1) Anaerobic tank

(1) The effective water depth (H) is between 2 and 4 meters .

(2) The total effective capacity V (m^3) of anaerobic tank is shown in the following formula.

n ≦ 100	V = 1.5qn
101 < n < 200	V = 150q + q (n-100)
n ≧ 201	V = 250q + 0.5 q (n-200)

note n : Total numbers of users for designing

total floor area (m^3) of a residence < 130 → n = 5

total floor area (m^3) of a residence ≧ 130 → n = 7

q : Average daily waste water flow rate (m^3/day ·n)

(Example of calculation) q = 0.2 m^3/day ·n

Plant treats 60 residences (n = 5) → n = 5×60 = 300

V = 250q + 0.5 q (n-200)

= 250× 0.2 m^3/day ·n + 0.5× 0.2 m^3/day ·n × (300 - 200)

= 50 + 10

= 60 m^3

(3) Anaerobic tank can be devided into several tanks.

When devided into 2 tanks,

The effective volume of 1st anaerobic tank is shown in the following formula.

(2／3)×V (m^3)

The effective volume of 2nd anaerobic tank is shown in the following formula.

(1／3)×V (m^3)

The solid matters in the in-flow waste water and sludge are separeated to the bottom of 1st anaerobic tank.

When devided into 3 tanks or more,

The effective volume of 1st anaerobic tank is shown in the following formula.

(1／2)×V (m^3)

The effective volume of the rest tank is devided proper. But, total effective volume is V.

(4) Inlet and outlet

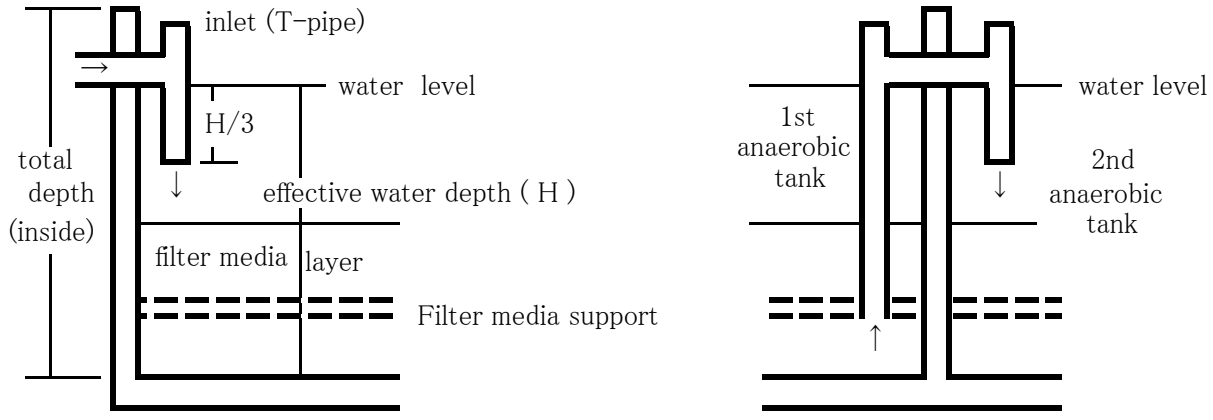
The inlet and outlet must be installed for the purpose of easy water flow.

The inlet and outlet is made of PVC -pipe or concrete (Buffle type).

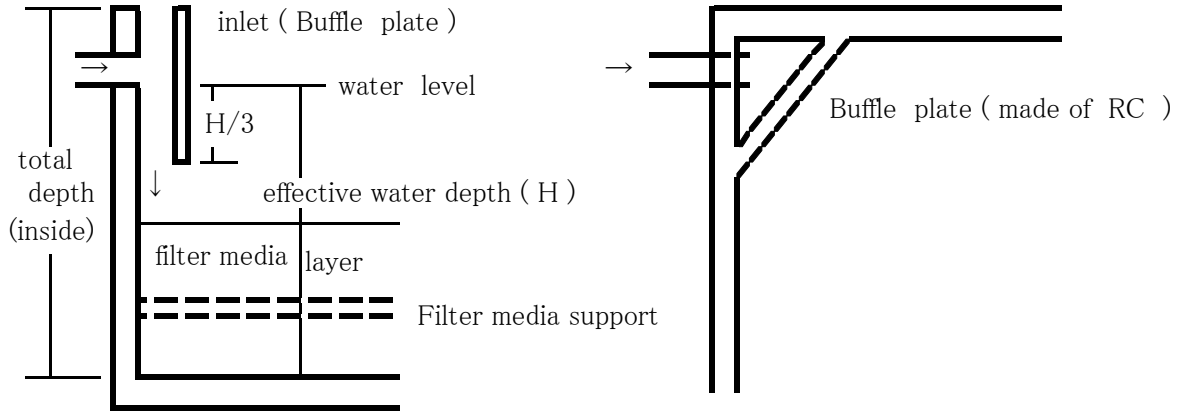
The position of opening of inlet is approximately 1/3 of the effective water depth below the water level.

The position of opening of outlet is below the support of filter media.

The diameter of outlet is the scale that vaccum hose enters easily at taking out the bottom om sludge. Approximately a circle with a diameter of 15 cm or more.



cross section of 1st anaerobic tank (inlet) (T- pipe type)



cross section of 1st anaerobic tank (inlet (Buffle plate type)

Plane figure of 1st anaerobic tank (inlet) (Buffle plate type)

(5) Filter media support

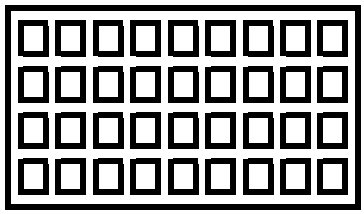
The hight from tank-bottom to the support is 40 ～ 60 cm.

The shape of the support is lattice , bar etc. , and made of RC.

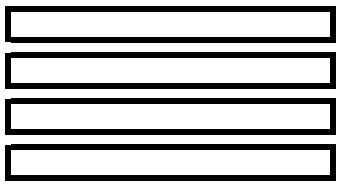
The opening width in the support is the length that a filter media does not drop down to the bottom.

Example

Plane figure of lattice shape



Plane figure of bar shape



(6) Filter media

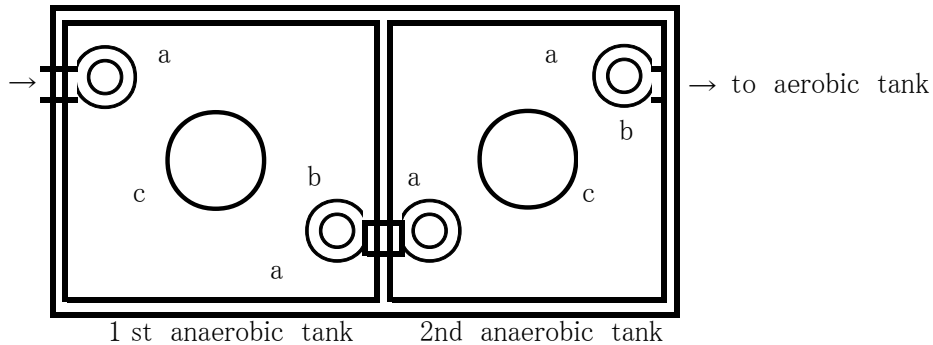
a. the material of filter media
   It can be used everything that the suiface is coase, and body is heavy.
   For example, the china, the stone, the glass bottle, the coconut shell.
b. the filter media is a form that easily traps sludge and permits as little short circuiting as possible in the water flow in anaerobic tank.
c. The diameter of a filter media in 1st anaerobic tank is between 10 cm and 15 cm. and, in 2nd anaerobic tank, it is between 5 cm and 10 cm.
d. the filter media packing ratio to the effective capacity (V) of each tank is approximately 40 % in 1st ananerobic tank, and approximately 60 % in 2nd anaerobic tank.

(7) The manhole for maintenance

The several manholeds need for maintenance. The purpose of manhole is following.

a. the manhole to clean the inlet/outlet pipe when it is stopped up with solid matter.
b. the manhole to take out the bottom sludge.
c. the manhole for construction and repair.

Example Plane figure of manhole



2) Aerobic tank

(1) The effective water depth (H) is between 2 and 4 meters (the same depth as anaerobic tank).

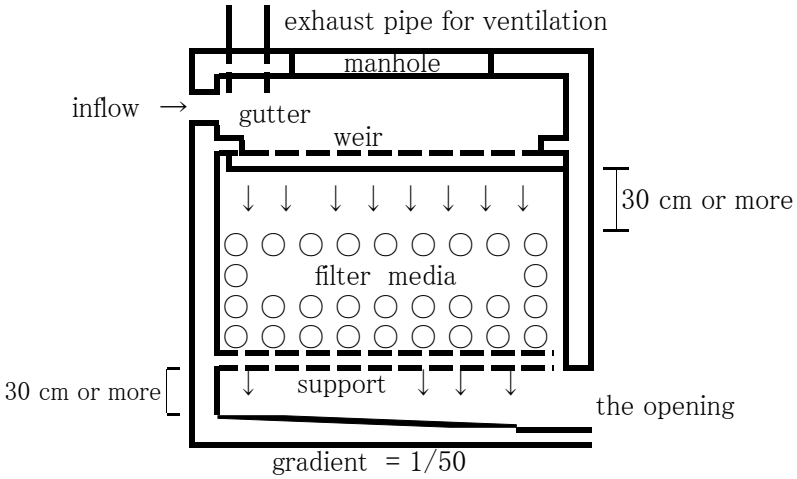
(2) The total effective capacity V (m^3) of aerobic tank is shown in the following formula. (the same volume as anaerobic tank)

n ≦ 100	V = 1.5qn
101 ＜ n ＜ 200	V = 150q ＋ q (n−100)
n ≧ 201	V = 250q ＋ 0.5 q (n−200)

(3) Aerobic tank is consist of following parts.

a. main gutter of sprinkling weir
b. several sprinkling weirs
c. filter media
d. support of filter media
e. pit of treatment water
f. exhaust pipe for ventilation

The cross section of aerobic tank is shown next.



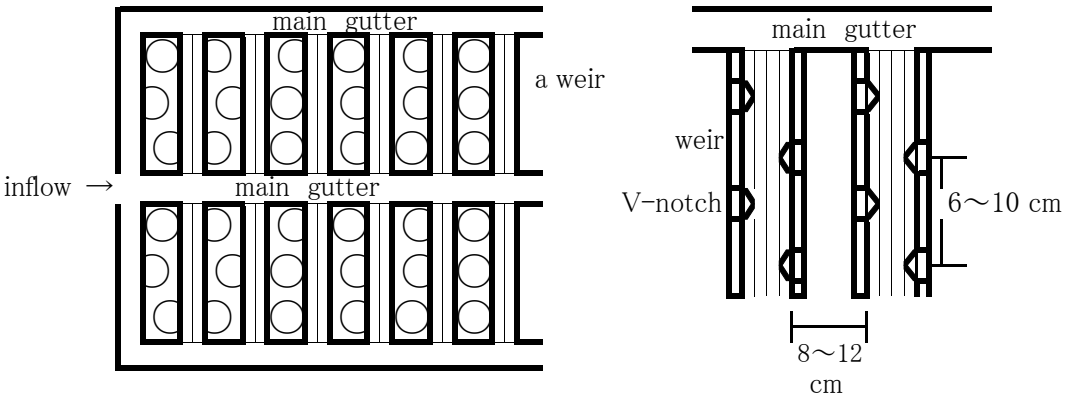
a. Main gutter of sprinkling weir

Main gutter is the ditch to receive treated water from 2nd anaerobic tank.
Main gutter is made of RC or PVC , and connected with many sprinkling weirs.
The width of Main gutter is from 15 cm to 30 cm.

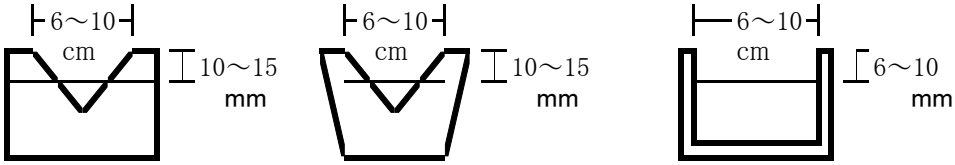
b. Several sprinkling weirs

Sprinkling weir is a part to drop the water on main gutter to filter media.
Sprinkling weir is made of RC or PVC .
There are many V−notch on a weir. The water drops from V−notch to filter media.
Those weirs are entered from manhole at construction. Therefore, a weir is not long.
The width between each weir is from 8 cm to 12 cm.

The plane figure of gutter and weir is shown next.



the kinds of sprinkling weir (cross section)



c. filter media

It can be used everything that the suiface is coase, and body is heavy.
For example, the china, the hard stone, the glass bottle, the coconut shell.
The filter media is a form that easily traps sludge and permits as little short circuiting as possible in the water flow in tank.
The diameter of a filter media is between 5 cm and 15 cm.
The surface area must keep 80 m^2/filter-media(m^2). And the void ratio must keep 90 % or more.
The space between weir and surface of filter media must keep 15 cm or more.
The filter media in this aerobic tank must be anti-acid .

d. Filter media bar is same as anaerobic tank.

The gradient of the bottom of tank must keep 1/50.
The space between tank-bottom and bar must keep 30 cm or more.

e. Pit of treatment water

Small pit is installed at the bottom of tank for the purpose of preventing the outflow of SS matters in effluent.

f. Exhaust pipe for ventilation

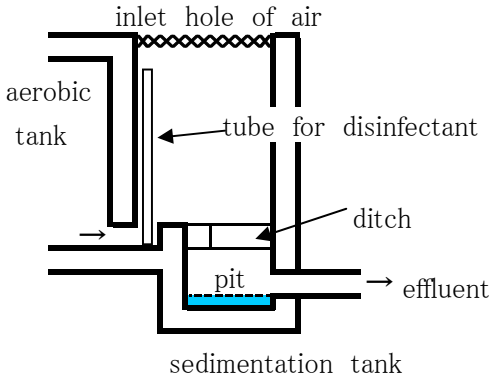
Several exhaust pipe for ventilation are installed near inflow position.
The diameter of exhaust pipe is 10 cm or more. Material of pipe is RC or PVC.
The hight of pipe is 3 meters or more. And, the top-openning of pipe is the windy position.
The top of pipe is installed the net for the purpose of preventing the escape of harmful insects (mosquito , fly).

g Others

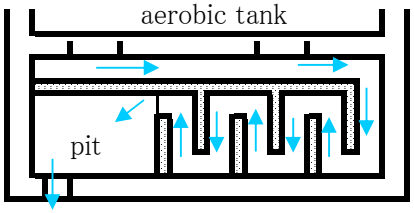
Several manholes is installed for the purpose of maintenance etc..

3) Sedimentation tank

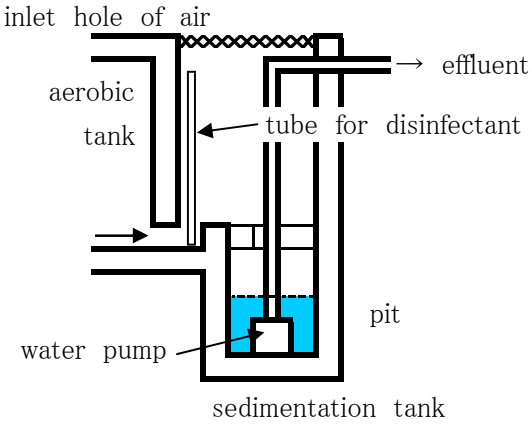
The purpose of sedimentation tank is to settle the SS substances in the treated water , to disinfect the effluent and to enter the air.
Disinfectant is the pellet . Main component is calcium hypochloride (CaCl(ClO) solid) .
The material of tube for disinfectant is PVC .
Disinfectant is supplied once a month.
Inlet hole of air is installed at the top of sedimentaion tank.
The openning of inlet hole is installed the net for the purpose of the escape of harmful insects.



It needs the ditch in the sedimentation tank for the purpose of keeping the contact time with disinfectant.
The gradient of this ditch is horizontal (natural flow).
The pit must be constructed at the below site compared with the ditch.



If it is impssible to discharge the effluent naturally, the effluent must be discharged by water pump. The position of water pump is shown following.



There are next problems in the water pump.

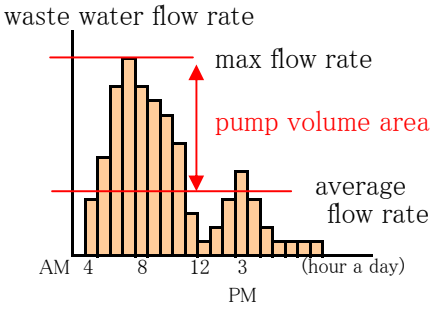
a the discharged volume of pump
b the control of pump
c the capacity of pump pit

a the discharged volume of pump

The discharged volume of pump (m^3/min or L/min) is within the range from the average daily waste water flow rate (m^3/day) to the max waste water flow rate (m^3/day) .

The aerobic tank needs fresh air always. So, if water level in the pump pit is over the ditch, the opening within the aerobic tank and the sedimentation tank is under the water. This is bad state for aerobic bacteria in the aerobic tank.

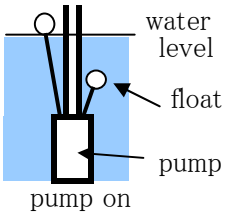
By this reason, the discharged volume of pump is same volume rate with the max waste water flow rate usually.

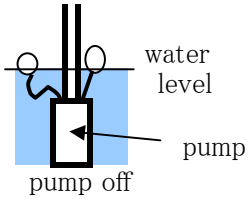


b the control of pump

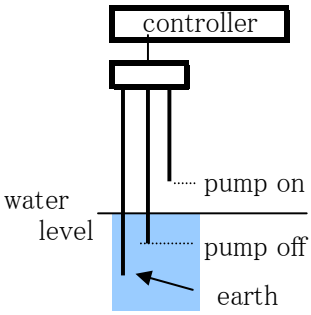
The operation of pump is controled by water level automaticly. There are many control types of pump. The most popular type is the folat-control type and the electrode -control type. The float-control type is for small discharged pump and the electrode-control type is for middle～large discharged pump.

the float-control type

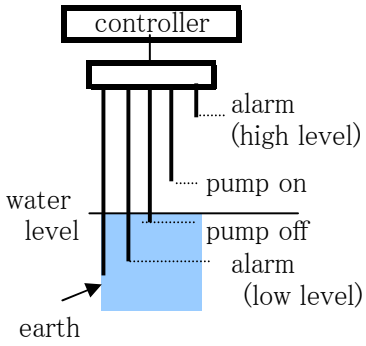




the electrode -control type



or

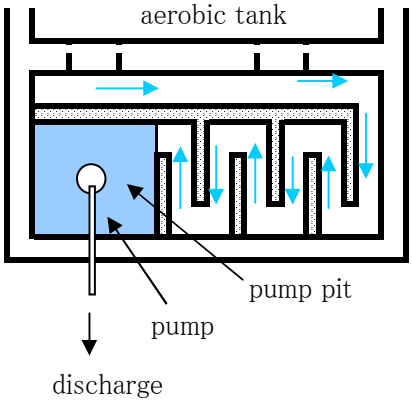


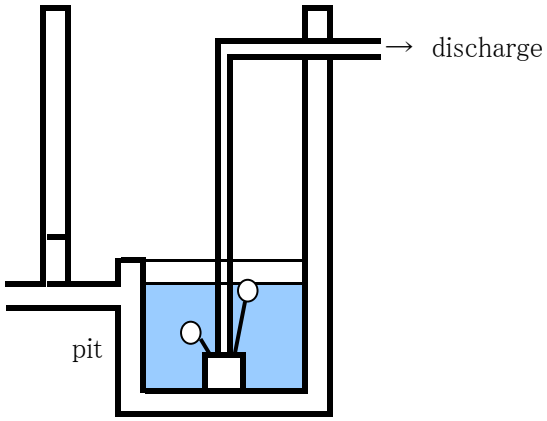
The capacity of pump pit is the volume between pump on and pump off.

c the capacity of pump pit

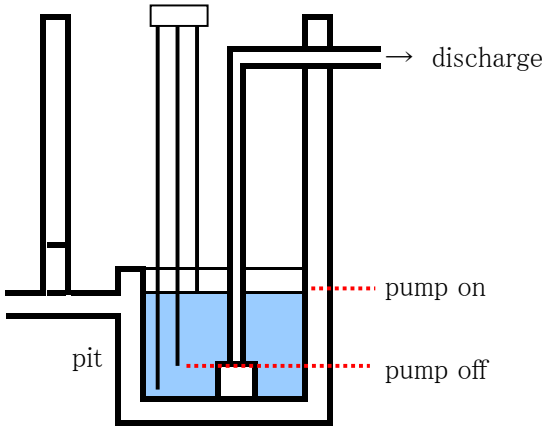
The capacity of pump pit is the equivalent volume to 15 min over of the max waste water flow rate.
For example, the max waste water flow rate = 30 m^3/day

The capacity of pump pit (m^3) = 30 ×(1/24) × (15min/60min) = 0.3125 over


aerobic tank
pump pit
pump
discharge


discharge
pit

or


discharge
pump on
pit
pump off

The specifications of STP in Cebu City

1 The installation Type Underground

2 The specification Reinforced Concrete

3 Inflow-Outflow type Inflow natural (sewage pipe)
outflow natural (no water pump)

4 Scale
1) Total width 2,200 length 9,700 depth 3,800
2) The inner scale of each tank
- the 1st anaerobic tank width 1,800 length 1,800 depth 3,000 (9.72 m^3)
- the 2nd anaerobic tank width 1,800 length 1,800 depth 3,000 (9.72 m^3)
- the aerobic tank width 1,800 length 3,800 depth 3,000 (20.52 m^3)
- the sedimentation tank width 1,800 length 1,300 depth 3,500 (8.19 m^3)

5 The effective capacity and the number of users for designing
- the 1st anaerobic tank width 1,800 length 1,800 depth 2,550 (8.262 m^3)
- the 2nd anaerobic tank width 1,800 length 1,800 depth 2,350 (7.614 m^3)

total effective capacity of the aerobic tank(V) = 15.876 m^3

calculation formula

$n \leqq 100 \quad V = 1.5qn$
$q = 0.2\ m^3/day \cdot n$

$n = V/1.5q = 15.876/1.5 \cdot 0.2 = 52.92 \rightarrow 53$

- the ability of water treatment = 53・0.2 = 10.6 m^3/day (japanese standard)

6 The removal of BOD
1) BOD concentration of inflow = 200 mg/L (presumption)
2) BOD concentration of outflow (effluent) = 30 mg/L (presumption)
The removal of BOD = 85%

7 The character of bacterias
BOD in the inflow is treated by the two kinds of bacterias. Those are the anaerobic bacteria and the aerobic bacteria. Both bacterias grow actively in proportion to water temperature. In Cebu City -- tropical area --- the water temperature is high constantly. It means the good condition for water treatment by bacterias.
The character of each bacteria is following.

1) the anaerobic bacteria
This bacteria is existing in the two anaerobic tanks. Especially, the filter medias is packed in the 2nd anaerobic tank. The anaerobic bacteria is adhering on the surface of the filter media.
The good condition for this bacteria is anaerobic state.
The anaerobic bacteria grows slowly as compared with the aerobic bacteria. So, Removal of BOD by the anaerobic bacteria is small as compared with the aerobic bacteria.
It is possible to pack the filter media into the 1st anaerobic tank. But many solid substanbes accumulate into the 1st anaerobic tank. So, the filter media is not packed into the 1st anaerobic tank usually.
There are water treatment methods by using the anaerobic bacteria only in the foreign country.
It can not be expected to lower the BOD concentration largely by the anaerobic bacteria only.

2) the aerobic bacteria
This bacteria is existing on the surface of the filter media in the aerobic tank.
This bacteria needs oxygen (air) in the growth. The air is supplied by natural ventilation.
The aerobic bacteria grows largely as compared with the anaerobic bacteria. So, Removal of BOD by the aerobic bacteria is large as compared with the anaerobic bacteria.

3) the suggestions
If the water is treated by using both the anaerobic and aerobic bacteria, the partation between the anaerobic tank and the aerobic tank must perfect except the flowing pipe.

Average daily waste water flow rate (m ^{3}/day ・pereson)

1 Japanese Standard

Source of waste water	waste water amount (Liter/day ・person)
Flush toilet	50
Cooking	30
Washing	40
Bathing	50
Washing face/hands	20
Cleaning (daily)	10
total	200 ⟶ 0.20 m^3/day・person
Concentration of BOD	200 mg/L

2 Average daily waste water flow rate (m ^{3}/day ・person) in Cebu City, Philippines

Average daily waste water flow rate (m^3/day ・person) in Cebu City, Philippines is measured by the cooperation of PCAPI in Barangay Sambag Ⅰ.

Source of waste water	waste water amount (Liter/day ・person)	
Toilet Cooking Washing Bathing		50 ⟶ 0.05 m^3/day・person
Washing face/hands	trace	
Cleaning (daily)	trace	
Concentration of BOD	? mg/L	

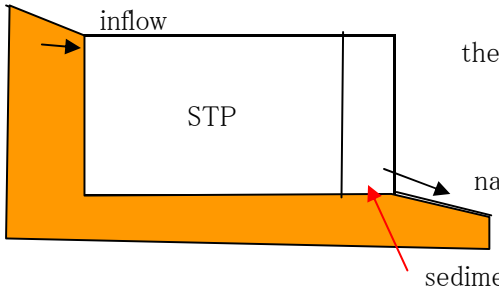
3 The comparison with the number of users for designing

See the table

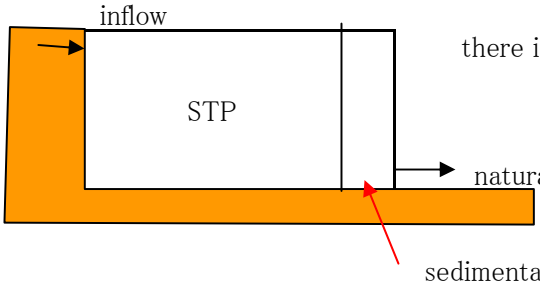
The selection of the installation site

1. The specifications of STP
 1) This plant needs the depth of 3-4 meters for natural water treatment with purifying by dropping water. The treated water is filled in the sedimentation tank(the bottom of plant). It is very important to discharge the treated water to outside.
 2) The dirty water fills in the anaerobic tank always. So, the strenght of anaerobic tank must is calculated strictly before the construction (inner water pressure and outside ground pressure).

2. The selection of the installation site
 1) Slope site or step site
 (Slope site)



 (Step site)



 2) Plane site
 (Underground)