CORRELATION BETWEEN SEDIMENTATION TANK DESIGN PARAMETER AND SEDIMENTATION EFFICIENCY

By

SON, Jaehyun

CAPSTONE PROJECT

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

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Committee in charge:

Professor Dong-Young KIM, Supervisor DongYoung Kim

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Professor Nahm Chung JUNG

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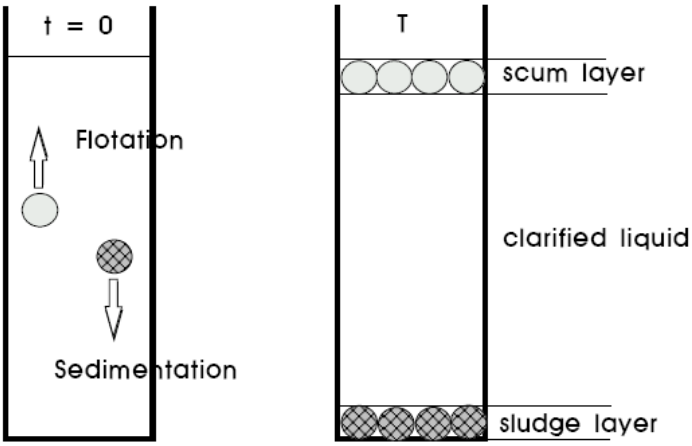
Chapter 1: Introduction

1.1 Background

Sedimentation, which is the process of gravity separation of suspended solids from aqueous solutions, is the oldest and most widely used method in the water treatment process by separating the suspension into clean and more concentrated suspensions. The sedimentation process is to remove most of the sedimentable material by gravity settling. So that the efficiency of the subsequent process such as filtration can be maximized through the sedimentation. Under the influence of gravity, particles having a density higher than that of a fluid are sediment, and particles having a density lower than that of a fluid are floated.



< Fig. 1-1 > Sedimentation and flotation (Huisma, 2001)

Almost all of the particulate matter in the raw water is heavier than water and sinks to the ground by gravity. The most common process for treating suspended particles in water using sedimentation characteristic is the precipitation process. Therefore the sedimentation design should be designed to maximize efficiency of sedimentation because sedimentation process has a great influence on the efficiency of the whole purification process

The design of sedimentation tank has been based on the conceptual basis by Hazen (1904) and Camp (1936). The concept of Hazen and Camp is simplifying flows in sedimentation tanks. A better hydraulic design makes for better understanding of the detailed flow processes in sedimentation tank. For this purpose a number of numerical models and turbulence models have been developed (Larsen 1977; Imam 1983; Celik and Rodi 1986; De Vantier and Larock 1987; Stamou 1889: Zhou and McCorquodale 1992; Zhou et al. 1994). However, such models are not complete to be able to compare with experimental results in detail.

Experimental design was performed to evaluate the experimental details and verify the numerical model for calibration of the imperfect model. Larsen (1977) carried out experiments in both field and laboratory tanks under pure water conditions with an ultrasonic current meter and a Laser–Doppler–Anemometer (LDA). Imam et al. (1983) introduced particles to the inflow to observe the settling process and carried out one component LDA measurements in the flow. Lyn and Rodi (1990) measured velocities and turbulence intensities the effect of a deflector. Krebs (1991a, 1991b) and van Marle and Kranenburg (1994) used turbid water produced by adding clay powder. Krebs determined velocity ad concentration in a rectangular model tank and chararerized the bottom current. Van Marle and Kranenburg described the three-layered flow field of turbid water. By using glass spheres as settling suspension, Krebs et al. (1998) discussed the density effects on velocity and concentration profiles and removal efficiency. The objective of the experiments presented in this paper is to investigate the effects of both two effluent system and the insertion of baffle on tank efficiency.

1.2 Research Problem

For designing the most efficient sedimentation tank, design with experiment is needed for every projects. However, there are lots of cost and time using experimental designed pilot test machine. Also, the experimental designed pilot test machine cannot reflect actual conditions such as external variables. For this reason, when designing sedimentation tank in South Korea, engineers set effective depth and length-width ratio considering the site condition, construction cost and waterworks facility standard. (2010, ministry of environment)

Due to problems of construction cost and difficulty of construction, the effective depth of sedimentation tank is generally set to a value between 4m and 5m. Also for optimal efficiency of sedimentation tank, the length-width ratio is set to any value within a certain range between 3 and 8. Sedimentation tank designer typically design center value between two boundary values. However only according to the design method of the ministry of environment's waterworks facility standard, it is impossible to arbitrarily define a design parameter value indicating an optimum efficiency.

1.3 Research objective

This paper will cover the correlation between sedimentation tank design parameter and sedimentation efficiency. Explain the basic principle of sedimentation and find main parameters which affect to efficiency of sedimentation tank. It will focused on finding the most efficient length-width ratio among K-water's purification plant sedimentation tanks.

K-water has forty eight water purification plants all over the country that operate rectangular sedimentation tanks. Therefore we can extract sedimentation efficiency data from currently operating sedimentation tank, and can check length-width ratio, sedimentation efficiency. In this case study, I selected six sedimentation tanks which are located in Chung-cheong province. Then, I will compare the width ratio of each sedimentation tank and the actual sedimentation efficiency to find out the best effective length-width ratio.

1.4 Research Structure

The structure of this study consists of seven chapters. Chapter 1 describes the background of the study, the problems of the current situation, and the purpose of the study. Chapter 2 provides information on previous research literature related to the study. Chapter 3 provides information on the choosing case study target and study method. Chapter 4 provides result and analysis of data. Chapter 5 describes conclusion of case study.

Chapter 2: Sedimentation principle and Tank design standard (document analysis)

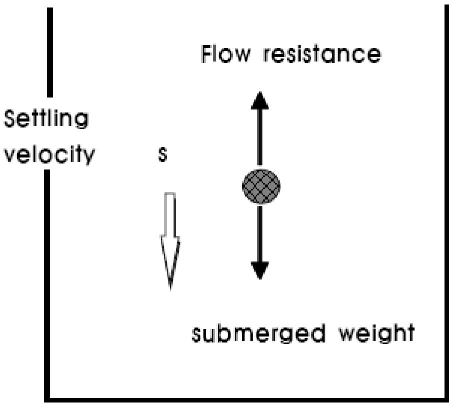
2.1 Principle of Sedimentation

2.1.1 Settling of Single Particle

Discrete settling occurs when during the whole process the suspended particle does not change its size, shape or weight.

All particles on Earth are accelerated by gravity when settling. However, in the actual calculation, the acceleration occurs within a very short time, and the subsequent settling velocity becomes uniform. For example, particles with a diameter of 0.05 mm will accelerate for an initial 0.003 seconds and then maintain a uniform settling rate. Therefore, it is generally assumed that the sedimentation rate of particles during sedimentation is constant without acceleration.

2.1.2 Sedimentation process and efficiency in Sedimentation Tank



$$F_d = C_d \frac{\rho_w}{2} s^2 A \quad (Newton, 1729)$$

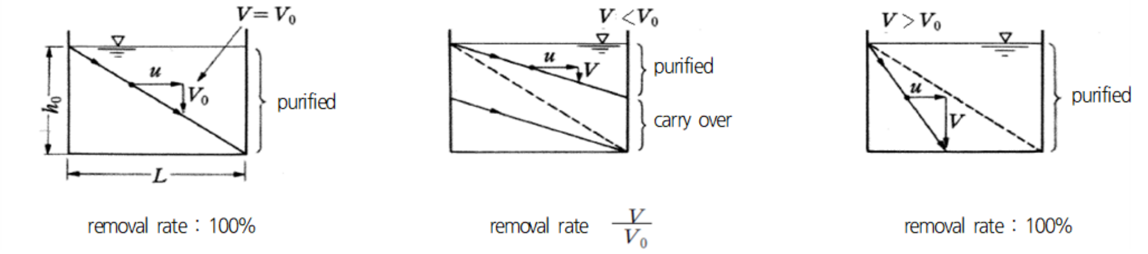
$$(drag\ resistance)$$

$$F_i = (\rho_s - \rho_w) g V$$

$$(impelling\ force)$$

< Fig. 2-1 > Settling of a single particle in quiescent water (Huisma, 2001)

The sedimentation in the sedimentation tank sets the particles in the raw water to the bottom of the sedimentation tank and is removed to the sludge during the time it takes for the raw water flowing into the sedimentation tank to flow out to the opposite side. Therefore the sedimentation tank should be designed so that sudden change of flow velocity or short-circuit flow does not occur inside the sedimentation tank, and that the sedimented sludge does not rise again.



(1) settling velocity $V = V_0$ (2) settling velocity $V < V_0$ (3) settling velocity $V > V_0$

< Fig. 2-2 > Paths traced by discrete particles in a rectangular horizontal flow sedimentation tank

Let *V* be the settling velocity of the particles in the sedimentation tank, and *u* be the flow velocity in the horizontal direction. Let V_0 be the settling velocity of the particles when the time taken for the particles fall to the bottom in the sedimentation tank and the time taken for the influent raw water to flow out at the horizontal velocity *u* are equal. If the settling of the particles is faster, the removal is done but over designed. If the settling of the particles is slower, the complete removal of the particles fails and affects the subsequent water treatment process efficiency. Therefore, the case of $V = V_0$ is the most efficient and ideal for design.

$$\frac{V_0}{u} = \frac{h_0}{L} \quad (u = Q/Bh_0) \quad . \quad \text{so,} \quad V_0 = \frac{Q}{BL} = \frac{Q}{A}$$

The efficiency of the sedimentation tank is independent of the sedimentation depth and residence time, only the relationship between the flow rate and the area of the sedimentation tank.

Therefore, the efficiency of the sedimentation tank is a function of the area of the sedimentation tank (surface loading rate). The depth of the sedimentation tank should also be determined taking into account the time the particles are completely settled to the bottom of the sedimentation tank.

Therefore, in order to improve the removal rate of the sedimentation tank, ① Increase the settling area *A* of the sedimentation tank, ② Increase sedimentation velocity *V* of particles, ③ Reduce the flow rate Q. These three things can be considered. In this case study, I will focus on ① as finding length and width ratio, because other things are difficult to control. We cannot change what particles raw water includes and it is impossible to change inflow Q which is an external factor.

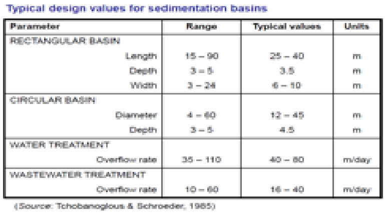
2.2 Design standards - waterworks facility standard (2010, ministry of environment)

The sedimentation tank is basically determined based on sedimentation rate through sedimentation test of floc. If there is no experimental value, the sedimentation tank is designed by arbitrarily setting the value within the range of past design result or facility standard. However, if there is no experimental value, design should be made within the range of past design results or waterworks facility standard values.

Generally, according to the waterworks facility standards, several considerations should be taken into consideration when designing rectangle type sedimentation tank. The number of sedimentation tank shall be two or more, and the inflow of raw water must be uniform. In addition, it shall be constructed so that it can be used independently for each shall for cleaning and repairing. The shape of the sedimentation tank shall be rectangular and the length shall be 3 to 8 times the width. Effective water depth should be 3 ~ 5.5m and sludge depth of 30cm should be considered, but reasonable adjustment is possible if necessary due to the structure of sludge removal equipment and sedimentation basin. The clearance from the high water to the top of the settler wall is set at 30cm and is inclined toward the drain for convenient sludge exclusion.

The retention time is generally designed to be 3 to 5 hours, and the average flow rate and surface load rate should be maintained at a constant value. For the formation of laminar flow condition and the prevention of short-circuit current, and Froude No. should also meet the appropriate values.

The flow in the sedimentation bed mostly forms turbulence. Generally, when the Re No. is less than 2,000, it is laminar flow. However, it is almost impossible to satisfy the laminar flow condition in the sedimentation tank design. Therefore, the Re No. is set at a reference value between 10,000 and 20,000, and a smaller value is more advantageous. Fr No. sets the criterion that the flow of the clarifier should be designed so as to be larger than 10-5 in order to prevent unstable short-circuit current. Therefore, if the Fr No. value is less than 10-5, sedimentation efficiency may decrease due to short-circuit flow. So, to increase the flow rate, it is necessary to reduce the sedimentation index or reduce the depth of water.

Parameter		Range	remarks
① Q	㎥/d	–	
	㎥/hr	–	
	㎥/min	–	
② number of tanks		–	more than 2
③ unit Q	㎥/d	–	①/②
	㎥/min	–	
	㎥/sec	–	
④ efficient depth (m)		3 ~ 5.5	3~4m + sludge cake depth
⑤ retention time (hr)	**water facility standards**	3 ~ 5	
⑥ length-with ratio	**water facility standards**	1 : 3~8	
size of sedimentation tank	⑦ B (width)		
	⑧ L (length)		
	⑨ h_0 (depth)		
⑪ velocity of water	m/min	≤ 0.4	
⑫ surface loading ratio (mm/min)	**water facility standards**	15~30	
⑬ Re. No.			
⑭ Fr. No.			

Typical design values for sedimentation basins

Parameter	Range	Typical values	Units
RECTANGULAR BASIN			
Length	15 – 90	25 – 40	m
Depth	3 – 5	3.5	m
Width	3 – 24	6 – 10	m
CIRCULAR BASIN			
Diameter	4 – 60	12 – 45	m
Depth	3 – 5	4.5	m
WATER TREATMENT			
Overflow rate	35 – 110	40 – 80	m/day
WASTEWATER TREATMENT			
Overflow rate	10 – 60	16 – 40	m/day

(Source: Tchobanoglous & Schroeder, 1985)

< Fig. 2-3 > Sedimentation tank design criteria (The ministry of Environment, 2010)

As mentioned above, since it is impossible to meet such site securing condition and it is difficult to solve the hydraulic analysis. Therefore it is necessary to establish the criteria for depth of water, Length/width ratio, surface loading value, Reynold No. and Froude No.

Among the design parameters of the sedimentation tank, the Froude number and Reynolds number, which are related to the stable water flow, are difficult to change. In addition, the depth of water that can affect construction work and construction cost is a parameter that cannot be easily changed when designing. To find the most effective value of the length-width ratio given in the water facility standards, this case study attempts to compare the efficiency of each sedimentation tank in operation.

3.1 Select target area and purification plant

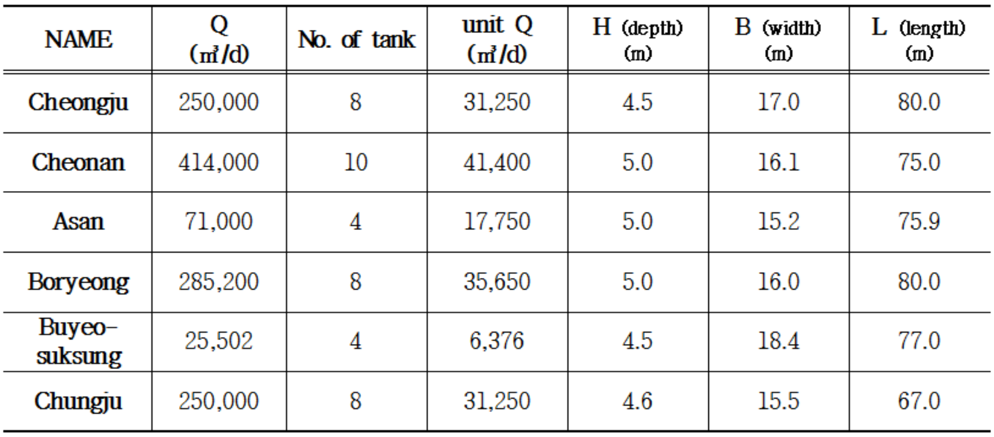
For case study, some of the 48 water treatment plants operated by K-water were selected and data were acquired and analyzed. Chungcheong province is selected, the area where the Cheonan water purification plant is located, where additional water treatment plant is under construction, so that the results of the case study can be applied to the design. Among the water purification plants in the Chungcheong province, six water purification plants operating a raw water settling tank were selected.

< Fig. 3-1 > Select target area and purification plants (extract from K-water system)

(Cheongju, Cheonan, Asan, Boryeong, Buyeo-suksung, Chungju water purification plant)

3.2 Data collection

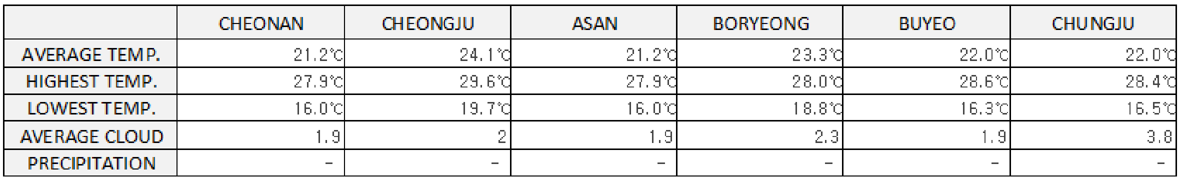
First, we collect the design data (construction data) of the actual sedimentation tank of K-water to find the optimal model of the sedimentation tank. Collect required design data such as flow rate, number of tanks, width, length, depth.



NAME	Q (㎥/d)	No. of tank	unit Q (㎥/d)	H (depth) (m)	B (width) (m)	L (length) (m)
Cheongju	250,000	8	31,250	4.5	17.0	80.0
Cheonan	414,000	10	41,400	5.0	16.1	75.0
Asan	71,000	4	17,750	5.0	15.2	75.9
Boryeong	285,200	8	35,650	5.0	16.0	80.0
Buyeo-suksung	25,502	4	6,376	4.5	18.4	77.0
Chungju	250,000	8	31,250	4.6	15.5	67.0

< Fig. 3-2 > Designed parameter of sedimentation tanks

Then, accumulate sedimentation tank inlet and turbidity data for a given day to calculate sediment removal rates. Turbidity check interval is 15min, duration is 24hours. I took September 5, 2018 as measurement and record data. As we can see <Fig. 3-3>, there was no rainfall on September 5, and temperatures in six areas were in similar outer boundary conditions.



	CHEONAN	CHEONGJU	ASAN	BORYEONG	BUYEO	CHUNGJU
AVERAGE TEMP.	21.2℃	24.1℃	21.2℃	23.3℃	22.0℃	22.0℃
HIGHEST TEMP.	27.9℃	29.6℃	27.9℃	28.0℃	28.6℃	28.4℃
LOWEST TEMP.	16.0℃	19.7℃	16.0℃	18.8℃	16.3℃	16.5℃
AVERAGE CLOUD	1.9	2	1.9	2.3	1.9	3.8
PRECIPITATION	-	-	-	-	-	-

< Fig. 3-3 > Boundary conditions of sedimentation tanks at September 5, 2018

3.3 Data analysis

A total of 97 inlet outlet measurements were carried out from September 5 to 23:45 for six water purification plant sedimentation sites, and the sedimentation efficiency was calculated as follows (Table 1).

$$Sedimentation\ \ efficiency(\%) = \frac{C_o(outlet\ \ NTU)}{C_i(inlet\ \ NTU)}$$

Assuming that the particle removal rates of each of the six water purification plants are based on normal distribution, the t-test is conducted to determine whether the particle removal rate of the water purification plant with the highest removal rate is significantly different from the other water purification plants. The boryeong water purification plant is selected as comparison because the average sedimentation efficiency rate of boryeong water purification is the highest among the six water purification plants. Tests were carried out five times with other water purification plants on the basis of boryeong water purification plant. If the difference in sedimentation efficiency with other water purification has significant difference, the lenght-width ratio of the sedimentation tank in boryeon is more efficient than that of other sedimentation tanks.

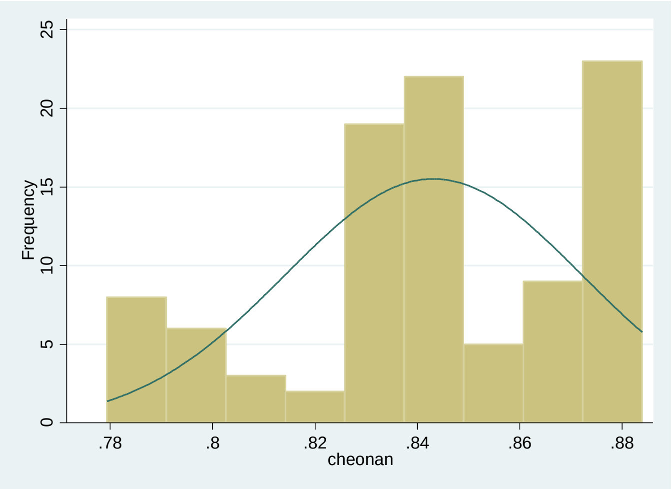
In this paper, we will also conduct a regression analysis between the length – width ratio of sedimentation tank and the sedimentation efficiency to see how much the two values have correlation significantly.

Chapter 4: Result and Analysis

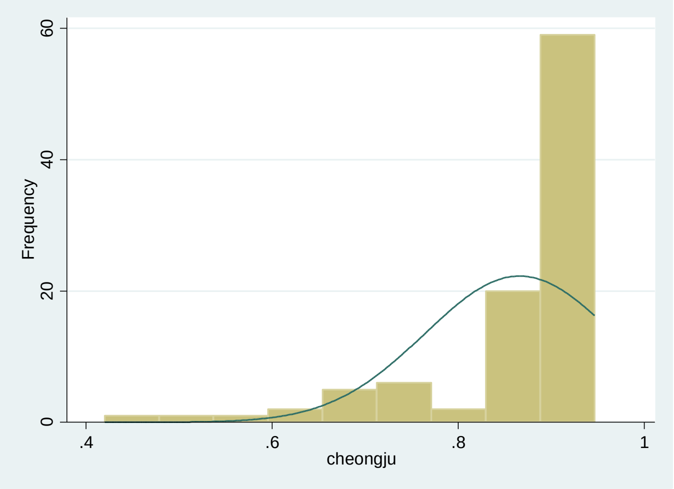
4.1 T – test analysis

The analysis result of six water purification plants data follows <Fig 4-1>. Assuming the normal distribution of the particle removal rate data of six water purification plants, the result < Fig4-1> can be calculated and the particle removal rate of sedimentation tank in Boryeong water purification plant is the highest. The t-test was used to analyze whether the particle removal rate of Boryeong water purification plant was significantly different from the other five water purification plant removal rates.

Cheonan Purification Plant	
Average	**0.843155371**
Standard error	0.002941043
Median	0.843973043
Mode	#N/A
Standard deviation	**0.028965911**
Dispersion	0.000839024
Kurtosis	-0.559381053
Distortion	-0.514791856
Range	0.104508018
Minimum value	0.779423647
Maximum value	0.883931665
SUM	81.78607101
Number of observations	97
Confidence level(95%)	0.005837924

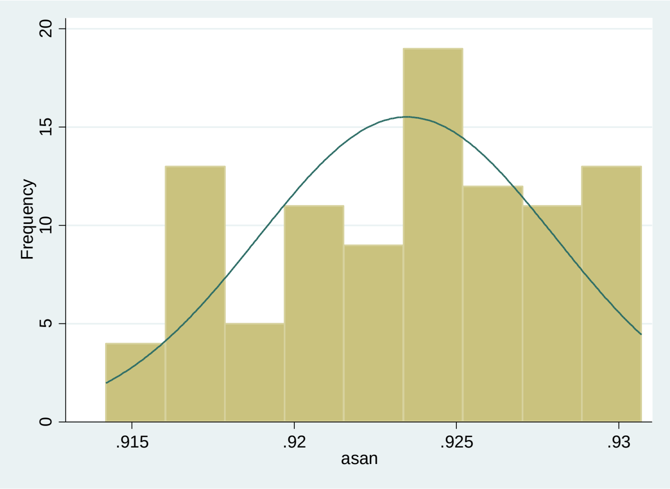


Cheongju Purification Plant	
Average	**0.866040007**
Standard error	0.010322644
Median	0.908152249
Mode	#N/A
Standard deviation	**0.101666258**
Dispersion	0.010336028
Kurtosis	4.948663829
Distortion	-2.175131008
Range	0.526719507
Minimum value	0.420225058
Maximum value	0.946944565
SUM	84.00588069
Number of observations	97
Confidence level(95%)	0.020490287



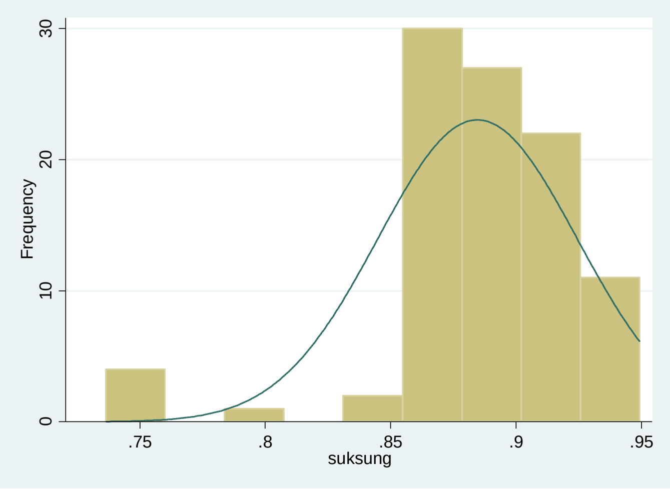
Asan Purification Plant

Average	**0.923468515**
Standard error	0.000463922
Median	0.924380029
Mode	#N/A
Standard deviation	**0.004569107**
Dispersion	2.08767E-05
Kurtosis	-0.966258376
Distortion	-0.251777574
Range	0.016489384
Minimum value	0.914227308
Maximum value	0.930716692
SUM	89.57644596
Number of observations	97
Confidence level(95%)	0.000920879



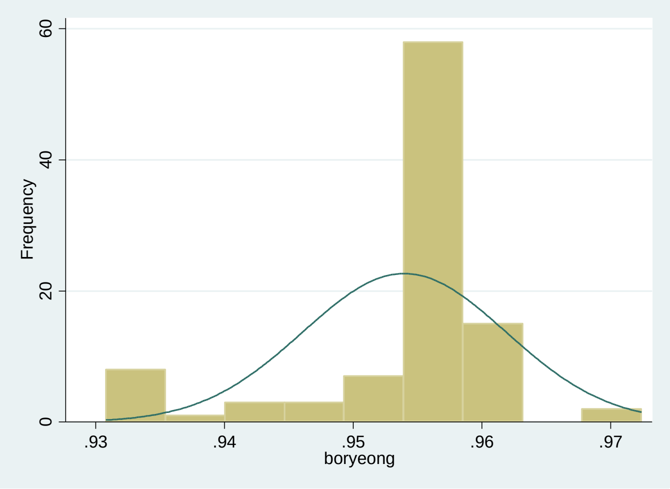
Buyeo-suksung Purification Plant

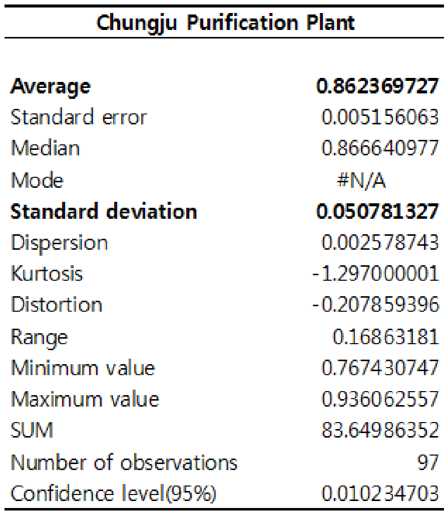
Average	**0.884652462**
Standard error	0.004035194
Median	0.883432592
Mode	0.904716981
Standard deviation	**0.039742049**
Dispersion	0.00157943
Kurtosis	5.331535435
Distortion	-1.80315316
Range	0.212900439
Minimum value	0.736455117
Maximum value	0.949355556
SUM	85.81128881
Number of observations	97
Confidence level(95%)	0.008009796



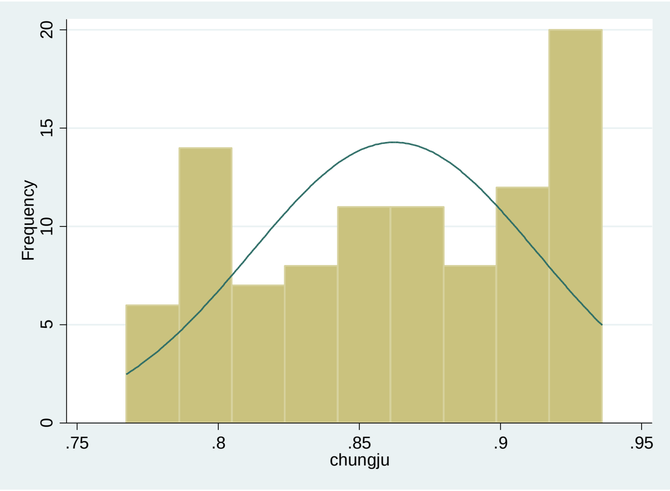
Boryeong Purification Plant

Average	**0.953982959**
Standard error	0.000801705
Median	0.9564845
Mode	#N/A
Standard deviation	**0.007895874**
Dispersion	6.23448E-05
Kurtosis	2.566616963
Distortion	-1.625724889
Range	0.04161221
Minimum value	0.930805071
Maximum value	0.972417281
SUM	92.53634698
Number of observations	97
Confidence level(95%)	0.001591371





Chungju Purification Plant	
Average	**0.862369727**
Standard error	0.005156063
Median	0.866640977
Mode	#N/A
Standard deviation	**0.050781327**
Dispersion	0.002578743
Kurtosis	-1.297000001
Distortion	-0.207859396
Range	0.16863181
Minimum value	0.767430747
Maximum value	0.936062557
SUM	83.64986352
Number of observations	97
Confidence level(95%)	0.010234703



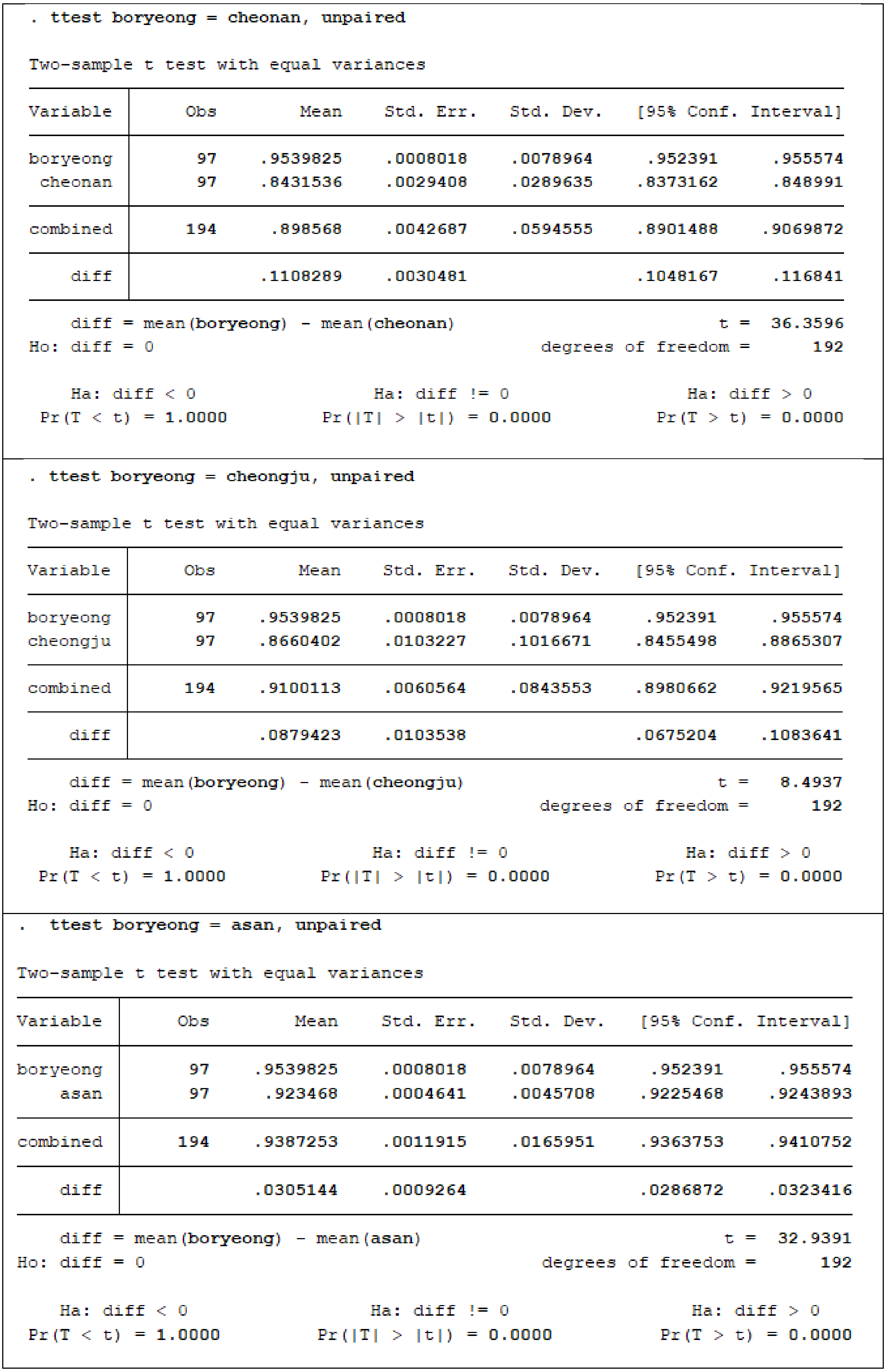
<Fig 4-1> Assume particle removal rate follows normal distribution

In order to compare the particle removal rates of Boryeong and other water purification plants, the following hypothesis was established and t-test was conducted.

H_0 : The particle removal rate of Boryeong water purification plant sedimentation tank is equal than that of each other purification plant.

H_1 : The particle removal rate of Boryeong water purification plant sedimentation tank is not equal compare to that of each other purification plant.

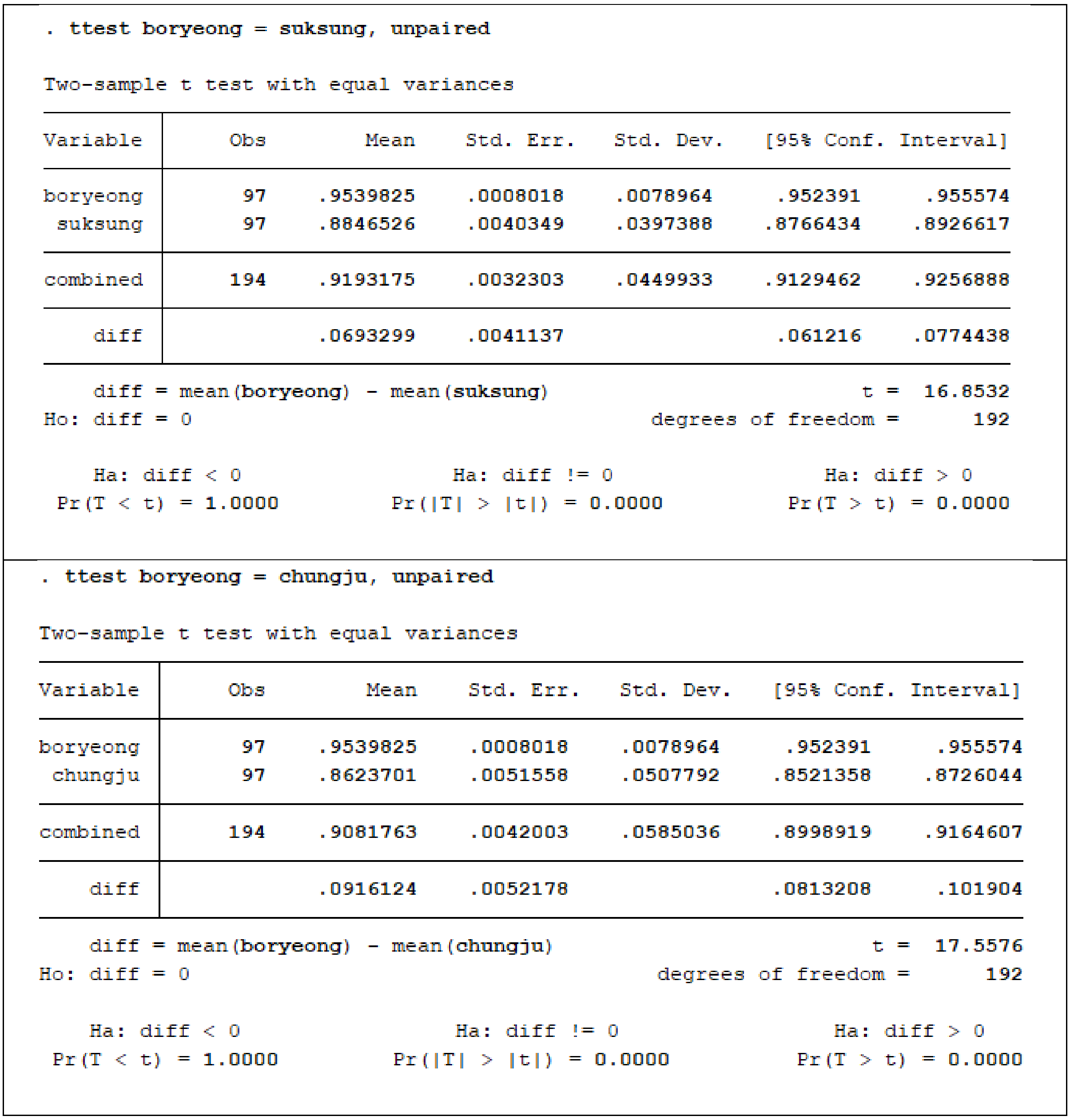
The null hypothesis and the alternative hypothesis are set as above. To verify this, T-test was performed with Boryeong water purification plant sedimentation tank and each other purification plant sedimentation tanks. As a result of the t-test for sediment removal rate, the null hypothesis can be rejected because the unilateral test comparison values are significantly smaller than the significance probability 0.05 (Fig.4-2). The experimental results show that the sedimentation efficiency of Boryeong water purification plant is the best and this value is significant.



```
. ttest boryeong = cheonan, unpaired

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
boryeong |      97    .9539825    .0008018    .0078964     .952391     .955574
 cheonan |      97    .8431536    .0029408    .0289635    .8373162     .848991
---------+--------------------------------------------------------------------
combined |     194     .898568    .0042687    .0594555    .8901488    .9069872
---------+--------------------------------------------------------------------
    diff |            .1108289    .0030481                .1048167     .116841
------------------------------------------------------------------------------
    diff = mean(boryeong) - mean(cheonan)                         t =  36.3596
Ho: diff = 0                                     degrees of freedom =      192

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
. ttest boryeong = cheongju, unpaired

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
boryeong |      97    .9539825    .0008018    .0078964     .952391     .955574
cheongju |      97    .8660402    .0103227    .1016671    .8455498    .8865307
---------+--------------------------------------------------------------------
combined |     194    .9100113    .0060564    .0843553    .8980662    .9219565
---------+--------------------------------------------------------------------
    diff |            .0879423    .0103538                .0675204    .1083641
------------------------------------------------------------------------------
    diff = mean(boryeong) - mean(cheongju)                        t =   8.4937
Ho: diff = 0                                     degrees of freedom =      192

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

```
.  ttest boryeong = asan, unpaired

Two-sample t test with equal variances
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
boryeong |      97    .9539825    .0008018    .0078964     .952391     .955574
    asan |      97     .923468    .0004641    .0045708    .9225468    .9243893
---------+--------------------------------------------------------------------
combined |     194    .9387253    .0011915    .0165951    .9363753    .9410752
---------+--------------------------------------------------------------------
    diff |            .0305144    .0009264                .0286872    .0323416
------------------------------------------------------------------------------
    diff = mean(boryeong) - mean(asan)                            t =  32.9391
Ho: diff = 0                                     degrees of freedom =      192

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```



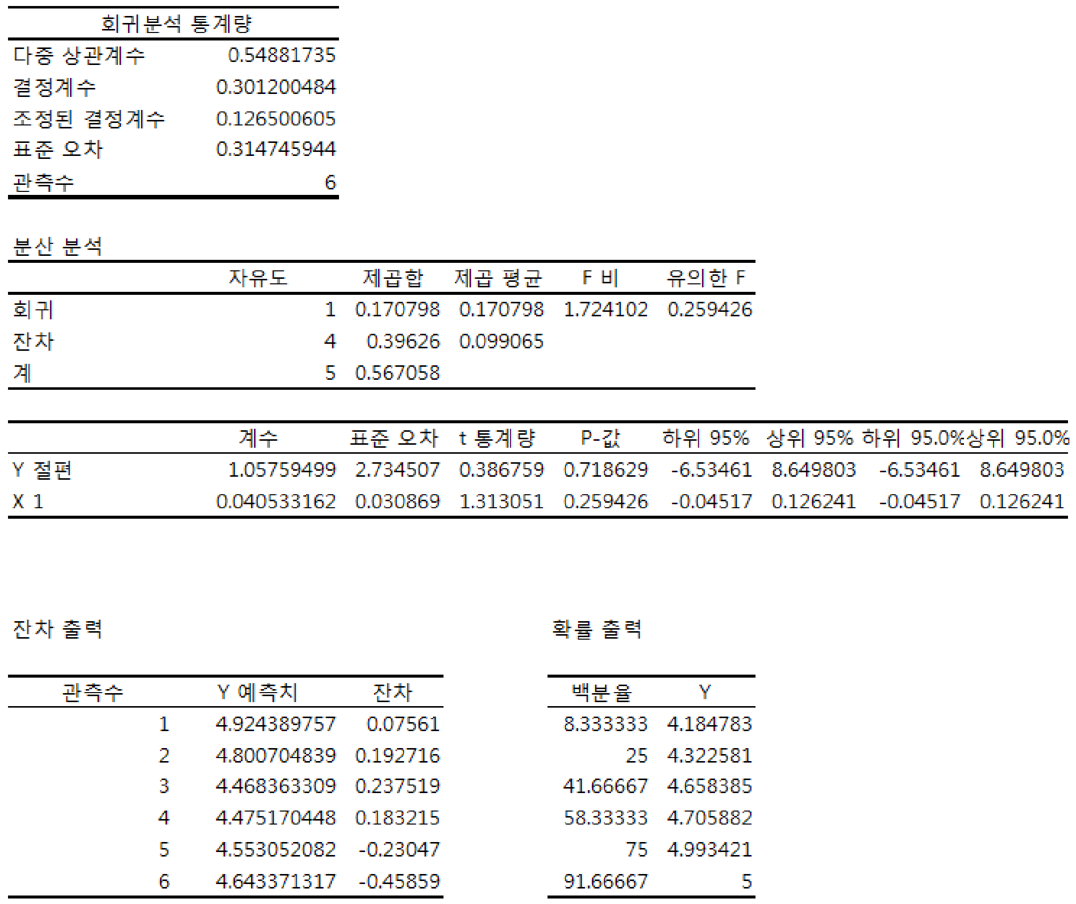
```
. ttest boryeong = suksung, unpaired

Two-sample t test with equal variances

Variable |   Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+------------------------------------------------------------------
boryeong |    97     .9539825    .0008018    .0078964     .952391     .955574
 suksung |    97     .8846526    .0040349    .0397388    .8766434    .8926617
---------+------------------------------------------------------------------
combined |   194     .9193175    .0032303    .0449933    .9129462    .9256888
---------+------------------------------------------------------------------
    diff |           .0693299    .0041137                 .061216    .0774438
----------------------------------------------------------------------------
    diff = mean(boryeong) - mean(suksung)                         t =  16.8532
Ho: diff = 0                                     degrees of freedom =      192

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000

. ttest boryeong = chungju, unpaired

Two-sample t test with equal variances

Variable |   Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+------------------------------------------------------------------
boryeong |    97     .9539825    .0008018    .0078964     .952391     .955574
 chungju |    97     .8623701    .0051558    .0507792    .8521358    .8726044
---------+------------------------------------------------------------------
combined |   194     .9081763    .0042003    .0585036    .8998919    .9164607
---------+------------------------------------------------------------------
    diff |           .0916124    .0052178                .0813208     .101904
----------------------------------------------------------------------------
    diff = mean(boryeong) - mean(chungju)                         t =  17.5576
Ho: diff = 0                                     degrees of freedom =      192

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 1.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 0.0000
```

<Fig 4-2> T-test between boryeong sedimentation tank and other sedimentation tanks

Therefore, we can think that the length-width ration of the boryeong sedimentation tank is the most efficient. Therefore, in this case study, the particle removal rate of Boryeong water purification plant is the best, and the ratio of the aspect ratio is 5.

4.2 Regression analysis

I conducted a regression analysis to see if there is a correlation between length-width ratio and sedimentation efficiency. Based on the results, I tried to find some trend of correlation between sedimentation efficiency and length-width ration of sedimentation tank. The regression analysis was performed to determine the correlation between the two values.



회귀분석 통계량	
다중 상관계수	0.54881735
결정계수	0.301200484
조정된 결정계수	0.126500605
표준 오차	0.314745944
관측수	6

분산 분석

	자유도	제곱합	제곱 평균	F 비	유의한 F
회귀	1	0.170798	0.170798	1.724102	0.259426
잔차	4	0.39626	0.099065		
계	5	0.567058			

	계수	표준 오차	t 통계량	P-값	하위 95%	상위 95%	하위 95.0%	상위 95.0%
Y 절편	1.05759499	2.734507	0.386759	0.718629	-6.53461	8.649803	-6.53461	8.649803
X 1	0.040533162	0.030869	1.313051	0.259426	-0.04517	0.126241	-0.04517	0.126241

잔차 출력

관측수	Y 예측치	잔차
1	4.924389757	0.07561
2	4.800704839	0.192716
3	4.468363309	0.237519
4	4.475170448	0.183215
5	4.553052082	-0.23047
6	4.643371317	-0.45859

확률 출력

백분율	Y
8.333333	4.184783
25	4.322581
41.66667	4.658385
58.33333	4.705882
75	4.993421
91.66667	5

<Fig 4-3> Regression analysis : correlation between removal rate and length-width ratio

Regression analysis showed that the correlation was 0.54, indicating that the relationship was not so high. The F value is also 1.72 and the significance probability is 0.259, indicating that the regression line is not suitable for the model.

Chapter 5: Key findings from Case study (conclusion)

In this case study, the water purification plant showing the best sediment removal efficiency was Boryeong water treatment plant with a ratio of 5:1. It is difficult to handle the boundary condition at the same condition as 100%, but since it showed a significantly better efficiency than the sedimentation bases with different ratios, I think it was meaningful to carry out the measurement.

However, when analyzing the correlation between the length-width ratio and the sedimentation efficiency through regression analysis, we can conclude that there is no significant correlation between the two values. It was thought that the influence of other parameters that were not controlled could be greater than the correlation between the two.

Sedimentation efficiency is related to settling velocity and horizontal velocity of rawwater. Therefore, the flow rate and cross-sectional area, which determine horizontal velocities, are the main determinants, as confirmed in the literature review. Since we performed a simple comparison of the cross-sectional area except for the Q value, the regression analysis was not significant at this case study.

The correlation between the length-width ratio and the sedimentation efficiency was not significant because of other parameters except the length-width ratio. Except the length-width ratio, there are many factors such as water inflow quantity, surface loading, efficient depth, and the type of sediment in raw water. In this case study, it seems that other parameters were not controlled or not considered, so it was difficult to find the correlation between length-width ratio and sedimentation efficiency. In future studies, multivariate regression analysis can be used to examine the correlation more precisely by considering several parameters at the same time.

The civil engineer must construct the water purification plant by using the limited land as efficiently as possible. Of course, we have to worry about many things such as construction cost, maintenance efficiency. The sedimentation efficiency of sedimentation tanks, which can affect overall water efficiency, is an important factor in the overall purification plant design. So far, we have proposed a proper ratio of the length-width ratio considering the construction cost and the sedimentation efficiency in the waterworks facility standards through many installation and operation cases.

In the fourth industrial revolution after the Third Industrial Revolution, there are many ways to develop the computing system and to apply the experiment through the system. If a method to utilize past values through big data as a factor of design is devised, more detailed design will be possible. In the future, we think that the design system should be applied to enable more accurate prediction through numerical method based on big data.

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