

*Key Laboratory of Chinese Ministry of Education of
Northwest Water Resource and Environmental Ecology
School of Environmental and Municipal Engineering
Xi'an University of Architecture and Technology*

西安建筑科技大学



城市污水的水质特点 及可处理性



Spectrum of impurities in water

Size μm	Ionic Range	Molecular Range	Macromolecular Range	Microparticle Range	Macroparticle Range		
	0.001	0.01	0.1	1.0	10	100	1.000
Approximate Molecular Weight	100	200	1.000	10.000	20.000	100.000	500.000
Relative Size of Various Materials in Water	Aqueous salts Metal ions	Viruses	Humic acids	Clays Asbestos fibers	Bacteria Algae Cysts Silt	Sand	



Methods of Characterizing Wastewater

Basic consideration for the characterization

- **According to bulk parameters**
 - ◆ suspended matter, organic matter, nutrients, bacteria etc
- **According to its state**
 - ◆ dissolved, colloidal, particulate, gaseous etc
- **According to its treatability**
 - ◆ settleable, coagulable, biodegradable etc

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1. Classification of Pollutants in Domestic Wastewater



General method to characterize dissolved and suspended matter

➤ Using a 0.45 μm filter for separation

< 0.45 μm dissolved

> 0.45 μm suspended

➤ There are some other criteria for the characterization, for example

< 1 nm dissolved

1nm ~ 1 μm colloidal

> 1 μm suspended

The 0.45 μm criterion is widely applied



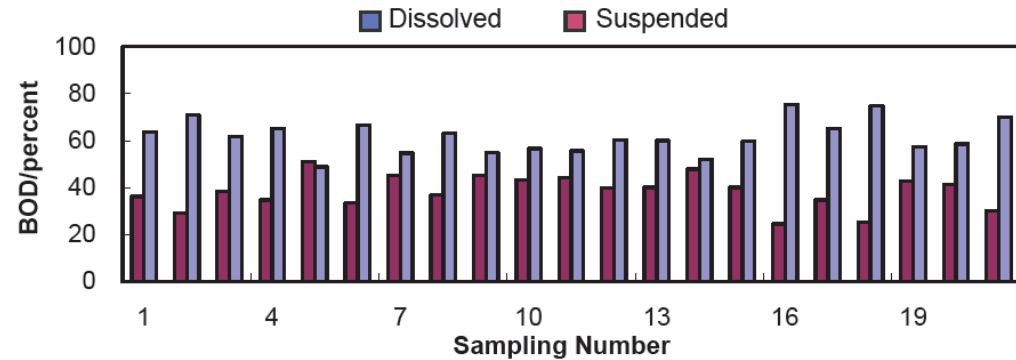
Evaluation Parameters

- **COD**
- **BOD**
- **Nitrogen**
 - **NH₃-N**
 - **NO_x-N (NO₃-N, NO₂-N)**
 - **Organic and inorganic nitrogen**
 - ✓ **KN=Organic nitrogen + NH₃-N**
 - ✓ **Inorganic nitrogen = TN – Organic nitrogen**
- **TP**



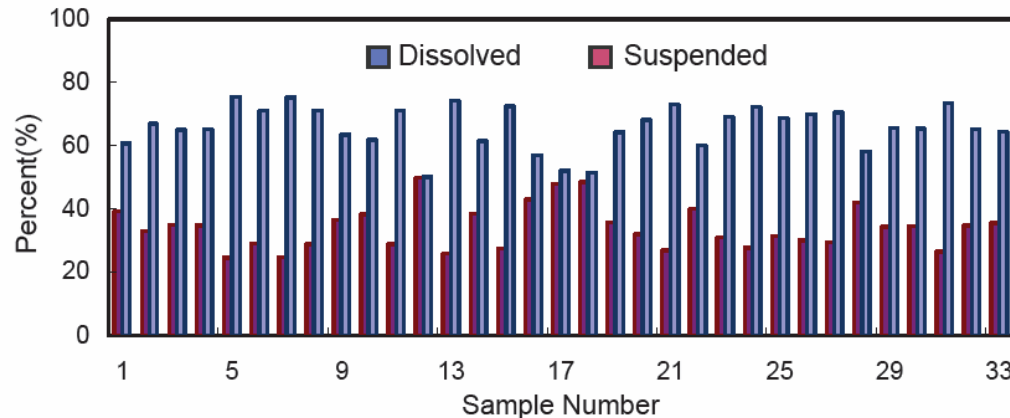
➤ BOD in domestic wastewater

COD and BOD in domestic wastewater



Dissolved average: 39.54%
Suspended average: 60.46%

➤ COD in domestic wastewater



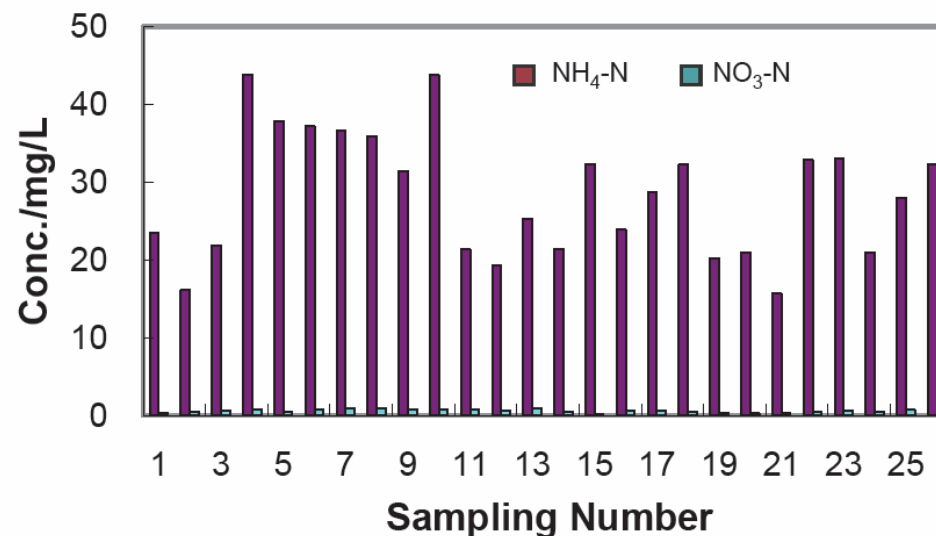
Dissolved average: 34.12%
Suspended average: 65.88%

- More than 60% of COD or BOD in the domestic wastewater are suspended matter.
- Less than 40% of COD or BOD in the domestic wastewater are dissolved matter.

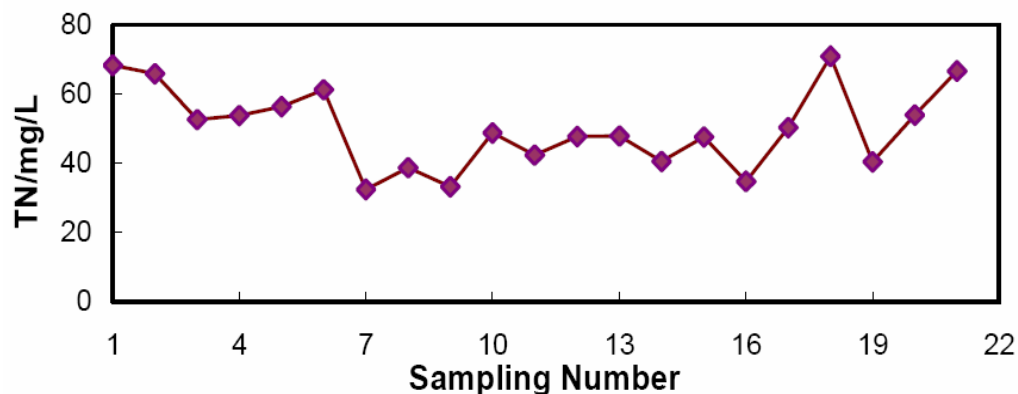


Nitrogen in domestic wastewater

Ammonia and nitrate



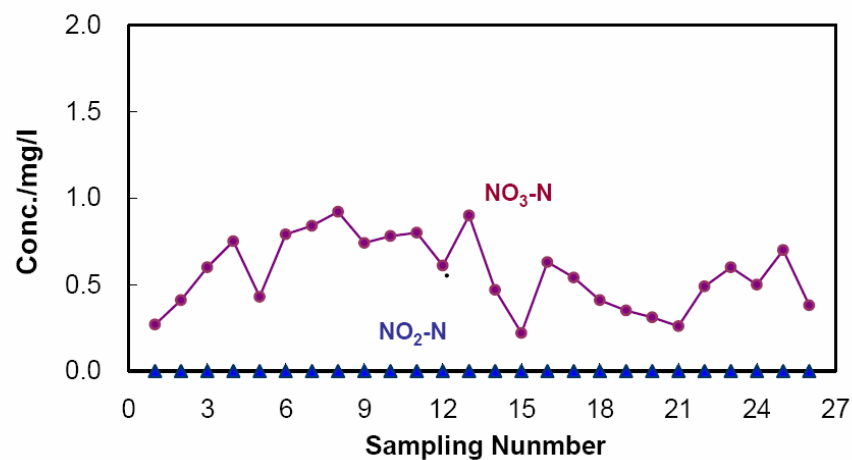
Total Nitrogen



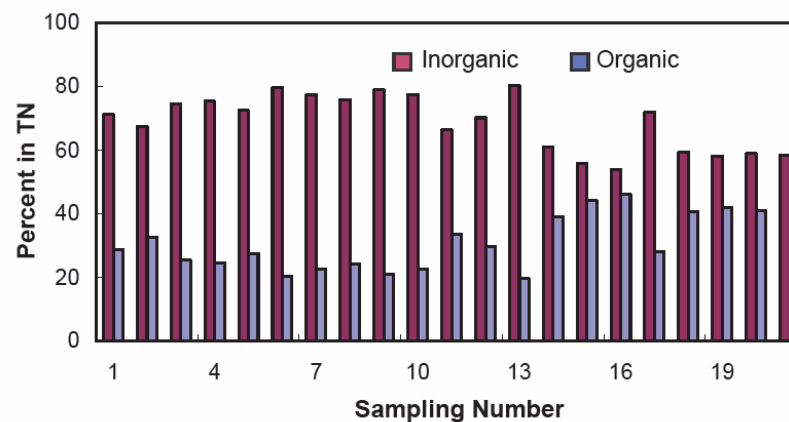
TN average: 50.18 mg/L



➤ Nitrate and Nitrite

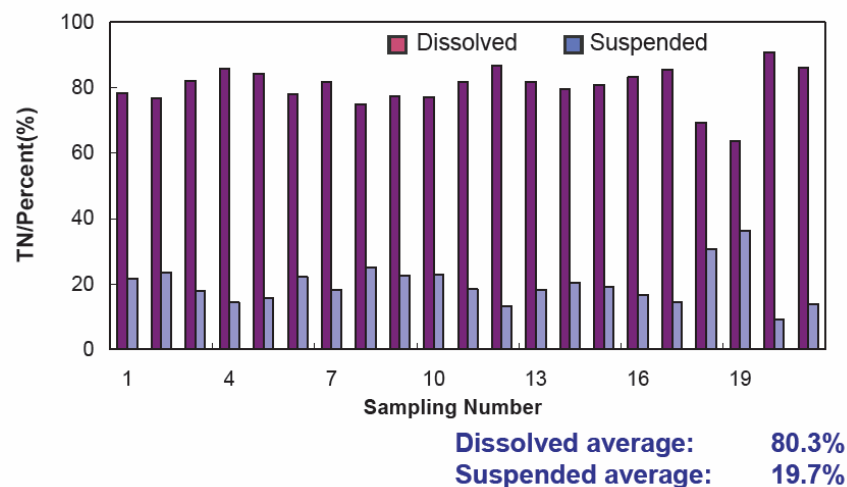


➤ Organic and inorganic nitrogen

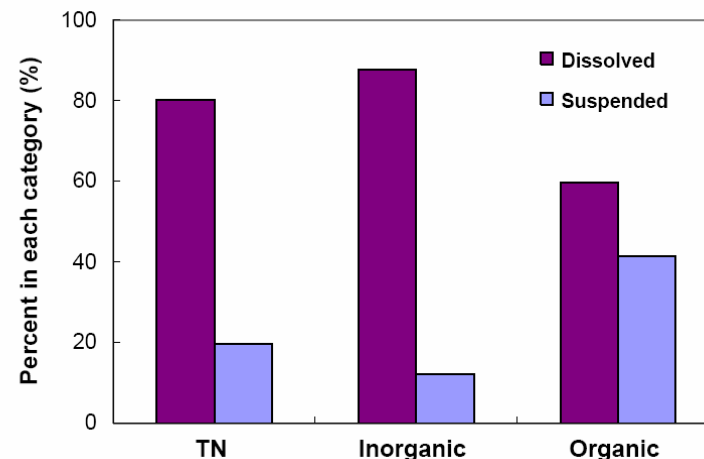


Inorganic average: 68.5%
Organic average: 31.5%

➤ Dissolved and suspended nitrogen (1)



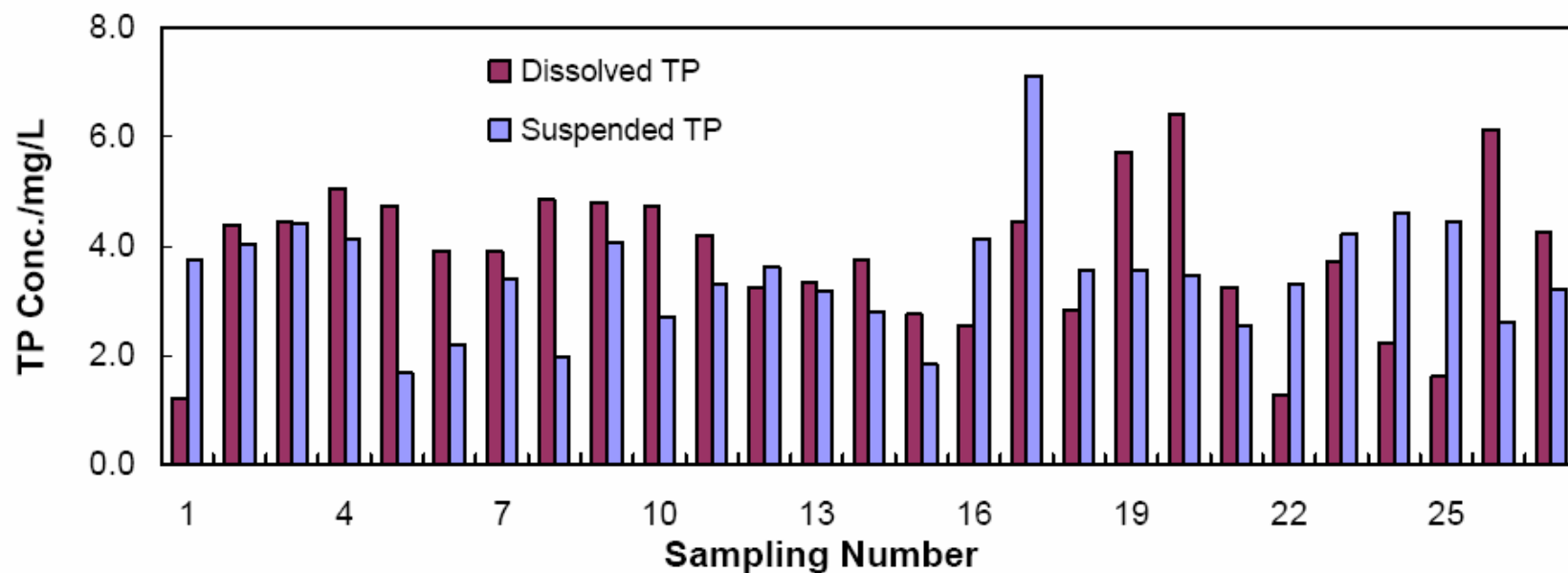
➤ Dissolved and suspended nitrogen (2)



- **Inorganic nitrogen takes about 70% of the total nitrogen, among them most are ammonia nitrogen;**
- **About 80% of the TN are dissolved matter and only 20% are suspended matter;**
- **Dissolved matter takes about 88% of the inorganic nitrogen and about 60% of the organic nitrogen.**



Phosphorus in domestic wastewater



Dissolved average: 52.5%
Suspended average: 47.5%

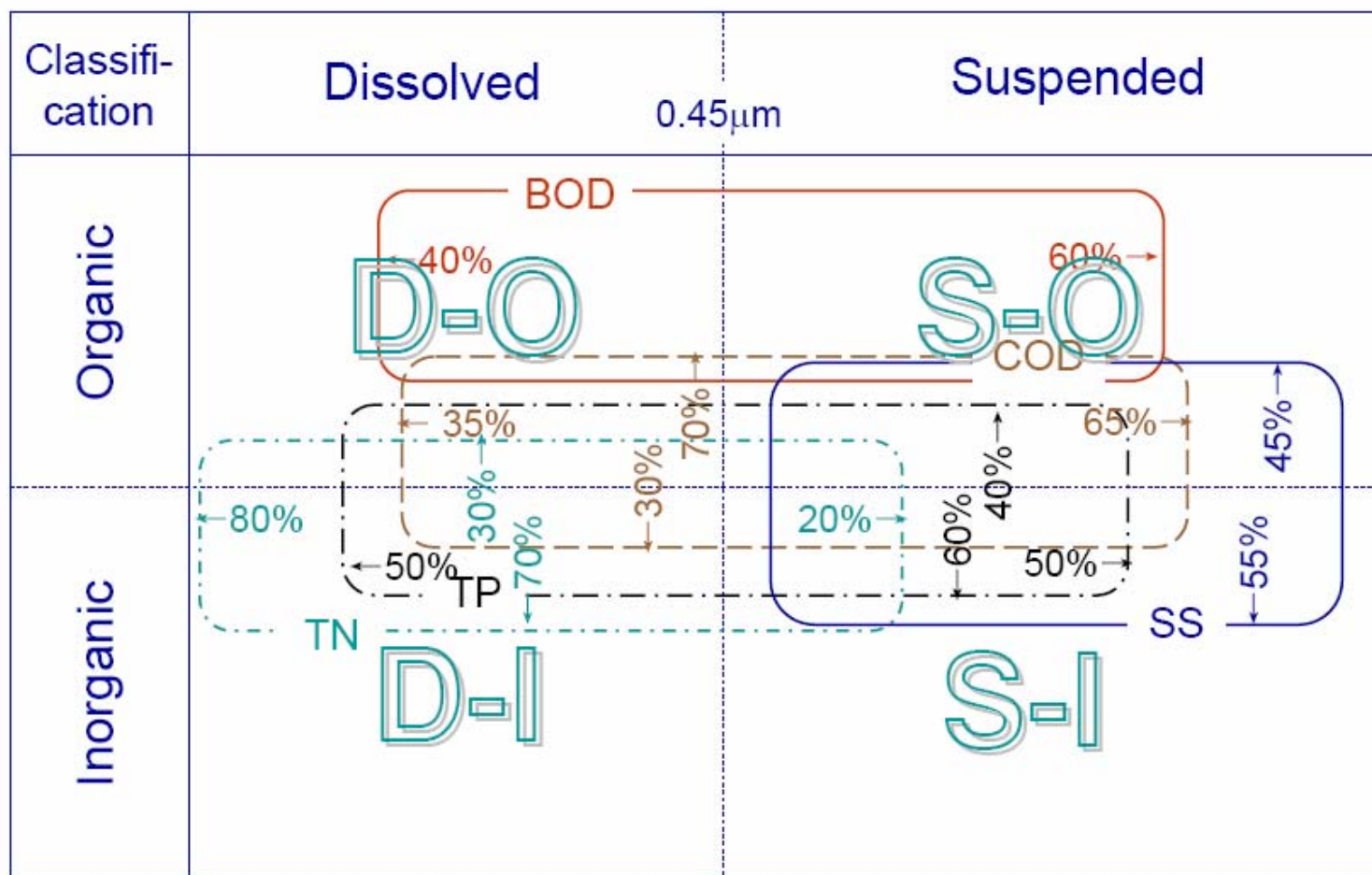


Establishment of a water quality matrix

- A water quality matrix is established based on the analytic results abovementioned using a 2×2 classifying method by
 - ◆ Pollutant size: dissolved, suspended (row)
 - ◆ Chemical property: organic, inorganic (column)such forming 4 classifications of pollutants in domestic wastewater
 - ◆ Dissolved organic matter (*D-O*)
 - ◆ Suspended organic matter (*S-O*)
 - ◆ Dissolved inorganic matter (*D-I*)
 - ◆ Suspended inorganic matter (*S-I*)



Water quality matrix for domestic wastewater





2. Treatability Evaluation of Pollutants in Domestic Wastewater



Settleability evaluation

Methods

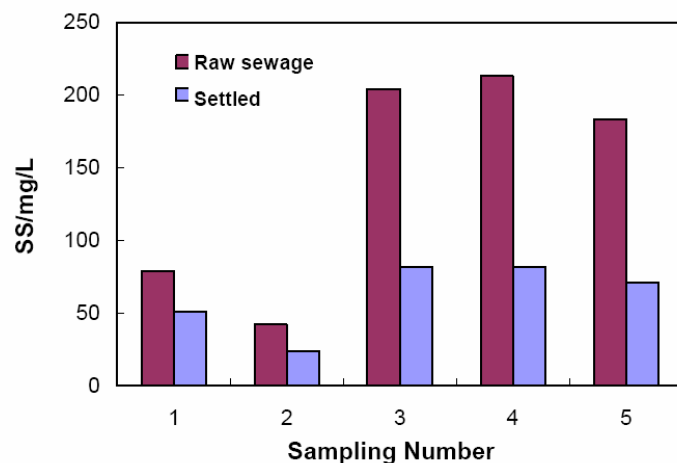
- Plain settling of raw sewage for 2 hours
- Analysis of the raw sewage and the supernatant

Parameters for the evaluation

- Suspended solids, COD, BOD5, total nitrogen (TN) and total phosphorous (TP)

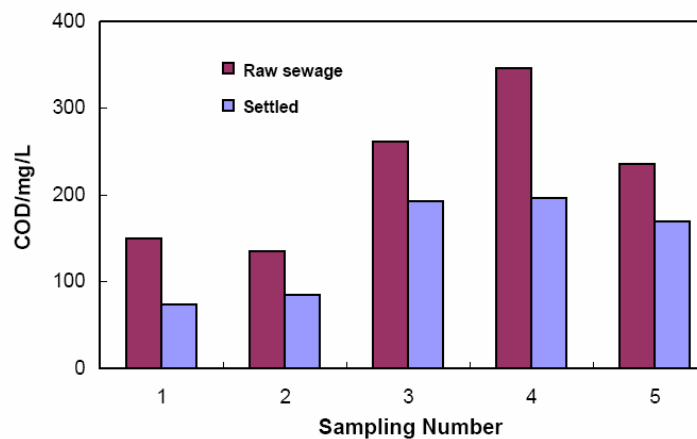


➤ Plain settling for 2 hours - SS



An average SS removal of 57% gained by plain settling

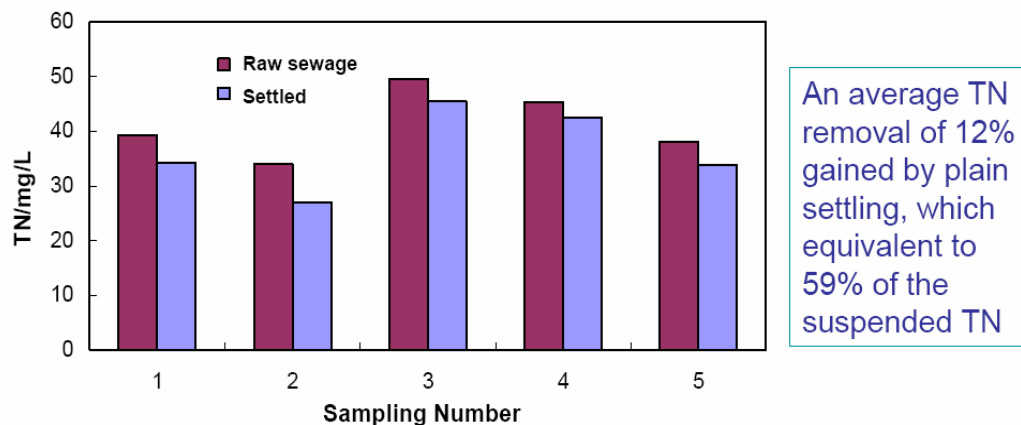
➤ Plain settling for 2 hours - COD



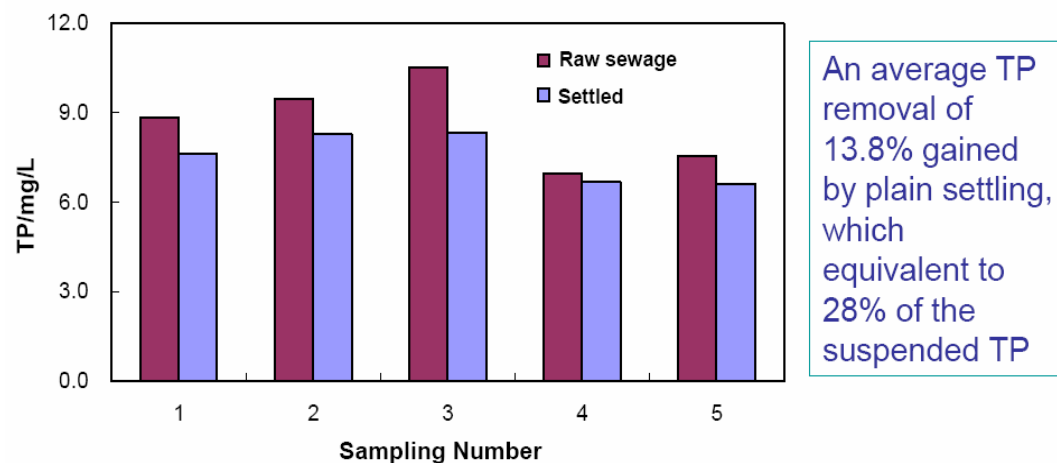
An average COD removal of 36.6% gained by plain settling, which equivalent to 56% of the suspended COD



➤ Plain settling for 2 hours - TN



➤ Plain settling for 2 hours - TP





Evaluation results

- **SS:** 57% of the suspended solids in the raw sewage are settleable
- **COD:** 37% of the total COD or 56% of the suspended COD are settleable
- **BOD:** 29% of the total BOD or 49% of the suspended BOD are settleable
- **TN:** 12% of the total TN or 59% of the suspended TN are settleable
- **TP:** 14% of the total TP or 28% of the suspended TP are settleable

The unsetttable suspended matter are thought to be of colloidal nature and have to be removed by other treatment methods



Coagulability evaluation

Methods

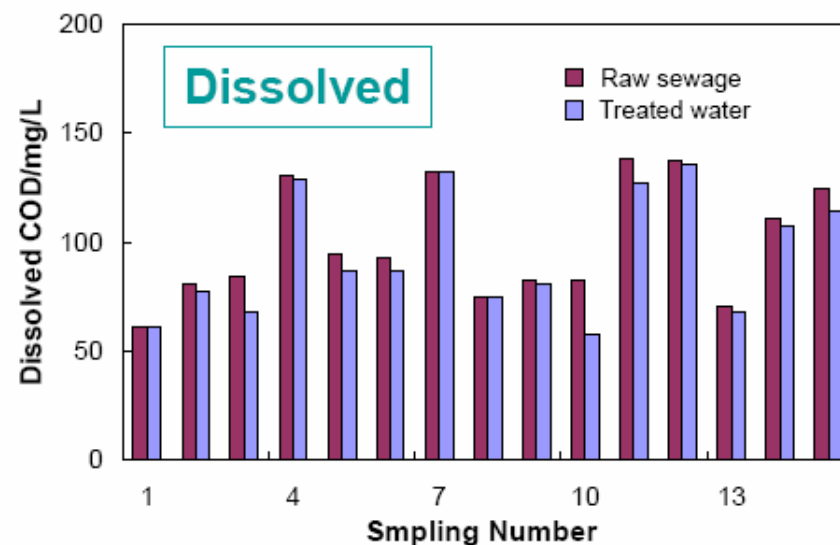
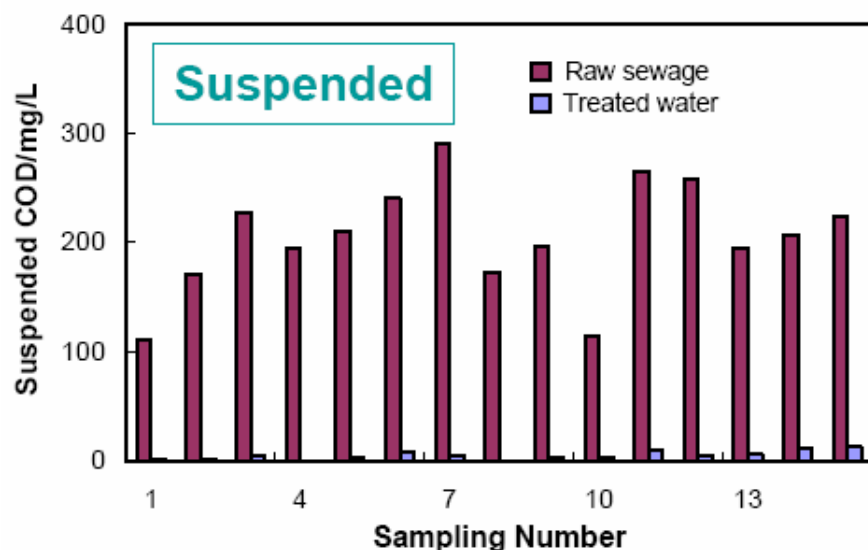
- Coagulation with Polyaluminum Chloride (PAC) as coagulant followed by settling
- Analysis of the raw sewage and the settled water

Parameters for the evaluation

- COD, BOD₅, total nitrogen (TN), ammonia nitrogen (NH₃-N) and total phosphorous (TP)



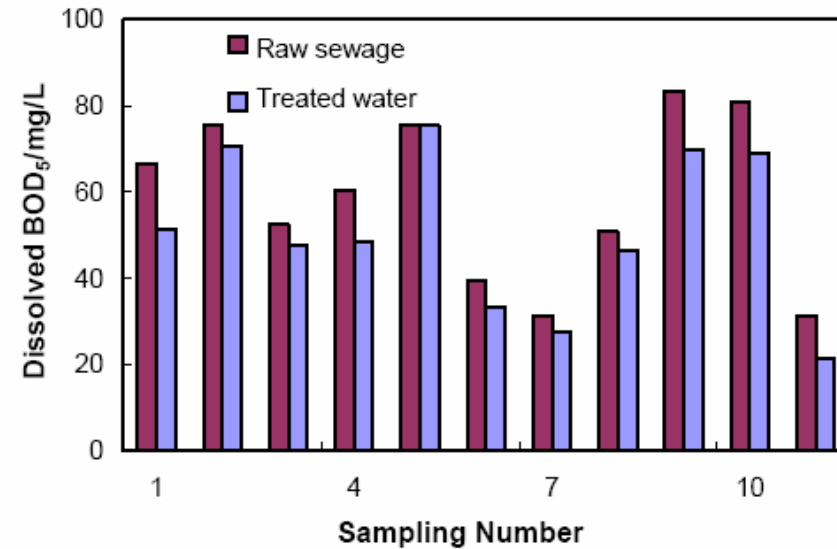
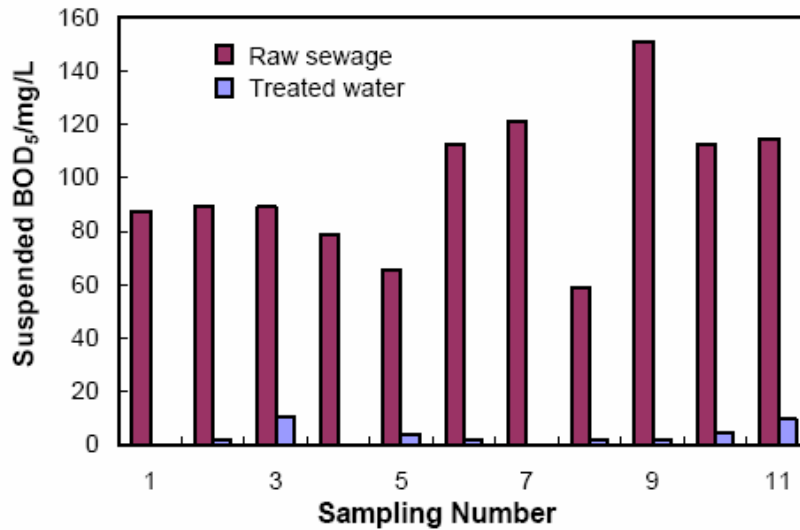
➤ Coagulation - COD



Total COD removal: 67.8%
Suspended COD removal: 97.8%
Dissolved COD removal: 6.0%



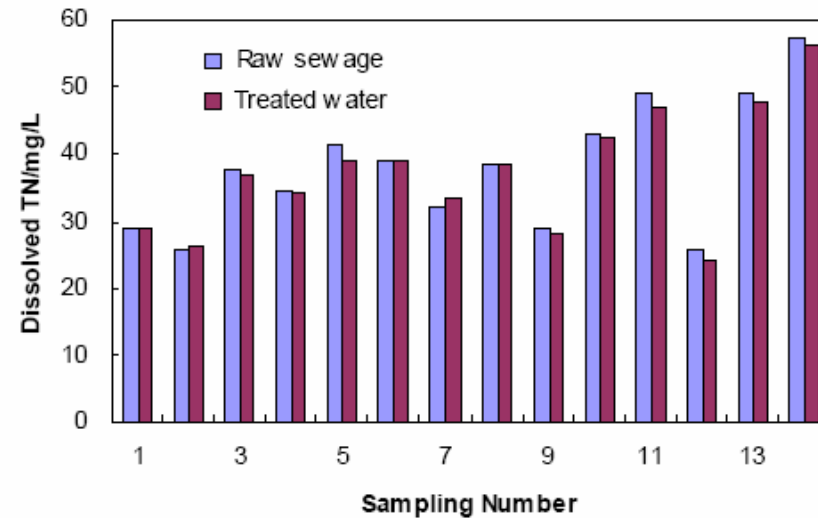
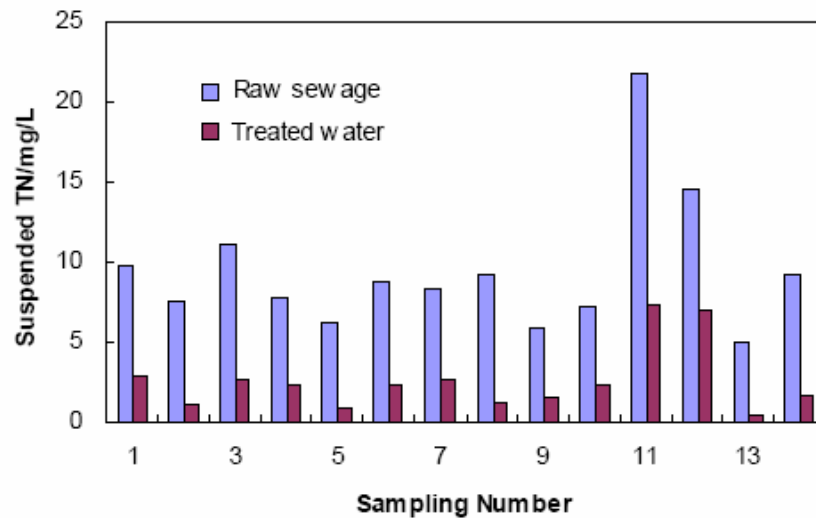
➤ Coagulation - BOD



Total BOD removal: 65.1%
Suspended BOD removal: 96.7%
Dissolved BOD removal: 13.3%



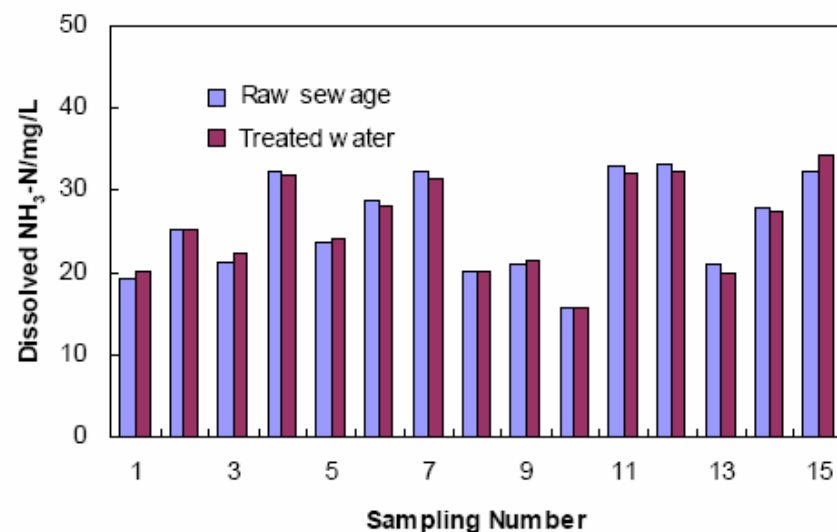
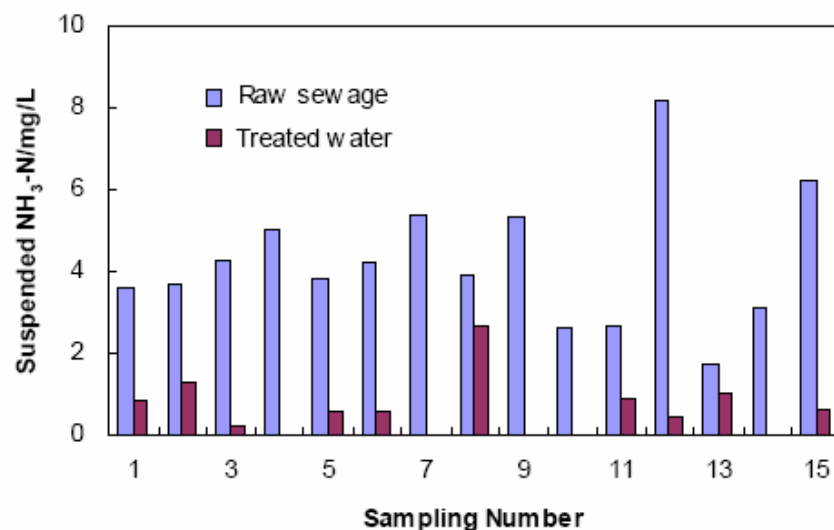
➤ Coagulation - TN



Total TN removal: 15.9%
Suspended TN removal: 72.4%
Dissolved TN removal: 1.8%



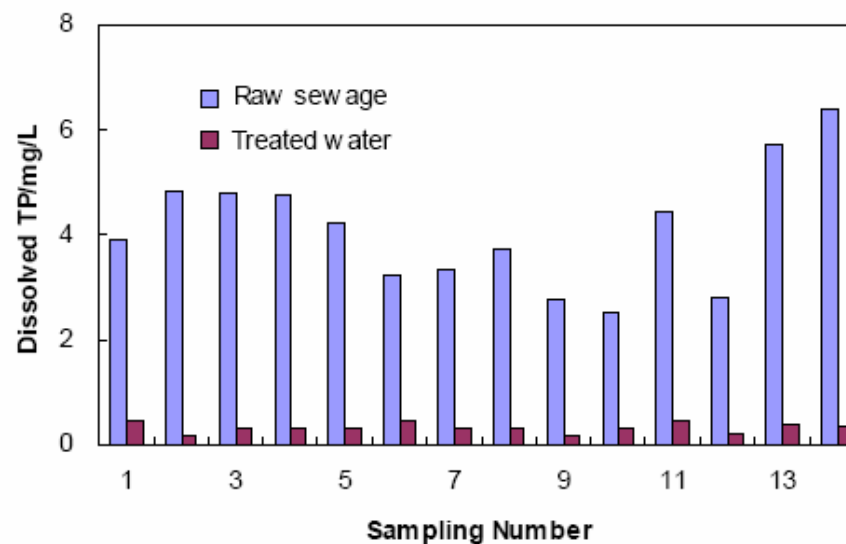
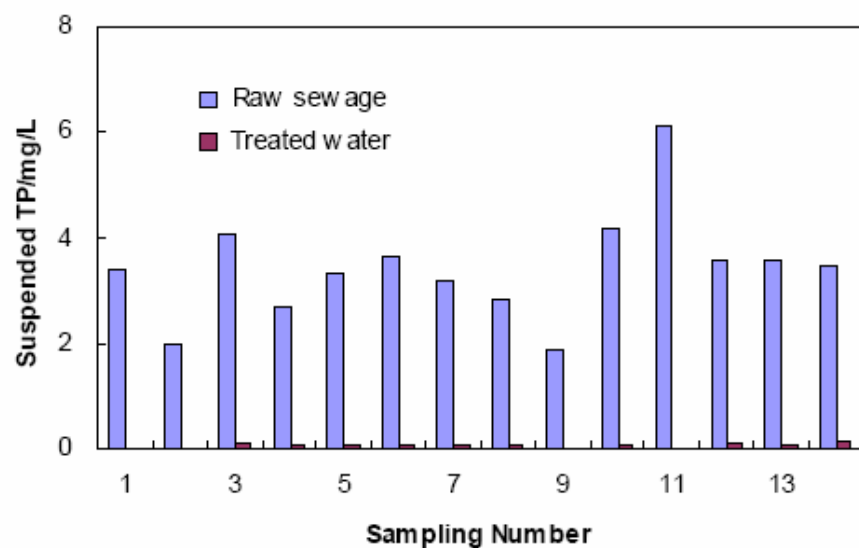
➤ Coagulation – $\text{NH}_3\text{-N}$



Total $\text{NH}_3\text{-N}$ removal: 11.7%
Suspended $\text{NH}_3\text{-N}$ removal: 85.7%
Dissolved $\text{NH}_3\text{-N}$ removal: 0.3%



➤ Coagulation – TP



Total TP removal: 95.1%
Suspended TP removal: 98.8%
Dissolved TP removal: 92.1%



Evaluation results

- **COD: 68% of the total COD or 98% of the suspended COD in the raw sewage are coagulable;**
- **BOD: similar to the COD results;**
- **TN: 16% of the total TN or 72% of the suspended TN are coagulable;**
- **NH₃-N: 12% of the total NH₃-N or 86% of the suspended NH₃-N are coagulable;**
- **TP: 95% of the TP are coagulable, and the coagulable percent is as high as 99% for suspended TP and 92% for dissolved TP.**



Evaluation of the secondary treatment process

Methods

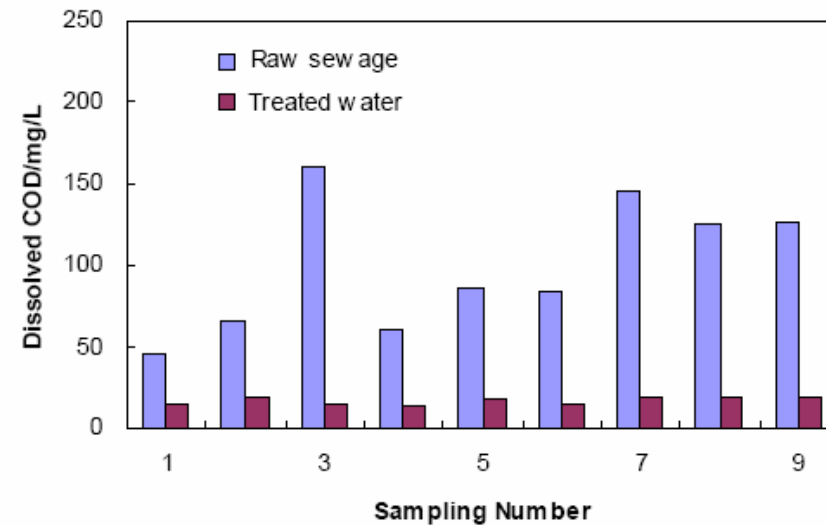
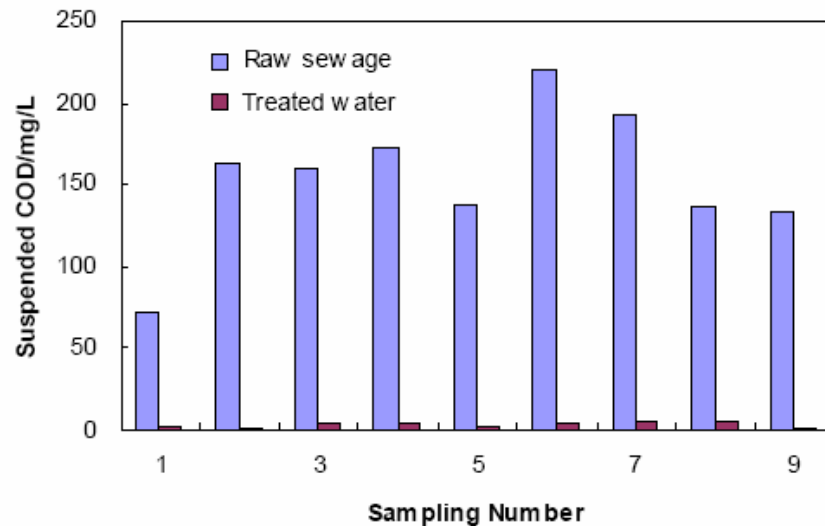
- Raw sewage and secondary effluent samples taken from a WWPT using an oxidation ditch process
- Analysis of the water sample

Parameters for the evaluation

- COD, BOD₅, total nitrogen (TN), ammonia nitrogen (NH₃-N) and total phosphorous (TP)



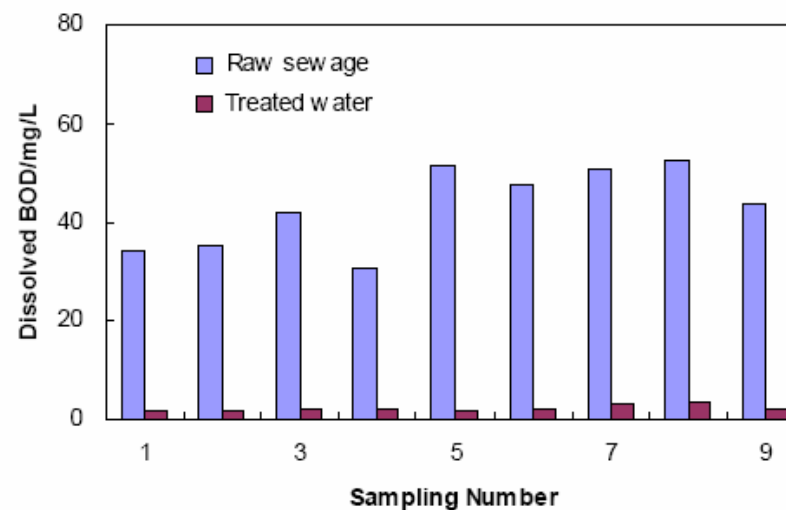
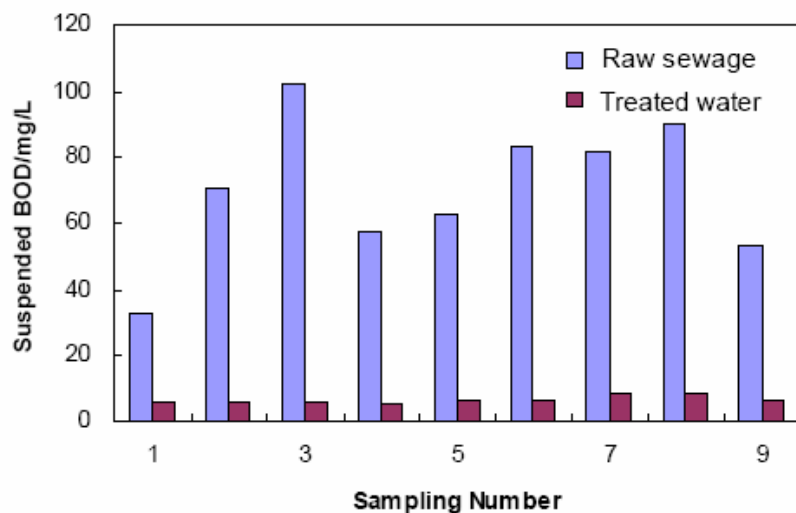
➤ Secondary T. – COD



Total COD removal: 91.8%
Suspended COD removal: 97.7%
Dissolved COD removal: 82.7%



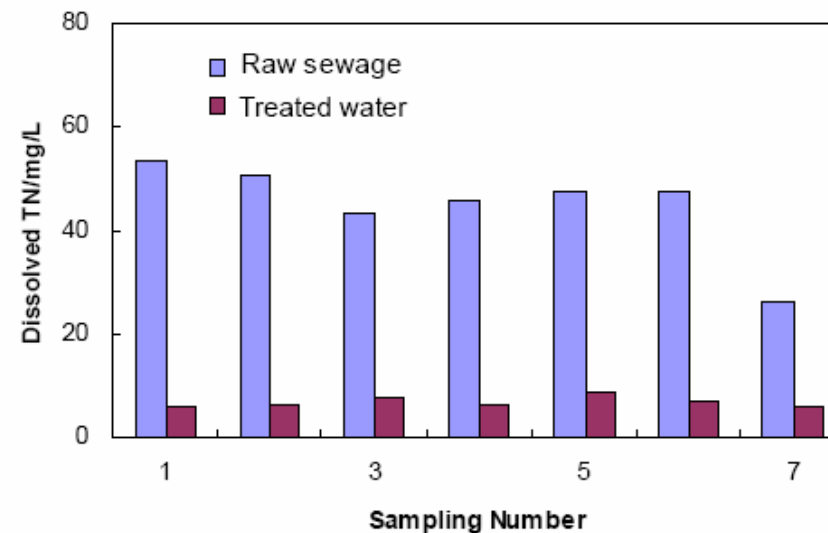
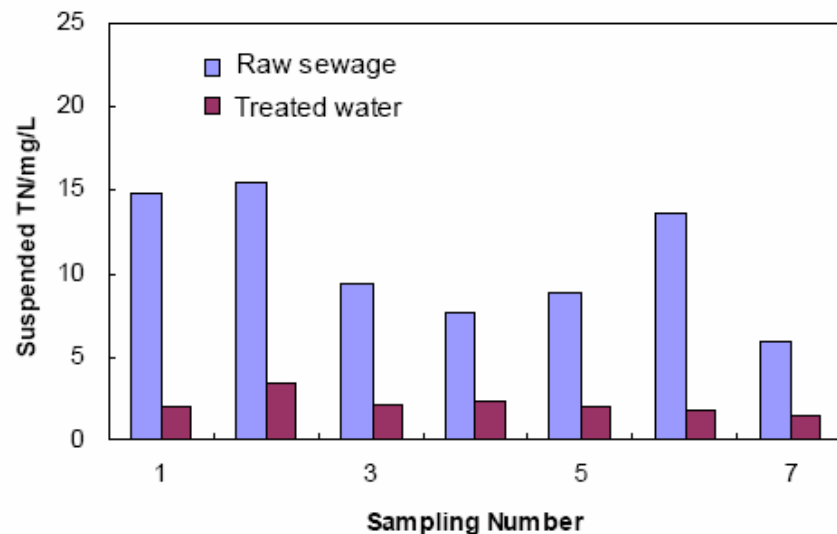
➤ Secondary T. – BOD



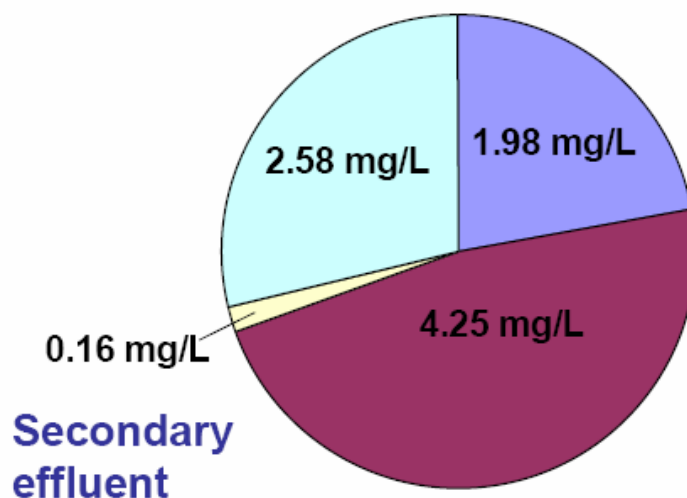
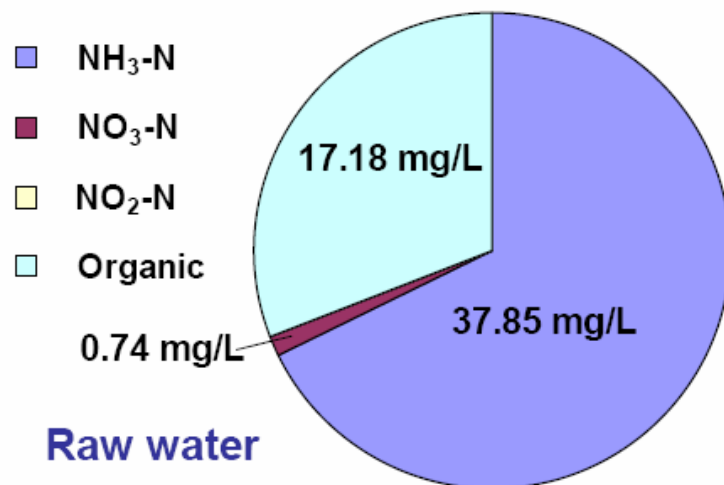
Total BOD removal: 92.2%
Suspended BOD removal: 90.6%
Dissolved BOD removal: 94.7%



➤ Secondary T. – TN



Total TN removal: 83.9%
Suspended TN removal: 80.1%
Dissolved TN removal: 84.8%

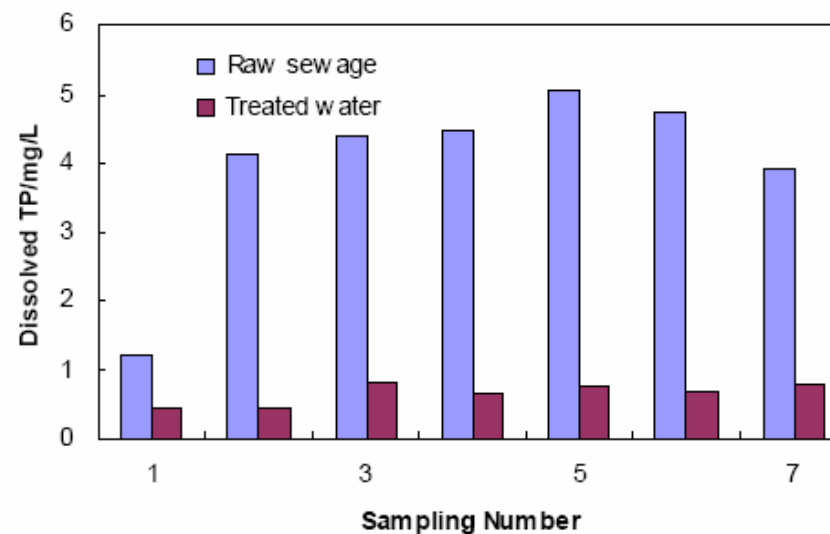
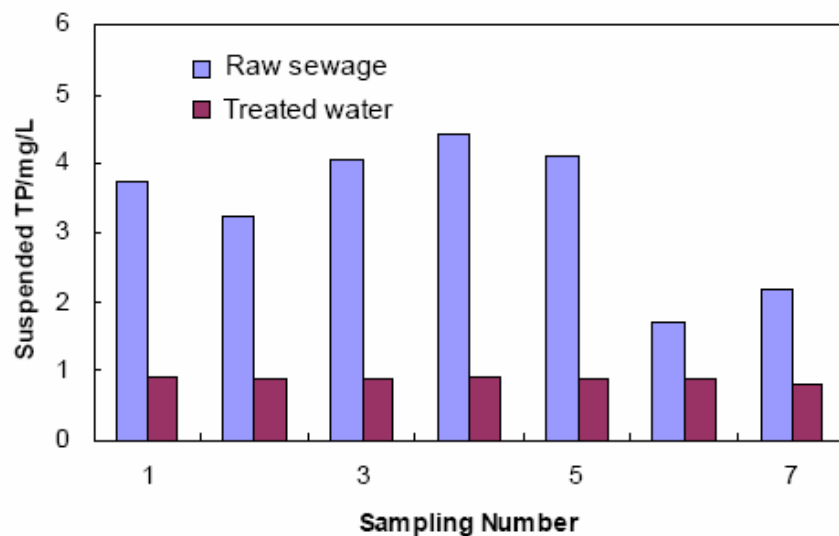


➤ Composition of Nitrogen in the raw water and secondary effluent

- ◆ Raw water TN: 55.77 mg/L
- ◆ Treated water TN: 8.97 mg/L
- ◆ Although a 83.9% removal is achieved, there are apparent alternation of NH₃-N into NO₃-N and NO₂-N due to nitrification in the activated sludge process



➤ Secondary T. – TP



Total TP removal: 88.1%
Suspended TP removal: 73.7%
Dissolved TP removal: 83.7%



Evaluation results

- **COD: 92% removal of the total COD, 98% of the suspended COD and 83% of the dissolved COD;**
- **BOD: 92% removal of the total BOD, 91% of the suspended BOD and 95% of the dissolved BOD;**
- **TN: 84% removal of the total TN, 80% of the suspended TN and 85% of the dissolved BOD;**
- **TP: 88% removal of the total TP, 74% of the suspended TP and 84% of the dissolved TP.**



Comparison of the enhanced primary treatment with the secondary treatment

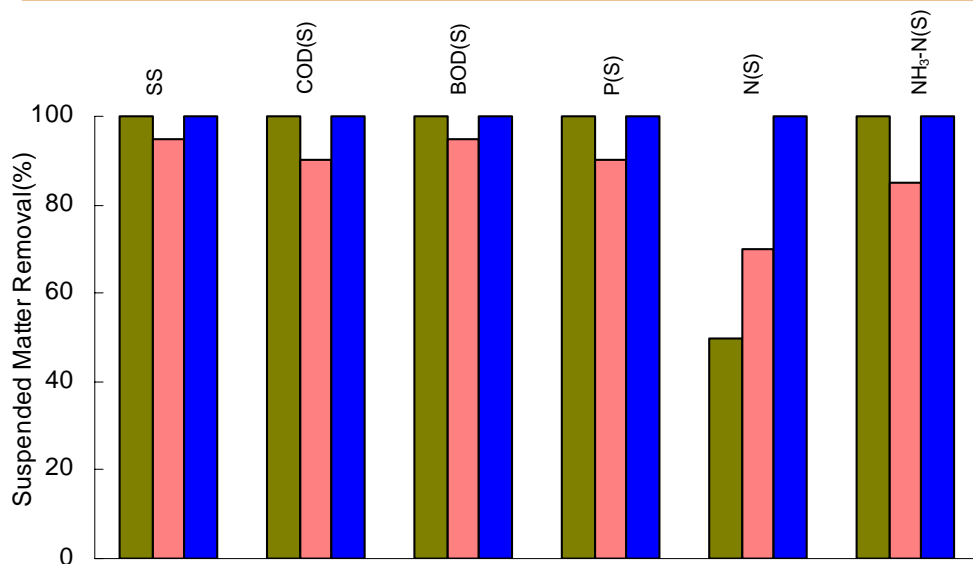
➤ Removal of the suspended pollutants (as percent)

Parameter	COD	BOD	TN	TP
Enhanced primary	98	97	72	99
Secondary	98	91	80	74

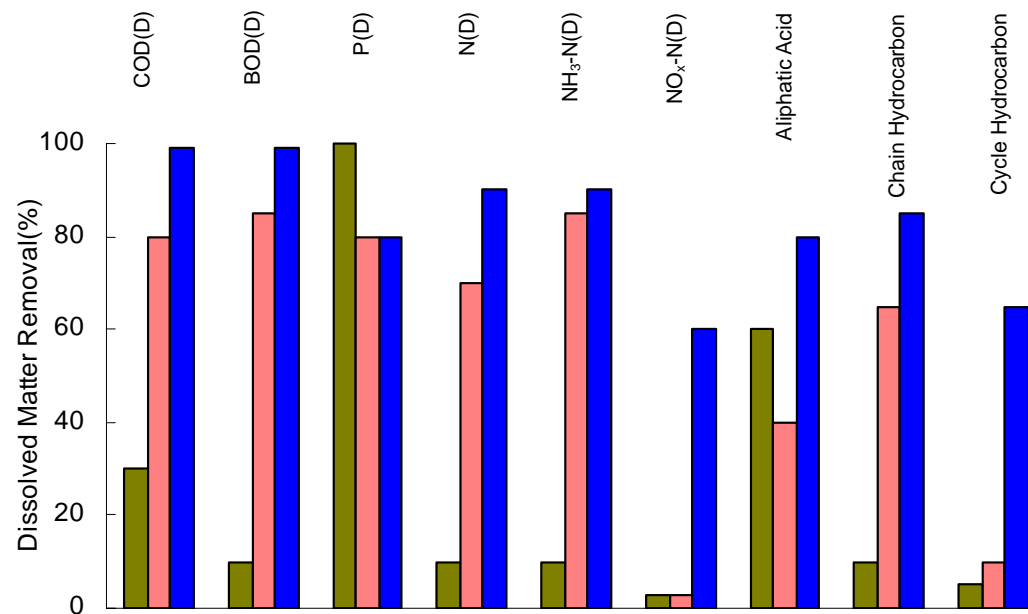


➤ Removal of the dissolved pollutants (as percent)

Parameter	COD	BOD	TN	TP
Enhanced primary	6	13	2	92
Secondary	83	95	85	84

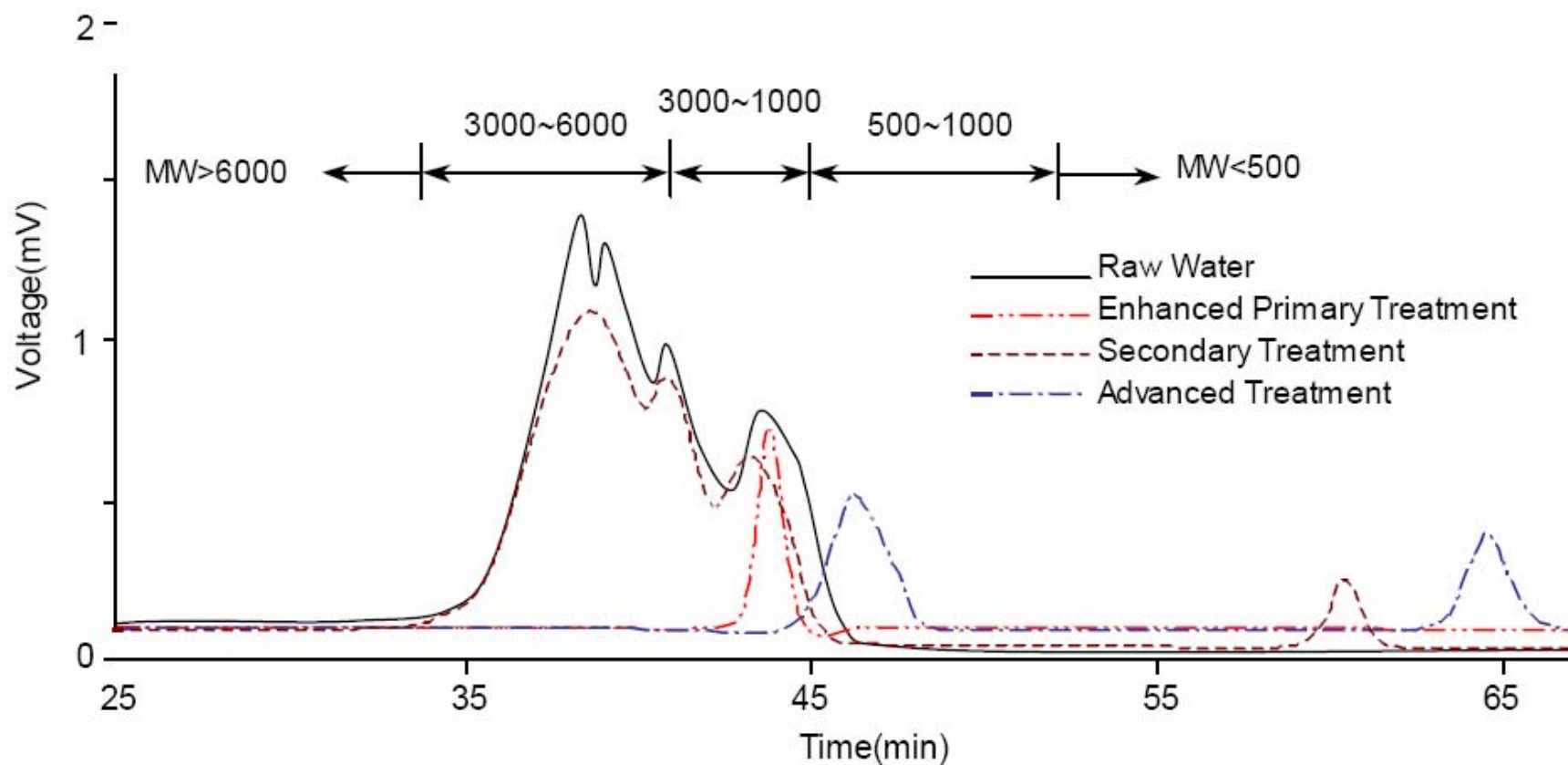


- Enhanced Primary Treatment
- Secondary Treatment
- Advanced Treatment





➤ Comparison of molecular weight of organic matter





Conclusions

- **Most of the suspended pollutants in the domestic wastewater can be effectively removed by enhanced primary treatment utilizing coagulation and sedimentation.**
- **Enhanced primary treatment is not effective in the removal of dissolved pollutants, except for phosphorous to which it performs a higher removal than the secondary treatment.**
- **Selection of a suitable process for wastewater treatment should be based on an evaluation of the characteristics of the pollutants which are related to their treatability.**