

Urban Environmental Engineering (1)

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BIOGRAPHICAL INFORMATION

- 1990 B.Eng., Urban Eng., Univ. of Tokyo
- 1995 Ph.D. (D.Eng.), Graduate School of Engineering, Univ. of Tokyo
- 1995 Research Associate of Urban Eng., Univ. of Tokyo
- 1997 Associate Professor, Environmental Science Center, Univ. of Tokyo
- 1999 Associate Professor, Dept. of Civil Engineering, Tokyo Institute of Technology

AFFILIATIONS:

- Japan Society of Civil Engineers
- International Water Association
- The International Solid Waste Association
- Japan Society of Waste Management Experts
- Japan Society on Water Environment
- Membrane Society of Japan
- Japan Society for Environmental Chemistry
- Society of Environmental Science Japan

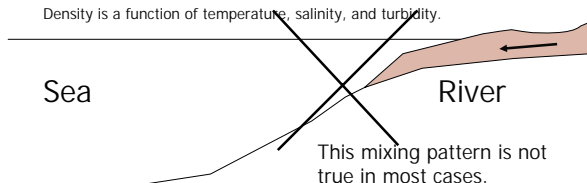
Today's Lecture

- Phenomena observed in
 - Estuary and Tidal River
 - Lakes and Reservoirs (Closed Waters)
- BOD, COD, TOC
 - Definition, Significance, Measurement
- Questions and Homework

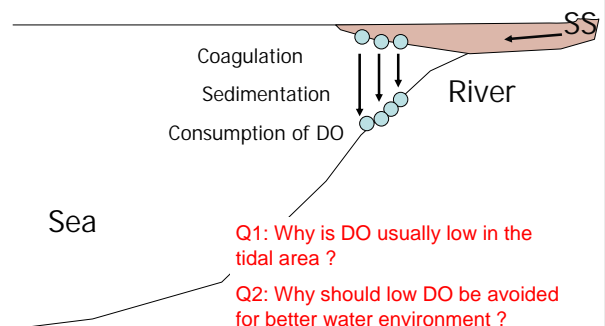
Estuary and Tidal River

- The place where seawater and freshwater mixes. Phenomena induced by difference in density may occur in this region.

Density is a function of temperature, salinity, and turbidity.



Low DO is often found where seawater and fresh water meets

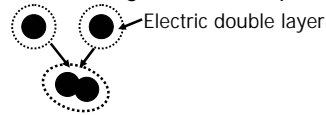


Seasonal Flow Change induces Coagulation



Coagulation

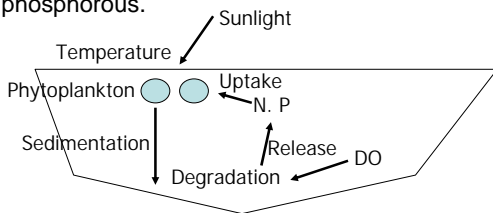
- Coagulation is a phenomenon that small particles aggregate with each other and form larger particles. When salt concentration is high, repulsion force between the particles become small and coagulation takes place easily.



- Q3: Please give an example in which coagulation is utilized in a engineering manner.

Lakes and Reservoirs

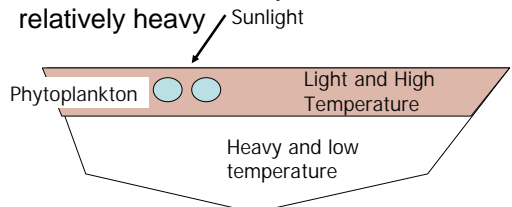
- The retention time of water is long in the case of closed or semi-closed waterbody.
- Eutrophication is caused by nitrogen and phosphorous.



- Q4: Why are N and P important in Eutrophication. How about K?

Layer Formation (Stratification)

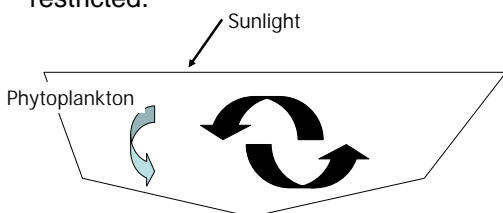
- In summer, upper layer is heated. On the other hand, bottom layer is cold and relatively heavy.



- Q5: What kind of devices do drinking water authorities install in a reservoir for destruction of layers ?

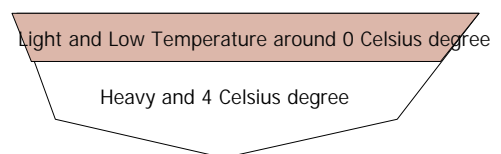
Breakdown of Layers

- In autumn and in spring, layers disappear and mixing occurs. In this condition, the abnormal growth of phytoplankton is restricted.

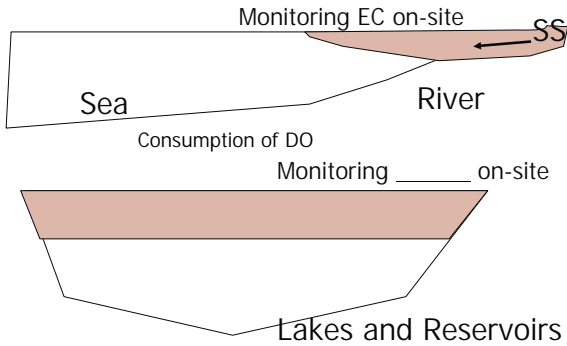


Layer Formation (Stratification) in winter

- In winter, lakes in the northern part of Japan have layers because the density of the water is maximum at 4 Celsius degree.
- However, abnormal algae growth may not occur because of low temperature.



We must take care the position of the sampling



BOD, COD, TOC - Definition

- All of these parameters are relating to organic content of water.
- The most important point of regulating organic matter in effluents is to avoid anoxic and anaerobic condition in water environment.
- BOD₅ measures the oxygen utilized for the biochemical degradation of organic material.
- COD measures the content of organic matter which can be oxidized by a specified chemical reagent (such as K₂Cr₂O₇ in most countries and KMnO₄ in the case of Japan).
- TOC measures carbon content.

BOD₅

- $BOD_5 = DO_0 - DO_5$, if dilution is not necessary.
- BOD measures oxygen demand which is required for decomposition of biodegradable organic matter.
- If the water contains NH₃-N and seed microorganisms includes nitrifying bacteria, BOD = Carbonaceous BOD + Nitrogenous BOD
- BOD has limitations when we want to measure BOD for toxic wastewater or seawater.
- BOD is useful to evaluate river water quality and biodegradable wastewater

Why 5 days for BOD ?



The Thames River and the construction of the Sewer

Measurement of BOD₅

- $BOD_5 = (DO_0 - DO_5)$, if dilution is not necessary .
- DO can be measured by the azide modification of the iodometric method or by membrane electrode method.
- DO₅ can be measured by using a glassware like the right figure.



Other BODs

- U-BOD. U-BOD measures the ultimate biodegradability for 30 days or longer, while BOD₅ measures readily biodegradable organic matter.
- D-BOD (Dissolved BOD). When we analyze water samples, we sometimes need the distinction of dissolved BOD and Particulate BOD. P-BOD can be measured by total BOD subtracted by D-BOD.

COD

- COD measures the content of organic matter which can be oxidized by a specific chemical reagent (such as $K_2Cr_2O_7$ in most countries and $KMnO_4$ in the case of Japan).
- COD is useful when we want to measure organic content of water which contains slowly or non biodegradable matters.
- COD is useful when we want to discuss lake water quality, because water retention time is longer than 5 days.
- Salt content may interfere the measurement of COD.

Measurement of COD

- Digest sample for a certain time (Typically two hours) by using the glassware like
- Titration method is used.
- There are many CODs like COD_{Cr} and COD_{Mn} with various heating condition and heating time, and digestion pH.



Various CODs

COD_{Cr} : $K_2Cr_2O_7$, 2 Hours heating by direct gas burner with open reflux or with closed reflux.

COD_{Mn} : $KMnO_4$, 30 minutes in 100 Celsius degree hot bath.

COD_{OH} : $KMnO_4$, 20 minutes in 100 Celsius degree hot bath. This method is used for sea water in Japan. (However, I do not recommend)

Comparison of COD_{Cr} and COD_{Mn} of standard solutions which theoretically give oxygen consumption of 100 mg/L.

Solution	COD_{Cr}	COD_{Mn}
Formic acid	99.4	14
Stearic acid	92.5	0
Methanol	95.3	27
Glucose	97.6	59
Starch	86.5	61
Glutamic acid	102	6

TOC

- TOC measures carbon content. TOC is expressed as mgC/L, while BOD and COD is expressed as mgO/L.
- TOC measures CO_2 gas when sample is broken down completely.
- Instrumental analysis with high temperature combustion method is often used.
- It is difficult to measure accurately the samples containing high SS by the high temperature combustion method using instruments.

TOC Instrumental Analysis

- The instrument measures CO_2 concentration when sample is burned at 600 Celsius degree to 950 Celsius degree. Higher temperature is preferable for complete decomposition, while lower temperature reduces interference caused by salts.
- $TOC = TC - IC$. If IC is high, acid pretreatment of sample is required to release IC.

DOC

- DOC (Dissolved Organic Carbon) is often measured.
- The ratio of DOC to E₂₆₀ is often used to evaluate biodegradability of the samples.

Questions and Homework

- Q1: Why is DO usually low in the tidal area ?
- Q2: Why should low DO be avoided for better water environment ?
- Q3: Please give an example in which coagulation is utilized in a engineering manner.
- Q4: Why are N and P important in Eutrophication. How about K?
- Q5: What kind of devices do drinking water authorities install in a reservoir for destruction of the layers ?