WATER TREATMENT

SKAA 2912

WATER QUALITY PARAMETERS (Microbiological)

Dr. Yong Ee Ling
Senior Lecturer
Faculty of Civil Engineering
Universiti Teknologi Malaysia
(eeling@utm.my)

INTRODUCTION

- **Waterborne disease -** a disease causing microorganism transmitted via ingestion of contaminated water
- **Pathogenic microorganisms** – disease causing microorganisms; normally comes in small quantities and detection is difficult
- **Indicator microorganisms** – only present when pathogenic microorganisms are present; easily measured; measurement coliform groups are universally adopted (fecal coliforms or total coliforms)

INTRODUCTION

- Three main groups of pathogenic organisms that can be transmitted via drinking water:

Organisms	Disease	Symptoms
Protozoa	Giardiasis Toxoplasmosis Cryptosporidiosis	Diarrhea Abdominal pain Weight loss
Bacteria	Cholera Salmonellosis Shigellosis	Watery diarrhea Fever Bloody darrhea
Virus	Viral hepatitis	Vomitting Diarrhea Hepatitis A & E

SOURCES OF WATERBORNE DISEASE

- Contaminated, untreated or inadequately disinfected drinking water source (normally from fecal wastes)
- **Protozoas (*Giardia, Cryptosporidium*) and viruses (Hepatitis A)** are **resistant to physico-chemical treatment**, including chlorination
- Aggregation or adsorption to organic or inorganic matter may serve to protect or shield enteric pathogens from the effects of sunlight, chemical treatments, or predatory organisms.
- Contamination of drinking water in water distribution system
  - normally for non-pathogenic microorganisms
  - biofilm growth along the pipelines → causes taste and odor problems
  - regrowth of pathogenic microorganism

INDICATOR ORGANISMS

- Requirements to be the assessor of fecal contamination:
  - Only found in human and non-pathogenic
  - Found in the intestine of healthy human
  - If found outside the environment, it must be from fecal origin
  - Only present when fecal pathogens are present
  - Numbers are much greater than fecal pathogens
  - Resistant to the natural environmental conditions and to water and wastewater treatment processes
  - Unable to grow outside intestine but the die-off rate is slower than pathogenic organisms
  - Easy to identify, isolate and enumerate

Most do not fulfill all requirements but many of the requirements are fulfilled by **coliform group**

INDICATOR ORGANISMS

- The coliform group:
  - **Total coliforms**: Bacteria found in soil or water that has come in contact with human or animal waste.
  - **Fecal coliforms**: Bacteria only present in the gut and faeces of animal and human. A better indicator than total coliform
  - ***Escherichia coli* (*E.coli*)**: major bacteria species in fecal coliform and cannot reproduce in the environment. Best indicator.

INDICATOR ORGANISMS

- Characteristic of coliform group:
  - Facultative anaerobic
  - Gram-negative
  - Non-spore forming
  - Rod-shaped bacteria
  - Developed red colonies with metallic sheen
  - **Non-coliform bacteria**: red, pink, blue white of colourless colonies **without metallic sheen**

USEPA 1989 TOTAL COLIFORM RULE

- Total coliforms are monitored in the distribution system proportional to the number of people served to prevent microbial contamination
  - < 1000 people – Test once monthly
  - 50 000 people – Test at least 60 times per month
  - 2.5 million people – Test at least 420 times per month
- In a month, the total coliform **should not be found in more than 5%** of the total drinking water sample
  - Boil alert if exceeded the maximum contaminants level

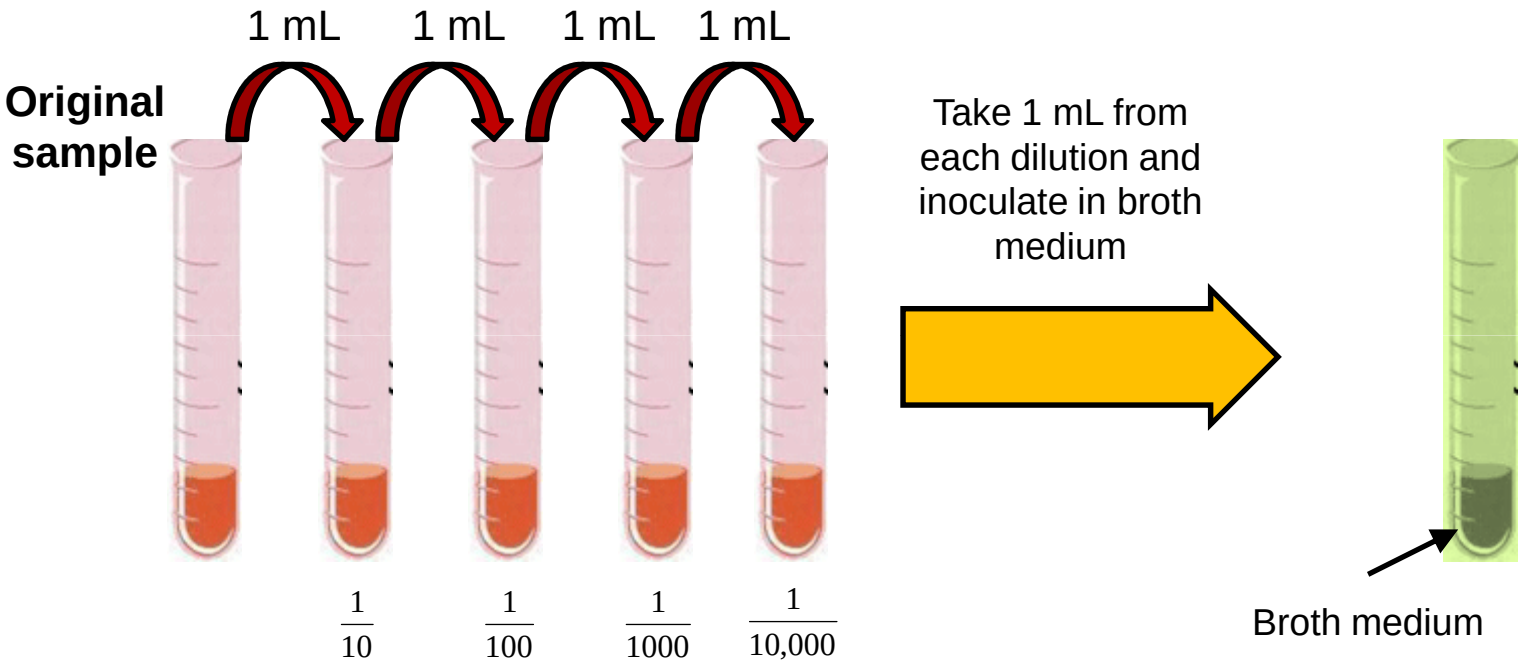
DETERMINATION METHODS

- Most Probable Number Method (MPN) (Standard Methods for Examinations of Water and Wastewater – Method 9221)
- Membrane Filtration Method (Standard Methods for Examinations of Water and Wastewater – Method 9222)

MOST PROBABLE NUMBER

- For multiple tube fermentation technique, results are reported in terms of MPN, a **probability estimation** on the **mean density** of the organisms in the sample
- Most satisfactory results
  - **Largest inoculums** show **gas release** in all or most of the tubes
  - **Smallest inoculums** show **no gas release** in all or majority of the tubes
- Limitations
  - Coliform density will be underestimated if the sample is **not adequately shaken before dilutions** or if **clumping of bacteria cells** occurs

MOST PROBABLE NUMBER



- **Each dilutions 5 replicates (min. 3). MPN is more accurate when more replicates are used.**
- **Incubate in 35±0.5ºC for 24±2 hours**
- **Presence of gas indicate growth of microorganisms - positive tubes**

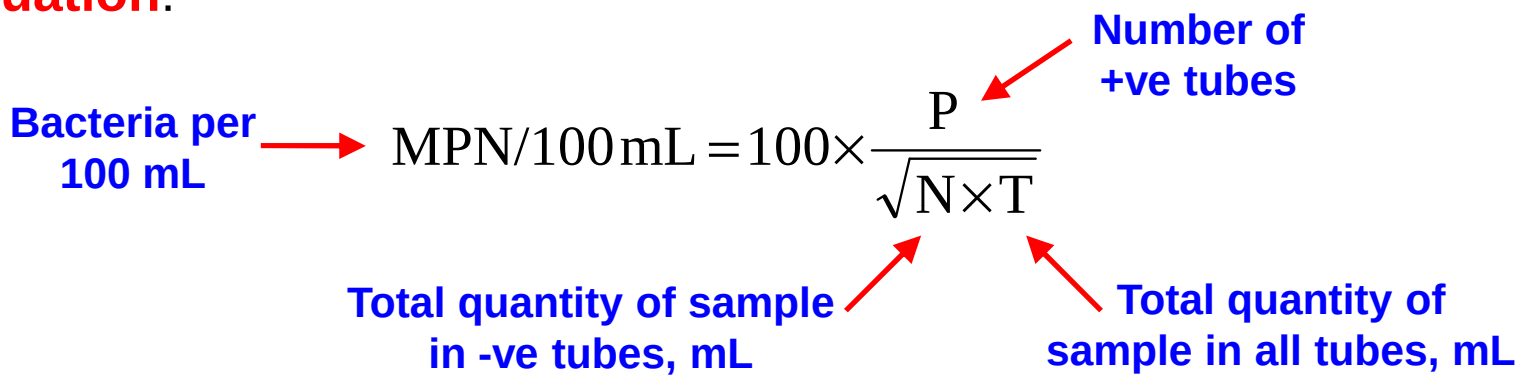
MOST PROBABLE NUMBER

- Selection of the combination of the positive tubes

Condition	Positive Five tubes, mL used					Combination of positive
	1	0.1	0.01	0.001	0.0001	
1	Select dilution that gives **all positive results** followed by the next two higher dilutions.					
	5/5	**5/5**	**1/5**	**0/5**	0/5	**5-1-0**
2	If **lowest dilution has less than five positive results**, select it and two next higher dilutions.					
	4/5	**5/5**	**1/5**	0/5	0/5	**4-5-1**
	0/5	**0/5**	**1/5**	0/5	0/5	**0-0-1**
3	If positive results occur at the dilution higher than condition 1 and 2, **select the lowest dilution that has less than five positive tubes** followed by the next two higher dilutions.					
	5/5	**4/5**	**4/5**	**1/5**	0/5	**4-4-1**
4	If positive results do not meet condition 1, 2 and 3, **add those higher-dilution positive results to the selected highest positive results.**					
	5/5	**4/5**	**4/5**	0/5	**1/5**	**4-4-1**
5	If there were no enough higher dilutions tested to select three different dilutions with positive results, **select the next lower dilution.**					
	5/5	5/5	**5/5**	**5/5**	**2/5**	**5-5-2**

MOST PROBABLE NUMBER

- To simplify the complexity of using tables, Thomas HA (1942) uses the following equation to calculate MPN – known as **Thomas equation**:



MOST PROBABLE NUMBER

Example

Determine the MPN value by using the Thomas equation.

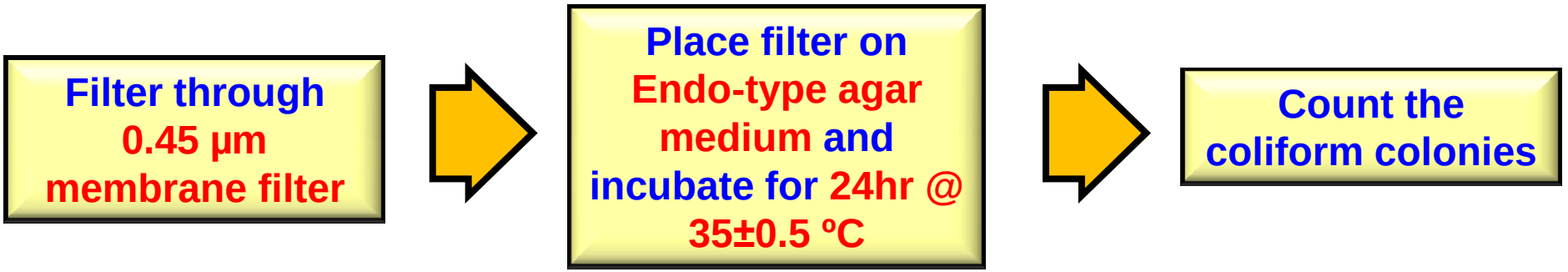
Sample	Positive Five tubes, mL used				Combination of positive	Ans
	1	0.1	0.01	0.001		
A-raw	5/5	5/5	3/5	1/5	5-3-1	11 000
B × 10^{-3}	5/5	5/5	3/5	1/5	5-3-1	11 × 10^{6}
C	5/5	3/5	2/5	0/5	5-3-2	1400
D	4/5	34/5	1/5	1/5	4-3-1	310
E	0/5	1/5	0/5	0/5	0-1-0	18

MEMBRANE FILTRATION METHOD

- Not suitable for water with **high turbidity** or **noncoliform (background) bacteria**
- **More precise** than MPN method.
- Standard sample volume 100 mL **BUT** due to the low densities of total coliform in standard volume, 1-L sample volume is recommended.
- Ideal sample volume will yield **20-80 coliform colonies** and **not more than 200 colonies** of all types on membrane filter surface

MEMBRANE FILTRATION METHOD

- Procedures:



Coliform count

$$\frac{\text{Total coliform colonies}}{100\ \text{mL}} = \frac{\text{Coliforms colonies counted}}{\text{mL of sample volume filtered}} \times 100\ \text{mL}$$

MEMBRANE FILTRATION METHOD

Example

A total volume of 250 mL of potable water was filtered at different volume of 100 mL, 75 mL, 50 mL and 25 mL for total coliform test. The colony counts obtained were 53, 36, 21 and 13 respectively. Find the coliform density for the water sample.

Ans: 49/100 mL

REFERENCES

- American Water Works Association (2011). *Water Quality and Treatment: A Handbook on Drinking Water 6th Edition*, Edzwald, J. K. (Ed.), McGraw-Hill: USA
- APHA (2005), Standard Method For Examination of Water and Wastewater
- Thomas HA (1942). Bacteria Densities from Fermentation Tube Tester, Journal of American Water Works Association.