Microbial source tracking and rapid method needs for recreational water quality monitoring

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- Background
- History of water quality regulations
- Monitoring by activities by Ottawa County Health Department
- Problems with water quality standards
- Solutions in practice

Water Borne Diseases:

Basis for Water Quality Standards

- **Source: Fecal/sewage contamination.**
- **Cause: Pathogens (protozoa, bacteria, viruses) in sewage.**
- **Need: Water quality standards to protect public from water borne diseases.**

SEWAGE-BORNE PATHOGENS

Bacteria

Salmonella* spp., *Shigella* spp., *Campylobacter.

Viruses

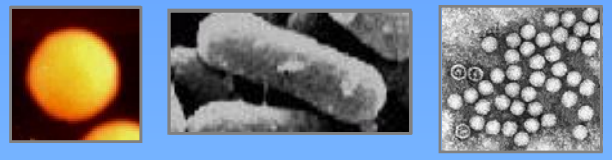
Adenoviruses, Enteroviruses (polio),

Hepatitis A, Norovirus, Rotavirus.

Protozoa

Cryptosporidium, Giardia , E. histolytica.

Transmission



INGESTION: Norwalk Virus, *Cryptosporidium*, Vibrio

INHALATION: *Legionella*

PASSIVE CONTACT
Staphylococcus
Vibrio, Pseudomonas

ACTIVE CONTACT

Leptospira

Sources of pathogens

-Sewage

-Urine

-Feces

-Skin/open cuts

USEPA's INTERPRETATION ON WATER QUALITY STANDARDS (WQS)

- **Concentrations of FIB in water measure the degree of sewage contamination.**
- **Feces of human & animals (sewage) is the only significant source of FIB.**
- **FIB shall not multiply to any significant degree under environmental conditions.**
- **WQS have to be adhered protect public health.**

EPA STRATEGY FOR USING FECAL INDICATOR BACTERIA TO ESTABLISH WQ STANDARDS

1. **Fecal Indicator Bacteria (Fecal coliform, *E. coli*, enterococci): High concentrations in feces and sewage.**
2. **Pathogens: Too many/too difficult to assay. They are sporadically present.**
3. **Method of Assay: Feasible and economical for all laboratories.**

EPA Water Quality Standards (WQS) Based on FIB

1950–1972 1000 Total Coliform/100 ml

1972–1986 200 Fecal Coliform/100 ml

1986–2011…! <u>Health Based (Epidemiology)</u>

FOR FRESH WATERS

33 Enterococci CFU/100 ml

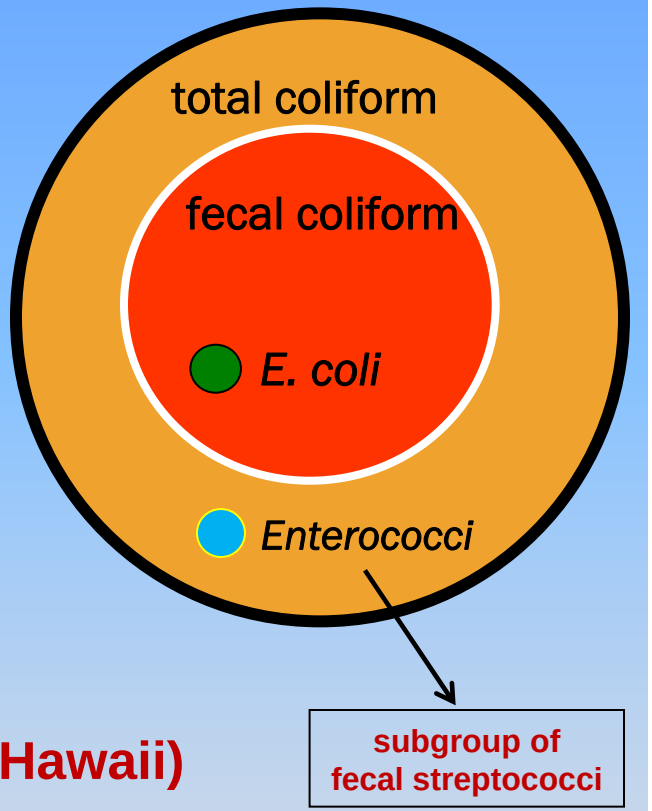
126 *E. coli* CFU/100 ml

FOR MARINE WATERS

35 Enterococci CFU/100 ml

7 Enterococci CFU/100 ml (Hawaii)

*Geo mean of at least five samples taken over a period of 30 days



235 *E. coli* CFU/100 ml

61 Enterocci CFU/100 ml

** Single sample regulatory limits

Michigan Beach Water Quality Standards

- Michigan Water Quality Standards for recreational beaches are slightly different from the EPA's criteria.

- Single sample standard : 300 CFU/100ml of E. coli (daily geometric mean of at least three samples).

- 130 CFU *E.coli*/ 100 mL (monthly geometric mean of at least 5 sampling events)

- Below the EPA's acceptable risk level of 1% (10 people per 1000 getting sick).

Beach Monitoring Activities of Ottawa County Health Department

Marker : E. coli
Method : Idexx (MPN)

Lake Michigan Beaches

Grand Haven State Park
Grand Haven City Beach
Monitoring Frequency : 4 days a week
Funded by GLRI

North Beach Park
Rosy Mound Recreation Area
Kirk Park
Windsnest Park
Kouw Park
Tunnel Park
Holland State Park- Lake MI
Monitoring Frequency : 1 day a week

Beach Monitoring Activities of Ottawa County Health Department

Marker : E. coli
Method : Idexx (MPN)

Inland Beaches

Lakeside Park
Pottawattomie Park
Dunton Park
Holland State Park Lake Macatawa
Grose Park
Georgetown community park
Maple wood park

Monitoring Frequency : 1 day a week

Funded by Clean Michigan Initiative

Results Summary - 2011
“One Day Later”

•Excedance based on single sample standard : 300 MPN /100ml of *E. coli*.

- **North Beach Park : 1**
- **Grand Haven State Park : 7**
- **Grand Haven City Beach : 4**
- **Kouw Park : 1**
- **Tunnel Park : 1**
- **Dunton Park : 7**
- **Gorse Park : 1**
- **Maplewood Park : 4**

Problem 1

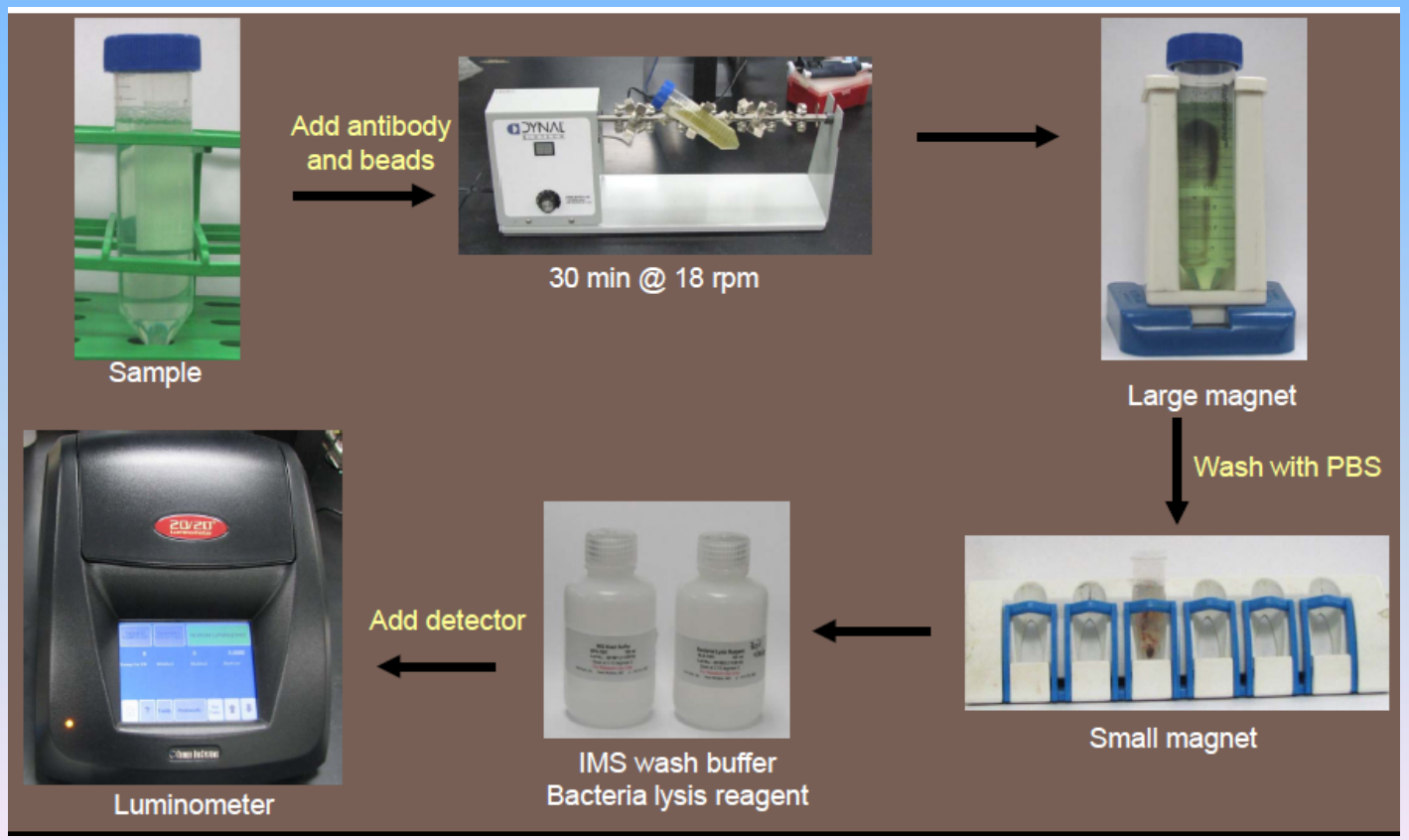
- **Current assay methods for fecal indicator organisms such as *E. coli* or *Enterococcus* spp. require 18- 24 hours for completion.**
- **Do not provide results on the same day of sample collection.**
- **Beach closure/opening decisions are delayed.**
- **Swimmers may be exposed to poor water quality even though the beach has been approved for swimming.**
- **Unnecessary beach closures, resulting in economic loss.**

Solution

- Need a rapid test feasible for routine water quality monitoring for fecal contamination.

- Beach closing decisions can be made on the same day of same collection and assessment.

IMS ATP
New Rapid Test (2 hr) Method for *E. coli*



Objective

- New method : No standards available yet

- Test, compare, and validate with IMS-ATP (2 hr) test results with Idexx Colilert (18 hr) of *E. coli*

- Grand Haven State Park and Grand Haven City Beach were tested using IMS-ATP.

Test Period : July 26th 2011 to September 21st 2011,

Samples Tested

36 beach waters
8 QA/QC samples from USGS,
4 Raw Sewage (serial dilutions)
12 blank samples

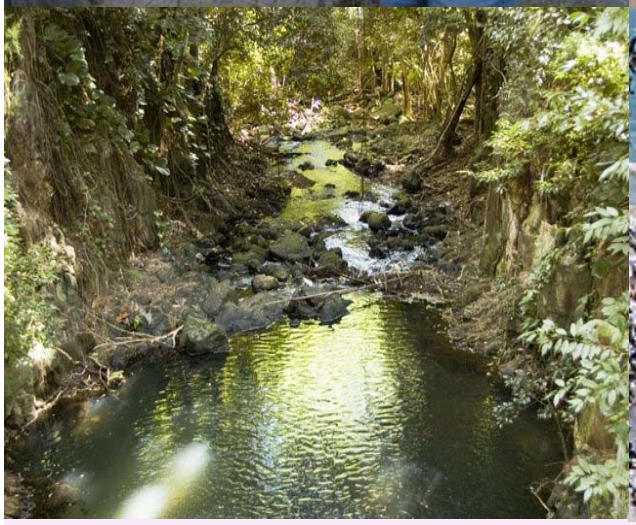
analyzed for *E. coli* by IMS ATP and Idexx methods.

Sewage Samples	Luminescence (RLUs)	MPN/100 mL	
10^-1	218,301,712	816400	
10^-2	8,910,464	81640	
10^-3	380,877	8164	
10^-4	48,020	816	0.99 R^2
Blank	20,273	0	
Grand Haven State Park	6,476,600	21	
Dunton Park	34,889,680	649	

Challenge is to relate and develop the Standards for RLUs versus MPN Numbers

Problem 2

“FIB such as *E. coli* and enterocci are not human specific.”



SOURCE OF FIB MULTIPLICATION DETERMINES RISK FOR WATER BORNE DISEASES

- **Human feces/sewage: High Risk.**
  Human intestine is habitat for growth of all known human enteric pathogens.
- **Non-human/animal feces: Moderate Risk.**
  Majority of human enteric pathogens (human viruses) cannot grow in animal intestines.
- **Environment (soil, plants, sediments): Low Risk.**
  No hard evidence that any human enteric pathogens can grow to any level of risk in the environment.

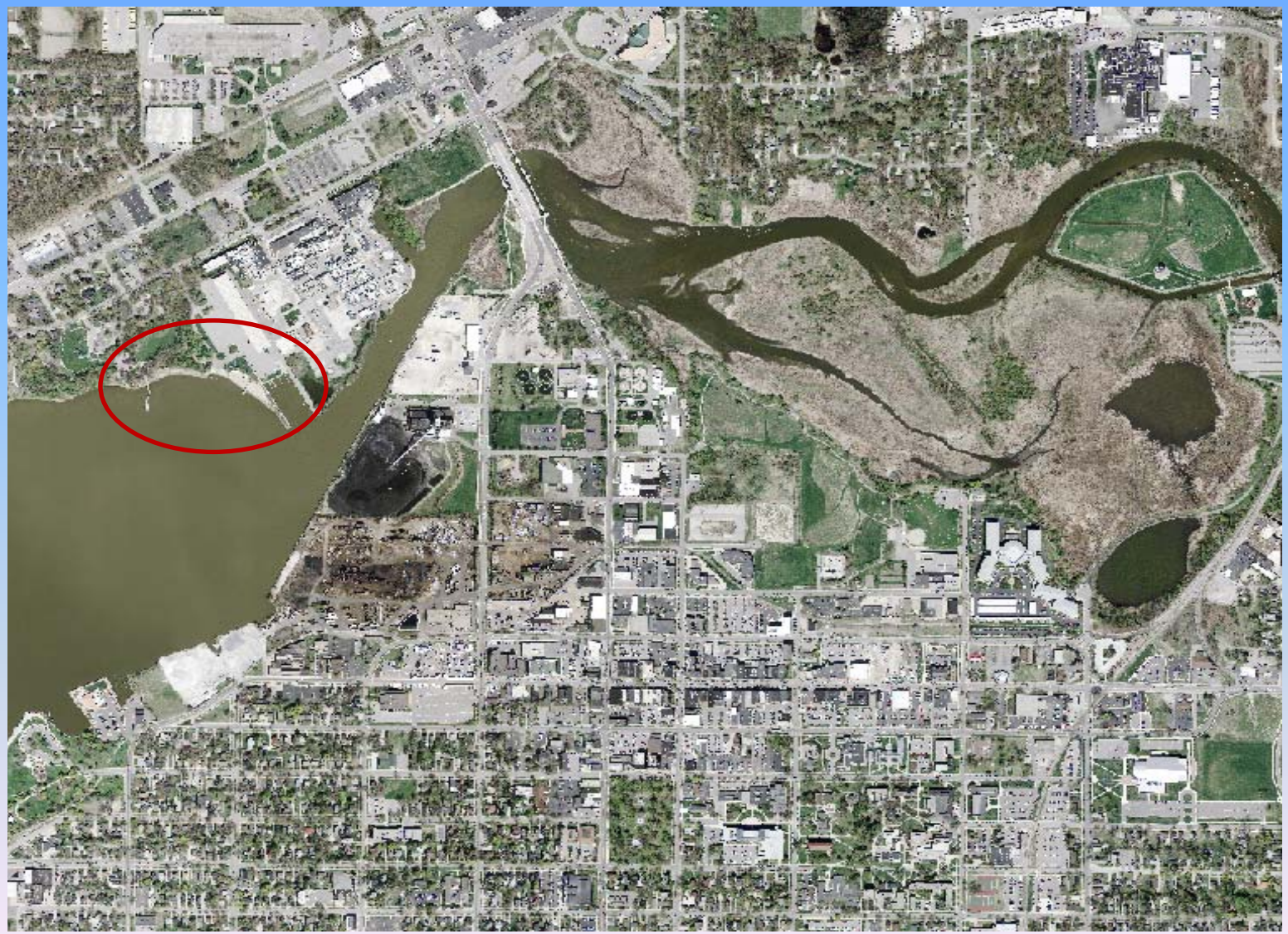
High *E. coli* levels in Dunton Park
- Long history of contamination

MPN/100 ml

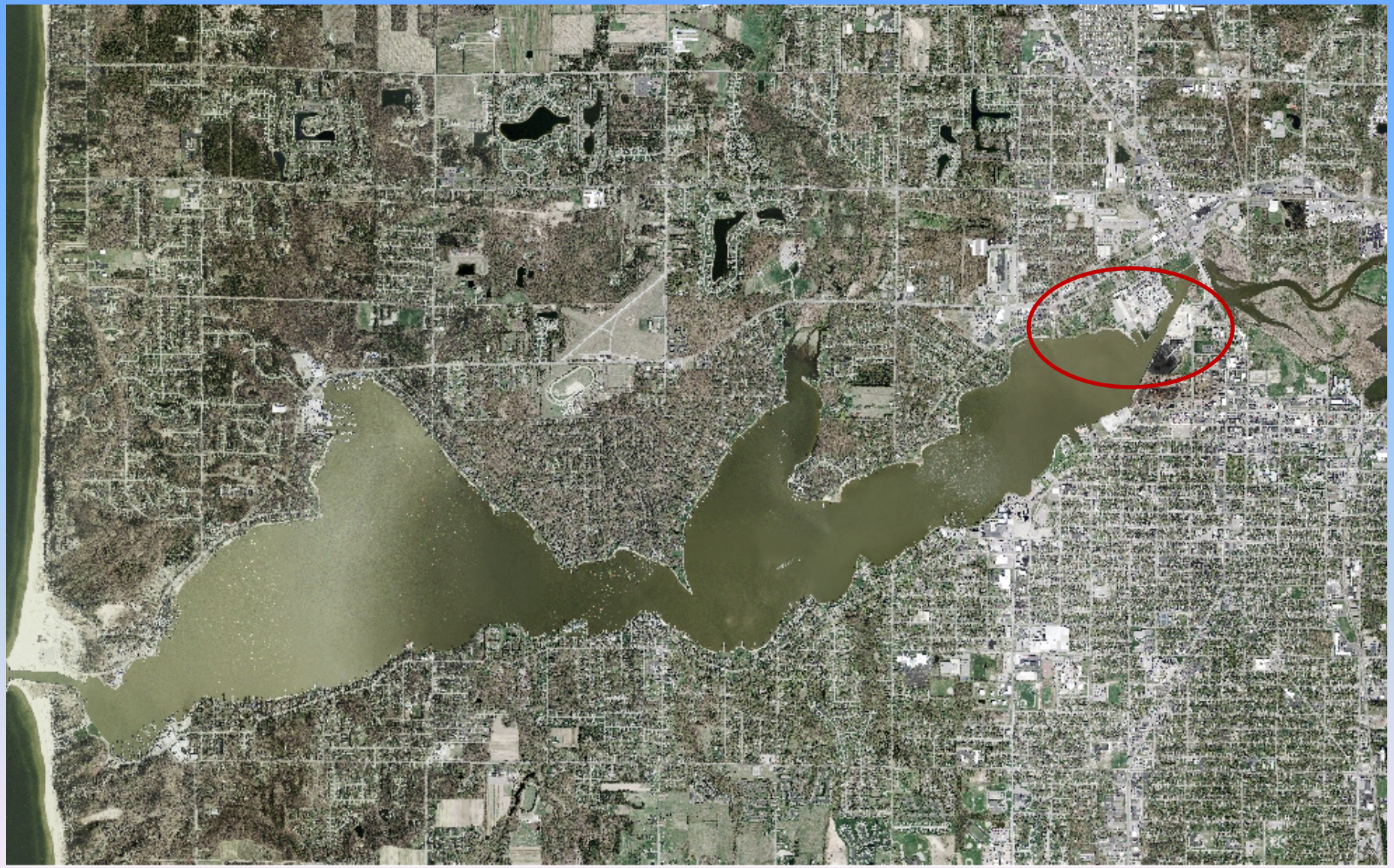
>2419.6
327
1049
555
2131
454
1855
504

Single sample standard : 300 CFU/100ml of *E. coli*
(daily geometric mean of three samples)

Aerial View of Dunton Park area



Aerial View of Lake Macatawa



Environmental health managers are in need of

“effective, easy, and low-cost methods”

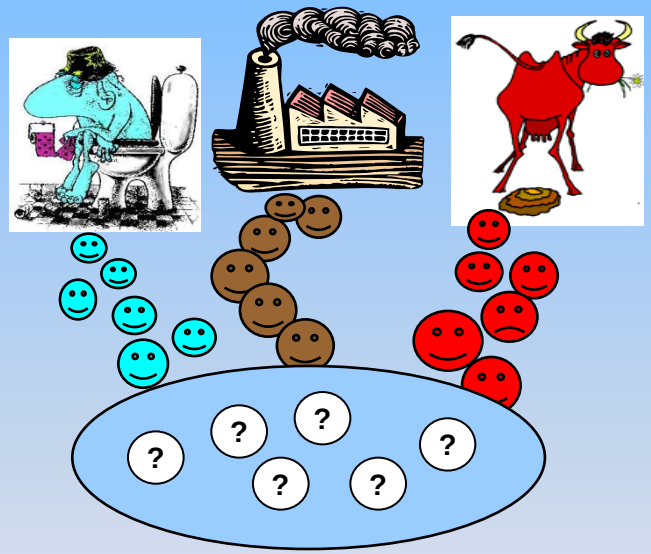
to identify and locate sources of fecal contamination in storm drains that discharge to creeks and beaches.

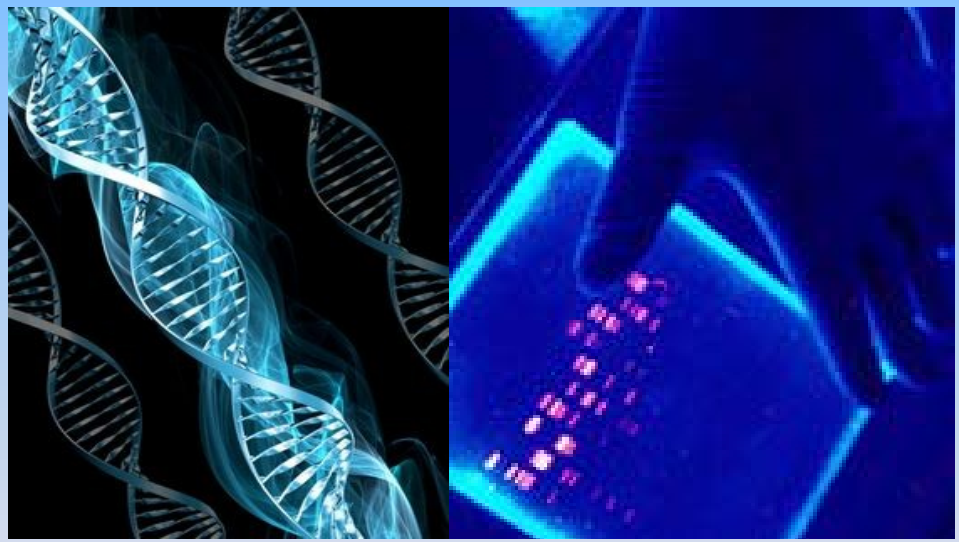


Solution

Microbial Source Tracking tools helps to identify the sources of FIB

“DNA Finger Printing: Library based method”



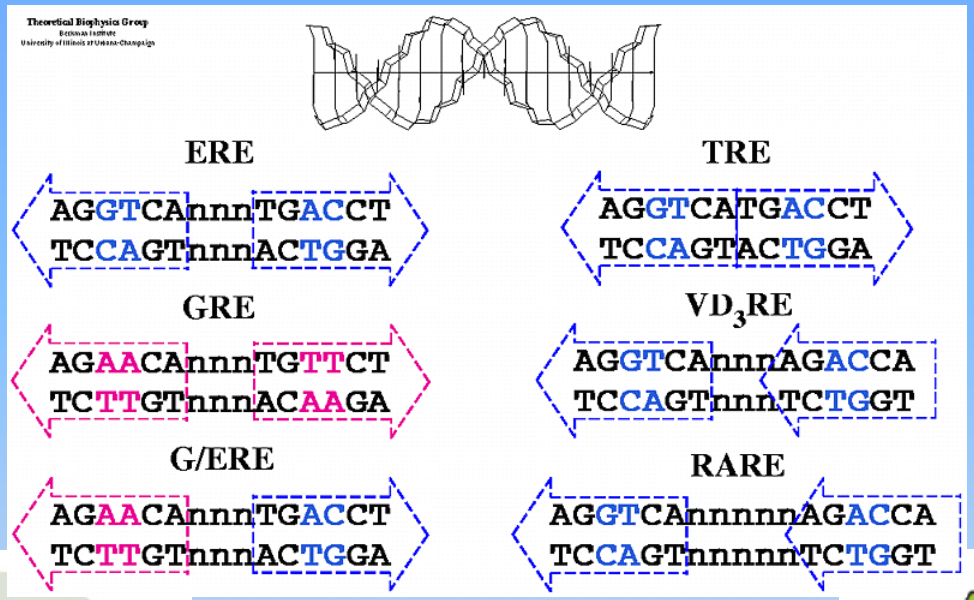


Knowing the sources helps to provide a more rational solution to recreational water-related disease

Costly ($500 for one sample)

Need fancy equipment's and well established laboratory $$$$$$$$$$$$$$$

Need scientific expertise to understand and interpret the results



Still pinpointing the human waste in the storm drain network is challenging






County of Ottawa Health Department used dogs???????

to help locate sources of human discharges in storm drains and creeks that flows into lake Macatawa

Dogs (Logan and Sable) : Environmental Canine Service are trained to scent tracking, or sewage-sniffing, to locate sources of human-waste in storm drains.


ECS
Environmental Canine
Service, LLC

Sorry dog lovers

Storm Drains

Sample ID	E. coli MPN/100 ml	Dog signal
Dunton Park Storm Drain	28.4	Negative
Dunton Park Boat Launch Storm Drain- 1	56.0	Positive
Dunton Park Boat Launch Storm Drain- 2	816.4	Positive
Black River Bridge Storm Drain	410.6	Positive
Window of the Water Front Storm Drain-1	81.5	Positive
Window of the Water Front Storm Drain-2	43.6	Positive
Window of the Water Front Storm Drain-3	113.0	Positive
Window of the Water Front Storm Drain-4	22.3	Negative
Windmill Island Storm Drain	102.4	Positive
6th St/College Storm Drain	24.3	Positive
6th St/Columbia Storm Drain	63.1	Positive
16th/Ottawa Storm Drain	5.2	Positive
South shore/Azalea Storm Drain	2419.6	Positive

Catch Basins

Sample ID	E. coli MPN/100 ml	Dog signal
Kollen Park Catch Basin -1	30.5	Positive
Kollen Park Catch Basin -2	38.9	Positive
Kollen Park Catch Basin -3	41.7	Positive

Creeks

Sample ID	E. coli MPN/100 ml	Dog signal
South shore (East of Golden Rod) Creek	816.4	Positive
Sanctuary woods creek	461.1	Negative
32nd st by Eldeans creek	980.4	Positive
1575 south shore creek	1299.7	Negative
120th/Chicago Dr creek	122.3	Positive
Ottogan Ave by Mobile Home Park creek	53.7	Positive
Felch West of 72nd st creek	410.6	Positive
16th/104th Black River creek	131.4	Positive
16th/ 104th North Branch creek	79.4	Positive
84th North of Ottogan creek	517.2	Negative
106th st / Bridge creek	613.1	Positive
Holland Waste Water Treatment Plant (spillway/runoff)	170	Positive

What's Next

- *E. coli* data doesn't mean anything beyond numbers
- How reliable are the dogs signals ??
- Conduct additional samplings >>>>>>>>>>
- Correlate the results of
  - Canine scent tracking,
  - Traditional indicator bacteria tests.
  - DNA-based microbial source tracking,

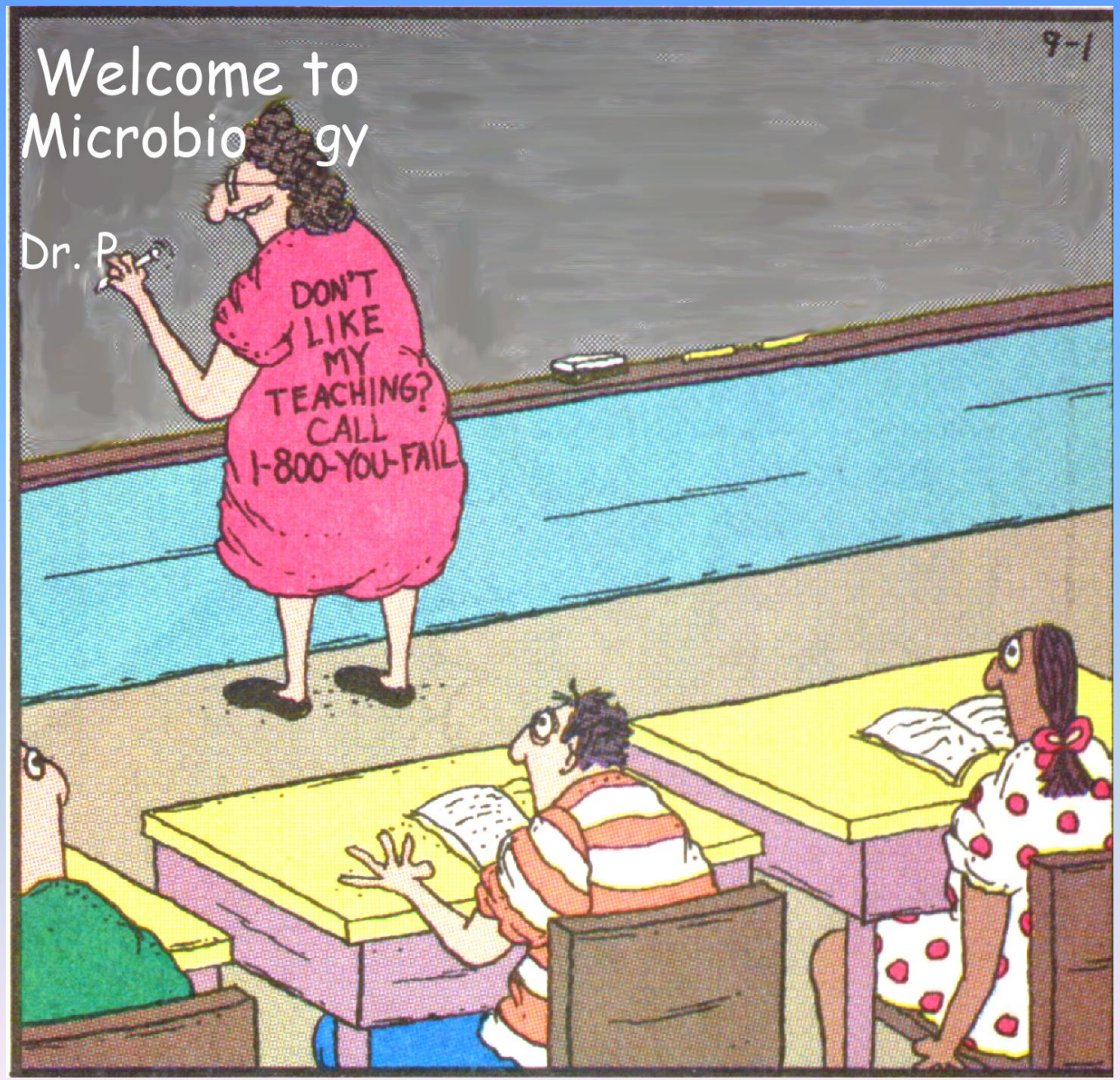
  - In collaboration with
    - Hope College,
    - Prude University.

Pretending in the field working!!!!!

Run! Run! It's Scary Poo!

Susan Gates & Charles Fuge

PUFFIN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