Low-Cost Water Quality Testing Methods

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INTRODUCTION

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BIG PICTURE

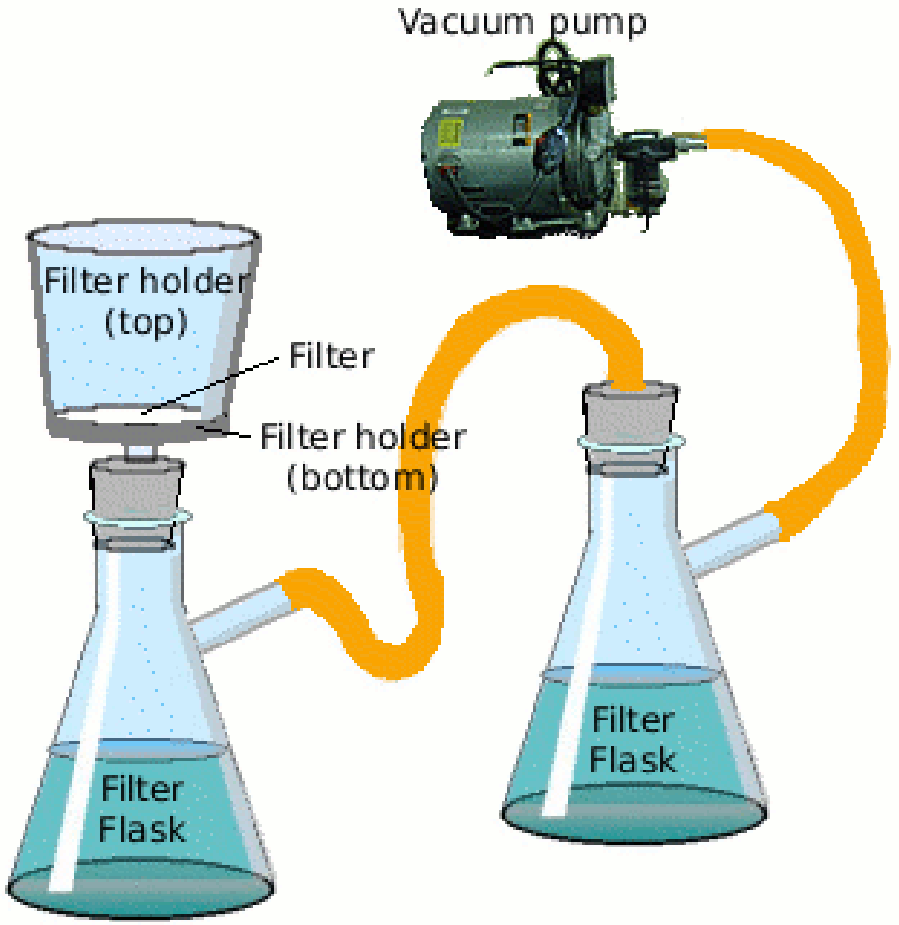
- Sustainable Development Goals: Access to safe drinking water for all by 2030
  - Need for scalable methods – microbial quality metrics being considered by UNICEF
- For all our partners present

CURRENT METHOD: CHALLENGES AND LIMITATIONS

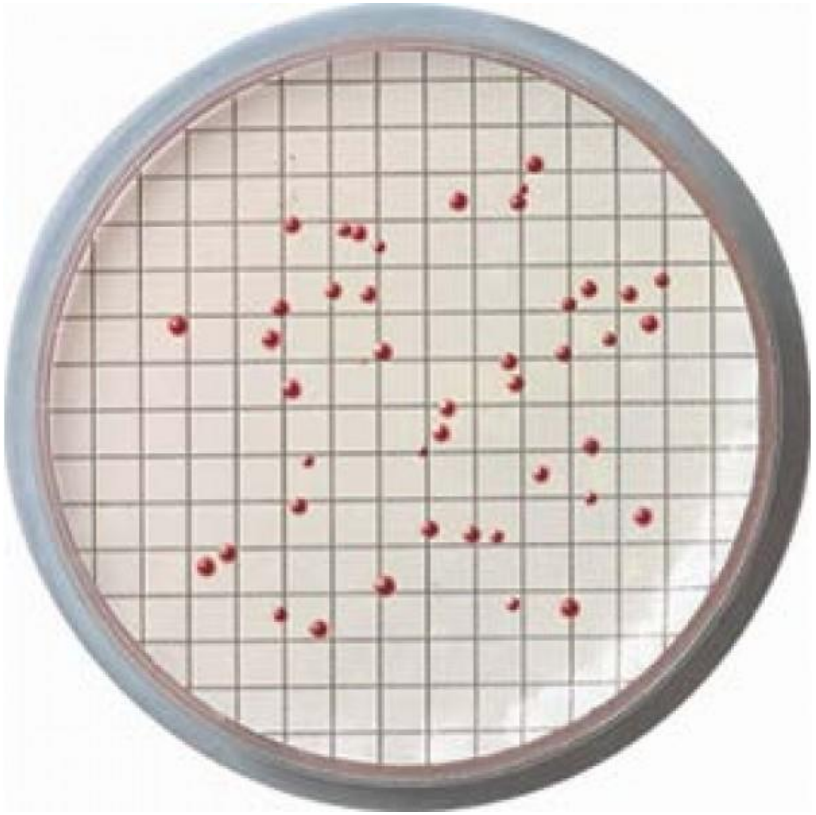
MEMBRANE FILTRATION

- Gold standard method
- Data output: *E. coli* Count (CFU/100mL)

MEMBRANE FILTRATION



MEMBRANE FILTRATION



- WHO Risk Levels:
  - Safe: <1 CFU/100mL
  - Low risk: 1-10 CFU/100mL
  - Medium risk: 1-100 CFU/100mL
  - High risk: 101+ CFU/100mL

MEMBRANE FILTRATION

PROS

- Very accurate
- Well characterized
- Widely used

CONS

- Space: Sterile
- Cost: >$9.00
- Time
- Skill
- Equipment
- Not field-friendly
  - Del Agua Kit

PROMISING LOW-COST ALTERNATIVES

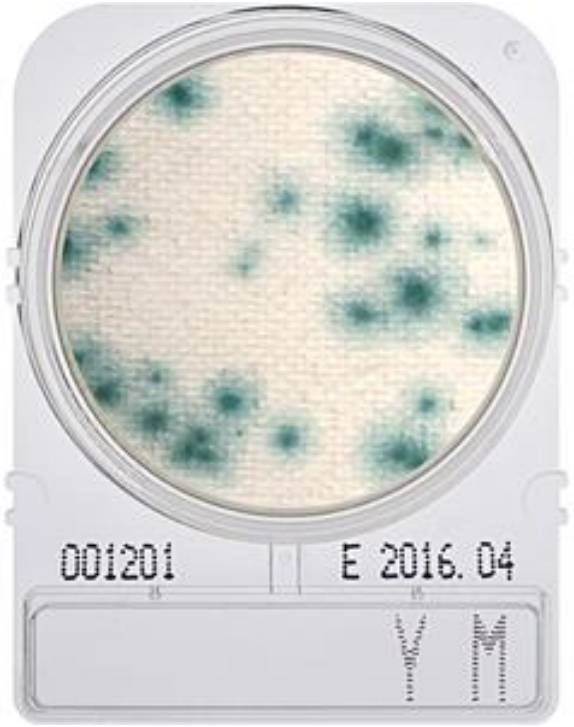
CompactDry

- Data output: *E. coli* colony count

- Assumption for all tests: equipment and practices are sterile

- Step 1: Remove lid from CompactDry dry tray well
- Step 2: Inoculate by pipetting 1 mL of sample onto center of dry tray well
  - Do not touch pipette tip to matrix
- Step 3: Replace lid and label
  - Write dilution
- Step 4: Incubate at 35C for 24 hours

CompactDry



CompactDry

PROS

- Cost per test: $1.50-$5.00
- Time per test: 2-10 minutes
- Lab requirement: no
- Skilled Personnel: no
- Ease of learning: 5/5
- Ease of use: 4/5

CONS

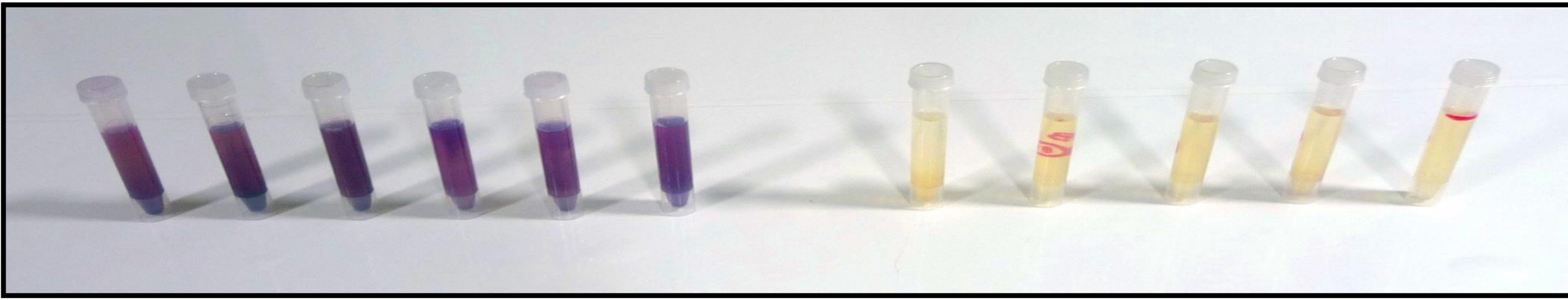
- Incubation: yes

LOW-COST PRESENCE-ABSENCE (LCPA)

- Data output: Presence-Absence (Detection Limit: 10CFU/100mL)

- Step 1: Put 0.31g of M-Tec or Aquatest (open source broth media) in 10mL vial
  - If testing drinking water samples, add 1 tablets of Sodium Thiosulfate
- Step 2: Pour 10mL of sample into vial
- Step 3: Shake to dissolve completely
- Step 4: Incubate at 35C for 24 hours
  - At ambient temp (25C or above) incubation time is 48hours

LOW-COST PRESENCE-ABSENCE (LCPA)



LOW-COST PRESENCE-ABSENCE (LCPA)

PROS

- Cost per test: $0.50 (going down further)
- Time per test: 1-2 minutes
- Lab requirement: no
- Incubation: no
- Skilled Personnel: no
- Ease of learning: 5/5
- Ease of use: 5/5

CONS

- Cannot differentiate between “low-risk” and “safe”.

3M Petrifilm

- Data output: *E. coli* colony count

- Step 1: Lift top film and pipette 1 mL of sample onto center of bottom film
- Step 2: Roll top film down onto sample gently to prevent pushing sample off film and to avoid trapping any air bubbles
- Step 3: Distribute sample across gel by applying pressure
- Step 4: Let gel dry for 1 minute and incubate at 35C for 24 hours

3M Petrifilm

3M Petrifilm

PROS

- Cost per test: $1.30-$5.00
- Time per test: 2-10 minutes
- Lab requirement: no
- Skilled Personnel: no
- Ease of learning: 4/5
- Ease of use: 3/5

CONS

- Incubation: yes
- Prone to bubble formation

Colitag

- Data output: Presence/Absence

- Step 1: Add powdered media packet to 100 mL water sample
- Step 2: Shake (minimum 25x) to dissolve
- Step 3: Incubate at 35C for 24 hours

Colitag

- Observe for yellow color and fluorescence under UV light (yellow and fluorescence = positive for *E. coli*)

Colitag

PROS

- Time per test: 2-3 minutes
- Lab requirement: no
- Skilled Personnel: no
- Ease of learning: 5/5
- Ease of use: 4/5
- Detection limit is 1CFU/100mL

CONS

- Cost per test: ≥$4.50
- Incubation: yes
- Only detects “safe” vs “unsafe”

Compartment Bag Test

- Data output: Presence/Absence and MPN

- Step 1: Mix chromogenic *E. coli* broth culture medium with 100 mL of the water sample and dissolve for15 minutes
- Step 2: Pour into the compartment bag
- Step 3: Gently squeeze the bag to distribute the correct volumes into the designated compartments
- Step 4: Seal bag with a reusable plastic clip and incubate at 35C for 24 hours or room temperature for 48 hours

Compartment Bag Test

- *E. coli* detected through production of blue-green color change in water sample

Compartment Bag Test MPN

Compartment #					MPN/100mL	Upper 95% Confidence Interval/100mL	Health Risk Category Based on MPN and Confidence Interval
1 10mL	2 30mL	3 56mL	4 3mL	5 1mL			
					0.0	2.87	Low Risk/Safe
					1.0	5.14	Intermediate Risk/ Probably Safe
					1.0	4.74	
					1.1	5.16	
					1.2	5.64	
					1.5	7.81	
					2.0	6.32	
					2.1	6.85	
					2.1	6.64	
					2.4	7.81	
					2.4	8.12	
					2.6	8.51	
					3.2	8.38	
					3.7	9.70	
					3.1	11.36	Intermediate Risk/ Possibly Safe
					3.2	11.82	
					3.4	12.53	
					3.9	10.43	
					4.0	10.94	
					4.7	22.75	
					5.2	14.73	
					5.4	12.93	
					5.6	17.14	
					5.8	16.87	
					8.4	21.19	
					9.1	37.04	
					9.6	37.68	
					13.6	83.06	High Risk/Possibly Unsafe
					17.1	56.35	
					32.6	145.55	High Risk/Probably Unsafe
					48.3	351.91	
					>100	9435.10	Unsafe

Compartment Bag Test

PROS

- Cost per test: unclear
- Lab requirement: no
- Incubation: no
- Skilled Personnel: no
- Ease of learning: 3.5/5
- Ease of use: 3.5/5

CONS

- Time per test: 17-20 minutes
- Filling compartments to correct volumes can be tricky

SUMMARY

Summary

Name of Test	Type	Cost/sample (US $)	Field Processing Time (mins)	Lab Requirement	Incubation	Skilled Personnel	Ease of Learning	Ease of Use	Time to Result (hrs)
Compact Dry	Colony Count	1.5-5.0	2-10	No	Yes	No	5/5	4/5	24
LCPA	Presence/ Absence	0.50 (and decreasing)	1-2	No	Yes/No	No	5/5	5/5	24/48
3M Petrifilm	Colony Count	1.3-5.0	2-10	No	Yes	No	4/5	3/5	24
Colitag	Presence/ Absence	≥4.5	2-3	No	Yes	No	5/5	4/5	24
CBT	Most Probable Number	unknown	17-20	No	Yes/No	No	3.5/5	3.5/5	24/48

ACTION PLAN

Fecha	Actividad	Insumos	Responsable
Lunes 21.03.2016 Hrs. 09:00 – 10:20 Hrs. 10:20 – 11:20 Hrs. 11:20 – 11:30 Hrs. 11:30 – 12:20	Sesión teórica: 1) Técnica de análisis de coliformes fecales (Joe Brown y estudiantes) 2) Técnicas de análisis de protozoos, virus y bacterias (Aaron Bivins) 3) REFRIGERIO 4) Evaluación de condiciones biológicas utilizando macro invertebrados bentónicos (Giovanna Rocabado)	- Data show - Computador - Sala de reuniones - Refrigerio	- UNICEF (Alejandro)
Martes 22.03.2016 Hrs. 09:00 – 16:30	Trabajo de campo día 1 - Monitoreo del río Choqueyapu	- Equipos/patógenos - Equipos/macroinvertebrados - Movilidad A/6p (UNICEF) - Movilidad B/6p (VRHR)	- Georgia Tech (Joe Brown) - VRHR (Giovanna) - UNICEF (Alejandro) - VRHR (José Manuel)
Miércoles 23.03.2016 Hrs. 09:30 – 16:30	Trabajo de campo día 2 - Monitoreo del rio Seco	- Equipos/patógenos - Equipos/macroinvertebrados - Movilidad A/6p (UNICEF) - Movilidad B/6p (VRHR)	- Georgia Tech (Joe Brown) - VRHR (Giovanna) - UNICEF (Alejandro) - VRHR (José Manuel)
Jueves 24.03.2016 Hrs. 09:00 – 12:30	Sesión teórica 1) Evaluación Coliformes f. (Joe) 2) Evaluación parásitos (Aaron) 3) Evaluación Cond. biológicas (Giovanna)	- Data show - Computador - Sala de reuniones - REFRIGERIO	- UNICEF (Alejandro)

VOLUNTEER