Early warning of microbiological contamination of water



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Outline of the talk

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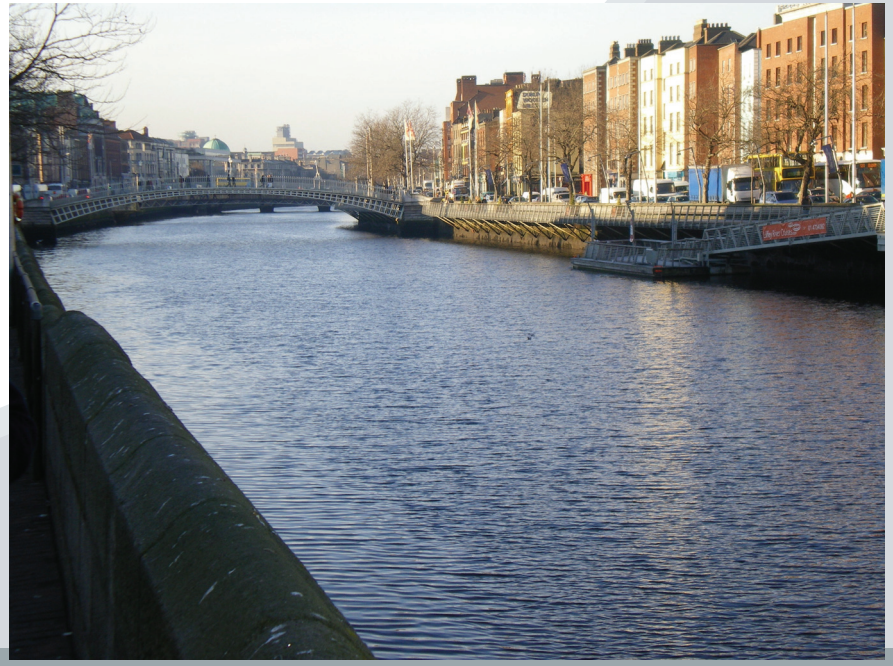
- **Background to the research**
- **Bacteriological analysis**
- **Potential remedies**
  - Turbidity
  - Particle size
  - Video sensing
  - Wireless sensor network
- **Conclusions**



Background to the research

EPA report
Water Quality in Ireland 2004 - 2006

"Faecal coliforms were detected in more than half of the groundwater locations sampled. This constitutes a risk for those using such untreated waters for drinking water purposes in the absence of disinfection."

Galway Cryptosporidium Outbreak 2007

Contamination of the city water supply was detected after 24 hours, by which 250 people and 900 households had been affected

Quality of drinking water

"The Food Safety Authority has confirmed that a survey in 2007 found that 1% of samples of bottled water had *E. coli* and 6.3 per cent contained coliforms. 7.2 per cent, or one bottle in 16, failed to comply with legal or EU requirements. " The Irish Times, 18 Nov 2008

Inefficient existing monitoring system

Background to the research

The main threat - **pathogenic micro-organisms**.

E. coli, a faecal coliform, in water is a strong indicator of faecal contamination and possible occurrence of pathogen (disease-causing) organisms.

E. coli along with **total coliforms** are the obligatory parameters for microbiological water quality assessment according to EC and National compliances.

Cause of contamination:
-overwhelmed treatment plant
-animal waste
-human waste

Bacteriological analysis

EPA report
Water Quality in Ireland 2004 - 2006

"Between 2004-06, a total of 1,330 samples (groundwater) were analysed for faecal coliforms at 135 monitoring locations. Positive faecal coliform counts were detected in 338 (25.4%) samples."

443 samples / year
3 samples / location / year

- **Sample collection, storage & transportation to the laboratory**

- **Analytical techniques** – based on cell growth
  - Membrane filtration
  - Most probable number
  - Commercially available sample-ready-culture medium systems

At least 18-24 hours is required for analysis
➢**Unacceptable for the cases, where an immediate action is required!**
➢**Lack of Continuous monitoring (only spot checks).**

Employed microbiological methods

Membrane Filtration

Water sample is filtered through 0.45µm membrane filter.

• Filter is placed in Petridish having Membrane Lauryl sulphate broth for incubation at 37 ºC and 44ºC for 24 hours.

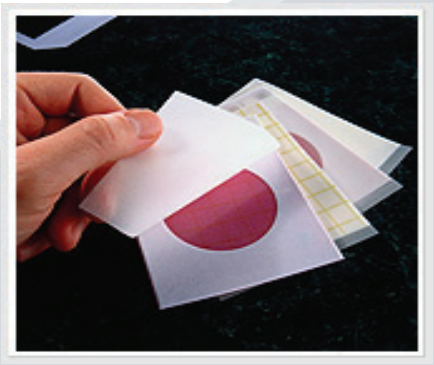
• Indole, Oxidase, Tryptone water and lactose peptone broth confirmation tests are carried out.

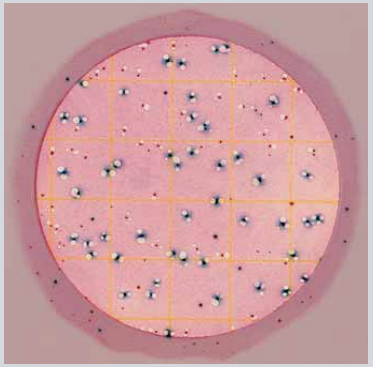
3M Petrifilms

3M Petrifilms for *E.coli*/coliform validated for environmental water samples[1-3].

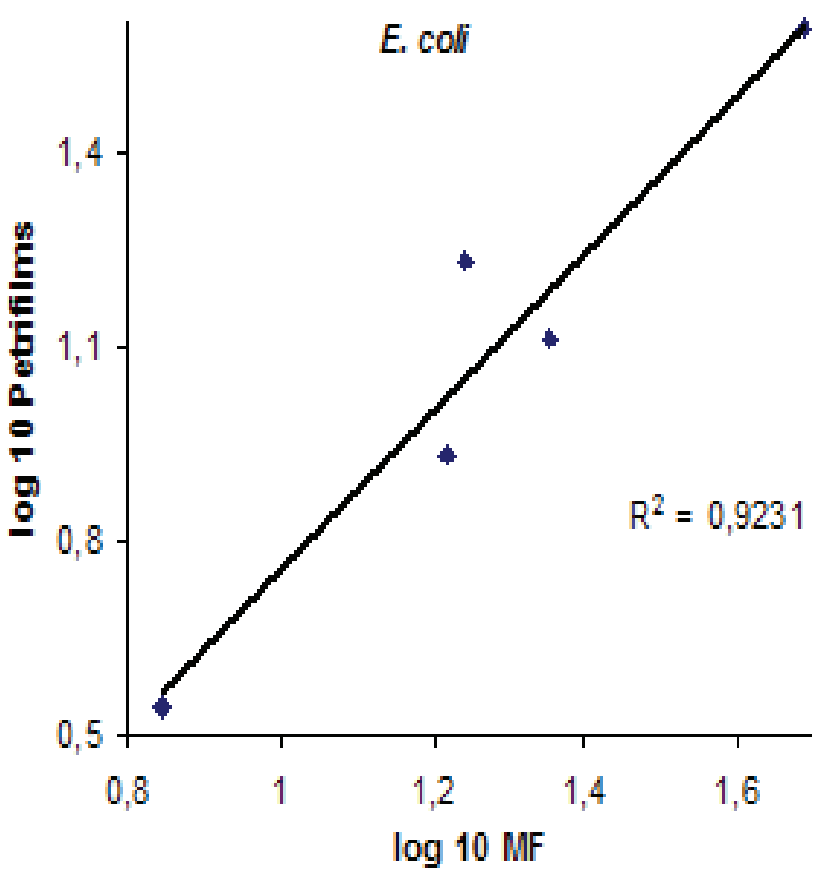
1. J.H. Vail *et al*., J. Environ. Qual. 32 (2003) 368-373.
2. H. Schraft and L.A. Watterworth, J. Microbiol. Methods 60 (2005) 335-342.
3. T. Wohlsen *et al*., Letters Applied Microbiol. 42 (2006) 350-356.

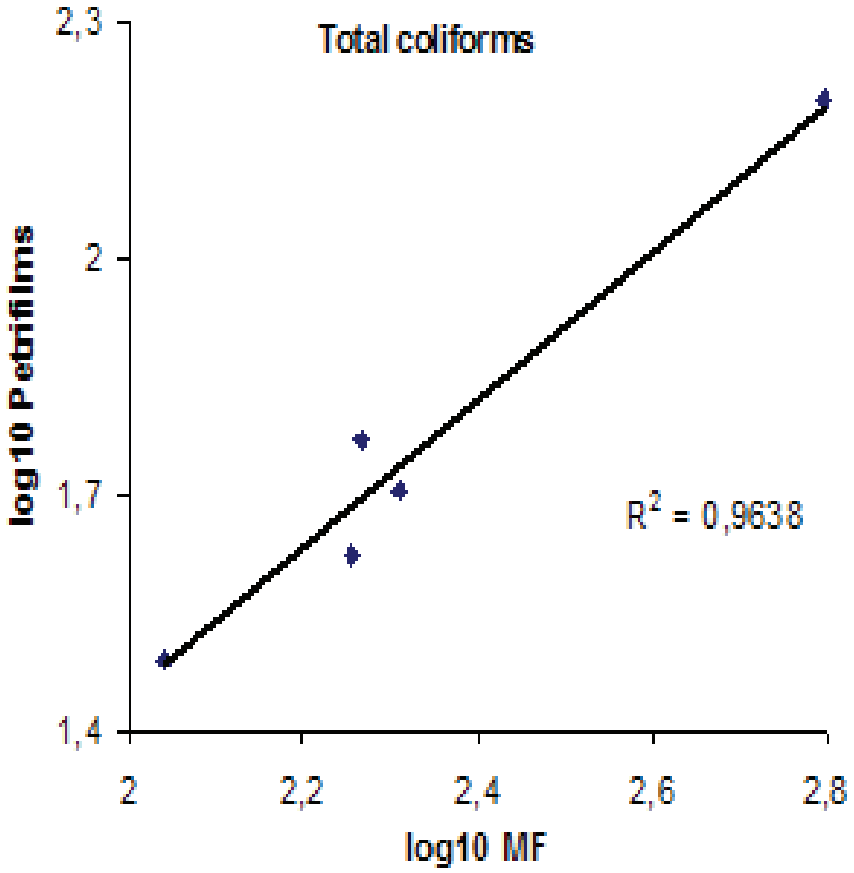
1ml of water sample is placed on the Petrifilm and results are interpreted after incubation at 37º C for 24 to 48 hours.



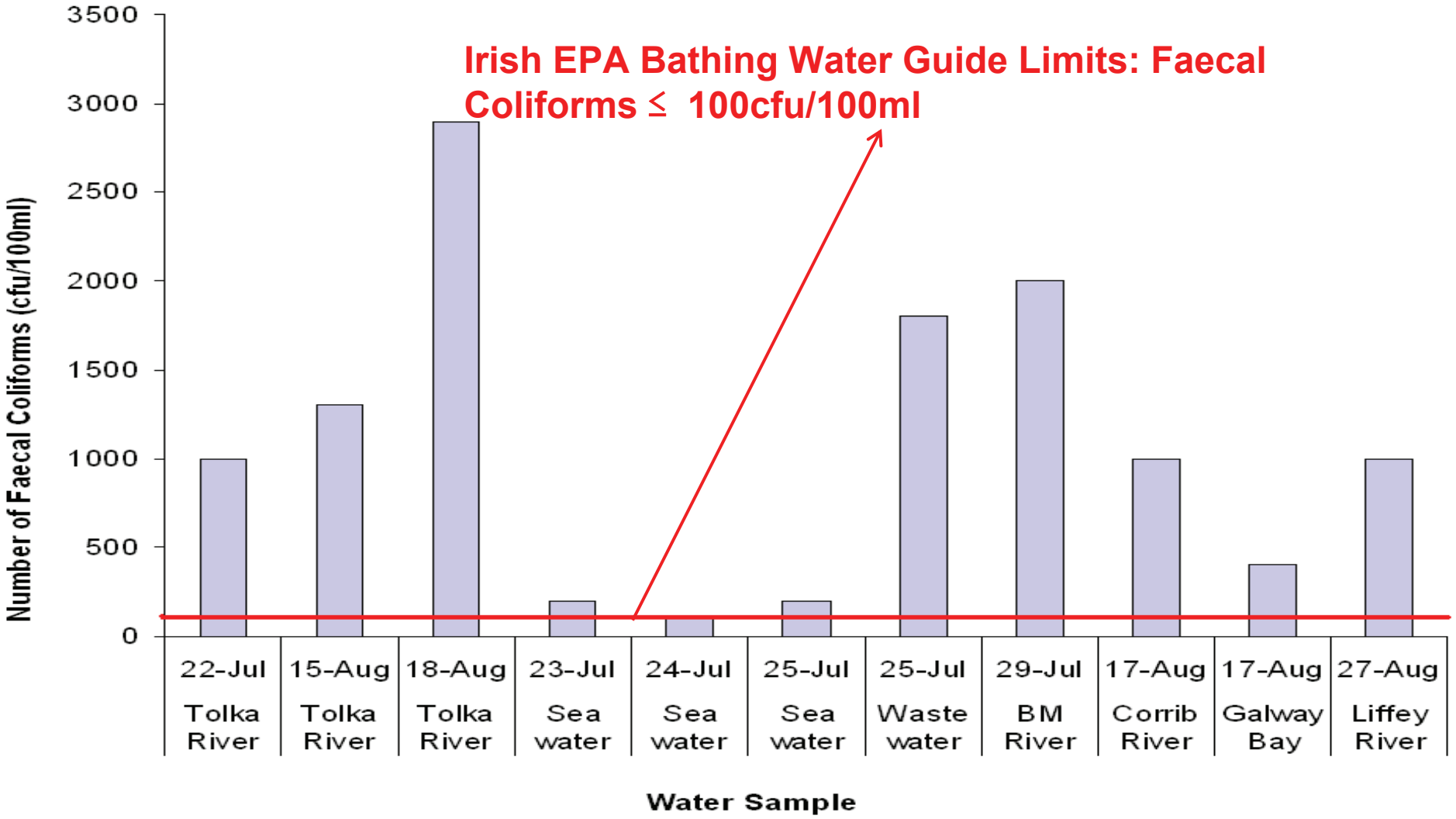


Correlation of *E. coli* and faecal coliforms counts obtained by MF and Petrifilms

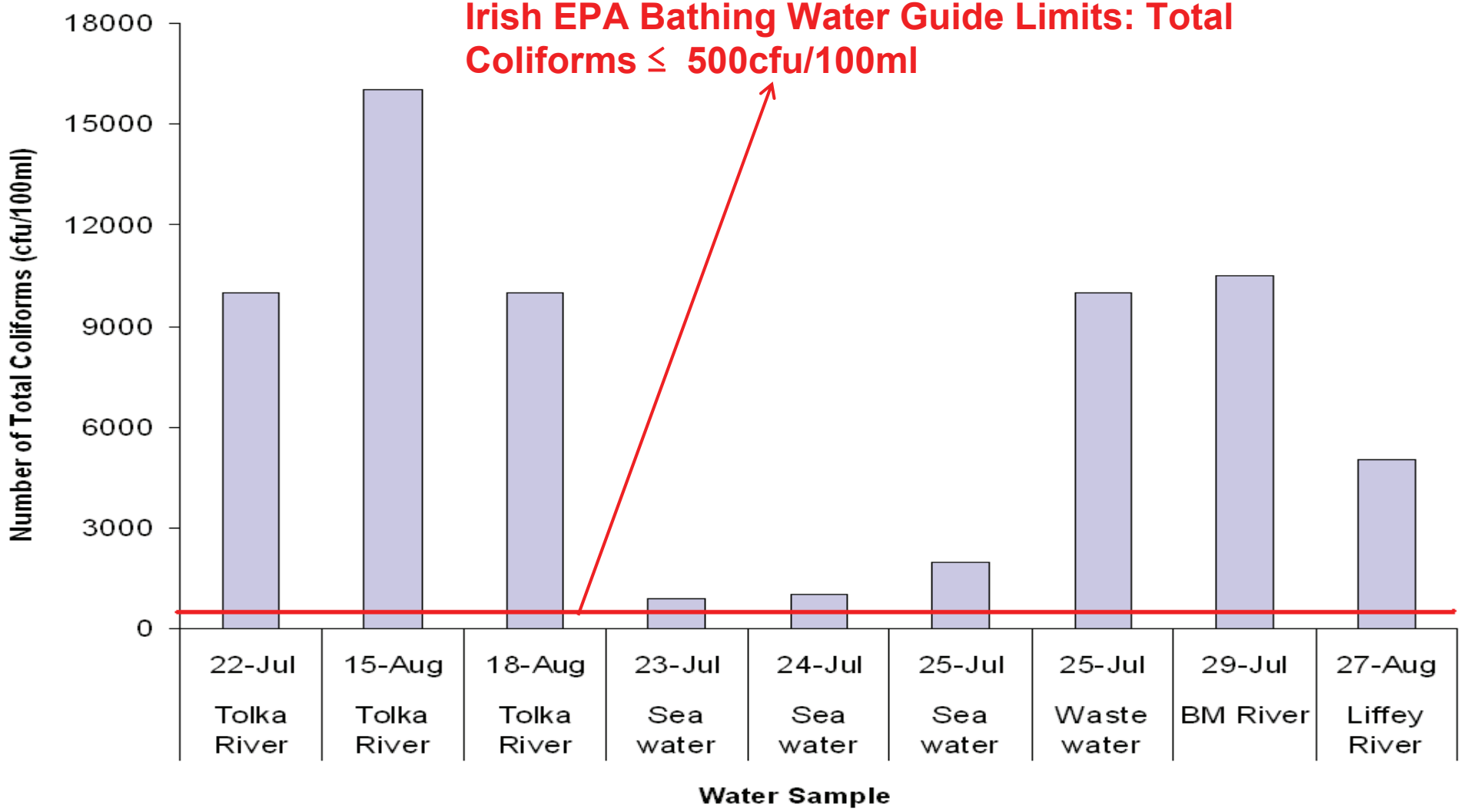




Faecal Coliforms in various samples from Ireland



Total Coliforms in various samples from Ireland



Early warning of microbiological contamination: potential remedies

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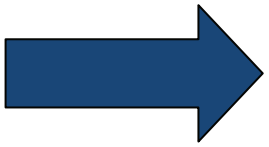
Analytical method: instant results & continuous monitoring

Microfabrication
Cell lysis
Flow cytometry
PCR
DNA/RNA analysis



Unambiguous identification of microbial contamination

Turbidity
Particle size distribution
Particle transport
Dissolved organic matter
Weather forecast models
Video sensing

<u>Surrogate approaches</u>
Only valuable if:
- Correlation is valid
- False negative & false positive are acceptably low

Turbidity & particle size

Turbidity and particle size have been correlated to the presence of *E.coli* and faecal coliforms[1-4]. Relative increase of finer particles(<10 µm) indicates possible faecal contamination.

1. R.W. Gentry *et al*., J. Environ. Qual., 35 (2006) 2244-2249.
2. P. Vidon *et al*., J. Environ. Qual., 37 (2008) 1761-1768.
3. A. Auckenthaler *et al*., Water Sci. Technol., 46 (2002) 131-138.
4. M. Pronk *et al*., Environ. Sci. Technol., 41 (2007) 8400-8405.

River Tolka (Dublin, Ireland) map and the location of the sampling points

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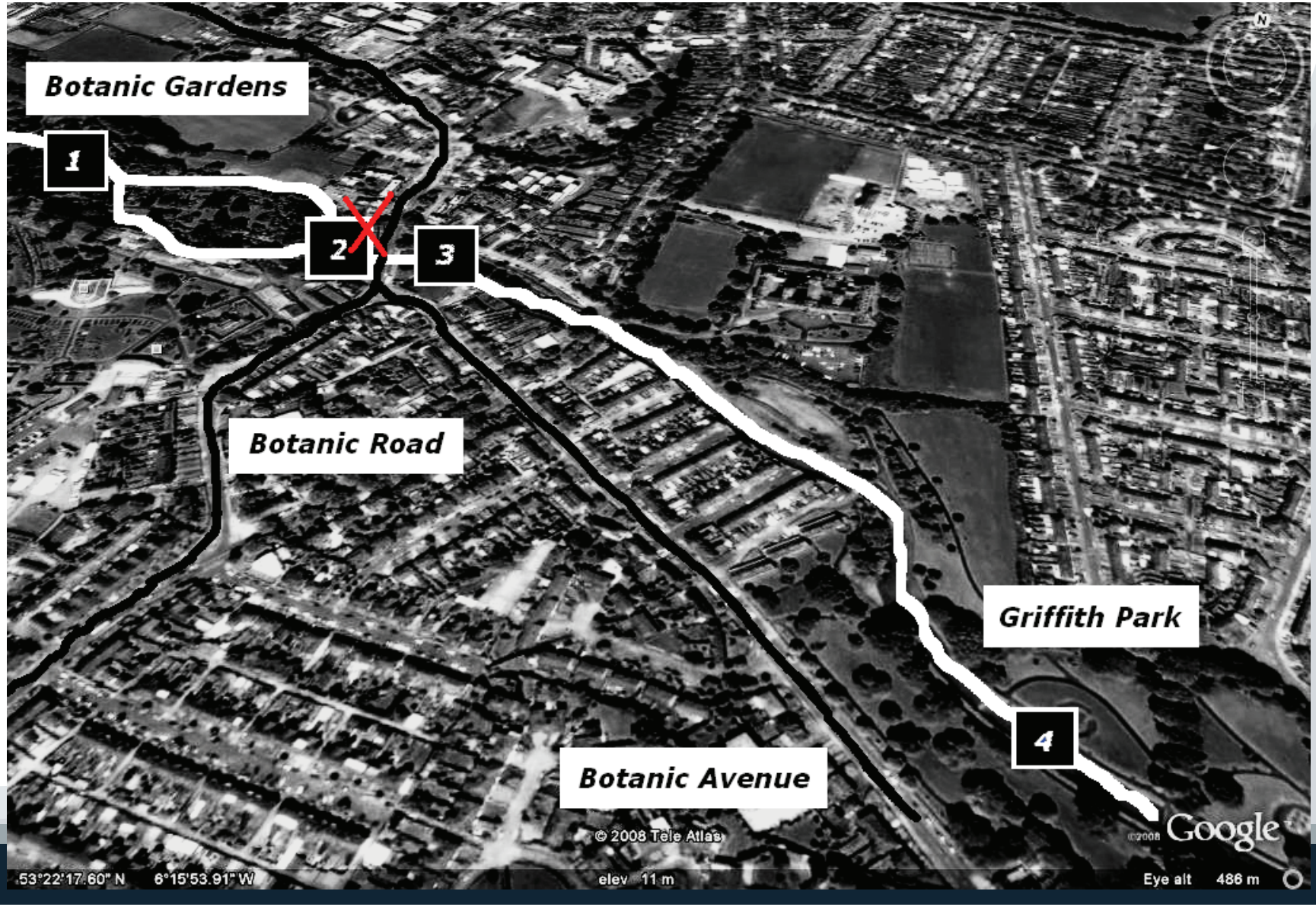
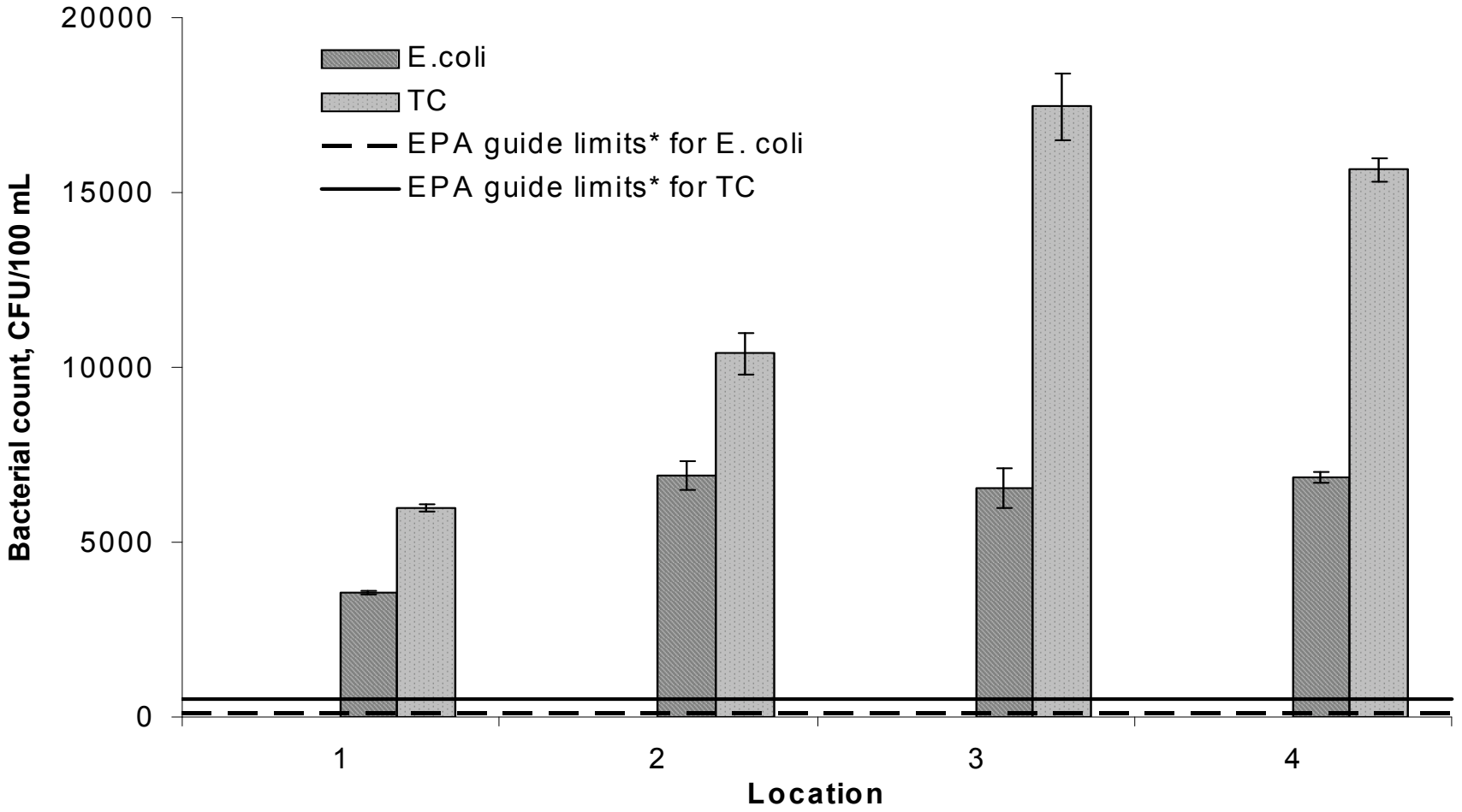


Microbiological count in water according to different sampling locations on the river Tolka.



Video sensing
1.Turbidity

Video sensing
2. Object identification

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Video sensing
3. At point discharge source

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Low-cost sensing

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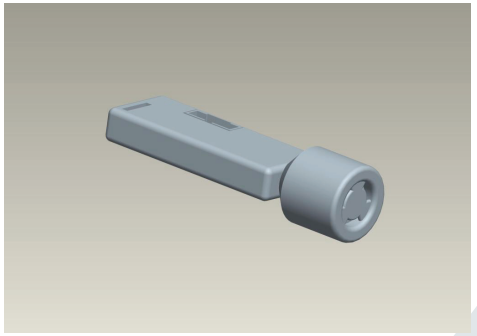
Low-cost video cameras are available ~ €50

Low-cost turbidity and particle size meter

- under development in our research group
- based on LEDs
- < **€100**



Communication systems & software (Bluetooth, GSM)

Phosphate sensor

Landfill gas monitoring system

Wireless Sensor Network

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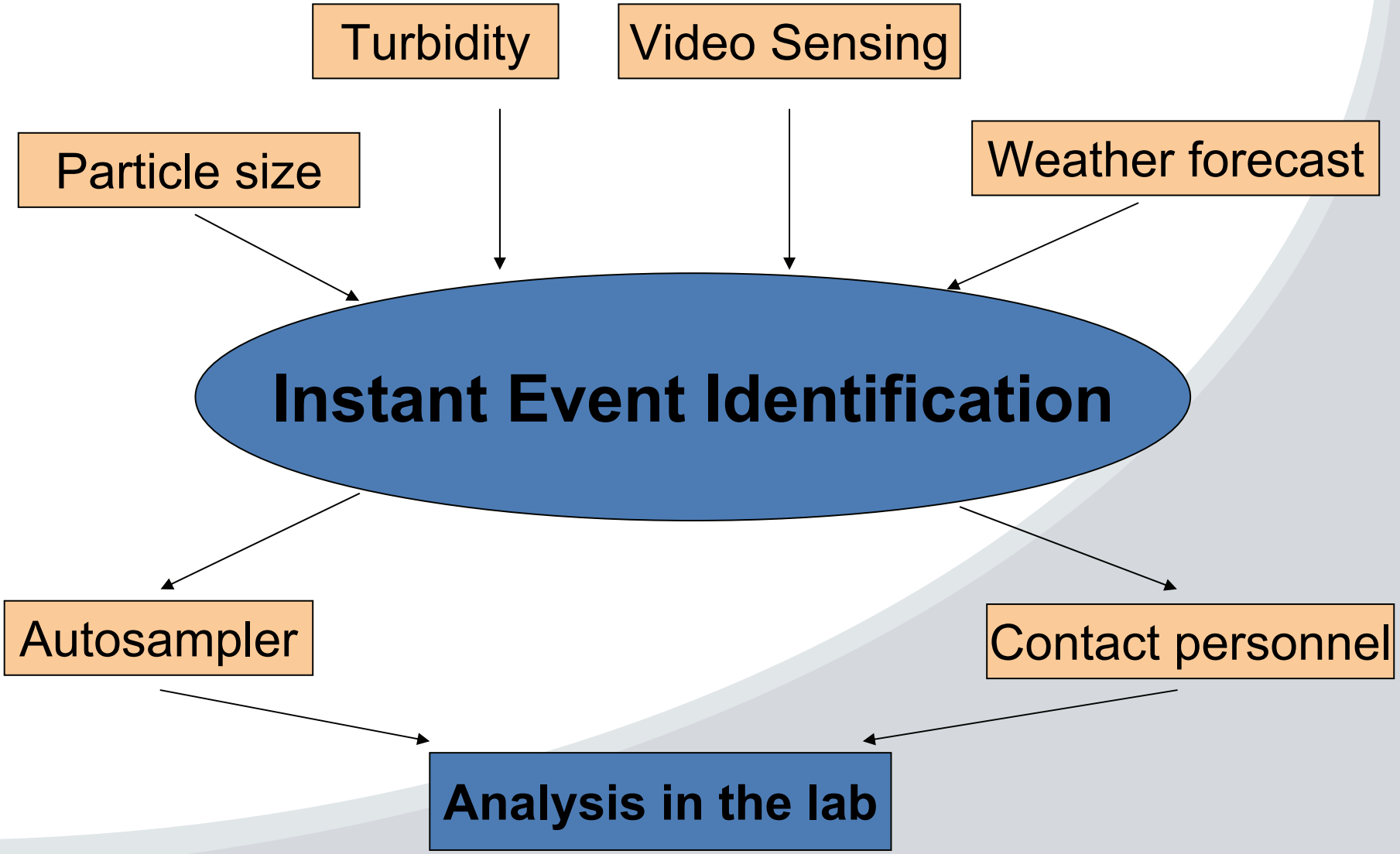

Conclusions

High levels of microbiological pollution in water require efficient monitoring

At present, the *solution* to monitoring microbiological pollution of water is a *combination* of early warning approaches with automated sampler systems and communications to key personnel for rapid responds

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