Delivering Healthy Water: building the science-policy interface to protect bathing water quality

Report from workshop 1

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UNIVERSITY OF STIRLING
PRIFYSGOL ABERYSTWYTH UNIVERSITY
LANCASTER UNIVERSITY

DELIVERING HEALTHY WATER

Participants:

Name	Organisation
Elaine Connolly (EC)	Defra
Andy Cummins (AC)	Surfers Against Sewage
Ana Maria de Roda Husman (AMdH) & Ciska Schets (CS)	National Institute for Public Health and the Environment (RIVM)
Lora Fleming (LF)	The European Centre for the Environment and Human Health (ECEHH)
Lidija Globevnik (LG)	European Topic Centre on Water
Valerie J Harwood (JH)	University of South Florida
Louise Heathwaite (LH)	Lancaster University
Chris Hodgson (CH)	Rothamsted Research
David Kay (DK)	Aberystwyth University
David Lees (DL)	CEFAS
Gordon Nichols (GN)	Health Protection Agency
Andreas Nocker (AN)	Cranfield University
David M Oliver (DO) & Melanie van Niekerk (MvN)	University of Stirling
Calum McPhail (CMP)	SEPA
Jonathan Porter (JP), Ian Dunhill (ID) & Amanna Rahman (AR)	Environment Agency
Richard Quilliam (RQ)	Bangor university
Ted Thairs (TT)	UKWIR
Tim Wade (TW)	USEPA

Overview

The first two workshops of the Delivering Healthy Water (DHW) project were hosted by UKWIR at their London headquarters and facilitated by David Oliver and Melanie van Niekerk of the University of Stirling. Workshop 1 was directed at the science user communities, predominantly regulators and policy makers while workshop 2 focussed attention on the science providers. This report provides a review of each seminar from **workshop 1** and a concise summary of the themes that developed over the day. It finishes with recommendations based on the key points that emerged across the workshop. In addition to members of the DHW Working Group, experts representing the science provider and science user communities were invited to participate. Four participants gave ten minute presentations and were asked to end their talk with the questions they considered needed addressing most urgently. For part of the workshop the participants divided into four groups to discuss a prepared set of questions that had been drawn up by the Working Group. These aimed to encapsulate the key problems facing science users in assessing the pros and cons of moving towards molecular methods.

Aims

- To identify and prioritise regulatory, policy and other stakeholder needs with respect to evolving and emerging molecular technology for microbial parameter enumeration and tracking.
- To ensure the effective communication of these needs to the science provider community.

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Workshop 1 got underway with a presentation by **Tim Wade** (TW) outlining the USA's experiences in using molecular methods. He described studies into whether there is an association between illness and recreational water quality as measured by novel and rapid methods of determining water quality. From these studies it was found that molecular-measures of faecal indicator bacteria were associated with gastro-intestinal (GI) illness among swimmers and dose dependent associations were established. Also associations with GI illness were stronger and more consistent than for culture-based measures of Enterococcus.

TW's questions for consideration:

- How can qPCR/molecular methods be used for beach monitoring, permitting and compliance when they are insensitive to chlorination?
- Are qPCR measures of FIB better indicators of swimmer-health risk? If so, why?
- How can quantification be accurate enough for risk characterization be obtained for inhibited samples, complex matrices?
- qPCR and culture-based measures show variable correlation and measure fundamentally different states of FIB. How can these differences be resolved if both methods are to be used?
- How can molecular measures of source tracking/source apportionment be incorporated into risk management?

Andy Cummins (AC) of Surfers Against Sewage gave the next presentation: **"A beach users' view on the role of new technology for bathing water monitoring".** AC focussed on concerns surrounding bathing water notifications and confidence in the information given out. Rapid information provision is important but he also pointed out that there is a gap between what information can be given and what is actually given to the public. SAS have a text alert system for beach warnings that is very popular and widely used by the surfer community.

AC's question was:

- 'What information is actually needed, by whom, and when?

Ian Dunhill (ID) of the Environment Agency (EA) then gave a presentation **entitled "The regulatory challenges of transition to molecular tools? – a view from the UK".** ID outlined the implications for monitoring and permitting that a move to using molecular technology would carry. Current hydrodynamic models are calibrated and validated by culture based methods. Many studies provide data which is used to test and develop existing knowledge and modelling frameworks. Thus, predictive models of FIO fate and transfer are essentially driven by culture-based data and the determination of culturable numbers is essential for the modelling of culturable responses of bacteria to environmental conditions. New techniques would carry with them implications for these models.

The questions that ID put forward for consideration were:

- Would molecular techniques improve the actual risk to which bathers are exposed?
- Would changing the analysis methods cause major resorts to prohibit bathing?
- What would the cost to the infrastructure and the public be?

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Jonathan Porter (JP) then gave a presentation "**view on the most promising molecular tools for the UK regulatory community"**. He put forward three main reasons why we might want to use molecular biological techniques: speed, access to information unavailable any other way and the possibility of 'nice to do' things as well as the 'have to do' things. A lot of this may be the investigatory work that can underpin the regulatory activity that the EA has to do as the legal body of the UK government. JP gave the example of a census of river water quality. If we have got a nucleic acid extract from a volume of water, what else could be done with it? There is information there that does not have to be 'read' now. It could be frozen and read later so we have a library of background data.

JP made a comparison of molecular with culture: We want to know how many *E.coli* are in 100ml of sea water, sampled at 9am on a Monday morning. For culture it can be sampled, filtered, incubated on TBX, counted and reported by Tuesday. If done by qPCR it can probably be done for Monday, 5pm. A two hour turnaround has been spoken of but the lab is doing about 250 samples a day, therefore you have to factor in a little bit more time. Would this extra speed make a difference to the regulator? Probably it wouldn't.

Current guidance for the Agency in using MST data is that it is additional information. Interpret it with care and a lot of samples are needed in order to try and explain what's going on rather than just taking a snapshot regulatory sample. JP considered the lab to be confident in reporting 'presence/absence' of specific sources, and 'ranking' - if you have sufficient samples. However accurate quantification of FIO sources is currently a step too far.

JP's key concerns and matters for consideration in moving from culture to molecular technology were:

- **Regulatory staff education**: Traditional techniques aren't always right. Using an example of work on diatoms, when examined morphologically down a microscope to get a diversity index for water quality assessments, they may look the same down the microscope but if their sequences are different, they're probably different and you need to look harder, morphologically.
- **Academic staff education**: DNA doesn't always give an answer. There are times, when culture could work just as well and can give us the information which we need.
- **Historical data-sets have value**: Culture may always have a place, and we can combine culture with a molecular assay.
- **Explanatory data vs regulatory data**: For MST to try and explain what's going on, which is what protecting public-health is about, we need more samples to account for natural variability in the environment and this may cost money.
- **Local knowledge**: You can get a good idea of what would generally be expected for one catchment in an area. Whether it would normally be ruminant or human', etc.
- **Sampling**: You get a snapshot of that sample environment, it tells you what's happening right there and then.

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Key Questions evaluated by the Workshop Participants

How important to regulators is a shift in microbial quantification methods (culture to molecular) for assessing bathing water quality?

- Regulators would change their view with evidence e.g. a dose/response plot.
- Establishing the relationship between the pathogen and a molecular assay could be useful. Does the pathogen behave differently to the faecal indicator? If it does, then there's a driver towards moving to a molecular method. If it doesn't then why are we changing?
- There is a role for rapid methods in the investigation of pollution incidents but speed itself was not considered to be an issue for the EA. Perhaps more of a matter for Local Authorities

When and if we move towards molecular approaches, what would be the most promising target or suite of targets to use for quantification?

- No big driver for using molecular methods for faecal indicators was established. Particularly in the absence of evidence or a lot more data to say 'we should move now and this is why we should move now'.
- Need some form of epidemiological study to see whether there were benefits in looking for pathogens directly as opposed to the FIOs.
- Variability in responses to environmental stress poses a conundrum for what we should target. Local hazards are important to help refine our choice of targets.

Will a shift in methodologies cause problems in consistency for comparing historical data and are regulators reluctant to change their standards?

- In terms of routine monitoring then the answer is 'why change?' there is no need....
- We have to define the overall objective: real time or background monitoring?
- Issues include changes in compliance record of a site – could be problematic
- This is politically charged, and policy are not eager to impose a change
- Methodologies can change general perceptions (and impacts on confidence of general public which has a much wider range of consequences)
- Developing methodologies, in terms of shifts from culture to molecular, also needs a way of building effective communication outwith those people who develop the new techniques. It's about communication to a wider audience.

It is suggested that new molecular methods should be as sensitive and accurate as reference methods but should not be more expensive. How do we achieve this?

- Volume: molecular can be made cheaper if it becomes routine but probably not as cheap as culture
- Automate to reduce costs, but there will still be training costs
- Accuracy of molecular methods can be questionable
- Method development is needed for initial clean-up of samples, R & D investment is needed but this is not done sufficiently with water.

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Does the regulatory community have concerns surrounding the deployment of MST in the identification microbial pollution sources? If so, what are they?

- Interpretation of the final outcome of a bathing water profile or some sort of study of that particular water body - once that's available, can that interpretation be used by the various sectors to deflect blame onto each other?
- Reliability of the source identification from source-tracking. At what point do you say that you've reliably got all the parts of the contributing factors?
- What if it's something you can't do anything about? Or you can do something but it would mean taking out the natural population of wildfowl for example? Regulators would have to recognise that there might be a component of the contribution of the overall load that they couldn't do anything about and therefore you have to work with the other 80% or 75%.
- The use of MST carries more complexity and 'yes buts' so how would all this evidence stand up in court given the doubts?

What, if any, are the institutional barriers that would hamper implementation of molecular techniques by regulators?

- **Resistance to change**. - thinking more of microbial source-tracking in the broadest sense. All organisations have got a natural resistance to change, particularly regulatory organisations because they're not driven by some of the drivers for change that other organisations are.
- **How difficult would it be to compare new data to older datasets**?
- **Co-ordinating change across agencies**- We have multiple agencies just in the UK, not only environment agencies, but also those who would have an interest in the MST work, source-tracking work, whether it's health-protection, or individuals and organisations more at a local level, and the water companies themselves.
- **Interpreting information and communicating with interested parties**
- **Competing demands on finite resources** - Why devote more resources to doing something which could be an additional method? When an organisation has competing priorities - health-protection, air quality etc

An array of molecular approaches is available - What are the leading contenders for water quality management in catchments? Is there a problem with bias from those who advocate different approaches influencing regulators?

- We should not use molecular methods just because they are available. Culture should be the starting point and this should be followed up by molecular methods (qPCR).
- An alternative view was that the first step should be an environmental assessment and that this should identify a question and then a technique can be chosen to follow it up
- There isn't a single approach to advocate for environmental assessment of water quality in catchments.
- The issue of whether bias could influence regulators was something that the group had not previously considered. However the discussion brought to light several possible areas of concern. In particular political pressure; academics wanting to pursue their own method; costs; public pressure to get information quickly; pressure on scientists to do the next big

thing and not stick with current technology because it is not exciting and the possibility that Local Authorities may employ private firms to run a cheaper method to get the desired results so they do not have to close a beach

How concerned should we be with the level of variability in qPCR data obtained from different investigators using the same approaches?

- The same sample sent to different labs ***should*** now generate consistent results ie inter-lab variability ***should*** not be a major concern: however, this can differ from practice.
- A lot of training will be needed so that staff are aware of the sources of variability in the technology and in the methodology.
- It requires a lot of standardisation and a lot of investment. Standardised methodologies exist for food, but not for water.

Is the culture of E. coli/IE an effective way to assess water quality & human health?

- It's **one** way of effectively measuring the concentrations of FIOs
- Absence doesn't mean everything Is ok
- We know what we have got. lots of public knowledge
- In answer to the question the epidemiological base would suggest so for enterococci however it was suggested that Norovirus would give you additional information (faecal source plus human pathogen) and a better relationship with the evidence base than EC. But it wasn't used at the time (enterococci was), because the methodology for Norovirus wasn't developed then.
- Parameters give us other water quality improvement information as well
- It is available worldwide, the infrastructure in place, it can be interpreted
- Effective with high pollution levels (point source)
- Bathing density shown to be correlated with FIOs resulting from bathers
- Can have a natural dimension to high EC and IE
- Can be good for trends over time and comparing different geographic areas
- FIOs do satisfy regulatory requirements
- What is the gap between survival of FIOs and pathogens – particularly important for different sources and in tropical areas (more regrowth)
- Potential negative is delay from taking test to having results
- Can't get away from culture due to viability issue – will end up having to do both
- Where is the evidence that agriculture leads to a human health risk? (Animal exposure vs human exposure)
- Need to consider natural pathogens. Environmental organisms (non-faecal bacteria) that can pose a health risk, which are not captured by FIOs.
- How well does it track respiratory & skin illness

Discussion Themes

Throughout the workshop a number of key themes emerged during the discussion sessions. Those themes are highlighted below and excerpts from the discussion included demonstrating the importance of these themes to the science user and provider communities Paragraphs in italics represent comments reproduced directly from transcripts of recordings made at the workshop.

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VARIABILITY

'*Every time you measure your environment, you are taking a discrete sample of a population. If you sample a river and then you resample in 20 minutes it will be different water. You will get different results. This was illustrated by at the EA by collecting one sample in a large bottle, taking it back to the lab, shaking it up and down and dispensing it into ten smaller bottles and then measuring all ten. They all give the same answer. If this is repeated an hour later the result will be different. But within the ten bottles the result was found to be the same. Changes are not due to the molecular assay they're due to the change in the environment. And the same will be seen with culture*'.

'*The EA lab receives about 250 bathing water samples per day during bathing water season. MST is done on a fair number. Variability within qPCR data has been investigated both within the lab, (intra lab variance) pipetting volumes, temperatures, etc and they have also had repeat samples from the same site, going through the same DNA extraction procedure and it was found that the majority of the variance seen is from the environment, (due to the water conditions at the time of the sample, the inhibition etc) not due to the lab assay*'.

JH has been involved in interlab tests. She commented that even just reading protocols was complicated and caused problems for consistency across labs.

You have to standardise everything not just the molecular bit.

COMMUNICATION

AC queried perceived levels of risk and 'labels'. What does health risk mean for bathing in a 'sufficient' bathing water versus a 'good' bathing water? This is a perception issue. It was commented that there was no difference – you can't package everything about a beach into one word. However, ID said that risk is very variable; most days water quality is perfectly fine but when it rains the risk is elevated.

AC said the rapid test has got a lot of potential to finish a pollution incident, to let people know that it's safe to go back in the water. He also thought that previous comments that there was little appetite for raid methods in the U.K. were assumptions. They may hold true from a regulator's point of view but is that true from a beach user's point of view, especially if it can provide a more meaningful statement of risk. Would beach users want that there? And we can't make the assumptions as regulators sitting here going 'I know what people on the beach want'.

SAS use a text message system to remove people from a risk.

It was stressed that any future change in methodology (if it should happen) would need to be accompanied by a thorough programme of communication to the public about the nature of the shifts in approach and what this mean in terms of classifications.

SPEED

How fast is fast enough?

SAS can get a message out within two minutes of a spill occurring or it two hours at most.

The EA tried to test daily predictive methods but validating a single sample proved difficult

AC would like a 2 hour turnaround time ie a sample at 8 am reported by 10 am when the beach opens. Then you can look at improving the quality of that information throughout the day so if you have anything up the catchment if there's a big rainstorm or if one of the award quality assets discharges, you can add to that base level that, the information you've got.

It was pointed out that a 2 hour turnaround meant that any technique has got to be delivered at the back of the van. It's not going to have time to get to the laboratory. This led to the question of whether we deliver quality-control from the back of a van. In previous projects trying to identify/ innumerate enterococci really quickly, LAMP (Loop Mediated Iso-thermal Amplification) was looked at. It was possible to generate milligrams of DNA in about half an hour but can you have that amount of DNA in the back of a van and still maintain quality over what's going on?

A rapid technique is important to determine that there no longer a problem, but less so to identify that there is a problem. A rapid method is only really useful for people wanting to use that beach on that day.

FUTURE RESEARCH

The following are items extracted from the presentations, feedback sessions and discussions that represent opportunities for future research in the area of emerging molecular tools:

1. We need to build consensus regarding the use of new and emerging tools through robust evaluation of key performance criteria for a range of environmental matrices under variable conditions. This requires a continued programme of laboratory and field based experimentation to build up an evidence base to populate any decision-making framework for considering future technology transition for enumeration of regulatory microbial parameters.
2. Continued cross-comparison of patterns and magnitudes of FIO vs molecular marker detected throughout a range of aquatic environments impacted by different catchment sources