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Prediction And Dissemination Of Bathing Water Quality In England And Wales – A Pilot Study

Juzer F. Dhondia

Deborah Tyrrell

Daniel Twigt

Ian Dunhill

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PREDICTION AND DISSEMINATION OF BATHING WATER QUALITY IN ENGLAND –A PILOT STUDY

JUZER DHONDIA(1), DEBORAH TYRRELL(2), DANIEL TWIGT(1), IAN DUNHILL(2)
(1*) Deltares, Delft, The Netherlands;*
(2) Environment Agency, England.

Water quality at some bathing waters can be adversely affected by heavy rainfall resulting from water running off the land, picking up faecal contaminants from the catchment and discharging this to bathing waters. The Environment Agency of England analysed the relationship between water quality and rainfall at each bathing site. The relationship between rainfall and water quality depends on the intensity and duration of the rainfall and site specific characteristics such as tidal flows, wind, and the response time of the surrounding catchment.

This paper describes a pilot study for setting up an operational bathing water quality prediction system for England using Delft-FEWS undertaken during the bathing period between June and September 2013. Around 30 bathing sites were selected for this pilot study. Each bathing site was associated with a telemetered rain gauge measurement station. The water quality at a bathing site was considered low risk if the rainfall total at the associated rain gauge station was below a site specific threshold and increased risk if the threshold was exceeded. The prediction of water quality at each bathing site was displayed via appropriately dated beach signage every morning at 10 am BST for the day.

INTRODUCTION

The Environment Agency of England has been committed to improving bathing water quality standards across England following the introduction of the European Bathing Waters Directive in 1976. Since then there has been a huge improvement in bathing water quality. The results of bathing water quality in 2013 showed that 99 percent of bathing waters in England met the minimum water quality standards.

The revised Bathing Water Directive [1] was adopted by the European community in 2006 and introduces more rigorous standards to be applied from 2015 onwards. The new standards aim to protect public health and improve the management of bathing water by providing information to the public so they can choose when and where to bathe.

The new directive not only tightens the standards for bathing water quality, but also provides an option of predicting bathing water quality and to advise the public against bathing during the short-term pollution events. The directive allows up to 15% of water quality samples

to be disregarded when determining overall bathing water quality for all bathing waters where the prediction system is in place.

The Environment Agency of England developed a method to predict pollution of bathing waters, to warn the public of an increased risk of poor water quality based on antecedent rainfall in catchments draining to bathing waters [2]. For the prediction of bathing water quality, The Environment Agency of England, decided to setup an operational bathing water quality forecasting system (BWQFS) using Delft-FEWS. This system was operational and issued warnings during the bathing period between May and September.

OPERATIONAL BATHING WATER QUALITY FORECASTING SYSTEM

An Operational Bathing Water Quality Forecasting System (BWQFS), which is an innovative online predictive tool based on the Delft-FEWS software, as described in Werner etal [2], Dhondia etal [3], and Twigt etal [4], will significantly improve the provision of information relating to human health risks. The schematic representation of Operational BWQFS is shown in Figure 1. Figure 2 shows the BWQFS Explorer screen. For general descriptions about the various systems components in Delft-FEWS, refer to Delft-FEWS documentation on Delft-FEWS WIKI (https://publicwiki.deltares.nl/display/FEWSDOC).

Figure 1. Schematic Representation of Operational BWQFS

The operational BWQFS Pilot for bathing season 2013 was setup at Deltares. This system produced a bathing water quality report at 08:30hrs BST, which was then used by the beach managers to put up the signs at each of the selected bathing sites.

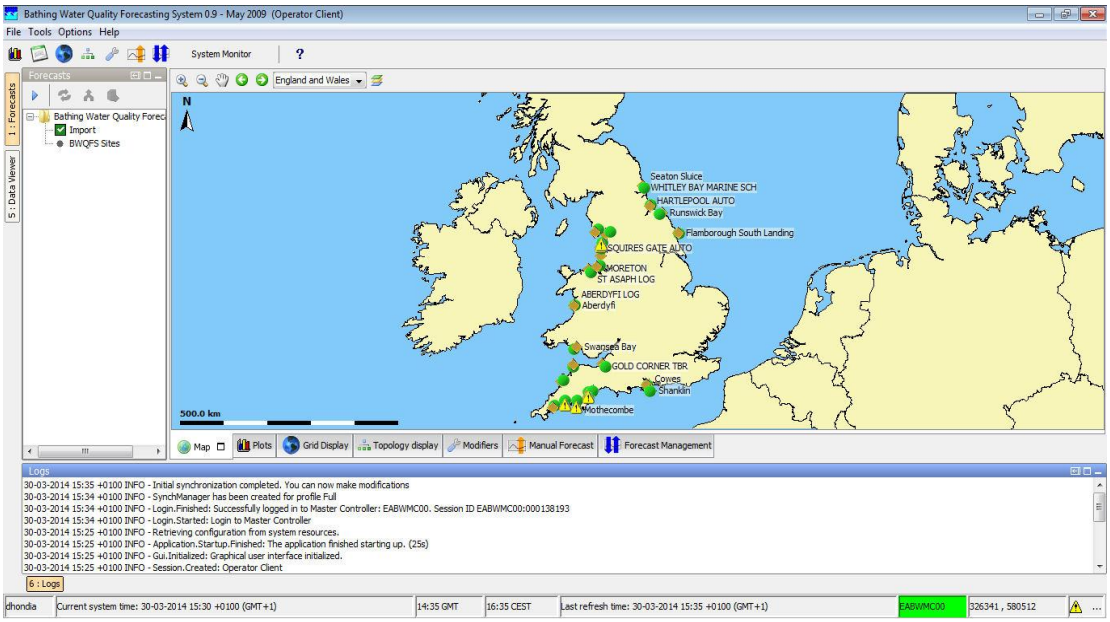


Figure 2. Explorer Screen of Operational BWQFS System

PROCESS OF PREDICTING BATHING WATER QUALITY

Traditionally, bathing water quality assessments are based on microbiological analyses for indicators of pathogen bacteria. The time lag between sample collection and analysis, and the limited representation in time and space are major problems of these assessments. The enumeration of intestinal enterococci and Escherichia coli, the faecal indicator organisms (FIOs) used to assess bathing water quality takes several days and by the time the results are available for the public typically a week has passed after the sample is taken.

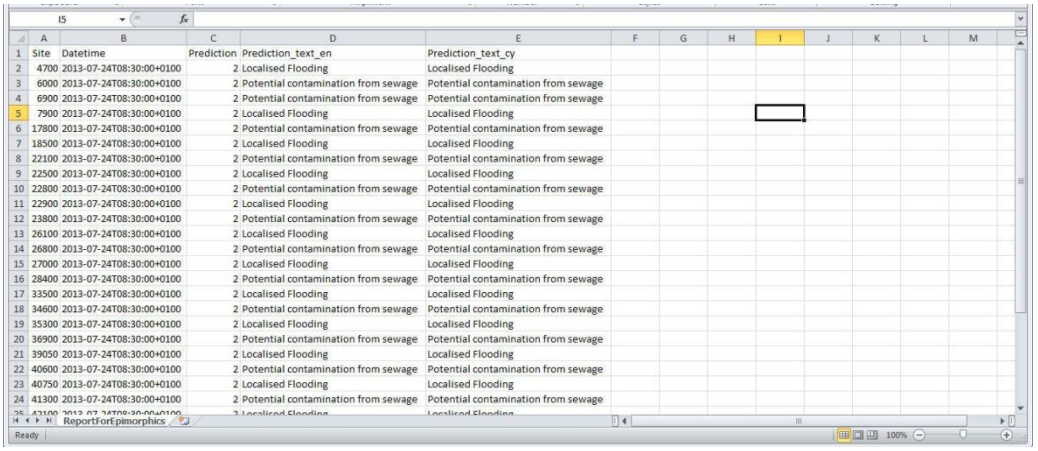
The rainfall (rain gauge) and radar data were imported to the BWQFS system using import functionality, an inherent functionality within Delft-FEWS. The processed rainfall and radar data are fed to the forecasting models. The forecasting models in the BWQFS are simple 24hr and 48hr triggers of accumulated rainfall and radar data for each bathing site. These triggers were developed by the Environment Agency of England, after extensive research based on data of FIOs in bathing waters. The triggers were set at rainfall levels above which the quality could be reasonably expected to be significantly reduced compared to background conditions for the site.

Sources of FIOs that are found in bathing waters include grazing livestock, farm yard runoff, septic tanks and pathways which lead these sources to the bathing sites may include drains, ditches, runoff, and livestock in streams. The revised Bathing Waters Directive (2006/7/EC) that comes into effect in 2015 introduces stringent microbial parameters, determined as concentrations of FIOs (CFU 100 ml-1) for both inland and coastal waters. This uses the percentile calculation of samples taken to classify bathing water quality into one of four categories (Excellent, Good, Sufficient or Poor) depending on the results. Situations such as the failure of a pumping station or sewage leakage are considered to be abnormal situations, which will affect the water quality at bathing site. Under such abnormal situations, water quality at bathing waters will be affected irrespective of rainfall at the corresponding rain gauge station.

It is important to note that only the bathing sites where the bathing water quality is known to be affected by rainfall qualify to be considered for the BWQFS. For the BWQFS pilot in 2013, 31 sites as shown in Table 1, were selected. The BWQFS sends a bathing water quality forecast report in CSV format (see Figure 4) to the BWQFS FTP site. The "handshaking" script downloads this forecast report and places the forecast for each selected bathing site on Bathing Water Explorer at "http://environment.data.gov.uk/bwq/explorer". This later process is performed by Epimorphics Ltd, UK. All these qualifying bathing sites received bathing water quality forecasts via Bathing Water Explorer, see Figure 5. The data will also be available for third party use as 'Linked data' in machine readable format.

Table 1: 31 Bathing Sites in 2013 pilot of BWQFS

Seaton Sluice	Ilfracombe Hele
Seaton Carew North	Burnham Jetty North
Runswick Bay	Swansea Bay
Flamborough South Landing	Aberdyfi
Cowes	Rhyl
Shanklin	West Kirby
Budleigh Salterton	Ainsdale
Dawlish Town	Blackpool South
Teignmouth Town	Blackpool Central
Shaldon	Blackpool North
Torre Abbey	Cleveleys
Mothecombe	Fleetwood
Seaton (Cornwall)	Morecambe South
East Looe	Morecambe North
Porthluney	Walney West Shore
Bude Summerleaze	



Site	Datetime	Prediction	Prediction_text_en	Prediction_text_cy
4700	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
6000	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
6900	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
7900	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
17800	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
18500	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
22100	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
22500	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
22800	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
22900	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
23800	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
26100	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
26800	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
27000	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
28400	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
33500	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
34600	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
35300	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
36900	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
39050	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
40600	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage
40750	2013-07-24T08:30:00+0100	2	Localised Flooding	Localised Flooding
41300	2013-07-24T08:30:00+0100	2	Potential contamination from sewage	Potential contamination from sewage

Figure 4. Bathing Water Quality forecast report in CSV format

Figure 5. Bathing Water Data Explorer web page of Environment Agency

For 2014 these warnings will also be sent via SMS to beach managers responsible for signage at bathing sites. In addition to this additional functionality will be added to the system via fully automated electronic signs which will display appropriate warnings at the bathing waters. This will allow warnings to be displayed at remote bathing waters where it would not otherwise be possible. These services will be carried out by Meteor communications. At 0830 every day of the bathing season they will take the forecasts from the data.gov.uk website and automatically compare this with a list of registered mobile phone numbers from the beach operators and electronic signs, and then send these via SMS.

Overall the BWQFS system ensures that bathing agencies and bathers are warned in-time when there is an increased risk that the water is likely to be unsafe to swim. Table 2 shows the four different predictions issues by BWQFS system.

Table 2: Predictions issued by BWQFS

Prediction	**Explanation**
No prediction possible	Issued when no prediction was possible may due one of many system failures
No warning	Water Quality suitable for bathing
Reduced water quality predicted after heavy rainfall	Water quality not suitable for bathing, prediction based on rainfall or radar data
Reduced water quality predicted due to manual override	Water quality not suitable for bathing, prediction based on rainfall or radar data

LOOKING FURTHER

As a result of the success of the pilot in 2013, the, Environment Agency for England will be setting up an Operational BWQFS system in 2014. Approximately 160 bathing sites will be included in this project which will operate in the bathing season starting from 5 May 2014. From 2015 onwards the first classification of the revised bathing water directive will take these predictions into account by allowing samples taken during these periods to be disregarded from the classification providing bathers have been warned via signage during these periods.

One of the challenges faced when attempting to predict bathing water quality is to separate the normal in-day variation from the extra risk associated with the predictor variable (rainfall). For this reason warnings are issued following significant periods of rainfall indicating as this has been demonstrated to increase the risk of reduced quality. Water quality at other times is assumed to be background quality, but that does not always equate to low-risk. The modeling criterion used to make forecasts in 2013 was based on antecedent rainfall alone. However in the future we hope to develop the system to incorporate other factors (for example UV, tides or river flow) that can be measured and assessed on a daily basis which influence bathing water quality.

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