
Monitoring of Bathing Water Quality with the Help of Radar Rainfall Forecast

Surveillance de la qualité des eaux de baignade utilisant la prévision de pluie par radar

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RESUME

Le département de Rendsburg-Eckernfoerde en Allemagne du Nord s'étend sur la côte de la Mer Baltique. Dans les eaux de baignade de la mer et des lacs à l'intérieur du pays, il y a des pollutions micro-biologiques occasionnelles.

L'objectif du projet de recherche présenté est d'analyser et de trouver l'origine et le cheminement des microorganismes polluants.

Basé sur les résultats de ce projet de recherche, des mesures de réduction de la pollution micro-biologique des eaux de baignade seront mises en œuvre. Quand ces mesures prises seront ineffectives, un système d'alerte et d'information sera mise en place pour les baigneurs. Utilisant une prévision de pluie par radar, ce système va fournir une information sur la qualité actuelle des eaux de baignade ainsi qu'une prévision sur leur évolution dans un avenir proche.

ABSTRACT

In the north-german district of Rendsburg-Eckernfoerde, located at the coast of the Baltic Sea, occasionally it comes to microbiological pollution of bathing waters.

The purpose of the research project presented here is to prove, analyse and evaluate the sources and paths of the contamination due to micro-organisms.

Basing on the results of the research project a set of measures shall be developed to mitigate the microbiological pollution of the bathing waters. In case these measures are not successful under the economic requirements, an information system for visitors to bathing locations with a forecast of the current and near future bathing water quality will be installed in connexion to the radar rainfall forecast.

KEYWORDS

Bathing water quality, hygienic pollution, monitoring programme, radar rainfall forecast.

INTRODUCTION

In the north-german district of Rendsburg-Eckernfoerde, located at the coast of the Baltic Sea, occasionally it comes to microbiological pollution of bathing waters. Regarding the revised version of the European Bathing Water Directive with a higher demand on bathing water quality, adopted on 15th February 2006, penalties and closure of bathing waters are threatening. Such a consequence would cause very negative effects for tourism, an important economic factor for this area.

The purpose of the research project presented here is to prove, analyse and evaluate the sources and paths of the contamination due to micro-organisms.

Combined and storm sewer overflows belong to the main sources as well as waste water treatment plant effluents and agricultural effluents (Bartram, J., Rees, G., 2000).

Further on, faecal micro-organisms might be caused by water birds or other wild animals living in or close to the receiving waters (Kirschner, A.K.T. et al., 2004).

Basing on the results of the research project a set of measures shall be developed to mitigate the microbiological pollution of the bathing waters. In case these measures are not successful under the economic requirements, a strategy shall be established how to inform and warn bathing guest or/and to close the bathing waters temporary.

This monitoring project serves as basis for a rehabilitation concept for the bathing areas transferable to other regions. The project is EU-funded by the programme INTERREG IIIA. This programme helps to form a partnership with a Danish research-group from Miljøcenter Fyn/Trekantområdet to work together on this common project.

1 MONITORING PROGRAMME

Previous investigations on the bathing water quality in the district of Rendsburg-Eckernfoerde were focussing on the water quality of the bathing waters very close to the beaches. In most cases the results showed no systematic between the sources and paths in the upstream catchment area and the microbiological pollution at the beaches. Obviously the sample frequency in space (only one investigation site per beach) and time (every 2 weeks) was too rough in order to find any systematic.

Increased hygienic pollution of bathing waters by faecal micro-organisms were identified at beaches located at the coast of the Baltic Sea (salty water) as well as at rivers and creeks of the inland (freshwater). Further on, the sources of contamination differ in their concentrations and loads very much and occur as point or non point sources. Great difference were also measured during dry and storm weather condition.

1.1 Design of the Monitoring Programme

The objectives of the monitoring are to determine the impact of the river outlets on the microbiological quality of the bathing sides and to quantify the temporal and spatial variability of the hygienic load along the river system. Further on the influence of meteorological parameters such as precipitation, duration of sunshine and wind and hydrological parameters such as discharge, velocity of flow and water temperature shall be investigated.

Another point to be clarified by the investigation is the interaction between sediment and bacteria regarding transport, sedimentation and resuspension.

All these requirements lead to a monitoring programme which is based on the following basic rules:

- Beside the hygienic pollution data of chemical, physical, hydrological and meteorological parameters will be collected to research the connections between hygienic and material water loads and their variation
- Composition of a basic programme, focussing on the water quality at all beaches and river outfalls of a region on one day and an intensive programme, focussing on all sources influencing the water quality of only one river system and the beach at several times a day.
- The intensive programme will be taken place on dry weather and storm weather conditions
- High sample frequency in space (number of investigation sites) and time (daily during dry weather, more often during storm weather condition).
- Only few automatic measurements, mainly measurements by hand, on site and in time.
- Using radar rainfall forecast (see chapter 3) to identify specific effects during wet weather condition.

1.1.1 Investigation Parameters

During the basic programme as well as during the intensive programme samples were taken from the aquatic system and analysed on

- Microbiological parameters: Escherichia coli and Intestinale Enterococci
- Chemical and physical parameters: pH, conductance, oxygen, turbidity, total nitrogen, nitrate, nitrite, ammonium, phosphate, chemical oxygen demand
- Local meteorological parameters: air temperature, humidity, air pressure, precipitation, evaporation, dew point temperature, wind speed and direction, global radiation UV A and UV B
- Hydrological parameters : discharge, velocity of flow, water level and water temperature

The microbiological parameters were analysed by a rapid identification test and a semi automated quantification method based on the Standard method Most Probable number, Colilert -18 and Enterolert-E.

The Parameters pH, conductivity, oxygen, turbidity and water temperature were analysed at every sampling by a Multiparameter Tube.

The parameters total nitrogen, nitrate, nitrite, ammonium, phosphate, chemical oxygen demand were analyzed by photometric Cuvette Tests.

The hydrological parameters were recorded by a local weather station.

1.1.2 Investigation Area

The investigation area covers 30 bathing locations on the Baltic Sea coast and at some inland waters which will be investigated from May till October over the period of three years, starting in 2006.

In 2006 the bathing sides in marine water at the bay of Eckernfoerde with thirteen river outlets and their watersheds were investigated. All the waters were small streams and ditches with a length of 1 to 7 km.

The catchment area is mainly agriculturally used and has a small population density in winter and a high increase in the tourist season. All the streams are receiving waters for communal or private sewage treatment plants.

In the basic programme samples were taken at the river outlets to the Baltic Sea. In the intensive programme samples were taken along the stream course at points where microbiological pollution is supposed to be, for example before and after a discharge of a sewage plant etc..

In 2007 the main investigation point is on the freshwater lake Wittensee and the catchment area of his feeder rivers.

1.2 Field Work

To obtain samples, that are as representative as possible and to react near-term on change of weather conditions a mobile laboratory was constructed. The mobile lab was placed in the investigation area to have short ways from sampling to analysis.

The basic programme takes place on three following days every week with sampling once a day. The remaining days of the week the intensive programme is carrying through, during dry or storm weather with sampling three to four times a day on every sampling point.

The sampling at storm weather conditions is planned with the help of radar rainfall forecast, to decide where, when and how many samples can be taken.

To clarify the role of sediment a method to analyse the microbiological content of sediment and suspended particles in the water will be developed.

2 RADAR RAINFALL FORECAST

2.1 Warning Concept for Sampling

The sampling had to be done at any time of the day. For the rainfall case, the distance between the fixed location of the measurement team and the different bathing water spots required a forecast of coming rainfall. Else, the team risked to be too late for catching the onset of the increased flow.

2.2 Realisation based on radar data

The Eckernförde Bay is situated in the far north of Germany on the Baltic Sea right on the edge of the visibility of the online radar product PF of the German Weather Service (DWD). From the north, the radar of Rømø Rømø (Danish Meteorological Institute) is – as well - just covering a part of the area (figure 1). Data characteristics are given in Table 1.

Therefore, the warning for the measurement teams had to be based on both radars. It consists of the calculation of the rainfall during the last hour plus the rainfall as forecasted by the SCOUT nowcast one hour ahead (Einfalt et al., 1990). If for one bathing location, this value was above a given threshold, in 2006 chosen to be 2 mm, a warning was sent out by email and SMS to the measurement team so that it could start to move to the indicated location.

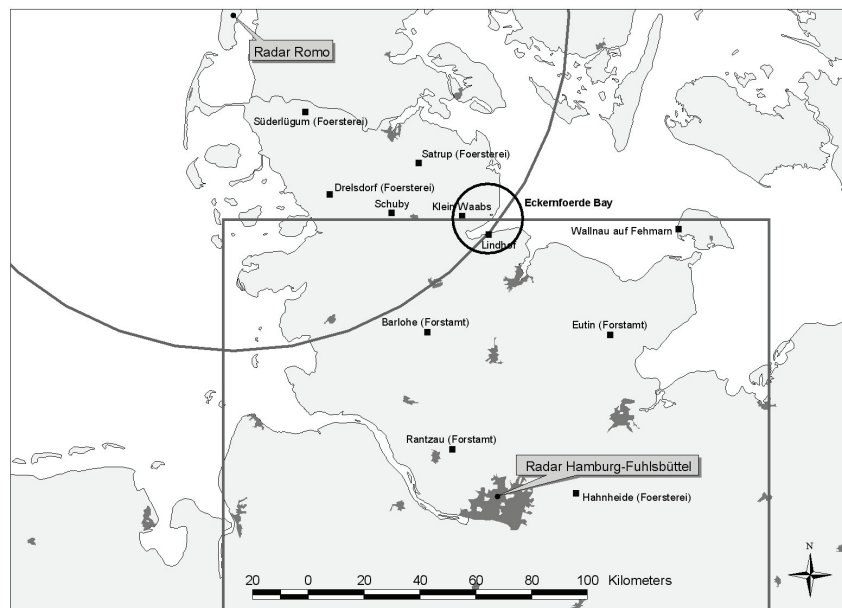


Figure 2: Location of the bathing waters (dark circle) and radar locations with respective range

	Radar data characteristics	
location	Hamburg	Römö
owner	German Weather Service	Danish Meteorological Institute
type	C-band	C-band
pixel size	1 x 1 km	1 km x 1°
levels	1	10 (?)
time step	5 minutes	10 minutes
classes	16	256

Table 1. Radar data characteristics

The warning scheme is redundant in the sense that it delivers a warning for each location, and there are some locations close to each other liable to be touched by the same rain field. In this way, a potential failure of delivery of one electronic message was planned to be compensated. After a delivery, a waiting time of two hours was efficient before sending a new warning message.

2.3 Outlook

While the warning scheme was based on individual treatment of the radar data from Rømø and Hamburg in 2006, there will be a common treatment for the nowcasting part for both radars in 2007. This new processing requires the data to be composited into one data set, after radar data correction and bias adjustment.

Additionally, raingauge data from continuous raingauges of the Land Schleswig-Holstein are available with one day delay. These data are used to adjust the radar data after the events, and to tune the two radars for the composite images.

3 RESULTS

After one of three sampling seasons the research project provides the first intermediate results. Statements can be made about random and unsystematic events in the investigation area from 2006. Furthermore the influence of rainfall, common and private sewage treatment plants can be defined. For the role of sediment the influence of agriculture, lakes and rain storage reservoirs there can be shown trends, which have to be verified in the sampling season of 2007.

3.1 Random and Unsystematic Events

In the investigation area of 2006 along the coast of the Baltic Sea between Damp in the north and Eckernförde in the south the investigation identified a few process upsets in connexion with sewage treatment plants and the sewer systems.

In most cases the maintenance of the technical equipment was not adequate or the sizing of the plants for example the inflow to the UV-disinfection or the sewer system was not sized right that in case of rainfall the untreated sewage flows beside the plant.

3.2 Systematic Events

The influence of rainfall concerning the hygienic pollution is obviously. From a defined quantity of rain the load of micro-organism is increasing decided.

We suspect a connexion to dispersion of sediment and the higher velocity, which is suspected to be the reason in other publications as well.

Micro-organisms discharged to the receiving waters can survive day to weeks in the sediment or connected to suspended particles (Davies, C.M. et al., 1995).

During wet weather condition germs were removed mainly from the sediment or the hyporheic water and may cause high concentration at the beaches (Bartram, J. et al., 2000).

This will be a main object at the investigation of the investigation season 2007 as well as the transaction in bio films in sewer systems.

The investigations of small private sewage treatment plants showed that secondary sedimentation ponds and soil filters reduced the content of bacteria sufficient but not do biological filters.

Lakes and rainwater catchments do although reduce the hygienic load, if their dimension is right for the water quantity, so that sedimentation can take place.

4 IMPROVING BATHING WATER QUALITY

At all sources of bacteria like sewage treatment plants structural and conceptual improvements have to effect to reduce or dispatch the hygienic pollution. Secondary sedimentation ponds or soil filter can be built, where it is necessary. Rainwater catchments can be installed, if it is necessary to force the sedimentation.

An information system for visitors to bathing locations with a forecast of the current and near future bathing water quality will be installed in connexion to the radar rainfall forecast.

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