Waterquality: Swim without risk?

Abstract

The quality of swimming water is checked annually according to guidelines that are the same for all EU countries. What are these guidelines? How are they determined and applied? Does the water near your school meetthe criteria? These are the questions that will be dealt with in this unit.

Students will investigate how water quality can be determined. Biology, chemistry and mathematics all play a role in this activity. Based on the testing of water samples, students will provide some advice for the local tourist office.

Aspect	Description
Mathematical content	- Interpreting and drawing graphs - Calculations using percentages (reliability) - Making maps (scale factors) - Accuracy
Scientific content	- Experimental work - Critically evaluate and justify norms - Document results and reflect, evaluate and discuss -Importance of acidic, alkaline and neutral solutions for living organisms, (chemistry) knowledge of abiotic factors that influence ecosystems (biology, chemistry)
Age of students	14-16
Number of lessons in mathematics	Approximately 1
Number of lessons in science	Approximately 4

1. Overview of the teaching unit

1.1 The situation

The quality of swimming water is checked annually, according to certain guidelines that are the same for all EU countries. What are the criteria by which water can be determined to be ´clean´? And how are these criteria determined and why no other criteria? How reliable are the results of the tests for the criteria?

These are the questions that will be dealt with and for which students will carry out research and formulate answers in this unit.

1.2 Overarching questions

- How can the purity of swimming water be tested?
- What exactly is the 'Blue Flag'?
- How reliable are the measurements and the criteria for the Blue Flag?
- What is the status of the quality of fresh and salt water for swimming in the Netherlands?
- Are there noticeable differences in water quality between EU countries?

1.3 Final product

Write a report for your local tourist office in which you explain why tourists should swim in this area or what should be improved. In this report you should refer to the experiments that you have carried out and to your findings from the tests.

1.4 Necessary materials

- Water samples from the local area. Students may collect these themselves after the first lesson.
- Testing equipment for identification of substances in the water (pH-value, nitrate-/nitrite- and phosphate-contents) (Activity 3)
- Testing equipment for copper sulphate solutions in various concentrations (Activity 4)
- Optional for biology: Nets, small water containers, magnifying glasses, identification aids for invertebrates in waters and microscopes for the identification of algae.

1.5 The task plan

Activity	Biology	Chemistry	Mathematics
0	**Task 1: Introduction to the topic** Homework: bring water samples from your area		
1		**Task 2: Is the water clean enough?** Discuss samples: what are the criteria for swimming/drinking water and how can they be tested?	
2		**Task 3: Are the criteria trustworthy?** Norms of chemical and biological parameters: accuracy, advantages and disadvantages of methods	**Task 3: Are the criteria trustworthy?** Calculations for Blue Flag criteria. Optional: Logarithmic relationship between concentration and pH-value
3	**Task 4: What is allowed?** Test samples for E-coli (bacteria) and other biological materials.	**Task 4: What is allowed?** Test samples for acid, chloride, nitrite	
4		**Task 5: Are the measurement results reliable?** Accuracy of test results	
5			**Task 6: How can you make a comparison between the Netherlands and other countries?** Comparison between countries, interpreting graphs
6	**Task 7: Discussion** of results from each of the groups		

2. Description of the tasks

2.1 Task 1 – Introduction to the overarching question: Is the water clean enough?

Students are confronted with the issue by means of an article from a newspaper on the pollution of swimming water (Summer 2010). Ideally, it would be helpful to invite a person who is involved in water treatment or testing to introduce the subject.

After reading, a group discussion should be held.

Potential issues for discussion:

- Is our swimming water clean enough?
- Why is purity an important consideration?
- How is this purity checked?
- How can the quality be maintained?
- Who checks this?
- Is approved swimming water potable (safe for drinking)?

Humans, plants and animals depend on water. Everyday a person consumes two litres of water. It is important that the water is pure enough, not just for drinking, but also for swimming. Although you might not really be aware of this, the quality of the water is checked in many different situations.

In various laboratories at breweries, waterworks, sewage works, etc., water quality is measured constantly. The results are then usually published.

Polluted water may lead to disease (think of the E-coli bacteria, cyanobacteria or the presence of heavy metals).

In preparation of the next lesson, students should to bring in a water sample (0.5 - 1 litre). Experiments will be carried out during the lessons on this water sample.

This task allows for differentiation for different school levels. Students learn to collect and handle data and to create measures to maintain water quality and to protect the world in general.

Students will look at guidelines for water quality (in particular: the "Blue Flag"), will recognise the benefits of generally accepted criteria for guidelines, and will understand the reasons behind the selection of criteria and guidelines.

Worksheets for task 1

Brussels, 11 June 2009

Bathing water quality improving in the EU

The annual bathing water report presented today by the European Commission and the European Environment Agency reveals that the large majority of bathing sites across the European Union met EU hygiene standards in 2008. During that bathing season some 96% of coastal bathing areas and 92% of bathing sites in rivers and lakes complied with minimum standards. The report provides useful water quality information for the millions of people who visit Europe's beaches every summer.

Commissioner for the Environment Stavros Dimas said: "High quality bathing water is essential for the well-being of European citizens and the environment – and this goes for all other bodies of water too. I am pleased to see that the overall quality of water in bathing areas is improving throughout the Union."

Professor Jacqueline McGlade, Executive Director of the European Environment Agency, added, "Information sources like this report and our web-based viewing tools enable citizens not only to check the quality of the bathing water in their local community or holiday destination, but also to allow them to get more actively involved in the protection of their environment."

Of the 21,400 bathing areas monitored throughout the European Union in 2008 two thirds were on the coast and the rest were along rivers and lakes. The largest number of coastal bathing waters can be found in Italy, Greece, France, Spain and Denmark while Germany and France have the highest number of inland bathing waters.

The overall quality of bathing waters in the EU has markedly improved since 1990. Compliance with mandatory values (minimum quality requirements) increased over the 1990 to 2008 period from 80% to 96% and from 52% to 92% in coastal and inland waters respectively. From 2007 to 2008 compliance increased both for inland and coastal waters (1.1 and 3.3 percentage points respectively).

[http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/903]

2.2 Chemistry – Task 2: How can water be tested for quality?

The aim of this task

- Students gain an understanding of the necessity for agreeing on common criteria to assess water quality.

Contribution to the overall question

Students gain an understanding that it is important and useful to apply objective and general criteria when checking the quality of swimming water. To achieve this, they test their own water samples using their own criteria. Discussion of these criteria should lead to general agreements on what these criteria should be. They can then be compared to the lawful demands that apply within the EU.

Chemical contents

- Testing the water samples using students' own criteria
- Discussion of the various criteria that have been used
- Setting up a work plan for Blue Flag measurements (lesson 3)

Students' water samples are tested for quality. Working in groups of 3 or 4, students should determine their criteria for quality. The results and opinions can be presented on posters, transparencies or in a PowerPoint presentation. These can then be used for a class discussion.

Activity 1 for students: Similarities and differences

Take a look at the posters produced by each group.

Potential questions you might wish to consider:

- What similarities and differences have you found between groups when it comes to evaluating water quality?
- Which samples are safe for swimming?
- How certain are you of the choice for these criteria?
- Have all risk factors been taken into account? Are you sure?

(see worksheet for task 2.2)

In the discussion it is likely that different criteria have been used on each sample and that it is not possible to be sure if all important aspects have been considered. This should prompt students to consider searching for precise and well-defined criteria and measurement methods by which the quality of swimming water can be determined. In the next lesson students will

learn to apply the criteria of the 'Blue Flag'. Towards the end, they will set up a plan for the testing procedure. Optionally, a comparison with the directives for drinking water can be explored.

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Worksheets for task 2

Task 2.1 – A first investigation of the quality of the water

Water quality is tested and evaluated in different situations. In this lesson, you will consider in greater detail how this works in real life. You will test and evaluate the quality of the swimming water by yourself. Therefore, you must determine your own criteria as a group: what do you want to test in order to find out if the water is safe for swimming? How will you carry out these tests? Finally, you must provide a clear statement of advice: can someone swim in this water or not? Present your findings on a poster.

A. Remove the lids of the water samples and carefully study the water. How does it smell? How does it look? Study the sample, for instance under a microscope. Do you think it meets the requirements for swimming or drinking? How certain are you?

I think this water does / does not meet the requirements for drinking water.
I am fairly sure / unsure of this, because .....

B. I think this water does / does not meet the requirements for swimming water.
I am fairly sure / unsure of this because .....

C. If you are not very sure, what type of information are you still missing?
To be sure that the water meets the requirements, I need to
know .....

Task 2.2: similarities and differences

Take a look at the posters produced by each group. Potential questions you may wish to consider:

- What similarities and differences can you find between groups when it comes to evaluating water quality?
- Which samples are safe for swimming?
- How certain are you of the choice for their criteria?
- Have all risk factors been taken into account? Are you sure?

2.3 Biology/Chemistry/Mathematics – Task 3: The Blue Flag criteria

The aim of this task

- Students should become familiar with Blue Flag criteria.
- Students should critically reflect on the choice for Blue Flag criteria: why these and not different criteria?
- Students consider the mathematical background for the statistical measures.

Contribution to the overall question

- Development of understanding of the Blue Flag criteria

Scientific contents

- Knowledge and application of the criteria that can be used to check water quality: pH-value, numbers of bacteria (especially Escherichia coli and cyanobacteria), transparency (called turbidity), nitrite and (optionally) also for cyanobacteria (nitrate and phosphate).
- Advantages and disadvantages of colorimetric measurements in comparison with biological and phenomenological measurements.

Mathematical content

- Statistical methods, such as average, deviation, percentiles
- Logarithms (optional)

Students should investigate how the granting of a "Blue Flag" can be determined for swimming water. This information can be found on the Internet.

Task 3.4 focuses on the parameters that are used during testing and the reasons for their selection.

Next, other parameters that could be taken into account to evaluate the quality of swimming water are considered during a class discussion.

Activity 1 for students: Why are no other parameters tested?

You have studied the Blue Flag requirements; why certain parameters and norms are reported in it and how the norms have been established. The question is: can we rely on these four criteria? Why are just these parameters chosen and no more?

Worksheets for task 3

Information sheet 3.1: The Blue Flag

Blue Flag

The Blue Flag originated in France in 1985, when the first French coastal communities were assigned a Blue Flag on the basis of criteria for the treatment of waste water and the quality of swimming water. The Blue Flag is now an international eco-label and therefore sets a minimal worldwide norm for water quality. The Blue Flag is a voluntary eco-label assigned to more than 3450 beaches and marinas in 41 countries in Europe, South-Africa, Morocco, Tunisia, New-Zealand, Brazil, Canada and the Caribbean. The Blue Flag-programme is owned and managed by the independent non-profit organisation Foundation for Environmental Education (FEE).

The Blue Flag works towards sustainable development on beaches / marinas by means of strict criteria regarding the handling of water quality, environmental education and information, environmental management and safety and other services.

More information about the Blue Flag criteria can be found here:

- http://www.blueflag.org/Menu/Criteria/Beach+Criteria
- http://www.blueflag.org/Menu/Criteria/Marina+Criteria

Criteria for beaches

The Blue Flag-programme demands that the quality of swimming water at beaches is excellent. The norms for the quality of the swimming water are based on the most appropriate international and national norms and legislation. All Blue Flags are granted for one season. If some of the stringent criteria are not met during the season or if conditions change, the Blue Flag will be withdrawn. A number of Blue Flag criteria can be found below:

Criterion 7. The beach must fully comply with the water quality sampling and frequency requirements.

A Blue Flag beach must have at least one sampling site and this must be located where the concentration of bathers is highest. In addition, where there are potential sources of pollution, e.g. near streams, rivers or other inlets, storm water outlets, etc. additional samples must be taken at these sites to provide evidence that such inflows do not affect bathing water quality. Samples for microbiological and physical–chemical parameters must be taken
Similarly, in the case of inland waters where the water is supplemented by outside sources during dry periods, the water quality of the outside source must meet the Blue Flag bathing water quality standards.
Samples should be taken 30 cm below the water surface except for the mineral oil samples that should be taken at surface level.

How often a sample must be taken?
There must be no more than 30 days between samples during the Blue Flag season. The Blue Flag programme does not accept applications from beaches, irrespective of the length of the Blue Flag season, where less than five samples have been taken. I.e. a minimum of five samples must be taken evenly spread out during the season. The first sample must be taken within 30 days before the official starting date of the Blue Flag season.

Criterion 8. The beach must fully comply with the standards and requirements for water quality analysis.
An independent person, officially authorised and trained for the task, must collect the samples. An independent laboratory must carry out the analysis of the bathing water samples.

Criterion 10. The beach must comply with the Blue Flag requirements for the microbiological parameter Escherichia coli (faecal coli bacteria) and intestinal enterococci (streptococci)
The microbiological parameters to be monitored are given below. Blue Flag limit values are the same for freshwater as for marine waters.

Parameter	Limit values
Faecal Colibacteria (Escherichia coli)	250 cfu/100 ml
Intestinal enterococci/streptococci	100 cfu/100 ml

cfu = colony forming units (of bacteria)

Accepted percentile:
For the evaluation of an applicant beach the Blue Flag programme requires 95 percentile compliance of the above limit values. This is in accordance with the EU Bathing Water Directive 2006 as well as the recommendation of the World Health Organisation. The percentile has to be
calculated for each parameter and also met for each parameter. For example, if the 95th percentile is below the limit values for Escherichiacoli but not for Intestinal Enterococci then the beach cannot
be awarded with the Blue Flag. In using this 95-percentile method, the norms refer to the values that would be exceeded less than 5% of the time.

The 95th percentile is derived through the following calculation (based on the explanation in the EU
Bathing Water Directive 2006):

1. Take the log10 value of all bacterial enumerations in the data sequence to be evaluated. Zero values cannot be used and should be replaced by a value of 1 (or the minimum value allowed)

2. Calculate the mean of the log10 values (μ)
3. Calculate the standard deviation of the log10 values (σ)
4. The upper 95 percentile is derived from the following equation: antilog ($\mu + 1{,}65\ \sigma$)
5. The resulting value must be within the limit values as stated above

Criterion 11. The beach must comply with the Blue Flag requirements for the following physical and chemical parameters.
Water quality can also be affected by physical and chemical parameters such as the pH value, oil and floatables:

- The pH value range is normally 6 to 9.
- There must be no oil film visible on the surface of the water and no odour detected. On land the beach must be monitored for oil and emergency plans should include the required action to take in case of such pollution.
- There has to be an absence of floatables such as tarry residues, wood, plastic articles, bottles, containers, glass or any other substance.

Worksheet 3.2: The criteria of the Blue Flag

The Blue Flag describes criteria and specific values for determining the quality of swimming water:

Criterion:	Limits for the value:
.....	Minimum/Maximum: .....
.....	Minimum/Maximum: .....
.....	Minimum/Maximum: .....

If the water satisfies these values it is considered appropriate for swimming.

A. Does your water meet these demands?
Yes/No
I am sure / unsure of this
because .....

B. If the water did meet the values above, would you trust it and swim in it?
I would / would not trust it
because .....

Worksheet 3.3: The parameters that are normally tested

Why are these criteria included in the Blue Flag criteria and how should the norms for these parameters be determined?

Together with your group, you will now examine why these parameters are usually tested for Blue Flag status and how the norms are established for each of these parameters. For this activity, use the information sheets provided.

A. Why is acidity included in the Blue Flag criteria?

Because:.....

Why should the acidity be neutral?

Because:.....

B. Explain the presence and possible values of the other variables that are mentioned in the Blue Flag legislation.

Task 3.4: Why are there no other parameters?

You have studied the Blue Flag requirements; why certain parameters and norms are reported in it and how the norms have been established. The question is: can we rely on these four criteria? Why are just these parameters chosen and no more?

A. Why did the Blue Flag legislation only report the parameters mentioned above (and not for example, the concentration of (very toxic) mercury)?

.....

B. Can you think of a situation in which a laboratory would test extra parameters?

.....

C. Imagine you have tested 20 samples for fecal colibacteria and 3 of them have a value above250 cfu/100 ml. What can you say about the 95-percentile?

.....

2.4 Task 4 – Test the water quality of the samples

The aim of this task

- Students test their own water samples to see if they meet the Blue Flag criteria and share their findings.
- Students will consider reliability with respect to taking and collecting samples.
- Other criteria selected by individuals or groups may be tested as well.

Contribution to the overall question

- Using the test results, students can later determine what advice to give to the local tourist office.

Chemical contents

- Application of the test kit to check water quality for pH-value, nitrite and (optionally) also for cyanobacteria (nitrate and phosphate).

Biological content

- Test for E-coli bacteria and (optionally)transparency (turbidity).Optionally, students could investigate the water sample using other biological parameters (like algae), and critically evaluate the usefulness of these investigations.

Note: The E-coli test takes time, because the culture needs to grow.

Activity 1 for students: Testing of your own samples with the test-kit

The method for using the kit is explained in the manual.

- What results did you get?
- Do they meet the Blue Flag requirements?
- Compare your results with fellow students.

(see worksheet for task 4.1)

Since the water samples have been collected at different locations, it should prove interesting to compare results and discuss how any differences may be explained.

The following tests are often used to determine water quality and are easily carried out with younger students. In particular, biological testing for indicator organisms (3) is easy to do. This method involves aspects from biology and promotes environmental awareness, not only of

human health, but also aquatic life. These tests may be included in later considerations of the parameters determining water quality.

(1) Visual depth measure

Tie some string to a non-floating white / light-coloured object. Attach a plastic bottle to the string one metre from the object. Hold the other end of the string, and throw the "visual depth instrument" into the water. Does the object remain visible? If so, then the water quality is in order. If you want to determine the exact depth of visibility, remove the plastic bottle and let the object sink to a depth where it remains only just visible. Measure the length of the string which was submerged in the water.

(2) Turbidity and odour of the water

Water quality can also be assessed based on the turbidity and colour. Turbidity and colour can be caused by pollution from various substances, including iron, soil particles, sludge materials, or with numerous small organisms, such as green algae and diatoms, bacteria, and water fleas. It can be determined from the visual depth of a water sample.

(3) Biological determination of water quality using indicator organisms

Many water organisms are dependent of the available food, oxygen, pH and other factors. If these organisms are present, then a certain level of the above factors must be available. They are then representative of a specific condition of the water and are called indicator organisms. Before carrying out this test, students should investigate possible indicator organisms for their geographic area, or a table with indicators and conditions could be provided.

Criteria by which the testing process can be evaluated are:

- Accuracy
- Requirement of technical expertise
- Expense
- Benefit / importance to the people's health
- Importance in maintaining the ecological balance

Worksheets for task 4

Task 4.1: Testing water

Merck kit tests

Nitrite and acidity can be measured using 'Merck kit' tests. Merck is a chemical plant which, among other things, makes testing kits for various types of research. Acidity and nitrite tests are part of a series of tests which can be quickly used to test water on-site.

They are so-called 'black box' tests. This means that a manual exists which tells you exactly *what* to do, but does not tell you *why*. Merck does this to prevent other companies from replicating their tests. You have to trust that if you carry out a Merck nitrite-test, you are actually measuring nitrite.

E coli bacteria

The presence of E coli bacteria is determined as follows. An E coli bacterium cannot be seen with the naked eye. But bacteria multiply at a fast rate. This test makes use of this rapid multiplication. By hand, a laboratory employee carefully applies a thin layer of water from the water sample to a plate, a type of petri dish, which can be sealed with a lid. All equipment must be sterile, such that only bacterial from the water sample may end up on the dish.The dish contains a breeding ground that is especially suitable for E coli bacteria, and (to a far lesser extent) for other bacteria. The E coli bacteria now multiply rapidly.

If a dish prepared in this way is left for 48 hours at 37 degrees Celsius, every bacterium multiplies to create a 'colony'. These colonies easily well visible to the naked eye and can be used to identify the types of bacteria present.

A. Now test your water samples as a group and write down the results.

Test results:

Nitrite ----------

Acidity (pH) ----------

E coli bacteria ----------

B. Does your water meet the Blue Flag requirements?
I am sure / unsure of this, because.....

C. Suppose your water does meet the requirements, would you trust the results enough to swim in it?
I would / would not trust it because.....

D. Can you tell from your test results if the water meets the requirements?

.....

If not, what information is it that you are still missing?

.....

2.5 Task 5 – Can you trust your measurement results?

The aim of this task

- Students reflect on the procedure followed during the testing process and to what extent it influences accuracy.
- Students consider the limited accuracy of the (colour) indicator test, using copper sulphate.

Contribution to the overall question

- This activity contributes to awareness of the fact that results may not be considered as very exact and that mention of this uncertainty should be included in any advice issued.

Chemical contents

- Accuracy of colorimetric analysis, using copper sulphate solution as an example.

The results of measurements are actually lists of numbers. To what extent can you be sure that the concentration of your sample really is representative for the water sample? In this activity we reflect on the testing procedure: what types of measurements did you carry out and how accurate were they?

Activity.1 for students: Did you measure properly?

As you noticed, all tests from the Merck kit were so-called black box tests (which mean that you do not know exactly what happens in the tests but only carry them out). This was also the case for the E-coli-bacteria tests. All you had to do is to make sure that you tested what you wanted to test. Perhaps you did not always strictly follow the instructions.

- Do you think you carried the tests out well?
- What does this means for the results of your measurements?

(see worksheet for task 5.1)

Using a given series of 10 coloured copper sulphate solutions with given concentrations, two 'anonymous' solutions should be placed in their appropriate location within the series.

Activity 2 for students: Accuracy of the measurement results

As you may have noticed, all tests from the Merck kit are based on the same principal: the higher the concentration of the solute, the more intense the colour of the solution. In some ways this also applies to the acidity test. For this reason, such measurements are called colorimetric determinations. To get an impression of the accuracy of a colorimetric determination you will be provided with a series of test tubes, numbered 1 to 10.

- Put them in the correct order
- Where do the samples in numbers 11 and 12 fit in?

(see worksheet for task 5.2)

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Worksheets for task 5

Task 5.1: Did you measure correctly?

As you noticed, all tests from the Merck kit were so-called black box tests (which means that you do not know exactly what happens in the tests but only carry them out). This was also the case for the E-coli-bacteria tests. All you had to do is to make sure that you tested what you wanted to test. And perhaps you did not always strictly follow the instructions. Do you think you carried out the measurements correctly?

A. How can you tell if a test and the way in which you carried out this test actually measured what you want to measure?

.....

B. Think back to the tests that you carried out and how you carried them out. Do you trust them more now?

Yes / no, because.....

C. What does the user manual say about the accuracy of the E-coli test?

.....

D. Do you think this claim is sufficiently accurate?
I think in this case the E coli-test was / was not sufficiently accurate because

.....

Task 5.2: Accuracy of the acidity and nitrite testing

As you may have noticed, all tests from the Merck kit are based on the same principal: the higher the concentration of the solute, the more intense the colour of the solution. In some ways this also applies to the acidity test. For this reason, such measurements are called colorimetric determinations. To get an impression of the accuracy of a colorimetric determination you will be provided with a series of test tubes, numbered 1 to 10. The tubes contain solutions with different concentrations of copper sulphate.

A. Arrange the tubes in order of ascending concentration, starting with the lowest concentration.

Concentration (in mg/l)	0	25	50	75	100	125	150	175	200	250
Number										

B. Did everybody choose the same order?

If the tubes have been put in the correct order, you will now receive tubes 11 and12.

C. Now estimate the concentration of copper sulphate in numbers 11 and12.

.....

D. What do you think of the accuracy of colorimetric determinations? Explain.

.....

E. Think back of the colorimetric determinations you carried out with the Merck kit. Do you think these were sufficiently accurate? Explain.

.....

2.6 Task 6 – Comparison with other countries

The aim of this task

- Students should compare the quality of swimming water in the Netherlands and Spain over a number of years.
- Students should identify differences in numbers, types and spread of swimming areas.

Contribution to the overall question

- By looking at quality in a broader sense, students can put their advice in an (inter)national context.

Mathematical content

- Compare and interpret diagrams.
- Interpret maps.

Heading for your favourite beach? Is the swimming water clean? Europeans have a diverse choice of beautiful beaches and bathing zones and many will look forward to cooling down in the sea water during long summer days. The quality of swimming water at your favourite beach or holiday destination can be an important factor in deciding where you will go. To help Europeans make their decisions between beaches, an annual report of the quality of coastal and bathing areas has been made, as reported by EU countries. The report assesses the quality of the swimming water in all 27 EU-countries during the swimming season of 2008 and thereby gives an indication of the areas where the quality of the swimming water is expected to be good in this year. Details of the swimming water quality in all EU countries for the 2008 season can be found in the national swimming water reports at www.eea.europa.eu/themes/water/status-and-monitoring/state-of-bathing-water-1.

Activity 1 for students: Comparing graphs and maps

The figures show compliance with Blue Flag standards in the Netherlands and Spain. Figure 1 shows a graph of swimming water and Figure 2 of bathing zones in coastal waters in the Netherlands. Figure 3 and 4 provide the same information for Spain.

- What can you find exactly in these graphs?
- Compare how the data changes over time for the Netherlands and Spain.
- Are there any notable years? Can you imagine why?
- Which country appears to have the best quality swimming water?

(see worksheet for task 6.1)

Worksheets for task 6

Task 6.1: Interpret and compare graphs

The four figures below show compliance with the set norms in the Netherlands and Spain of inland swimming water and of seaside bathing zones.

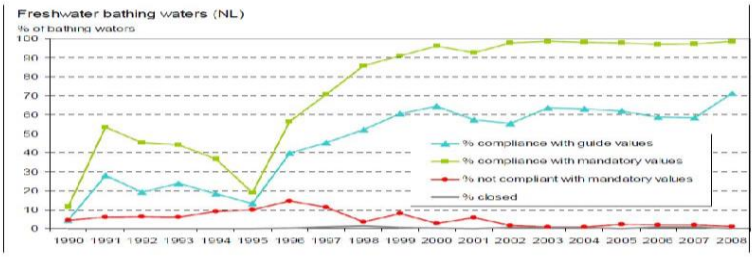

Figure 1

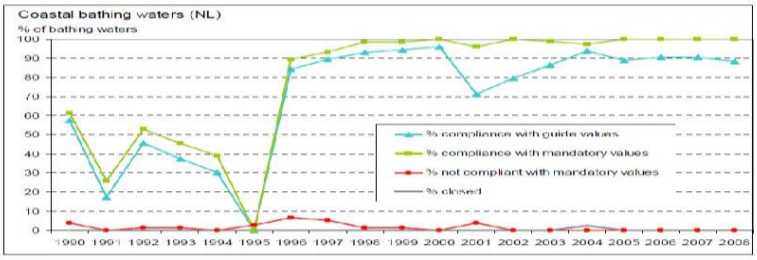

Figure 2

A. Comparing figures 1 and 2; what can you conclude?

B. According to the graphs, were there any notable years? What is special about these years?

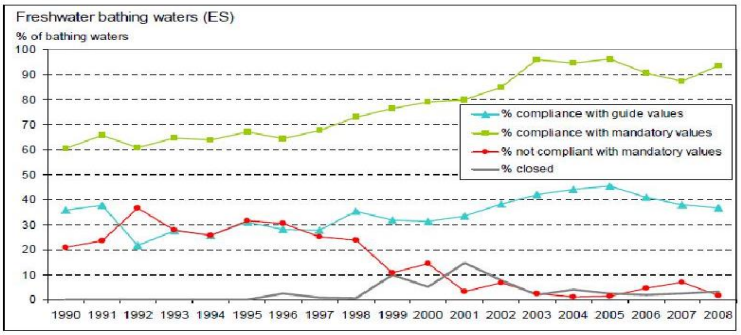

Figure 3

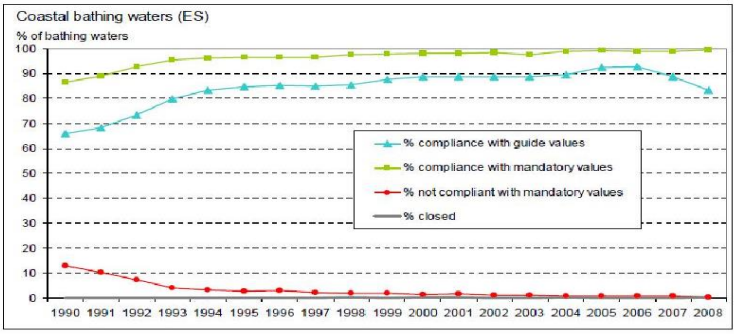

Figure 4

C. Comparing figures 3 and 4; what can you conclude?

D. What can you say about the difference in quality between the two countries? Which country has a better water quality?

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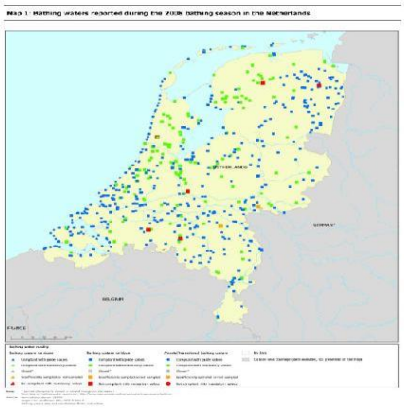
The figures below show the bathing zones in the Netherlands and Spain.



E. Compare the maps of the Netherlands and Spain. How can you explain similarities and differences?

F. Do both countries have a comparable number of bathing areas?

2.7 Task 7 – Discussion and advice

The aim of this task

The students summarise all the research they have carried out and provide advice for the local tourist office.

Now that all the steps in testing and determining water quality have been taken, you now need to give clear advice on whether the water is safe: is it safe to swim in it?

Final activity for students: provide advice for your local tourist office

Formulate advice for your local tourist office in which you indicate why tourists should come and swim in your area. This report should refer to the sample tests that you carried out and their results. Also add a map of the swimming locations you tested in your area.