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The Rhine
for Beginners





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Introduction

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1 Clean? – Chemistry

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The Rhine is used for drinking water production and some people go swimming in its branches. How clean is the water today?

2 Living? – Biology

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30 years ago, following a chemical accident near Basel, life in the Rhine was extinct along large stretches. Which animals and plants are living in the Rhine today?

3 Wild? – Physics

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The Rhine is controlled and canalized along large stretches. But floods are threatening. Which preventive actions are taken?



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After the Sandoz accident in 1986, tons of eel were disposed of and Rhine alarm was raised down to the Netherlands.

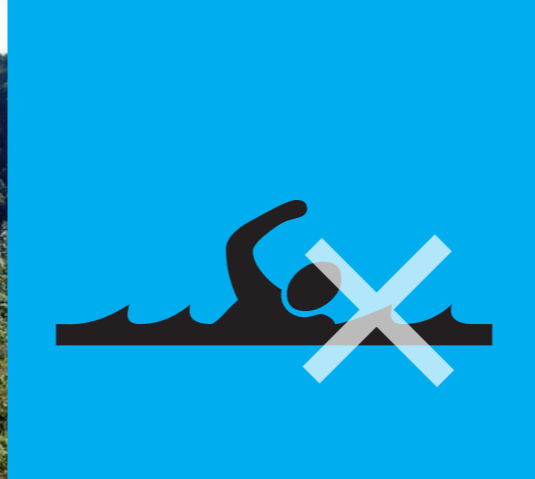
International Rhine

Water flows across the frontiers. 9 states share the Rhine catchment with its countless sources, brooks and tributaries.

The ICPR = International Commission for the Protection of the Rhine was founded in 1950. At first, it fought against the use of the Rhine as wastewater sewer. That was the main problem until the 1970s. As more and more wastewater treatment plants were built, the river recovered, but in 1986, a warehouse for chemicals of the Sandoz works near Basel in Switzerland burnt down. Highly toxic wastewater polluted with pesticides flowed into the Rhine, turned the river blood-red and caused fish death along several hundreds of kilometres. For weeks, the riparian waterworks from Germany to the Netherlands could not use Rhine water for drinking water production.



Rhine 2020



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Required standard: Good

After the disaster along the Rhine, the Rhine bordering states triggered the Rhine Action Programme in 1987. The target was to cut the pollutant load by half, to revitalise the ecosystem and to enable salmon to return to the Rhine. Additionally, a Warning and Alarm Plan aimed at rapid reporting of accidents.

The European Union boosted the project with the "Water Framework Directive" in 2000 and with the "Floods Directive" in 2007. In these Directives, river districts are considered as entities, respectively as ecosystems and the objective is set for all water bodies to achieve the "good status" and flood

damages are to be reduced. The corresponding ICPR programme is "Rhine 2020".

The states along the Rhine aim at jointly achieving three targets:

- 1) Rhine water is to become cleaner.
- 2) The Rhine system is to recover biologically.
- 3) Flood prevention is to be improved.

1 Clean Rhine? – Chemistry

Has the water of the Rhine become cleaner?

Yes - on the whole, water quality has improved!

The wastewater load has diminished.

It is not possible to directly drink Rhine water, but 30 million inhabitants use Rhine water treated in waterworks.

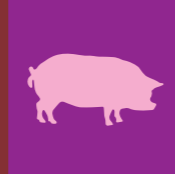
Can we go bathing in the Rhine?

No - not as far as the main stream downstream of Basel is concerned, as EU standards for bathing waters are not met. Strong currents and navigation may threaten the lives of the swimmers.

Is fish from the Rhine edible?

Yes - to a certain extent. Fish in the Rhine, e.g. fatty eels still contain numerous toxins, such as dioxins and mercury.

Salmon are protected all year long and there is a ban on salmon fishing.



Industry & Power Plants
Metals (e.g. mercury)
Chlorinated hydrocarbons
accumulating in fish
(e.g. HCB)

Microplastics
e.g. originating from cosmetics
accumulate pollutants and are
resorbed by aquatic
animals.



Oestrogens
from oral contraceptives,
may feminize, male fish!



Micro-pollutants from households
Pharmaceuticals, hormones,
odoriferous substances in detergents

Remedy for Father Rhine?
The concentration of micro-
pollutants in the Rhine water
corresponds to a pill dissolved in a
swimming pool, but highly dissolved
diclofenac e.g. gets the fish down.

© J. Schneider



Agriculture
Fertilizers
Chemical plant protection



© Stadtentwässerung Koblenz

1a Problematic substances

Why does the list of noxious substances become longer and longer?

- Because it has been easier to detect pollutants
- Because new pollutants are being produced.

1b Treatment Plants

Success for Water Quality

- Today, 96 % of the 60 million inhabitants in the Rhine catchment are connected to treatment plants.
- Nitrogen and phosphorus discharges have been heavily reduced.
- The quantities of further substances carried by the Rhine into the North Sea have strongly diminished, as they are being recycled or have been phased out.
- Also, international conventions to reduce certain pollutants (e.g. mercury) have entered into force.

What remains to be done?

- Continuously reduce pollutants!
- Further improve wastewater treatment plants!

As an example, active carbon filters may filter micro-pollutants from wastewater. So far, traditional wastewater treatment plants discharge pharmaceuticals contained in urine and artificial odoriferous substances from detergents into the Rhine.



© J. Schneider



Do you know how many...?
...little flies play
In the bright summer heat?
How many little fishes
cool themselves
In the clear water tide?

Lullaby by
Wilhelm Hey (1837)

© K. Wendling



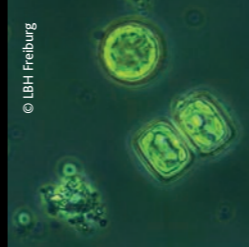
Biology Monitoring Programme

Periodic inventories of the biocoenosis in the Rhine document and assess their state.



© P. Hebert

Zooplankton



© LBH Freiburg

Phytoplankton



© M. Mañas

Molluscs

The **river nerite** *Theodoxus fluviatilis* lives on diatoms browsed from stones. Its spreading in the Rhine indicates ecological improvement.



© A. Kureck

Insects



Crayfish are omnivorous, they feed on insect larvae, molluscs, fish and plants.

The **mayfly** *Ephoron virgo* only flies for one summer evening, and then there are swarms of them. For one year, its larvae live on the bottom of the Lower Rhine and filter the smallest food particles from the Rhine water.

2 Living Rhine? – Biology

How many fish species are living in the Rhine today?

64 - all but the sturgeon have returned!
The species number is almost complete, but the species composition is different from what it used to be. Today, carp species such as roach and immigrated gobies are dominant.

What plants are living in the Rhine?

Algae, the so-called phytoplankton, are floating in the water. Diatoms live on the water bottom. Higher species of water plants such as pond weeds are living on the river banks and in side waters.

Are there other animals in the Rhine?

Apart from fish, the Rhine fauna includes worms, mussels, snails, crustaceans, insects, birds and mammals. From the Alpine Rhine until the North Sea, more than 500 invertebrate species were detected on the bed of the Rhine.

2a Biological Network

The Rhine ecosystem is as strong as the links of its food chains.

Fish

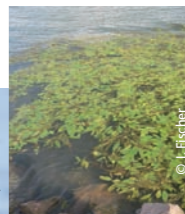


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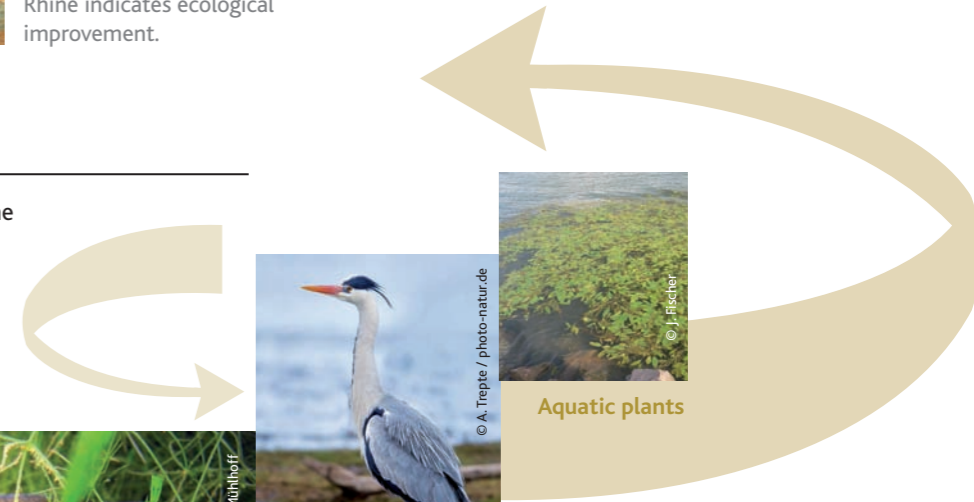
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Birds



© J. Fischer

Aquatic plants





The **spinycheek crayfish** comes from North America and is crowding out the European crayfish.

Via the Rhine-Main-Danube Canal the **round goby** (photo redd) has immigrated from the Black Sea into the Rhine system.

Nuttall's waterweed originally came from North America.

For some time, the **Asian clams** were the most common mussel species in the Rhine but are today declining, which might be due to reduced thermal discharges.



The **Egyptian goose** has fled from European zoos and is spreading from the Netherlands upstream the Rhine system.

Salmon again migrate upstream from the North Sea and into the Upper Rhine and Rhine tributaries.



2b New Rhine species

Is the species diversity in the Rhine natural?

The biology of the Rhine has become more diversified, but it is not, what it used to be. Several non-indigenous species, so-called *alien* species have immigrated from faraway countries or have come attached to the hulls of ships, for example.

Invasive species

(at times) crowd out native species and may be a threat to natural ecosystems. Some of the new species in the Rhine are considered to be "invasive".

2c Ecological Balance

A good sign

In 2015 and compared to previous years, the biomass of plankton algae in the Rhine has sunk

- as less nutrients enter the river
- because the immigrated species, such as mussels filter out the algae.

What remains to be done?

- River banks, tributaries and brooks must be made more natural!
- Downstream migrating eel and other fish must be protected against turbines of hydropower plants along the Rhine!

Success of the Master Plan Migratory Fish

In future, salmon, sea trout, sea lamprey and allis shad are supposed to migrate upstream as far as Switzerland and to reproduce naturally. By 2012 and with a view to achieving this target:

- 480 barriers in the Rhine system were made passable for fish
 - 80 alluvial water bodies were reconnected with the river
 - 21 % of spawning biotopes were again made accessible.
- Since about the year 2000, annually several hundreds of salmon again migrate upstream into the Upper Rhine and reproduce naturally in the accessible salmon waters!



The **floodplain forests along the Rhine** are havens of biological diversity, they tolerate floodings, filter water, fill-up underground aquifers and retain floods.



View from the Isteiner Klotz upstream the Rhine towards Basel (Painting of Peter Birnmann about 1800)



Cut-off meander of the Rhine at Kùhkopf 1829

Today, the Kùhkopf is an island



3 Wild Rhine? – Physics

Why do floods occur in the Rhine?

Variations of the water level are quite a normal phenomenon. They are caused by the seasons, precipitation and snow melt.

What room does the river need?

In natural rivers, floods spread to the floodplains. Floodplains are valley areas which are naturally flooded, retain water and reduce flow velocity.

Is there any life in the floodplains?

Floodplains offer valuable habitats for rare plants and animals which tolerate or even love varying water levels, such as amphibians.

3a As his bed has been made...

The formerly winding and braided river has been straightened, modified and cut off its alluvial areas and oxbow lakes. However, the modified bed of the Rhine is not capable of coping with high flood stages. That means that flood water may flow into former alluvial areas where people are living and working today. Also, in the main stream, the flood surge flows more rapidly than it would be natural.



Flood near Cologne 1995



Before relocating the dike Lent-Nijmegen, in the past



After relocating the dike Lent-Nijmegen, today



Flood near Koblenz



The Rhine-Atlas available under www.iksr.org indicates the settlements and industrial areas at risk of floods as well as EU nature protection areas and cultural heritage sites along the entire Rhine.

3b Flood prevention

During the 1990s, great floods along the Middle and Lower Rhine caused damages worth millions of euros. That is why the ICPR drafted and implemented an Action Plan on Floods. Today, all EU member states must coordinate their flood prevention in the different river districts.

More room for the river:

- = create retention areas along the river
 - Open oxbow lakes to the river
 - Relocate dikes
 - Create controllable retention areas

What are the objectives?

1. International planning and coordination of flood prevention
2. Protect people, goods, the environment and cultural heritage against negative flood impacts
3. Reduce the risk of flood-related damages
4. Lower flood levels
5. Increase awareness (e.g. risk maps)
6. Improve forecasting and announcement systems

3c Wild Rhine - Balance

Successful flood prevention

- Since 1995, the states in the Rhine catchment have invested more than 10 billion euros into flood prevention measures.
- The population is being warned at an earlier stage and information has improved.
- By the end of 2014, retention areas had been created on the Upper and Lower Rhine with a capacity of 251 million m³.
- In the Rhine delta, foreshores have been dugged off to widen the river bed.
- Areas have been renaturalized along tributaries.
- Dikes have been restored, reinforced or relocated.

What remains to be done?

- Increase alluvial and retention areas:
Target: 535 million m³ by 2030
- Improve flood announcement and effective information of the public!



The Rhine for Beginners

The Rhine

- is 1,233 km long and connects the Alps with the North Sea
- is an old **settlement axis** with rich urban culture since Roman times
- today represents the most important **economic axis** in Central Europe
- with its tributaries without the Meuse covers a catchment area of about 200,000 km²
 - All sources, brooks and rivers in this catchment pour into the North Sea
 - 60 million people are living in the 9 states of this catchment
 - 30 million people drink treated Rhine water.



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