The Rhine for Beginners
Introduction

1 Clean? – Chemistry

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

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

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

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.
Clean Rhine? – Chemistry

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.

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.
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.

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.

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

Agriculture
- Fertilizers
- Chemical plant protection

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

Oestrogens from oral contraceptives, may feminize, male fish!

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

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
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2a Biological Network

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

Do you know how many...?

... little flies play
In the bright summer heat?
How many little flies cool themselves
In the clear water tide?

Lullaby by Wilhelm Hey (1837)

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.

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.

What plants are living in the Rhine?
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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.

Fish

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

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

Zooplankton

Phytoplankton

Aquatic plants

Insects

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

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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!
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.
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 digged 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
- 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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