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Water Quality

The E13 indicator records changes in the water quality of Switzerland's standing waterbodies, watercourses, and groundwater as regards nutrient load. Apart from a few minor watercourses on the Central Plateau, water quality is presently good in all bodies of water nationwide. Since species richness is greater in clean as opposed to polluted rivers and lakes, this development has a favorable impact on Switzerland's waterfauna. While groundwater quality as assessed by nutrient load is generally good as well, nitrate concentrations are frequently found to be too high in areas subjected to intensive land use, such as settlements and agricultural regions.

Status: October 2010

Contents

The indicator details the development of nitrate and orthophosphate concentrations in watercourses, total phosphorus concentrations in lakes, and nitrate concentrations in groundwater, complemented by changes in the water temperature of watercourses. However, assessing the quality of a body of water also inevitably requires considering water withdrawals and control structures (cf. E11 and E12 indicators).

Since available data is primarily the result of measurements geared to implementation of legal requirements, reported findings are limited to the situation in Switzerland overall and to select examples.

Development in Switzerland

Nitrate concentrations and five-day biochemical oxygen demands (BOD_5) have been low in most major rivers since the 1980s, leaving water quality virtually unaffected. BOD_5 values indicate the total amount of oxygen aquatic bacteria consume within a time span of five days in order to break down organic waste. The higher this value, the higher the organic load found in water. BOD_5 values in Switzerland's watercourses are so low that they are often no longer surveyed at all. Ever since laundry detergents have to be phosphate-free by law, orthophosphate concentrations have been dropping sharply, too. However, to this day, nitrate and orthophosphate levels are still too high in some minor watercourses on the Central Plateau.

Most lakes have also regained good water quality by now. As a result of—among other things—wastewater treatment plants being extended and upgraded, total phosphorus concentrations have been decreasing for the past 20 years in a large number of Swiss lakes.

Water temperatures have been rising in many of the Central Plateau's watercourses for the past 30 years, both in the winter and in the summer. This trend makes life difficult for quite a few water dwellers, the Brown Trout being just one example.

Since Switzerland's NAQUA[1] National Groundwater Monitoring program was launched in 1997, groundwater quality has generally remained good. Still, nitrate concentrations are frequently found to be too high, particularly in regions subjected to intensive agricultural land use.

Watercourses

Table 1 below lists nitrate concentrations sampled at 12 measuring stations of the NADUF National River Monitoring and Survey Program between 1976 and 2005. Concentrations are indicated in milligrams of nitrogen per liter (mg/l N), with the 90th percentile computed for every five-year period at each station; n = number of measurements. Color codes characterizing water quality are based on the classification system of the Modular Stepwise Procedure for Chemistry (MSPChem, cf. "Surveying methods"): blue = very good, green = good, yellow = fair, orange = unsatisfactory, and red = bad.

[1] *Federal Office for the Environment 2004: NAQUA – Grundwasserqualität in der Schweiz 2002/2003. Bern. 204 S.*

Tab. 1: Nitrate concentrations at 12 NADUF measuring stations (1976–2005)

Watercourses	Stations	Measuring periods					
		1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005
		mg/l N (n)	mg/l N (n)	mg/l N (n)	mg/l N (n)	mg/l N (n)	mg/l N (n)
Aare	Hagneck	1.6 (104)	1.6 (52)	1.8 (78)	1.7 (51)	2.1 (25)	1.8 (72)
Aare	Brugg	2.0 (125)	2.3 (128)	2.6 (130)	2.7 (127)	2.5 (124)	2.3 (101)
Glatt	Rheinsfelden	5.9 (106)	7.2 (128)	7.4 (129)	7.8 (128)	6.3 (129)	4.5 (52)
Kl. Emme	Littau-Reussbühl	-	2.1 (74)	2.2 (47)	2.3 (76)	1.6 (25)	1.7 (122)
Reuss	Mellingen	1.1 (129)	-	1.5 (104)	1.6 (78)	1.1 (25)	1.4 (128)
Rhine	Diepoldsau	0.7 (106)	0.8 (128)	0.9 (130)	0.8 (130)	0.8 (130)	0.8 (131)
Rhine	Rekingen	1.6 (127)	1.7 (130)	2.0 (131)	1.8 (129)	1.7 (127)	1.7 (130)
Rhine	Village Neuf/ Weil	1.9 (104)	2.0 (129)	2.2 (130)	2.3 (129)	2.0 (130)	1.9 (131)
Rhone	Porte du Scex	0.8 (129)	0.8 (130)	1.0 (129)	0.9 (130)	0.8 (125)	0.8 (126)
Rhone	Chancy	0.5 (69)	0.6 (52)	0.9 (129)	0.9 (131)	0.8 (127)	0.9 (123)
Saane	Gümmenen	-	-	2.0 (103)	1.8 (52)	2.2 (26)	2.1 (50)
Ticino	Riazzino	0.6 (83)	0.6 (50)	1.2 (74)	1.1 (26)	1.1 (76)	1.2 (26)

Comments

- Substance concentrations are color coded in accordance with the Modular Stepwise Procedure for Chemistry (cf. “Surveying methods”). Good and very good values (blue and green) fulfill the requirements stipulated by the Ordinance on Water Protection (WPO).
- For decades, nitrate concentrations have remained within a range that may be considered ecologically safe. The only place where levels have been exceeding the legally required threshold of 5.6 milligrams of nitrogen per liter until the late 1990s was the Glatt river near Rheinsfelden.
- 1 mg/l of nitrogen correspond to 4.43 mg/l of nitrate.
- The following measuring stations have not been sampling continuously: Hagneck, Littau, Mellingen, Gümmenen and Riazzino.
- There are no measurement data available for the following periods: Kleine Emme 1976–1980, Reuss 1981–85, Saane 1976–80 and 1981–85.
- Measurements were made based on bulk samples taken over a period of 14 days.

Table 2 below lists orthophosphate concentrations sampled at 12 measuring stations of the NADUF National River Monitoring and Survey Program between 1976 and 2005. Concentrations are indicated in milligrams of phosphorus per liter (mg/l P), with the 90th percentile computed for every five-year period at each station; n = number of measurements. Color codes characterizing water quality are based on the classification system of the Modular Stepwise Procedure for Chemistry (MSPChem, cf. “Surveying methods”): blue = very good, green = good, yellow = fair, orange = unsatisfactory, and red = bad.

Tab. 2: Orthophosphate concentrations at 12 NADUF measuring stations (1976–2005)

Watercourses	Stations	Measuring periods					
		1976–1980	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005
		mg/l P (n)	mg/l P (n)	mg/l P (n)	mg/l P (n)	mg/l P (n)	mg/l P (n)
Aare	Hagneck	0.04 (103)	0.03 (52)	0.02 (72)	0.02 (51)	0.02 (25)	0.01 (72)
Aare	Brugg	0.15 (124)	0.11 (125)	0.08 (124)	0.05 (127)	0.03 (124)	0.03 (100)
Glatt	Rheinsfelden	1.38 (105)	1.0 (125)	0.41 (125)	0.13 (130)	0.13 (130)	0.08 (52)
Kl. Emme	Littau-Reussbühl	-	0.08 (75)	0.07 (47)	0.04 (76)	0.03 (25)	0.03 (123)
Reuss	Mellingen	0.1 (128)	-	0.06 (98)	0.05 (78)	0.01 (25)	0.02 (128)
Rhine	Diepoldsau	0.03 (105)	0.02 (130)	0.01 (124)	0.01 (130)	0.01 (130)	0.01 (130)
Rhine	Rekingen	0.12 (126)	0.09 (130)	0.06 (125)	0.04 (129)	0.02 (128)	0.02 (128)
Rhine	Village Neuf/ Weil	0.16 (103)	0.14 (129)	0.09 (124)	0.06 (129)	0.03 (130)	0.03 (131)
Rhone	Porte du Scex	0.05 (128)	0.03 (130)	0.02 (123)	0.02 (130)	0.02 (124)	0.01 (126)
Rhone	Chancy	0.06 (68)	0.08 (52)	0.08 (123)	0.06 (131)	0.05 (126)	0.04 (124)
Saane	Gümmenen	-	-	0.03 (97)	0.02 (52)	0.02 (26)	0.01 (50)
Ticino	Riazzino	0.01 (82)	0.02 (50)	0.02 (67)	0.02 (26)	0.02 (76)	0.01 (26)

Comments

- Substance concentrations are color coded in accordance with the Modular Stepwise Procedure for Chemistry (cf. “Surveying methods”). Good and very good values (blue and green) meet the target.
- Phosphate (PO_4^-) concentrations are mostly ecologically safe nowadays. Ever since the use of phosphates in laundry detergents was banned in 1986, phosphate levels in watercourses have undergone a marked decline.
- Since 2000, a large number of measured orthophosphate values has been failing to meet the limit of quantification at the Porte du Scex measuring station. These values have been replaced by values corresponding to 50% of the lower threshold value.
- The following measuring stations have not been sampling continuously: Hagneck, Littau, Mellingen, Gümmenen and Riazzino.
- There are no measurement data available for the following periods: Kleine Emme 1976–1980, Reuss 1981–85, Saane 1976–80 and 1981–85.
- Measurements were made based on bulk samples taken over a period of 14 days.

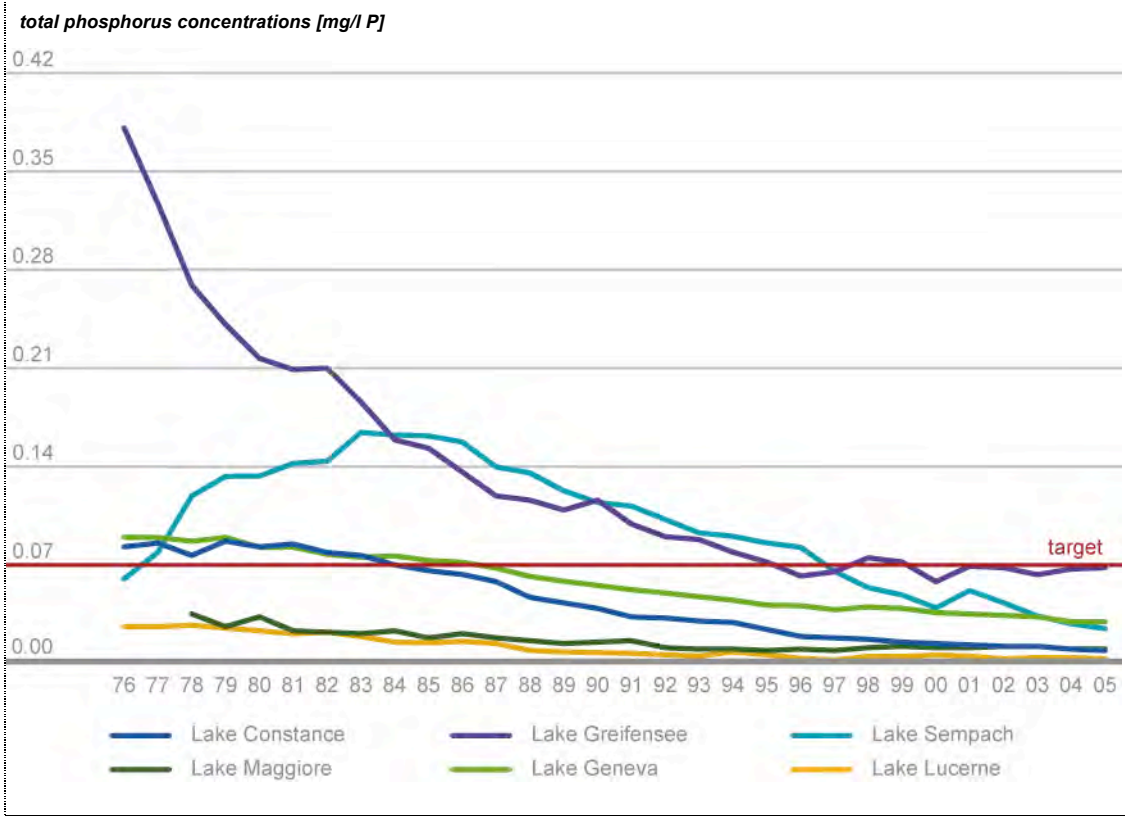
Lakes

While total phosphorus (P_{tot}) values in some lakes were still high above today’s target as stated in the Modular Stepwise Procedure for Chemistry (MSPChem) until the early 1980s, today’s water quality in most Swiss lakes is good again as regards their phosphorus loads. However, MSPChem requirements concerning total phosphorus concentrations are not met everywhere yet. Particularly lakes located in densely settled regions or surrounded by large agricultural catchment basins such as Lake Zug or Lake Greifensee partly exceed target values to this day.

densely settled regions or surrounded by large agricultural catchment basins such as Lake Zug or Lake Greifensee partly exceed target values to this day.

Figure 1 below illustrates the development of mean total phosphorus concentrations in select Swiss lakes between 1976 and 2005. Curves reflect mean values in milligrams of phosphorus per liter (mg/l P).

Fig. 1: Changes in mean annual P_{tot} concentrations in select Swiss lakes (1976–2005)



Comments

- Since wastewater treatment plants have been upgraded and phosphates have been banned from use in laundry detergents (in 1986), total phosphorus concentrations have been declining in a great many Swiss lakes for the past twenty years.
- Total phosphorus concentration data of Lake Maggiore is lacking for the years 1976 and 1977.
- Total phosphorus concentrations are measured during spring overturn, when lake waters are mixed from top to bottom.
- Total phosphorus concentrations are established based on unfiltered water samples (raw water).
- Nowadays, only minor lakes located in large agricultural catchment basins, such as Lake Greifensee, are affected by increased total phosphorus concentrations.
- For water samples of a lake to be included in this analysis, measurement series had to be as complete as possible.

Groundwater

Groundwater data has been acquired by the NAQUA National Groundwater Monitoring program. The NAQUA monitoring network consists of just under 550 measuring sites representatively distributed throughout Switzerland.

Table 3 below lists percentage shares of measuring sites in concentration categories established based on maximum nitrate concentrations measured at each site between 2002 and 2009. Measuring sites were categorized according to FOEN guidelines (2009).

Tab. 3: Percentage shares of NAQUA measuring sites in concentration categories (2002–2009)

Nitrate concentrations [mg/L]	Percentage shares of measuring sites in each category							
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
≤ 10	40	39	38	44	36	39	47	47
10–25	42	42	42	37	39	40	37	36
25–40	15	16	14	15	19	17	13	14
> 40	3	4	5	4	6	5	4	3
Number of measuring sites	448	445	456	526	469	482	526	531

Comments

- Nitrate concentrations were assigned to categories according to FOEN guidelines (2009).
- The NAQUA National Groundwater Monitoring program covers just under 550 measuring sites representatively distributed throughout the country. Sites are sampled one to four times a year.
- A little over 80% of all measuring sites yield nitrate concentrations considered to represent good water quality. Groundwater nitrate concentrations have slightly increased between 2003 and 2006, subsequently declining again somewhat.
- As per the Ordinance on Water Protection (WPO), groundwater that is being used or designed to be used as potable water shall be legally required to contain no more than 25 milligrams of nitrate per liter. In accordance with the Ordinance on Foreign Matter and Components in Foodstuffs issued by the Federal Department of Home Affairs FDHA on June 26, 1995, the tolerance level for potable water has been set at 40 milligrams of nitrate per liter. The level required by the WPO is exceeded at roughly 20% of all measuring sites.
- Minimum deviations of ±1% against total percentage shares of 100% in 2003, 2004, 2007 and 2008 have been caused by round-off differences.

Development on the Central Plateau

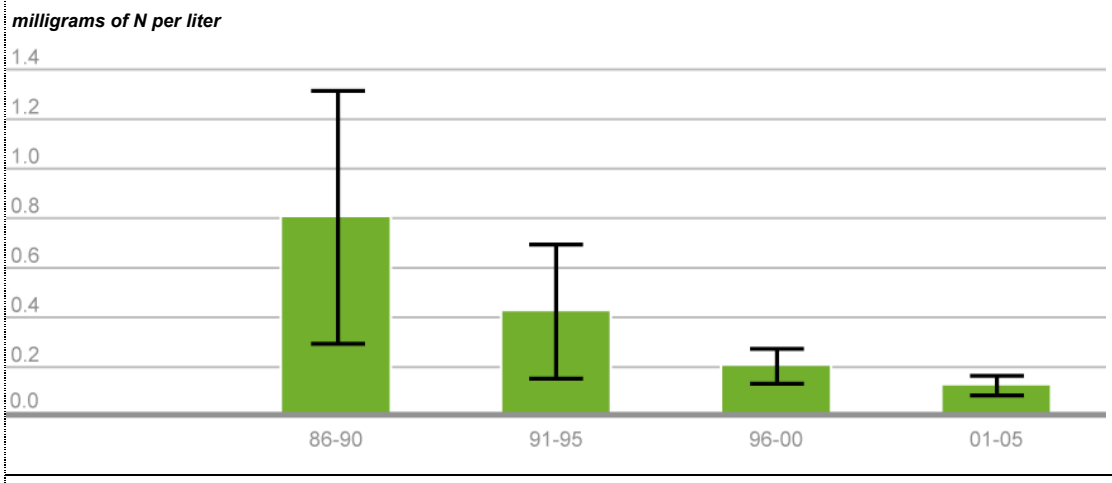
In addition to the measuring stations of the NADUF National River Monitoring and Survey Program, there is a large number of watercourse measuring sites operated by cantonal authorities. However, as most measurements—both on a cantonal and on a national level—are geared to implementation of legal requirements, regular monitoring for years on end is rare.

Table 4 below lists ammonium, nitrate and orthophosphate concentrations in watercourses on the Central Plateau between 1986 and 2005. 90th percentiles have been computed for every five-year period at each site. The table indicates means of 57 measuring sites with a 95% confidence interval.

Tab. 4: Ammonium, nitrate and orthophosphate concentrations in watercourses on the Central Plateau (1986–2005)

	Measuring periods			
	1986–1990	**1991–1995**	**1996–2000**	**2001–2005**
Ammonium (mg/l N)	0.81 (0.30–1.33)	0.43 (0.17–0.70)	0.21 (0.14–0.28)	0.13 (0.10–0.17)
Nitrate (mg/l N)	5.0 (4.3–5.8)	4.9 (4.1–5.7)	4.3 (3.7–5.0)	4.0 (3.5–4.6)
Orthophosphate (mg/l P)	0.16 (0.12–0.20)	0.13 (0.09–0.17)	0.09 (0.06–0.12)	0.07 (0.05–0.09)

Fig. 2: Development of mean ammonium concentrations on the Central Plateau based on mean 90th percentiles computed for periods of 5 years (1986–2005)



Comments

- Since the start of the measurement series until the early 1990s, mean ammonium concentrations were still above the legally required value of 0.4 milligrams of nitrogen per liter.
- Between 1986 and 2005, mean nitrate concentrations remained below the legally required value of 5.6 mg/l of nitrogen as stipulated by the Ordinance on Water Protection.
- Exceeding the required value determined in accordance with the MSPChem from 1986 until 2005, mean phosphate concentrations are assessed to be unsatisfactory or bad.
- As water is frequently being sampled geared to implementation of legal requirements, sampling is characterized by differences in time and location. For this reason, both the nature and the frequency of surveys tend to vary considerably from canton to canton. While watercourses may be individually sampled 4, 12 or more times a year, water quality surveys may also be based on 12 to 365 24-hour bulk samples a year.

- As regards the Central Plateau, BDM does not consider all measuring sites listed in the Hydrological Atlas of Switzerland, but focuses on those 57 cantonal measuring sites that provide complete measurement series on all three monitored parameters (ammonium, nitrate and phosphate).

Additional findings

Five-day biochemical oxygen demand (BOD_5)

The five-day biochemical oxygen demand (BOD_5) is used to determine water pollution with biodegradable substances. Nowadays, this kind of pollution is no longer an issue for the large majority of Switzerland's watercourses, so the BOD_5 is not even surveyed anymore at most measuring sites. However, some of the Central Plateau's minor problem watercourses, such as the Furtbach brook in the cantons of Zürich and Aargau, are still being monitored for their BOD_5 on a continuous basis.

Table 5 below lists the five-day biochemical oxygen demand (BOD_5) as well as nitrate and orthophosphate concentrations (in milligrams per liter) measured in the Furtbach between 1990 and 2009. Color codes characterizing water quality are based on the classification system of the Modular Stepwise Procedure for Chemistry (MSPChem, cf. "Surveying methods"): blue = very good, green = good, yellow = fair, orange = unsatisfactory, and red = bad. Good and very good values fulfill the requirements stipulated by the Ordinance on Water Protection (WPO).

Tab. 5: Five-day biochemical oxygen demand (BOD_5) as well as nitrate and orthophosphate concentrations in the Furtbach (1990–2009).

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
BOD_5 (mg/l O_2)	7.2	6.0	7.9	8.3	4.5	2.5	3.1	1.9	2.7	3.2
Nitrate	11.0	12.0	12.6	11.5	10.1	9.1	9.4	11.1	10.2	8.7
Orthophosphate	0.41	0.54	0.44	0.30	0.32	0.10	0.10	0.12	0.14	0.08

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
BOD_5 (mg/l O_2)	1.9	2.0	2.2	2.9	2.6	2.3	1.7	3.4	1.8	3.2
Nitrate	8.6	7.7	9.1	12.2	10.7	10.4	10.6	9.7	8.6	10.1
Orthophosphate	0.09	0.07	0.09	0.12	0.11	0.12	0.12	0.12	0.10	0.14

 Data source: Zurich Cantonal Office for Waste, Water, Energy and Air AWEL, surface water protection division. Status: 2010

Comments

- Color codes characterizing water quality are based on the classification system of the Modular Stepwise Procedure for Chemistry (cf. "Surveying methods"). Good and very good values fulfill the requirements stipulated by the Ordinance on Water Protection (WPO).

- The five-day biochemical oxygen demand (BOD_5) corresponds to the total amount of dissolved oxygen consumed by microorganisms for biodegradation of organic substances. BOD_5 values are measured at 20°C after a five-day incubation period.[2]
- The “Furtbach” measuring site that the Zurich Cantonal Office for Waste, Water, Energy and Air AWEL is concerned with is located in the community of Würenlos in the canton of Aargau. With about a third of the Furtbach’s water composed of clarified wastewater, wastewater treatment plants have a strong impact on this brook’s water quality. Until the middle of the 1990s, the Furtbach’s water quality was unsatisfactory, particularly due to wastewater not being properly clarified by the overloaded Regensdorf wastewater treatment plant. While the five-day biochemical oxygen demand has dropped below the legally required value of 4 milligrams of oxygen per liter since 1993, nitrate and phosphate concentrations continue to exceed acceptable limits, most likely above all as a result of the large share of agricultural areas situated in the Furtbach’s immediate vicinity (AWEL, 2007).
- Since 2007, daily sampling has been replaced by weekly sampling.

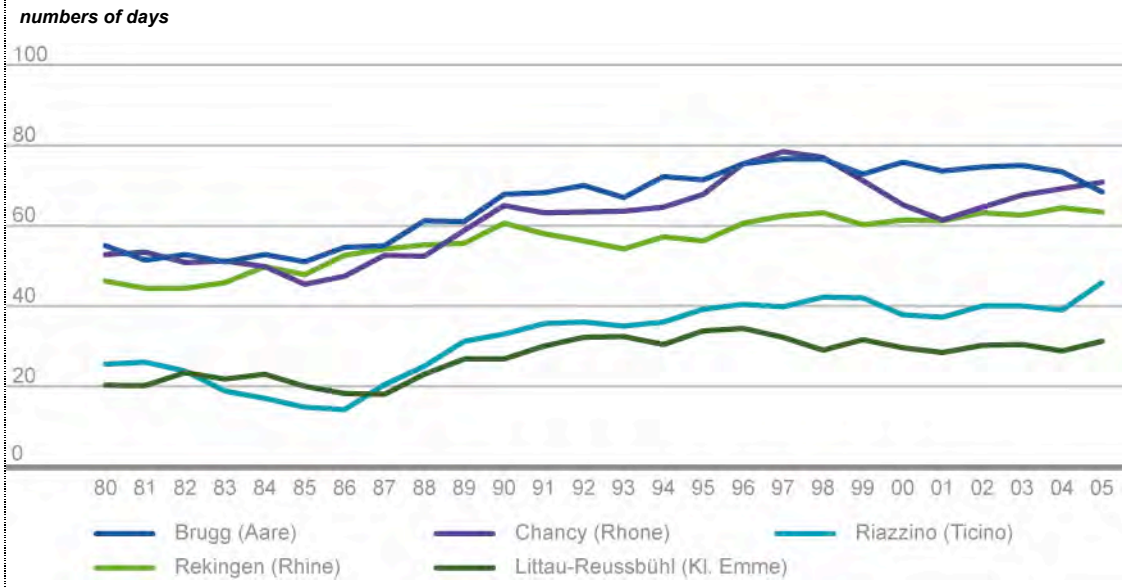
[2] *Zurich Cantonal Office for Waste, Water, Energy and Air AWEL, surface water protection division, 2007. http://www.hw.zh.ch/chemie/fg/913_B.pdf (accessed on September 16, 2008).*

Water temperature

Water temperature not only impacts the development of aquatic organisms, but also has an effect on the occurrence of germs and the solubility of oxygen. For this reason, most measuring stations have been monitoring water temperatures for many years, recording mean daily values.

Figure 3 below illustrates changes in water temperature registered at five select measuring stations in the months of November through May of 1976 till 2005 (load graph data supplied by the FOEN). Curves represent the numbers of days (expressed as moving averages formed over a period of 5 years) on which mean daily temperatures reached at least 9°C. Temperatures dropping below 1°C or exceeding 9°C increase the mortality rate of Brown Trout eggs. Brown Trout primarily spawn during the months of October through January, with optimum water temperatures for their eggs at approximately 5°C.[3] In other words, water temperature is of crucial importance for the biology of this fish species that is so typical for Switzerland's watercourses.

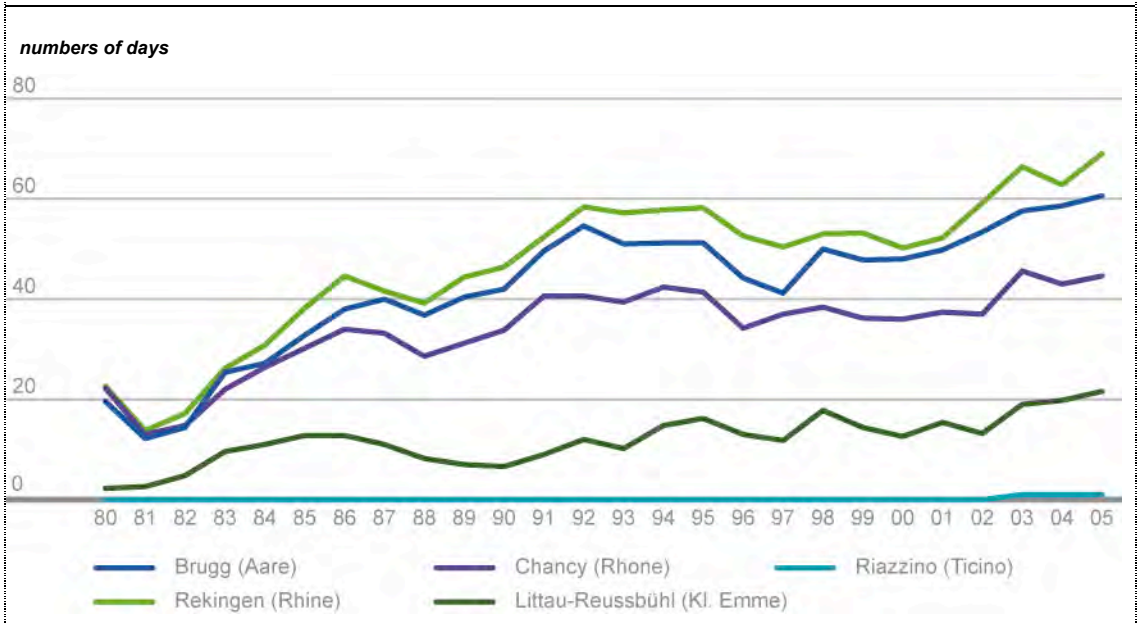
Fig. 3: Changes in the numbers of days on which water temperature reached ≥ 9°C at select stations between November and May (1976–2005)



[3] *Güttinger, H., 2004: Hypothese: Veränderungen der Wassertemperatur haben zu einem Rückgang der Fischpopulation und des Fischfangertrages geführt. In: Dem Fischrückgang aus der Spur. Schlussbericht des Projekts Fischnetz: EAWAG. Dübendorf. 109-116 S.*

Figure 4 below illustrates changes in water temperature registered at five select measuring stations in the summer months of June through October of 1976 till 2005 (load graph data supplied by the FOEN). Curves represent the numbers of days (expressed as moving averages formed over a period of 5 years) on which mean daily temperatures exceeded 19°C. Adult Brown Trout prefer water temperatures to remain between 7°C and 19°C, with the optimum temperature range at 13°C to14°C. Temperatures of more than 15°C lasting for two to four weeks may favor outbreaks of the fatal proliferative kidney disease (PKD), while water temperatures of more than 25°C will not be survived for long. Hence, high water temperatures represent a serious threat for Brown Trout populations.[4]

Fig. 4: Changes in the numbers of days on which water temperature exceeded 19°C at select stations between June and October (1976–2005)



© BDM (E13 indicator). Data source: Federal Office for the Environment FOEN. Status: 2010

Comments

- Water temperature is continuously being monitored at all measuring stations by the Federal Office for the Environment FOEN.
- For reasons of clarity, temperatures measured at the Diepoldsau (Rhine), Hagneck (Aare), Mellingen (Reuss) and Porte Du Scex (Rhone) stations have not been included in the graph.
- Water temperatures measured in the winter semester (November till May) have been rising for the past 25 years. The number of days on which water temperature reached at least 9°C has markedly increased.
- Water temperatures have also been rising in the summer semester. While the number of days on which average water temperatures exceeded 19°C has increased on the Central Plateau, this limit has not been reached at the Riazzino measuring station located at the outskirts of the Alps, even though watercourses have been warming there as well.

[4] *Güttinger, H., 2004: Hypothese: Veränderungen der Wassertemperatur haben zu einem Rückgang der Fischpopulation und des Fischfangertrages geführt. In: Dem Fischrückgang aus der Spur. Schlussbericht des Projekts Fischnetz: EAWAG. Dübendorf. 109-116 S.*

- Between 1976 and 2005, water temperatures have been measured at above 25°C on a total of 32 days, with 22 of these 32 days part of the “summer of a century” in 2003. In the period under review (1976-2005), water temperature in the River Rhine as measured at Rekingen station exceeded 25°C for 21 days, placing the Rhine at the top of this ranking. Mean values for the River Reuss as measured at Mellingen station went above 25°C on 10 days, and even the River Rhone as measured at Chancy station exceeded 25°C on one day. Mean daily values at all other measuring stations always remained below this limit.

Significance for biodiversity

Switzerland harbors not only a large variety of watercourses and standing waterbodies, but also substantial groundwater resources. Owing to such wealth, the country is wholly responsible for preserving these bodies of water and the organisms living in them. The quality of water habitats, however, is determined by more than water quality as such: water withdrawals (cf. E11) as well as control structures on river bottoms and riverbanks, ground sills, river power plants or barrages (cf. E12) are of crucial importance as well.

Until the middle of the 20th century, wastewater was simply discharged into watercourses without any clarification whatsoever, noticeably impairing water quality. Once Switzerland started to build water treatment plants in 1957, water quality was on its way to recovery. Using state-of-the-art treatment techniques resulted in a significant improvement of overall water quality in recent decades.[5]

Nitrate found in water primarily originates in agricultural use, wastewater, and various combustion processes (nitrogen oxide emissions). As vascular plants mainly absorb nitrogen in nitrate form (cf. E6), nitrate ending up in groundwater points to a kind of land use that is not compatible with the local environment. To this day, groundwater monitoring yields increased nitrate concentrations, just under 20% of them even exceeding the legal limit of 25 milligrams of nitrate per liter. This particularly applies to regions subjected to intensive agricultural use or dense settlement, such as the Central Plateau or the valleys of the Jura.

Phosphate has been banned from use in laundry detergents since 1986, causing phosphorus and phosphate concentrations in the water to decline markedly. Primary sources of phosphorus and phosphate are again, as for nitrate, wastewater and agriculture. Declining phosphate concentrations have a favorable impact, since phosphate is the limiting nutrient for algae and other aquatic plants in Switzerland. High phosphate concentrations can result in abundant growth of plant biomass. Microorganisms breaking down dead plant biomass require oxygen, which will then not be available to animals like fish. Moreover, degradation products of plant biomass include cytotoxines such as ammonium. Both the lack of oxygen and the presence of toxic degradation products may cause a waterbody to die, i.e. become inhabitable for most aquatic organisms. Lake Sempach, Lake Hallwil and Lake Baldegg have been aerated with either oxygen or air for more than 20 years to keep them alive.[6]

For certain organisms, ammonium has the effect of a neurotoxin, which makes it very harmful even at low levels. What is more, ammonium (NH_4^+) is at a chemical equilibrium with ammonia (NH_3), a dangerous fish poison. Among other things, this equilibrium depends on water temperature. Increasing water temperatures cause the equilibrium to shift towards ammonia, potentially wreaking havoc on fish populations.

Overfertilization is no longer a major problem for most bodies of water. However, water quality is impaired by pesticides, fuel additives and micropollutants, particularly in small to medium-sized bodies of water on

[5] Federal Office for the Environment, 2006: Wege des Wassers. Magazin UMWELT. 4/2006. S.63.

[6] Spreafico, M.; Weingartner, R., 2005: Hydrologie der Schweiz. Ausgewählte Aspekte und Resultate. Berichte des BWG Serie Wasser Nr. 7. Bern, Bundesamt für Wasser und Geologie. 137 S.

the heavily used Central Plateau. Micropollutants are residues from countless man-made products used in everyday life, such as body care products, medications, hormones, detergents, disinfectants or wood preservatives. These substances are detected in the water at very low levels, as low as micrograms or nanograms per liter. Yet even at very low concentrations, some of these substances may have a negative effect on aquatic ecosystems.

High water temperatures not only have an influence on water chemistry, but also directly impact the biology of aquatic organisms. Any increase in ambient temperature results in an increase in activity, which in turn increases energy and oxygen demands. However, increases in temperature also cause oxygen concentrations in the water to decline. Dependent on a cool and oxygen-rich environment, Brown Trout are easily affected by increases in water temperature, above all in the warmer watercourses of the Central Plateau. As watercourses are warming, Brown Trout habitats shifts to higher altitudes.[7] Conversely, an increase in water temperature in the cold brooks and rivers of the foothills of the Alps and the Alps themselves may have a positive effect on Brown Trout population development, as it creates more favorable habitat conditions.

Deteriorations of water quality and increases in water temperature may be reflected in macroinvertebrate species composition. Large sections of watercourses and standing waterbodies are dominated by species that are less demanding from an ecological point of view (ubiquitists), while species with more specific demands disappear.[8]

Definition

Changes in the levels of problematic organic substances in and the water temperature of Switzerland's watercourses and standing waterbodies as well as changes in groundwater nitrate concentrations.

Surveying methods

Surveying the development of nitrate and phosphorus concentrations as well as water temperatures, the E13 indicator records the water quality of watercourses, standing waterbodies and groundwater in Switzerland. For further information, please consult the Hydrological Atlas of Switzerland. Measured values are reported in milligrams per liter.

Information on the development of Swiss watercourses is based on data acquired at 12 measuring stations of the NADUF National River Monitoring and Survey Program. NADUF has been measuring concentrations of substances found in the water of major watercourses since 1972, with its network of measuring stations operated by the Federal Office for the Environment FOEN, the Swiss Federal Institute of Aquatic Science and Technology EAWAG, and the Swiss Federal Institute for Forest, Snow and Landscape Research WSL. Within the NADUF program, 14-day bulk samples are being analyzed for various chemical parameters. Considering availability of datasets, BDM selected two parameters—nitrate and orthophosphate concentrations—to stand for the total load of Switzerland's watercourses. All

[7] *Güttinger, H., 2004: Hypothese: Veränderungen der Wassertemperatur haben zu einem Rückgang der Fischpopulation und des Fischfangertrages geführt. In: Dem Fischrückgang aus der Spur. Schlussbericht des Projekts Fischnetz: EAWAG. Dübendorf. 109-116 S.*

[8] *Rey, P.; Ortlepp, J., 2002: Koordinierte biologische Untersuchungen am Hochrhein 2000; Makroinvertebraten. BUWAL-Schriftenreihe Umwelt , 345. Bern, Bundesamt für Umwelt, Wald und Landschaft. 98 S.*

information published refers to 90th percentiles. Measuring values are color coded in accordance with the classification system of the Modular Stepwise Procedure for Chemistry.

For the purpose of monitoring water quality in Switzerland's lakes, BDM analyzes data acquired by cantonal measuring sites located at six lakes. Each spring, 2 to 12 samples are taken at various depths. Total phosphorus is indicated in mean annual concentrations.

Groundwater data is surveyed as part of the NAQUA National Groundwater Monitoring program, which has been monitoring groundwater quality at just under 550 measuring sites representatively distributed throughout Switzerland since 2002. Individual measuring sites are being sampled one to four times a year. The indicator registers maximum nitrate concentrations measured.

Water quality as regards nutrient loads in watercourses on the Central Plateau is assessed analyzing data acquired at 57 cantonal measuring sites. These measuring sites have supplied continuous measurement series on ammonium, nitrate and orthophosphate concentrations for the years of 1986 to 2005. Watercourses are either individually sampled 4, 12 or more times a year, or monitored taking 12 to 365 24-hour bulk samples a year, with 90th percentiles computed for every five-year period. Values are indicated in mean 90th percentiles with 95% confidence intervals. Measuring sites are located in the cantons of Aargau (5), Bern (5), Lucerne (13), St. Gallen (1), Thurgau (1), Waadt (6) und Zürich (26).

Water temperatures measured at measuring stations are converted into mean daily values (load graph data supplied by the FOEN). With moving averages formed over periods of 5 years, temperatures are subdivided into three temperature ranges:

- ≥ 9°C between November 1 and May 31 of the following year (212 days).
- > 19°C between June 1 and October 31 (153 days).
- > 25°C between June 1 and October 31 (153 days).

This subdivision corresponds to temperature ranges that are directly related to the biology of the Brown Trout (see above).

Data on the five-day biochemical oxygen demand (BOD_5) are acquired by the Zurich Cantonal Office for Waste, Water, Energy and Air AWEL. Since 2007, daily composite samples have been replaced by weekly composite samples.

Aiming to develop standardized methods for examining and assessing the condition of Switzerland's watercourses, the Modular Stepwise Procedure is a joint project of the Federal Office for the Environment FOEN and the Swiss Federal Institute of Aquatic Science and Technology EAWAG. The Modular Stepwise Procedure for Chemistry is used to assess water quality based on substance concentrations, classifying it into five steps from very good to bad. Individual steps have been color coded, with blue representing the best quality and red the worst. Values that are color coded blue or green meet the requirements stipulated by the Ordinance on Water Protection, provided a substance is covered by the Ordinance.

Tab. 6: Substance classification system of the Modular Stepwise Procedure for Chemistry

Quality assessments	Nitrate level (mg/l N)	Orthophosphate (mg/l P)	Ammonium (< 10°C) (mg/l N)	Total phosphorus (mg/l P)	BOD_5 (mg/l O_2)
Very good	< 1.5	< 0.02	< 0.08	< 0.035	< 2.0
Good	1.5–5.6	0.02–0.04	0.08–0.4	0.035–0.07	2.0–4.0
Fair	5.6–8.4	0.04–0.06	0.4–0.6	0.07–0.105	4.0 - 6.0
Unsatisfactory	8.4–11.2	0.06–0.08	0.6–0.8	0.105–0.14	6.0–8.0
Bad	≥ 11.2	≥ 0.08	≥ 0.8	≥ 0.14	≥ 8.0

Further information

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Related indicators

> E6 “Nutrient Supply in the Soil”

> E11 “Volume of Water Withdrawn from Watercourses”

> E12 “Proportion of Adversely Affected Watercourses”

Additional sources of information

> http://www.bafu.admin.ch/index.html?lang=en website of the Federal Office for the Environment FOEN

> http://www.bafu.admin.ch/grundwasser/index.html?lang=en FOEN pages on groundwater

> www.gewaesserqualitaet.zh.ch AWEL pages on water quality management (no information in English)

> http://www.eawag.ch/index_EN website of the Swiss Federal Institute for Aquatic Science and Technology EAWAG

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This information is based on the German language document 875 328.10 Produkt E13 V1.docx dated October 14, 2010.