Restoration of Unio crassus rivers in the Luxemburgish Ardennes
LIFE11 NAT/LU/857

September 1st 2012 – February 28th 2019

Annex 33

Action D1 : Surveillance de la qualité de l'eau et du substrat interstitiel
Period : 2013 - 2018

LE GOUVERNEMENT DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère du Développement durable et des Infrastructures
Département de l'environnement

LE GOUVERNEMENT DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Agriculture, de la Viticulture et de la Protection des consommateurs

Action D1: Surveillance de la qualité de l’eau et du substrat interstitiel 2013-2018

Contents

1 Data

Based on the good collaboration with national and international partners Fondation Hellef fir d´Natur has access to a brought pool of data of discharge and water height. These data represent an essential contribution to the following interpretations and conclusions.

Following parameters were measured every week in the lab of Kalborner Millen:

- temperature [°C]
- dissolved oxygen [mg/L]
- conductivity [µS/cm]
- pH
- turbidity [FNU]
- ortho-phosphate PO_4^{3-} [mg/L]
- nitrite NO_2^- [mg/L]
- ammonium NH_4^+ [mg/L]
- nitrate NO_3^- [mg/L]
- chloride [mg/L] – weekly since September 2013

The online measurement station at the river Our is measuring every 5 minutes following parameters:

- Temperature [°C]
- Oxygen [mg/L]
- Conductivity [µS/cm]
- pH
- turbidity [FNU]
- ammonium NH_4^+ [mg/L]
- nitrate NO_3^- [mg/L]
- chloride Cl^- [mg/L]
- potassium K^+ [mg/L]

1.1 River Our

Data of discharge and water height are provided by the Service Public de Wallonie, Direction générale opérationnelle Agriculture, Ressources naturelles et Environnement Département de la Ruralité et des Cours d'Eau, Direction des Cours d'eau non navigables (http://aqualim.environnement.wallonie.be/).

Discharge and water height are measured in Ouren/ Belgium. The distance between Moulin de Kalborn and the point of measurement is about 5 km (upstream). Discharge is useful to calculate the mass transport of substances in the water.

A further point of measurement for the water height is located about 12 km downstream from Moulin de Kalborn. These data are not used for the interpretation and calculation.

Data of rain from the station in Reuler/ Luxembourg are provided by the Administration des Service Techniques de l'agriculture (http://agrimeteo.lu).

The overview from 2013 to 2018 (see figure 1) starts with a high winter discharge and normal rain. In the following years, the amount of rain decreased. The average of the discharge is strongly influenced by the rain during the wintertime. Therefore, no changes in the trend of the discharge are visible.

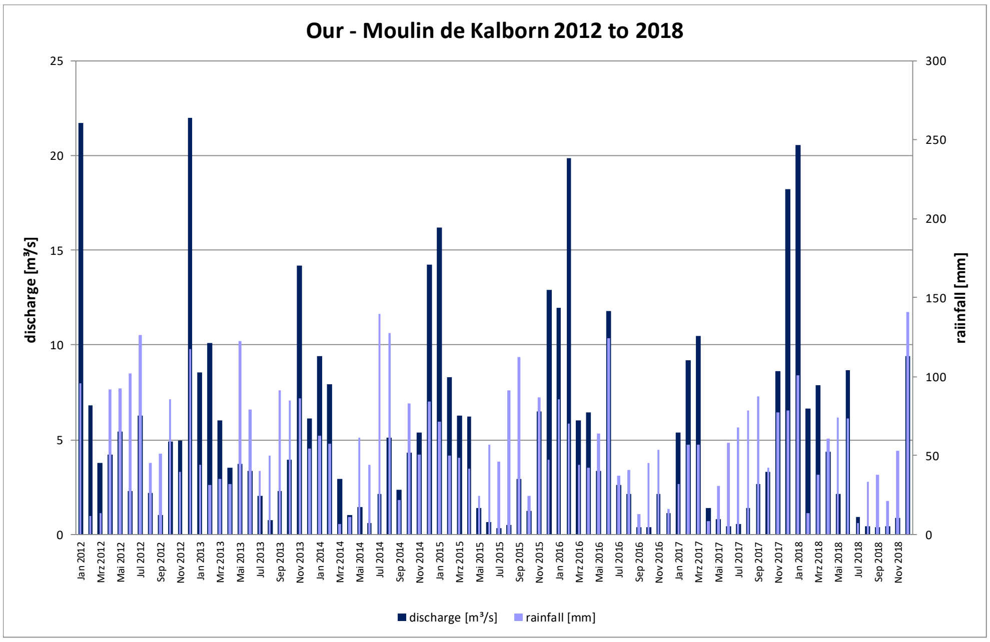


figure 1: Our 2012 -2018 – discharge (Ouren/ Belgium) and rain

1.2 River Sauer

Two measurement stations are located upstream to the sampling site at the river Sauer (Moulin de Bigonville).

Discharge and water height are measured in Martelange/ Belgium. The distance between the sampling site Moulin de Bigonville and the measurement station is about 15 km (upstream). This is too far away for any interpretation and calculation.

Next to the sampling site for the weekly measurement a measurement station for water height and discharge is installed (Moulin de Bigonville). We used these data (water height) for our interpretation.

Data of discharge and water height from the online measurement station are provided from Service Public de Wallonie, Direction générale opérationnelle Agriculture, Ressources naturelles et Environnement Département de la Ruralité et des Cours d'Eau, Direction des Cours d'eau non navigables (http://aqualim.environnement.wallonie.be/).

Data of water height and discharge from the station Moulin de Bigonville are provided by the administration of water/ Luxembourg (http://www.inondations.lu/).

Data of rain from the station Arsdorf/ Luxembourg are provided by the Administration des Service Techniques de l’agriculture (http://agrimeteo.lu).

The overview from 2013 to 2018 (see figure 2 and figure 3) starts with a high winter discharge and normal rain. In the following years, the amount of rain decreased. The average of the discharge (height) is strongly influenced by the rain during the wintertime. Therefore, no changes in discharge or height are detectable.

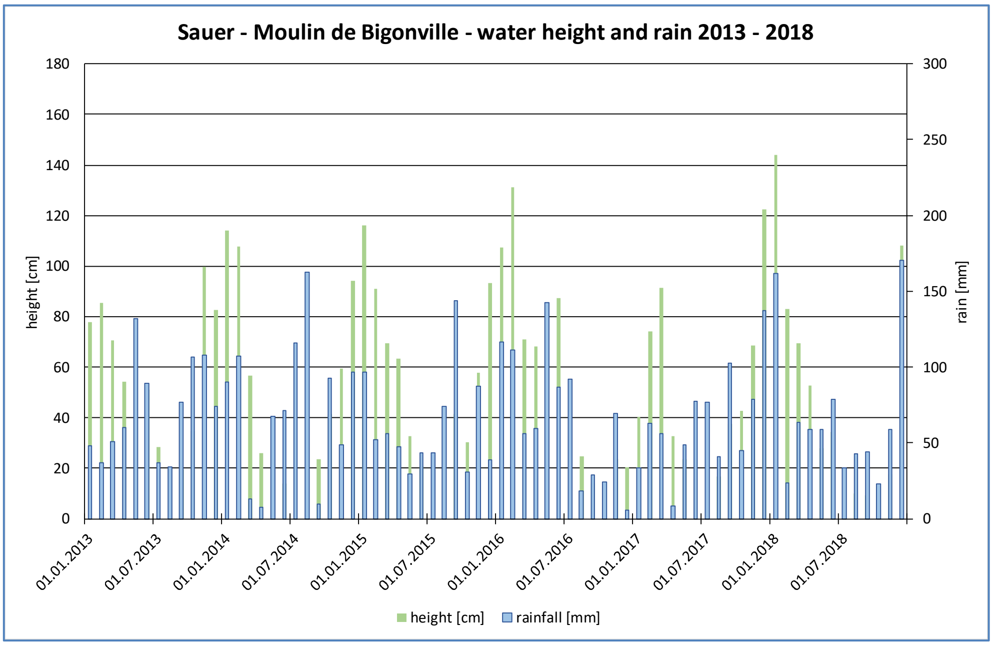


figure 2: **Sauer 2013 -2018 – height (Moulin de Bigonville) and rain**

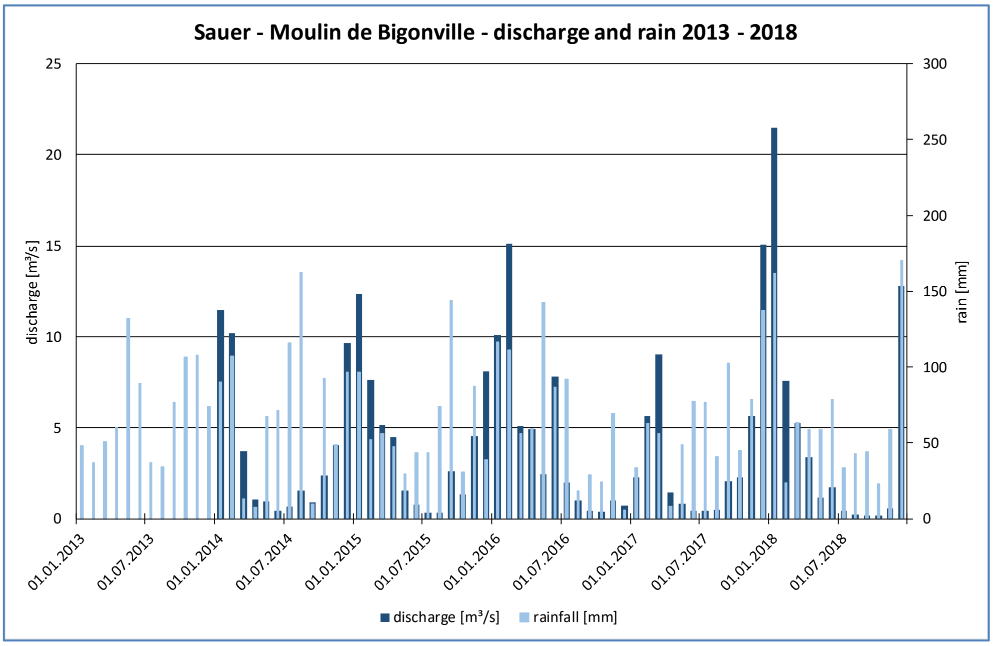


figure 3: **Sauer 2013 -2018 – discharge (Moulin de Bigonville) and rain**

2 Water quality of the river Our

2.1 Overview 2013-2018

In table 1 the annual average of the water quality is given.

table 1: Overview from 2013 to 2018 of the river Our

Year	discharge [m³/s]	rain [mm]	turbidity [FNU]	conductivity [µS/cm]	nitrate [mg/L]	ammonia [mg/L]	nitrite [mg/L]	chloride [mg/L]
2013	5,4	751,7	6,5	162,5	18,2	0,08	0,05	---
2014	4,7	749,9	5,8	136,7	16,5	0,06	0,05	13,1
2015	5,3	699,8	5,6	147,0	14,5	0,06	0,04	17,3
2016	5,7	636,7	4,7	141,7	15,2	0,06	0,04	16,3
2017	5,2	674,4	7,6	156,6	14,8	0,07	0,05	19,2
2018	5,2	653,5	4,8	161,2	16,3	0,05	0,04	19,4
average	**5,5**	**694,6**	**6,4**	**154,4**	**15,8**	**0,06**	**0,05**	**17,1**

In the following figures the concentration of the different ions are represeted as annual or monthly average.

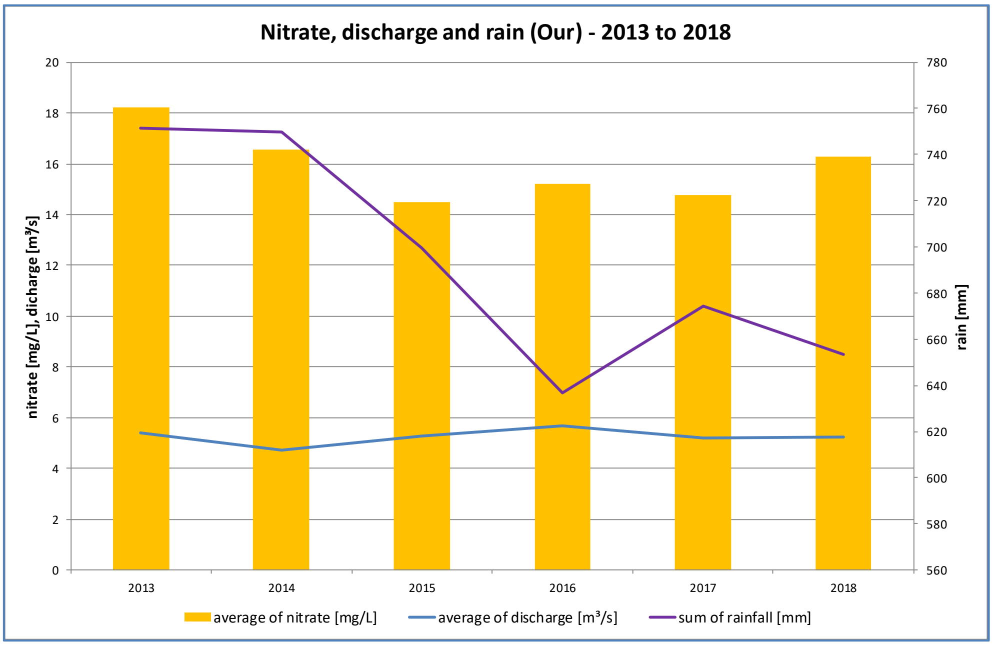


figure 4: Nitrate concentration compared with discharge and rain – 2014 to 2018

In the first years a decline of the nitrate concentration was observed but the nitrate concentration seems to be between 14 and 18 mg/L depending on the weather conditions.

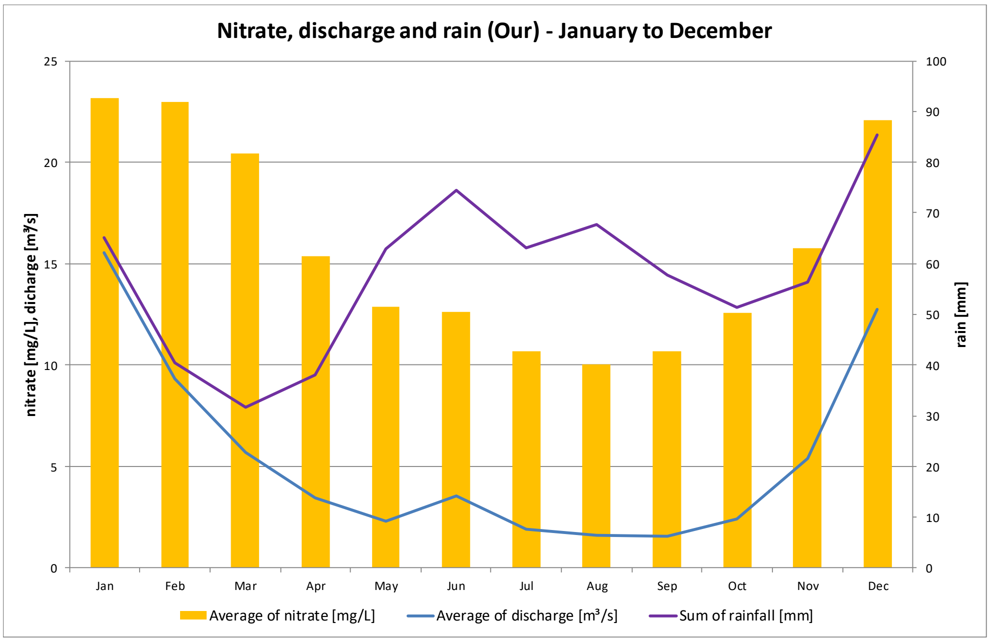


figure 5: Nitrate concentration compared with discharge and rain –January to December

During the year the highest nitrate concentration are measured in the months January, February and March. In autumn, the increase of the nitrate concentration depends on the rain amount in October and November.

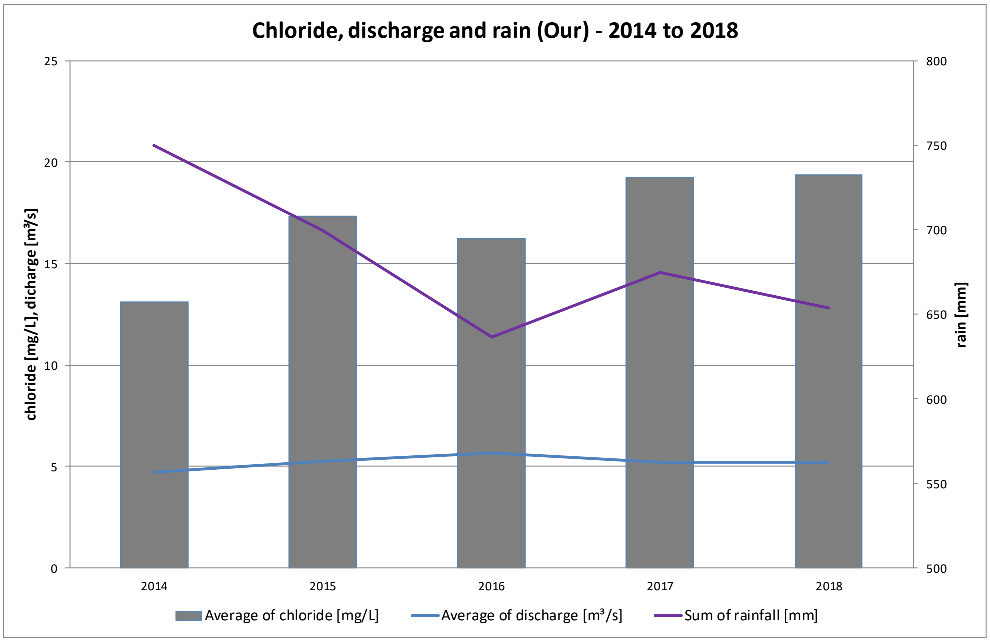


figure 6: Chloride concentration compared with discharge and rain – 2014 to 2018

The chloride concentration depends on the season and the discharge. During winter time there are high concentration because of the road maintenance and road salt is washed into the river. In the summer the concentration is increasing because of the low water discharge.

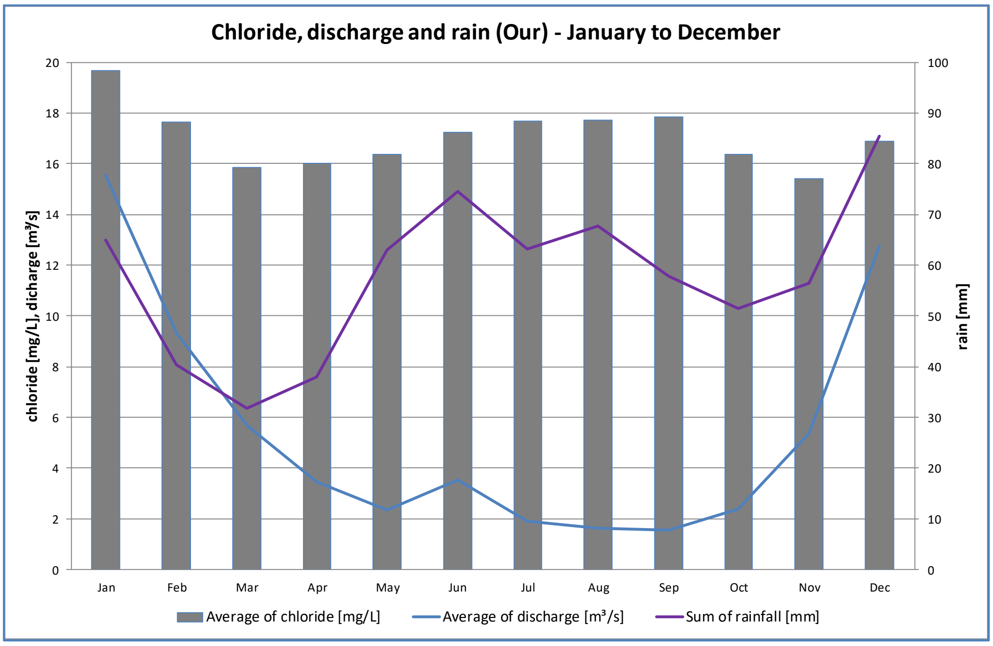


figure 7: **Chloride concentration compared with discharge and rain –January to December**

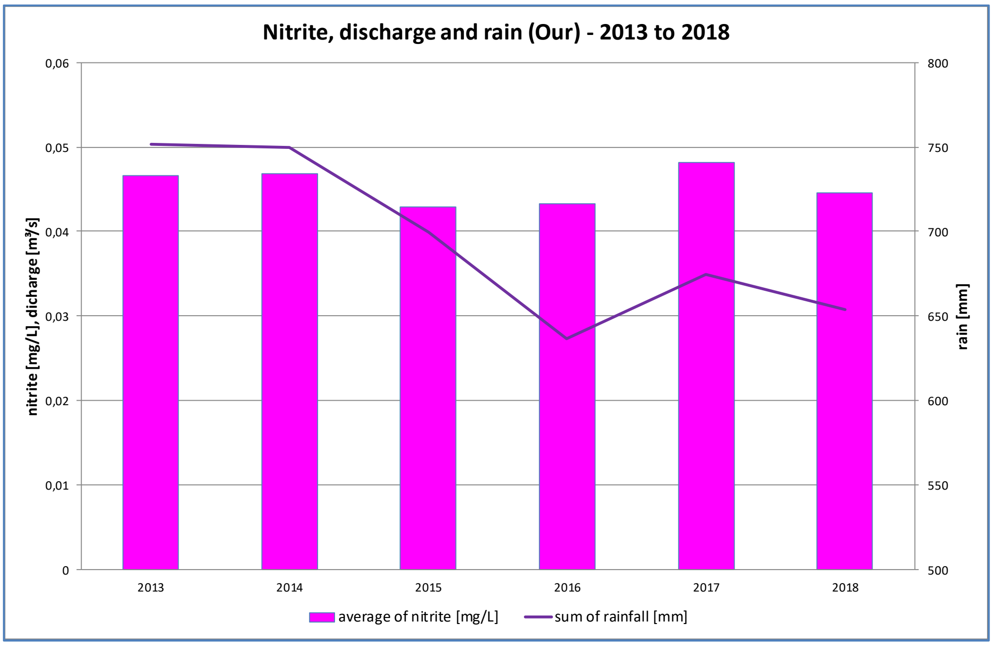


figure 8: **Nitrite concentration compared with discharge and rain – 2014 to 2018**

The nitrite in the river is a degradation product of ammonium. Ammonium is transformed to nitrate in two steps.

table 2: Nitrification and temperature

Step	Educts	Products	Microbiology	Less activity under
1	ammonium	nitrite	Nitrosomonas	5 °C
2	nitrite	nitrate	Nitrobacter	14°C

In winter time less microbial activity is found in the rivers due to the cold temperature. In April and May, the microbial activity is high enough to degrade organic matter but the second step of nitrification is too slow to produce nitrate out of nitrite. Therefore from April to June a high nitrite concentration is found in the river Our.

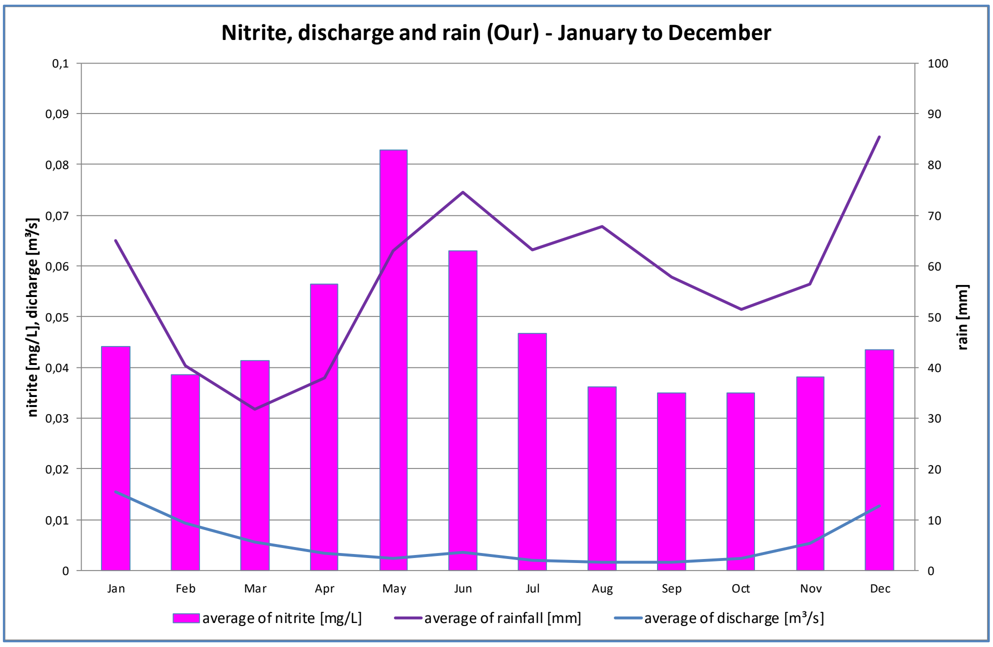


figure 9: Nitrite concentration compared with discharge and rain –January to December

There is no correlation between nitrite concentrations, discharge and rain (see figure 9).

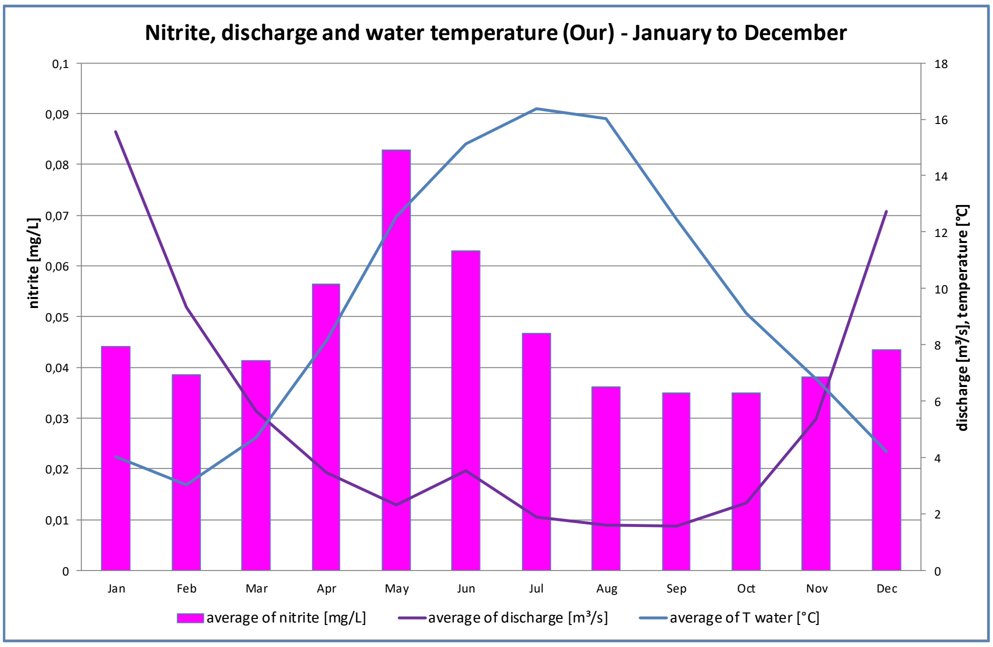


figure 10: Nitrite concentration compared with discharge and water temperature –January to December

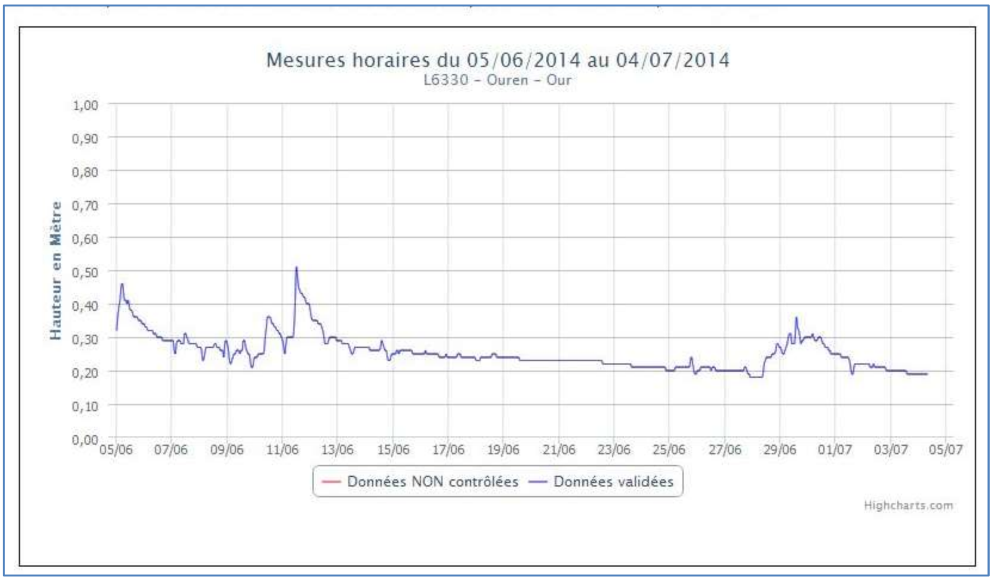
Comparing the nitrite concentration with discharge and water temperature no correlation is obvious.

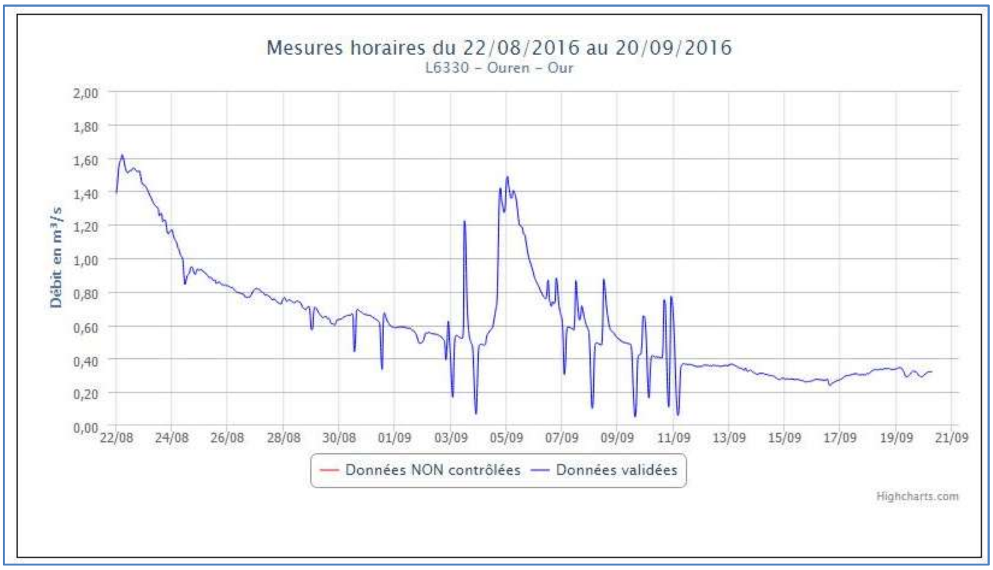
2.2 Hydro peaking – river Our

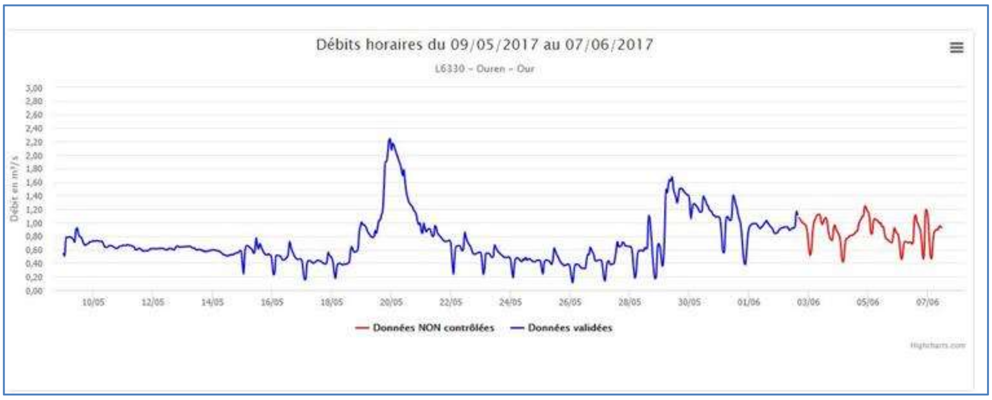
As we described in our progress reports we observed a hydropeaking at the river Our. We informed the administrations in Luxembourg and Germany about this and asked to change the situation (see figure 11 and figure 12).

2.2.1 Discharge measurement station– Ouren/ Belgium

The Administration of Water in Germany visited the Stuppacher Mill and found out that the dam was blocked by wood and other trash. After removing these flood debris the hydro peaking decreased (measurement station in Ouren).







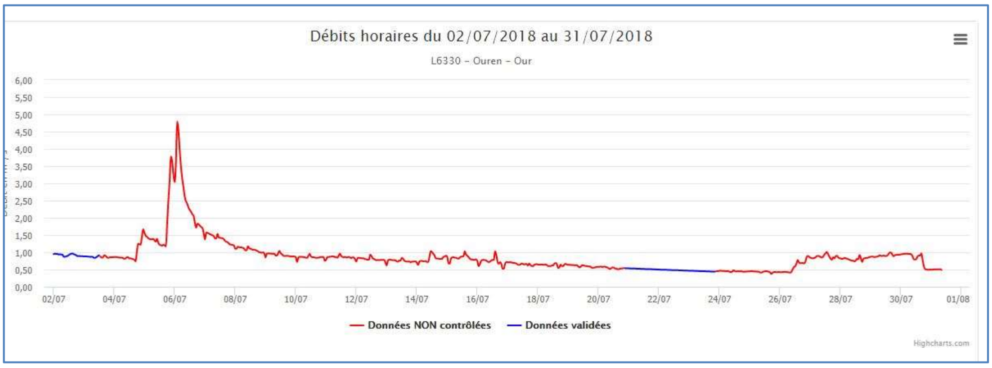


figure 11: Hydro peaking in the river Our – 2014 to 2018-(Ouren - BE)

2.2.2 Discharge measurement station – Dasburg/ Luxembourg

At the Relles Millen no change was observed (see figure 12). We were told by the Adminstration of Water that there is no possibility to stop hydro peaking. We had contact with the Adminstration of water of Germany. We will go on with observing the water level down stream the Relles Millen.

Wasserstände [cm] vom 04.07.2014

Uhrzeit		Diff.
07:00	08:00	
25	25	0

Wasserstand am Pegel Dasbourg / Our

Wasserstände [cm] vom 03.08.2015

Uhrzeit		Diff.
09:00	10:00	
27	27	0

Wasserstand am Pegel Dasbourg / Our

Wasserstand am Pegel Dasbourg / Our

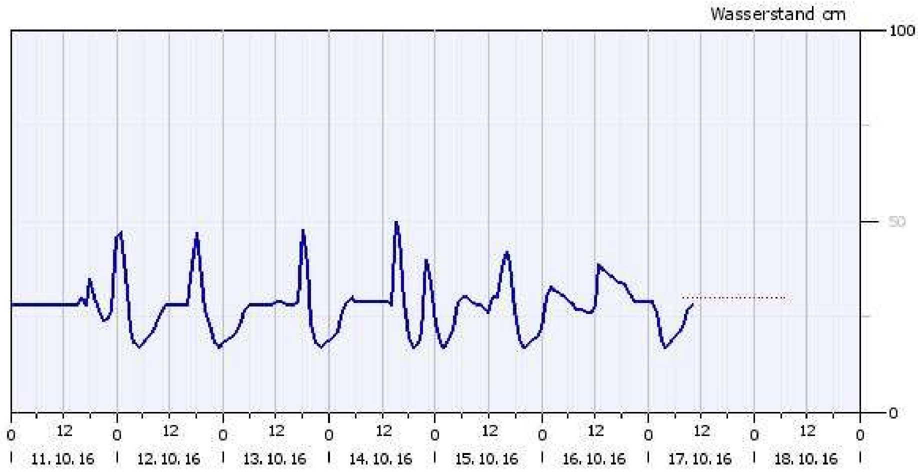


figure 12: Hydro peaking in the river Our –2014 to 2018 (Dasburg -LU)

3 Water quality of the river Sauer

3.1 Overview 2013 - 2018

Every week a sample of the river Sauer was taken and analysed. In **Error! Reference source not found.** an overview over these 6 years is given.

table 3: Overview over 2013 to 2018 , river Sauer

Year	height [cm]	discharge [m³/s]	rain [mm]	turbidity [FNU]	conductivity [µS/cm]	nitrate [mg/L]	ammonia [mg/L]	nitrite [mg/L]	chloride [mg/L]
2013	57,0		854	8,8	164,9	18,2	0,10	0,05	15,46
2014	51,0	3,9	884,1	8,6	141,9	15,0	0,07	0,05	15,1
2015	53,2	4,1	746	7,9	155,4	13,4	0,08	0,05	19,9
2016	48,4	4,2	812,1	7,6	152,9	15,7	0,08	0,04	18,19
2017	48,3	3,8	768,3	10,5	173,6	14,9	0,10	0,06	22,5
2018	48,3	4,6	818,5	16,5	169,6	15,6	0,07	0,056	21,7
average	**51,9**	**4,1**	**814**	**10,0**	**159,7**	**12,9**	**0,08**	**0,056**	**19,0**

The sampling point overall these years was at Moulin de Bigonville. But upstream of the measurement station of Moulin de Bigonville a hydropower plant is located. Unfortunately the water level rose up and down very quickly and during low water level periods the amount of left water was minimal. Because of this hydro peaking the correlation between rain and water height is disturbed and the data cannot be used.

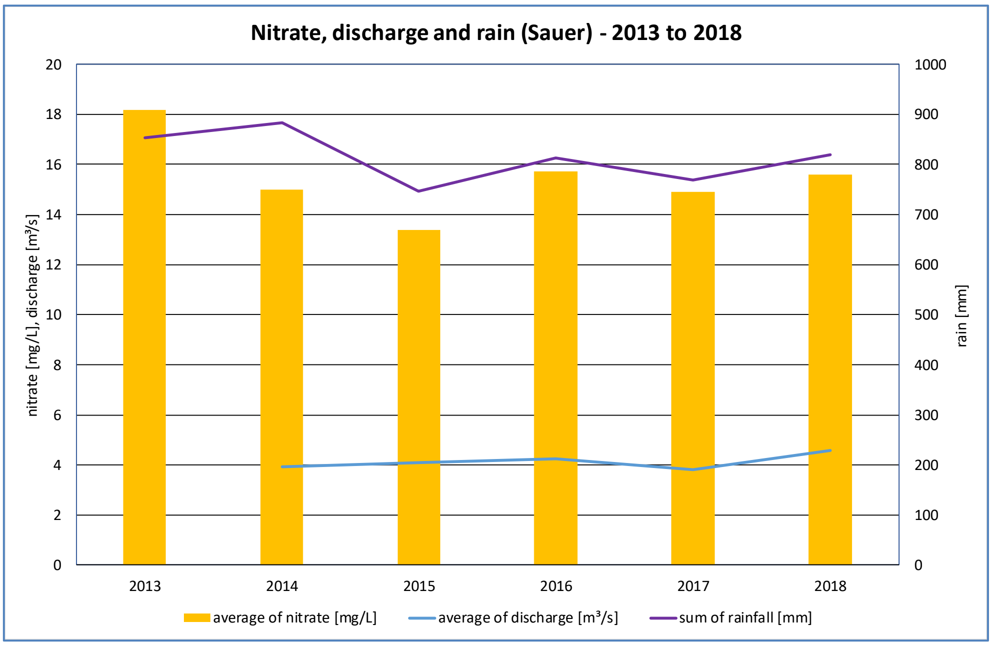


figure 13: Nitrate concentration compared with discharge and rain 2013 to 2018 in the river Sauer

In the first years a decline of the nitrate concentration was observed but the nitrate concentration seems to be between 14 and 18 mg/L depending on the weather conditions.

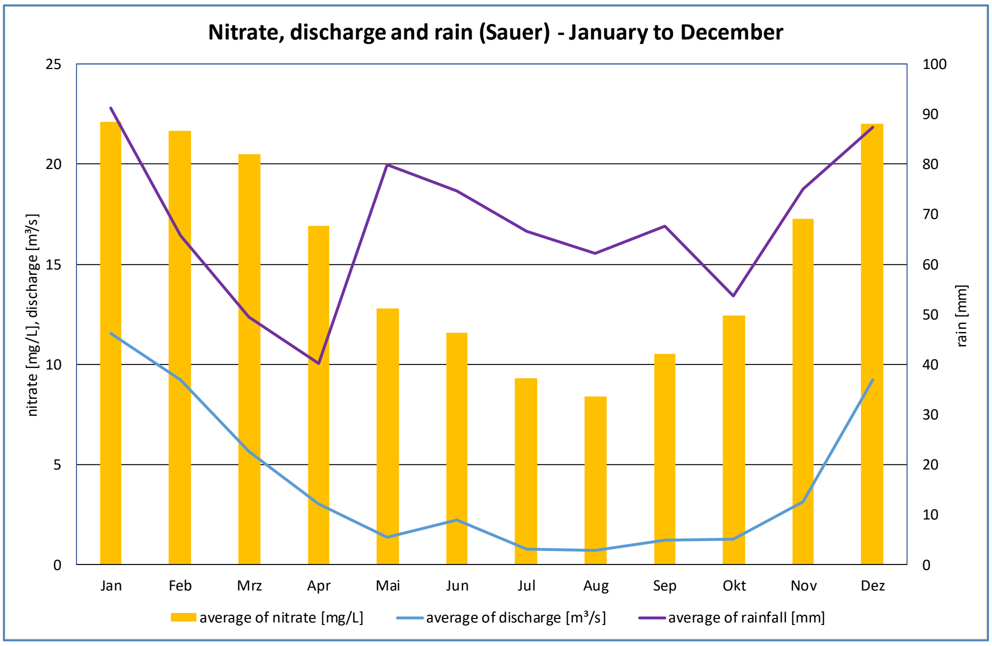


figure 14: **Nitrate concentration compared with discharge and rain –January to December in the river Sauer**

Over the year, the highest nitrate concentrations are measured in January, February, March and December. In autumn, the increase of the nitrate concentration depends on the rain amount in October and November.

As in the river Our the chloride concentration is increasing over the last 6 years. The reason is unknown (see figure 15).

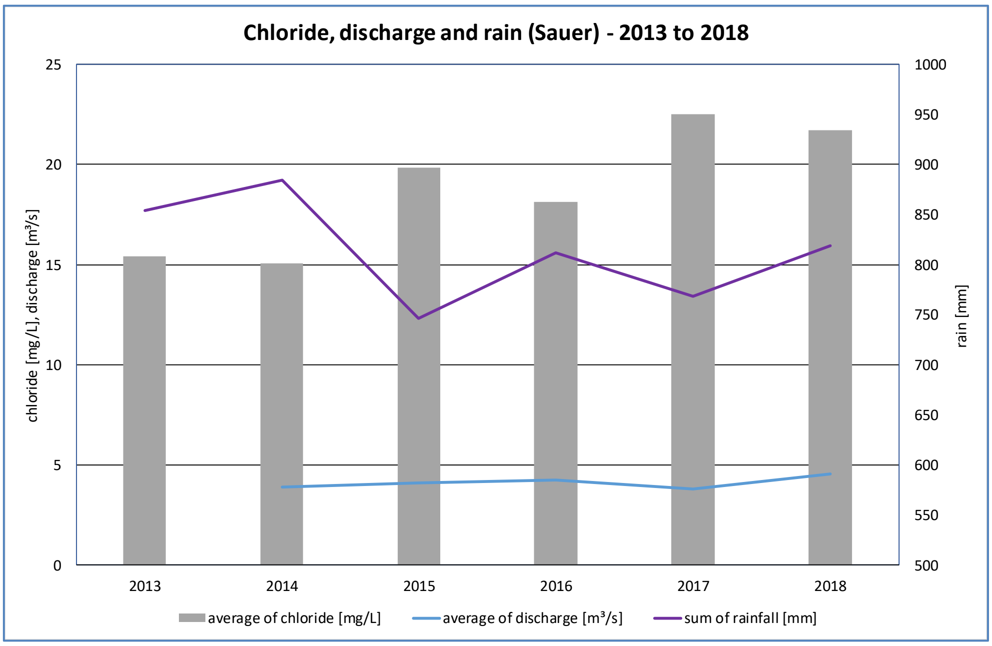


figure 15: **Chloride concentration compared with discharge and rain –2013 to 2018 in the river Sauer**

In winter, the high chloride level is caused by road salt. During the summer the concentration is increasing because of less water in the river (see figure 16).

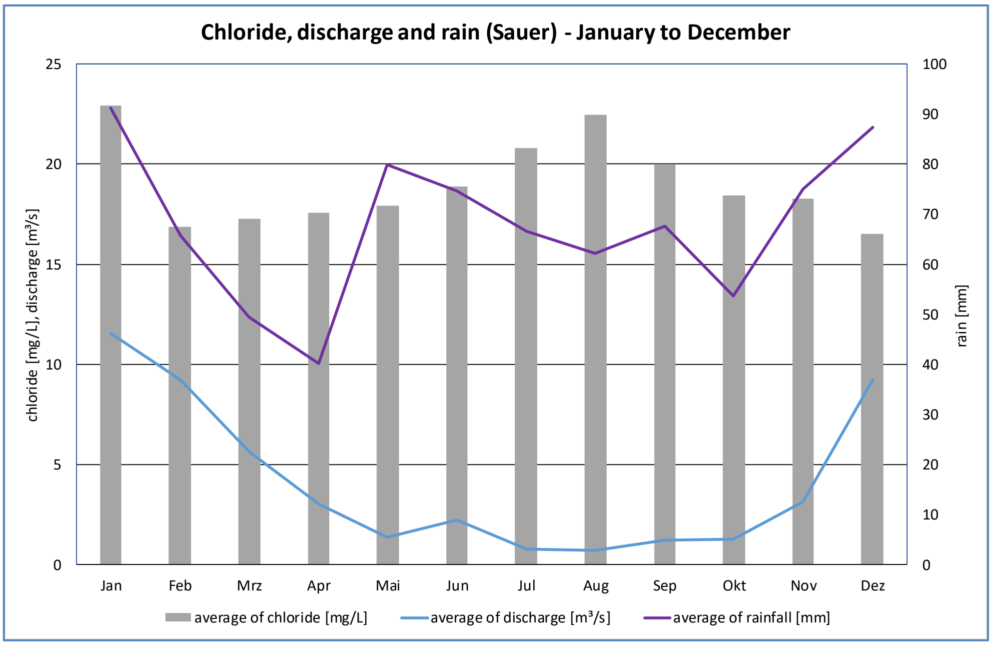


figure 16: Chloride concentration compared with discharge and rain –January to December in the river Sauer

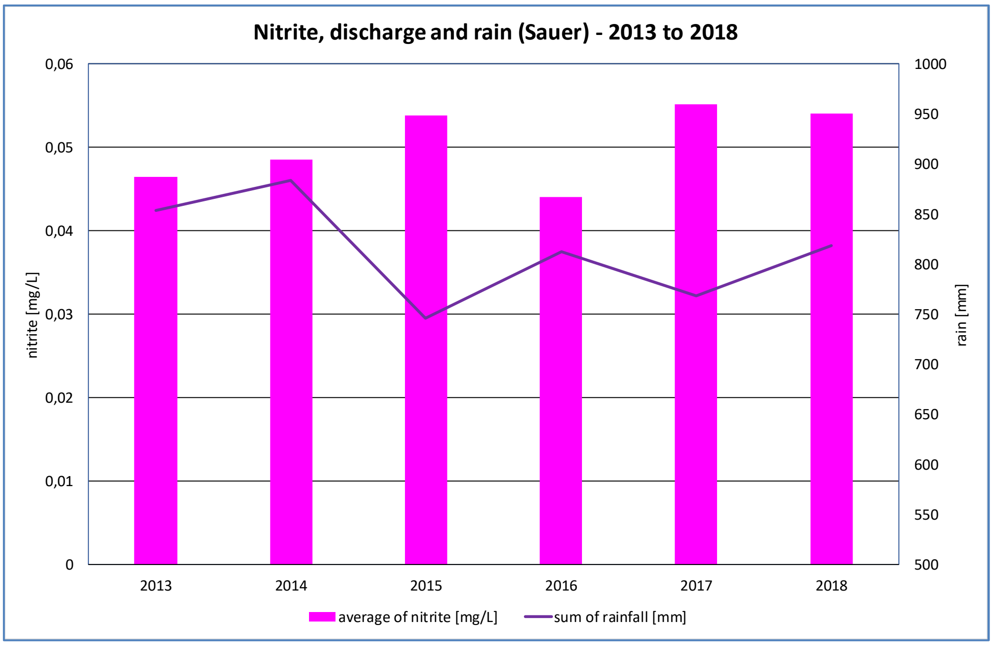


figure 17: Nitrite concentration compared with discharge and rain –2013 to 2018 in the river Sauer

The nitrite in the river is a product of nitrification of ammonium. Ammonium is transformed to nitrate in two steps shown in table 4

table 4: Nitrification and temperature

Step	educts	products	microbiology	Less activity under
1	ammonium	nitrite	Nitrosomonas	5 °C
2	nitrite	nitrate	Nitrobacter	14°C

In winter, less microbial activity is found in the rivers due to the cold temperature. In April and May, the microbial activity is high enough to degrade organic matter but the second step of nitrification is too slow to produce nitrate out of nitrite. Therefore, in May to July a high nitrite concentration is found in the river Sauer.

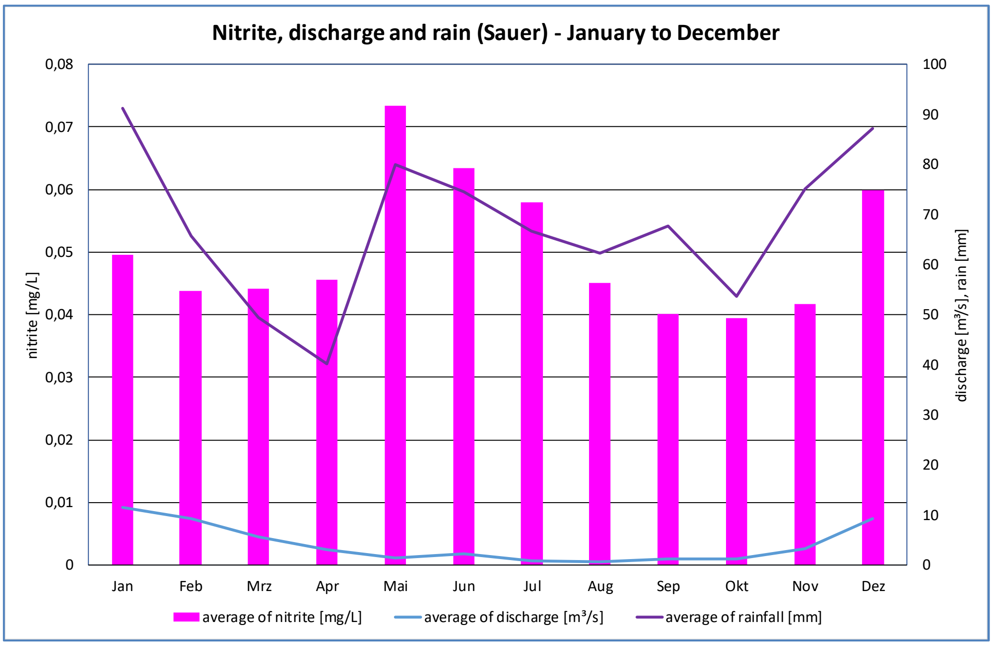


figure 18: Nitrite concentration compared with discharge and rain –January to December in the river Sauer

There is no correlation between nitrite concentration, discharge and rain obvious.

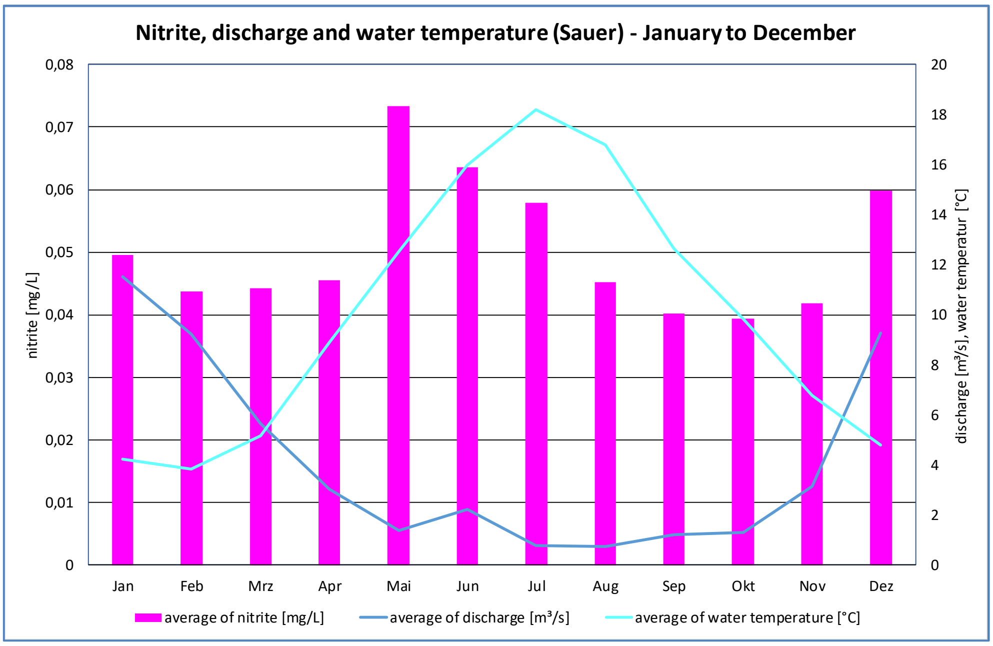


figure 19: Nitrite concentration compared with discharge and water temperature –January to December in the river Sauer

The highest level of nitrite concentration in May is not correlated to discharge or water temperature.

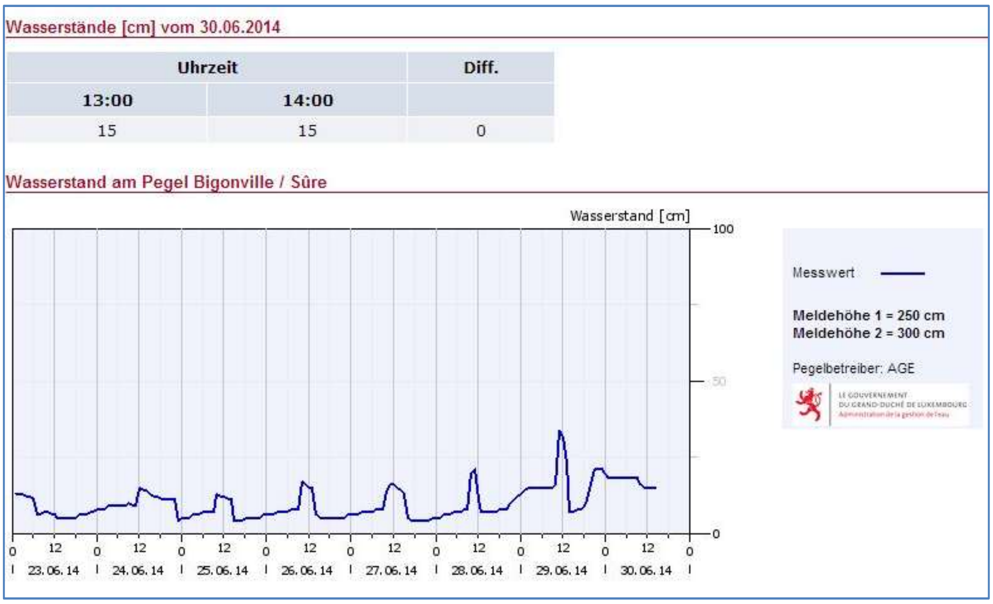
3.2 Hydro peaking – river Sauer

The mill located upstream to the measurement station changes the water level periodically. This can cause problems as described in 1.2.

In the following figure 21, examples of periodic and drastic changes of the water level is shown. The Administration of Water knows this problem since summer 2014 but unfortunately they have no legal possibilities to stop the hydro peaking.

The Administration of water built a fish pass to avoid the peaking in the future. A defined minimum of water passes the channel. But as seen in figure 21 there is still hydro peaking observed.

figure 20: Fish pass in Moulin de Bigonville



Wasserstände [cm] vom 08.06.2015

Uhrzeit		Diff.
07:00	08:00	
22	22	0

Wasserstand am Pegel Bigonville / Sûre

Wasserstand am Pegel Bigonville / Sûre

Wasserstände [cm]

Uhrzeit	Diff.
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Wasserstand am Pegel Bigonville / Sûre

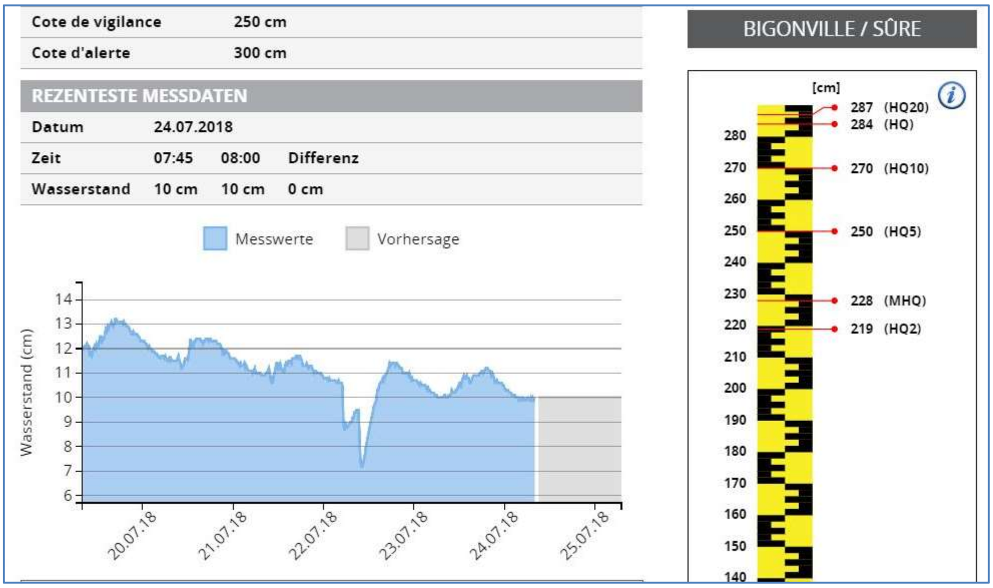

figure 21: Sauer 2014 to 2018 – Periodic changes of the water level at Moulin de Bigonville/ Luxembourg

4 Online measurement of Our (Moulin de Kalborn)

Since September 2013 an online measurement station is at Moulin de Kalborn installed.

The graph in figure 22 shows the good correlation between rainfall, discharge and turbidity. In general the impact of rainfall and discharge on chemical parameters such as chloride and conductivity can be described (see figure 23).

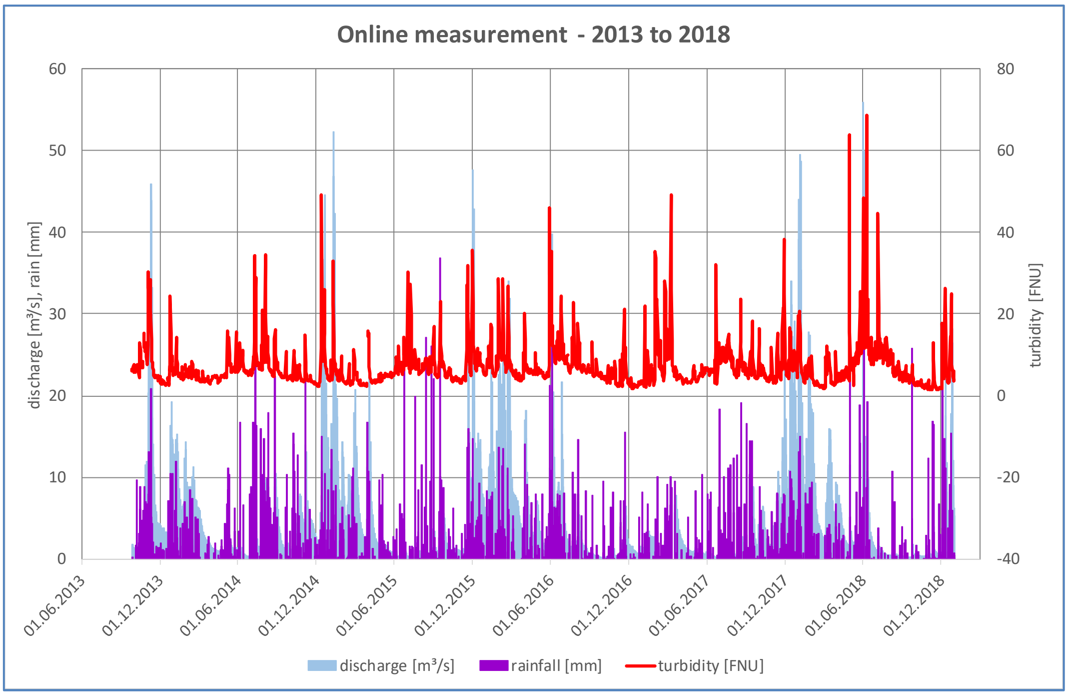

figure 22: Our online 2013 to 2018 – discharge, rain and turbidity

During the winter and periods of cold temperature an increase of chloride concentration is measured. This can be related to the use of sodium chloride for road maintenance (February 2018).

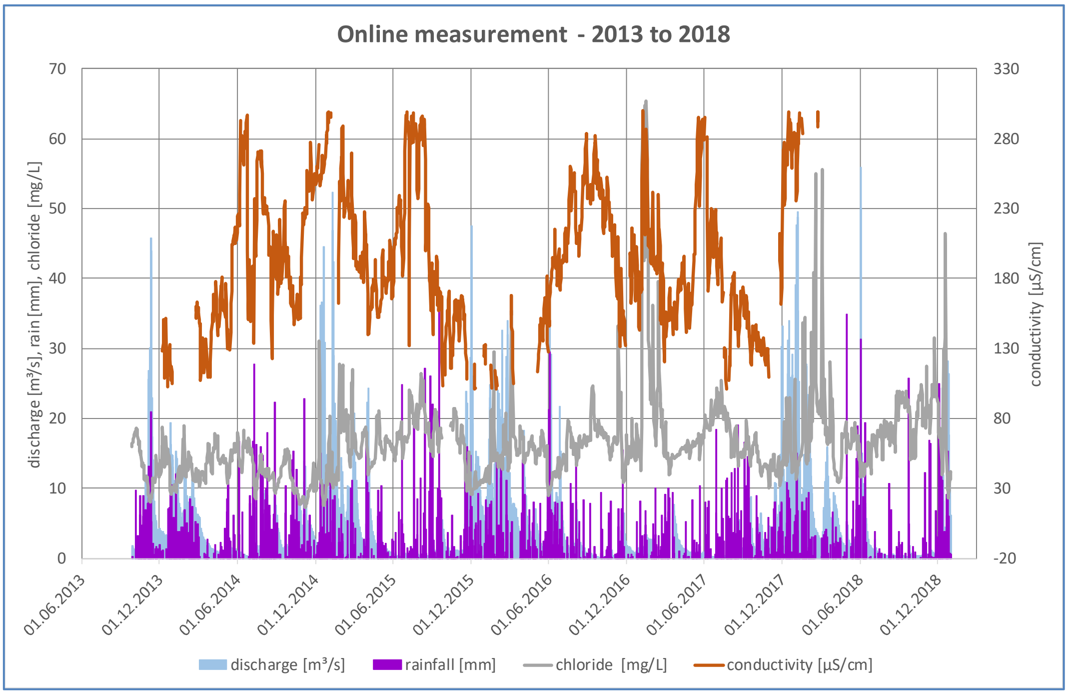

figure 23: Our online 2013 to 2018 – discharge, rain, chloride and conductivity

Rain decreases the concentration by dilution. The chloride concentration increased during the summer and autumn because of the less rain. The conductivity is direct related to the chloride concentration.

The nitrate concentration is increasing during winter, rain and high discharge periods. This is caused by the high discharge of the springs where the nitrate is coming from.

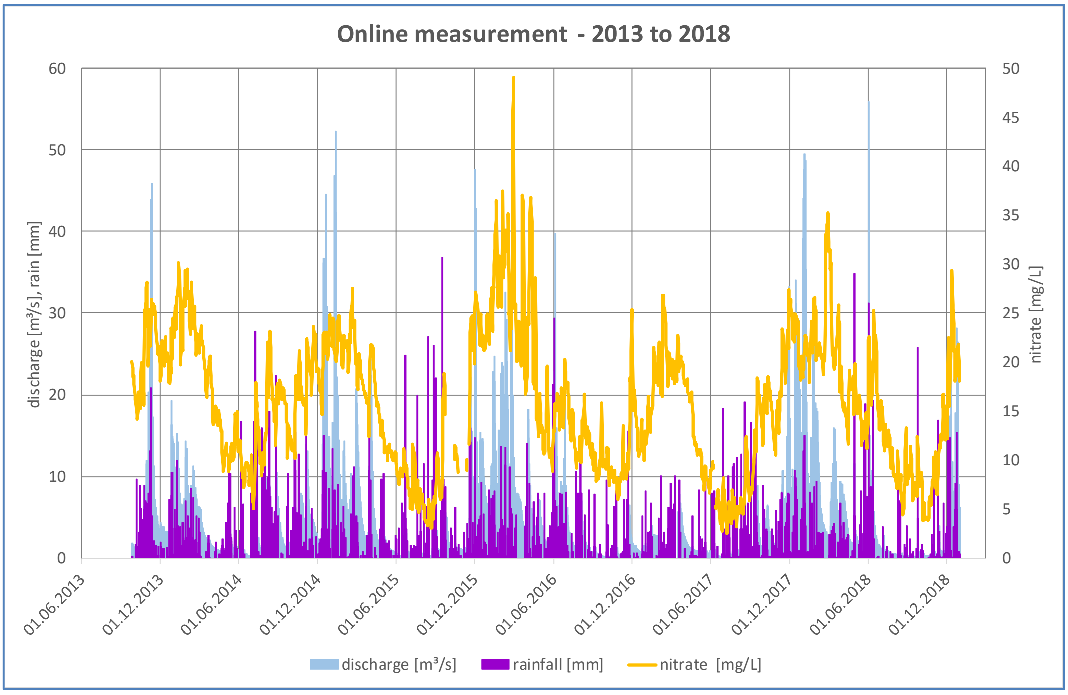

figure 24: Our online 2013 to 2018 – Overview discharge, rain and nitrate

Considering the discharge, the amount of nitrate-nitrogen passing by the Moulin the Kalborn during that period from September 2013 to December 2018 can be calculated (4200 tons, see figure 24). The financial loss of 4.200 tons of nitrogen can be estimated up to € 4.200.000.

The average per year or per month are very similar to the samples done weekly. But with the online measurement station the correlation between water temperature, pH and oxygen during spring time is observable.

The pH value drifts from April to May dramatically. There are differences up to 2 pH values during this time (see figure 25). This means a lot of stress to a aquatic species especially for the mussels.

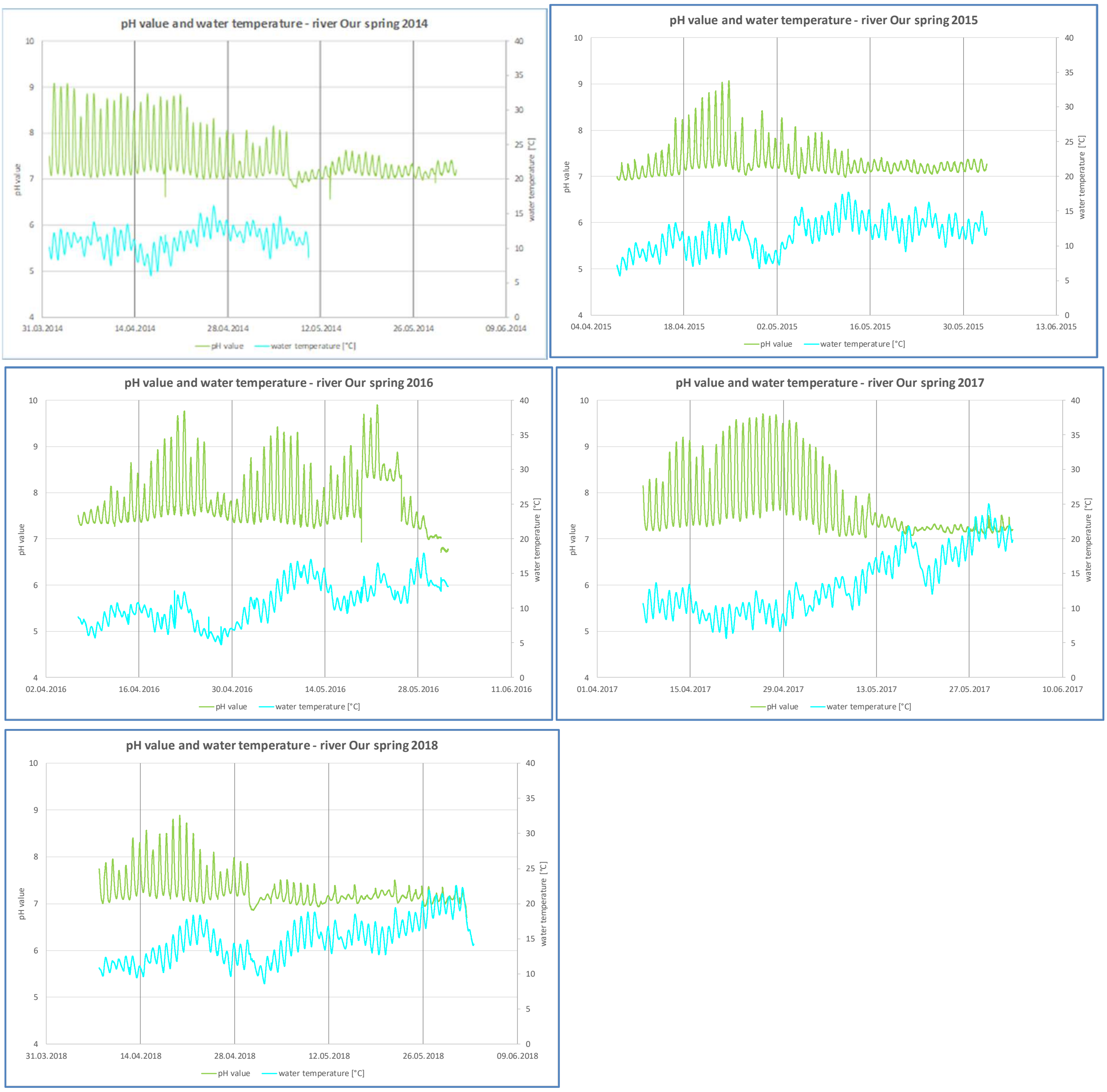

figure 25: pH drifting in spring in the years 2014 to 2018

In spring when the temperature starts to increase the pH value moves daily up and down. There can be a difference up to 2,5 values. In the middle of May the pH fluctuation is decreasing (with a stable water temperature average around 15°C).

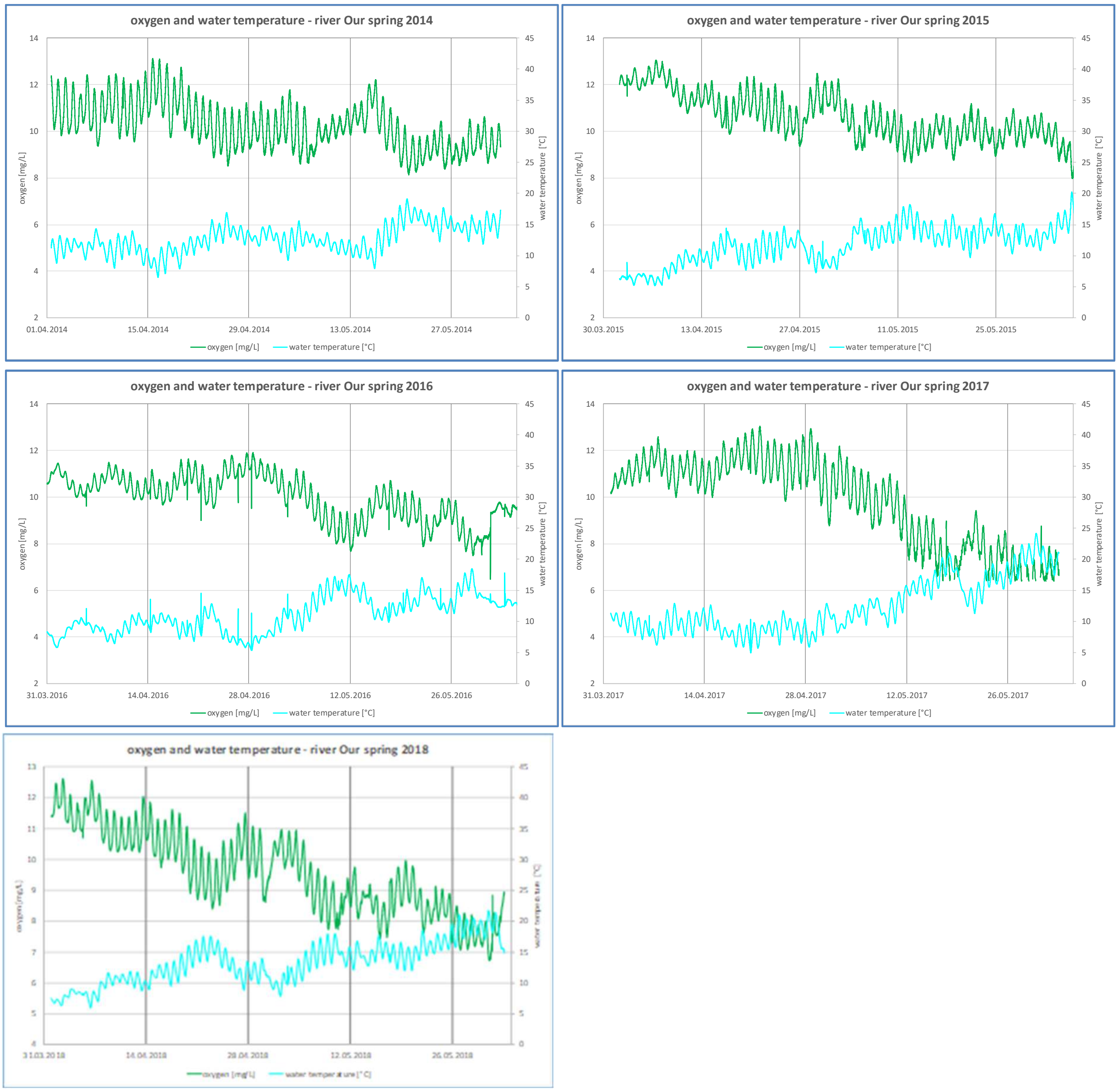

figure 26: oxygen drifting in spring the years 2015 to 2018

The oxygen fluctuation in spring depends on the water temperature changing during the day. Less temperature movement leads to less variation of the oxygen concentration.

5 Tributaries 2013 - 2018

In the project area 18 tributaries of river Our and 3 tributaries of river Sauer are monitored (springs and mouths). Most of these tributaries have several springs.

We took samples in February, May and September each year from these springs and mouths of the tributaries. In September 2018 we did not do all samples but selected some. The springs were nearly dry because of the less rain.

5.1 Springs 2013 - 2018

In table 5 the average of all samples taken from the springs from 2013 to 2018 are shown. High values of phosphate, nitrite and ammonium occur in springs with direct income of untreated sewage water into the springs.

table 5: Springs of tributaries of Our and Sauer (1265 samples) – physic-chemical parameters- average of 2013 to 2018

year	value	water T [°C]	conductivity [µS/cm]	pH	turbidity [FNU]	o-phosphate [mg/L]	nitrite [mg/L]	ammonia [mg/L]	nitrate [mg/L]	chloride [mg/L]
2013	average	9,0	328	6,7	7,2	0,53	0,04	0,77	38,2	40
	max	16,6	1522	8,1	90,8	12,50	0,95	42,40	72,9	219
	min	0,6	107	5,3	0,0	0,05	0,00	0,00	2,0	0
2014	average	10,4	242	6,7	8,1	0,50	0,07	0,37	35,7	32
	max	18,0	899	8,5	240,0	23,90	2,80	27,90	93,1	192
	min	3,8	80	5,4	0,0	0,05	0,02	0,02	1,7	2
2015	average	9,5	223	6,9	3,7	0,27	0,05	0,28	37,0	29
	max	16,1	1047	8,8	59,0	7,12	2,12	21,05	94,5	204
	min	1,5	103	5,5	0,0	0,05	0,02	0,02	1,9	2
2016	average	9,0	209	6,8	4,0	0,36	0,05	0,22	44,9	25
	max	16,3	833	8,1	95,1	15,25	1,45	19,30	110,8	243
	min	1,6	86	5,5	0,0	0,02	0,02	0,02	1,0	4
2017	average	9,9	240	6,9	3,3	0,35	0,04	0,11	42,5	35
	max	18,0	874	8,0	87,3	15,25	0,65	3,86	102,4	194
	min	1,4	87	5,5	0,0	0,05	0,01	0,00	1,7	1
2018	average	8,1	280	6,7	4,2	0,25	0,04	0,32	49,4	48
	max	23,0	1632	8,9	70,1	1,30	0,28	19,80	100,2	243
	min	-0,3	59	5,4	0,0	0,05	0,02	0,00	5,3	5
total	**average**	**9,3**	**254**	**6,8**	**5,1**	**0,38**	**0,05**	**0,35**	**41,3**	**34,8**

In springs themselves the level of phosphate is very low. Positive results of phosphate concentration can be related from case to case to contamination during sampling (less water, problems with taking the sample). Nevertheless, high concentration is clearly caused by income of sewage water. Nitrite and ammonium are not detectable in natural springs. There are caused by income of sewage water. Both parameters can give clear and reliable evidence of anthropogenic and agricultural impact.

Nitrate is detectable in all the natural springs, although at different levels. The high levels of nitrate are caused by intensive use of fertilizers in the catchment area of springs.

The average nitrate concentration in the springs is around 41 mg/L. Sample points with sewage water contamination showed low nitrate concentration.

Chloride is a widespread ion. The measured concentrations show high variations with the different locations. The chloride concentration likely depends on the geological characteristic of the catchment area.

5.2 Mouths 2013 - 2018

The quality of the water in the mouth of the tributaries influences directly the water quality of the river Our and Sauer. On one hand, it is important to avoid the income of untreated sewage water. On the other hand it is necessary to enhance the self-cleaning potential of the tributaries.

High concentration of nitrite and ammonium indicates the income of untreated waste water and less self-cleaning potential of the tributary (e.g. during winter time).

table 6: Mouth of tributaries of Our and Sure (549 samples) – physic-chemical parameters- average of 2013 to 2018

year	value	water T [°C]	conductivity [µS/cm]	pH	turbidity [FNU]	o-phosphate [mg/L]	nitrite [mg/L]	ammonia [mg/L]	nitrate [mg/L]	chloride [mg/L]
2013	average	6,9	201	7,3	2,1	0,25	0,03	0,07	28,4	18
2013	max	13,1	390	8,9	31,9	1,91	0,13	0,62	60,0	53
2013	min	0,9	111	6,7	0,0	0,05	0,00	0,00	9,6	0
2014	average	9,3	174	7,3	5,0	0,30	0,04	0,08	23,7	16
2014	max	15,6	321	8,3	71,6	2,63	0,21	1,19	69,4	42
2014	min	3,6	109	6,7	0,1	0,06	0,03	0,02	2,2	3
2015	average	8,2	172	7,4	6,1	0,28	0,06	0,07	20,7	20
2015	max	19,0	348	8,0	67,4	2,42	0,22	0,49	65,2	50
2015	min	1,3	114	6,8	0,0	0,07	0,02	0,02	2,2	2
2016	average	8,0	171	7,4	5,6	0,34	0,05	0,11	24,4	19
2016	max	16,9	388	8,4	52,5	4,00	0,34	2,99	77,6	45
2016	min	-0,1	121	6,9	0,0	0,00	0,02	0,03	4,8	6
2017	average	10,0	201	7,5	10,7	0,57	0,06	0,21	26,0	23
2017	max	18,0	465	8,9	162,0	4,90	1,16	7,95	89,1	68
2017	min	-0,3	134	6,8	0,0	0,07	0,00	0,02	6,4	5
2018	average	8,0	185	7,6	7,0	0,47	0,06	0,13	23,9	24
2018	max	25,0	410	8,9	59,2	6,10	0,62	4,75	87,7	54
2018	min	-0,5	122	6,8	0,4	0,06	0,02	0,02	8,1	6
total	**average**	**8,4**	**184**	**7,4**	**6,1**	**0,37**	**0,05**	**0,11**	**24,5**	**19,9**

The average nitrate concentration in the springs is around 25 mg/L. This means a reduction of nitrate of 40% (uptake by algae and plants).

5.3 Nitrate concentration 2013 to 2018

The nitrate concentration can be correlated with the influence of intensive agriculture. But it is clearly seen that the self-cleaning potential of streams can be very high and reduce the nitrate income to the rivers. In figure 27 to figure 31 the nitrate concentration of springs and mouths of the tributaries in the different season are compared.

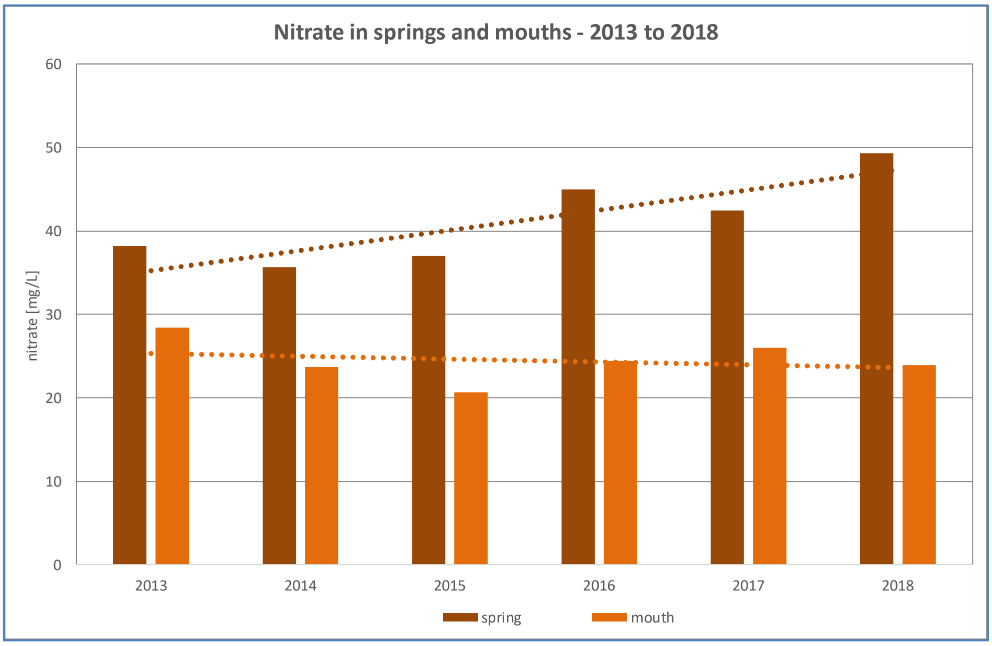

figure 27: Average of nitrate concentration over the years in springs and mouths of the tributaries (river Our and Sauer)

The nitrate concentration in the springs is increasing but the level in the mouths of the tributaries is constant.

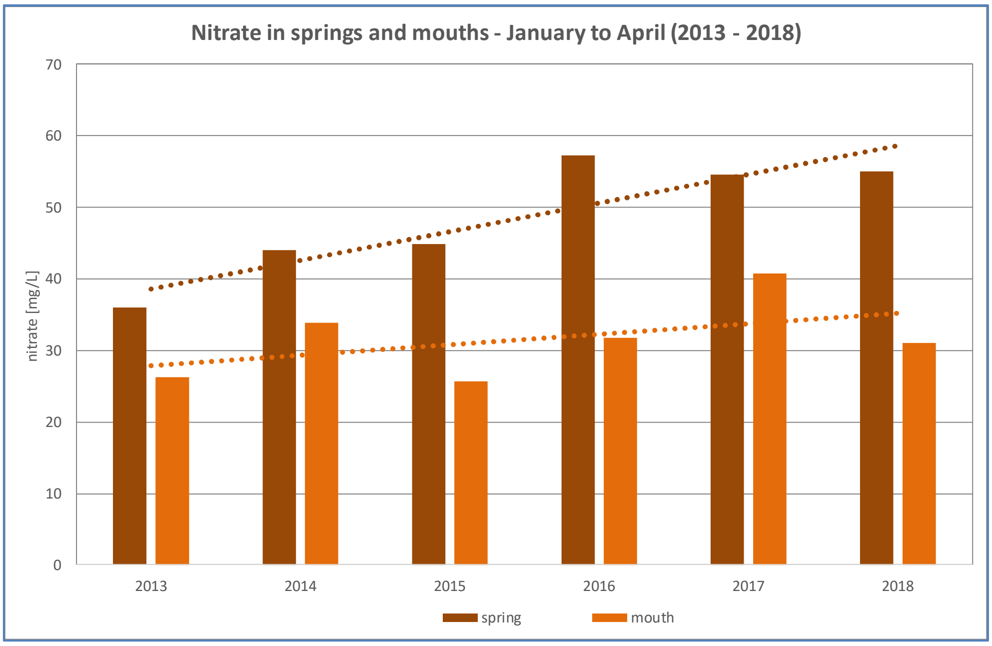

figure 28: Average of nitrate concentration over the years in springs and mouths of the tributaries in spring time (river Our and Sauer)

Between January and April the water temperature is very low and the biological activity is reduced. Therefore, the nitrate concentration in the mouths (31,6 mg/L) shows the same trend as the concentration in the springs (48,6 mg/L). In this time the springs have their highest discharge and a lot nitrate is washed into the river.

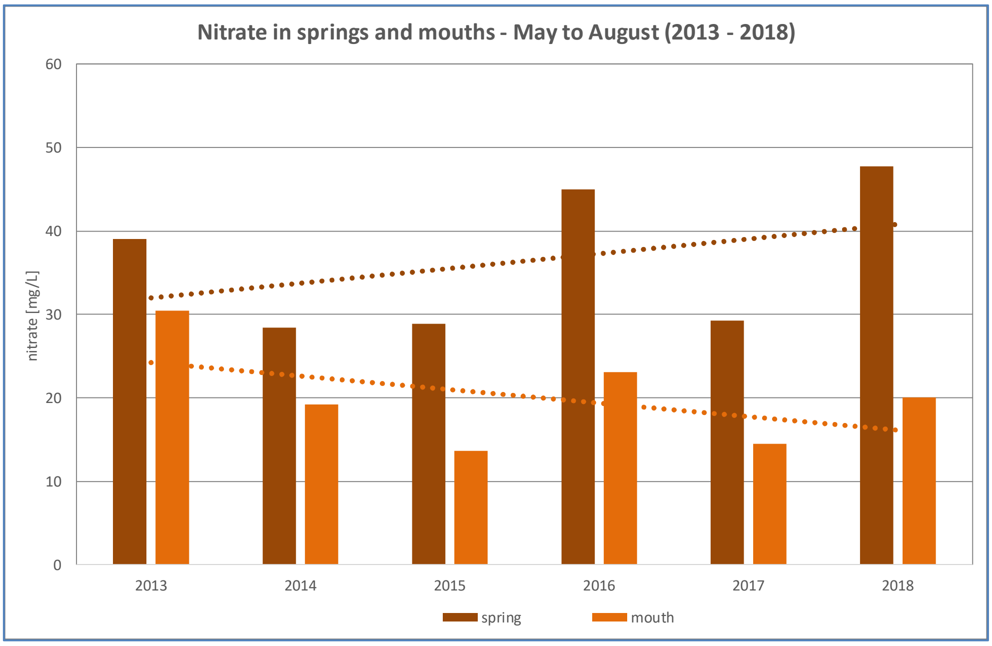

figure 29 :Average of nitrate concentration over the years in springs and mouths of the tributaries in summer time (river Our and Sauer)

The nitrate concentration in the springs in the seasons summer and autumn shows the same increasing trend as the total average and the average from January to April. In contrast the concentration in the mouths are going down. This can be caused by biological activity in the tributaries during May to December.

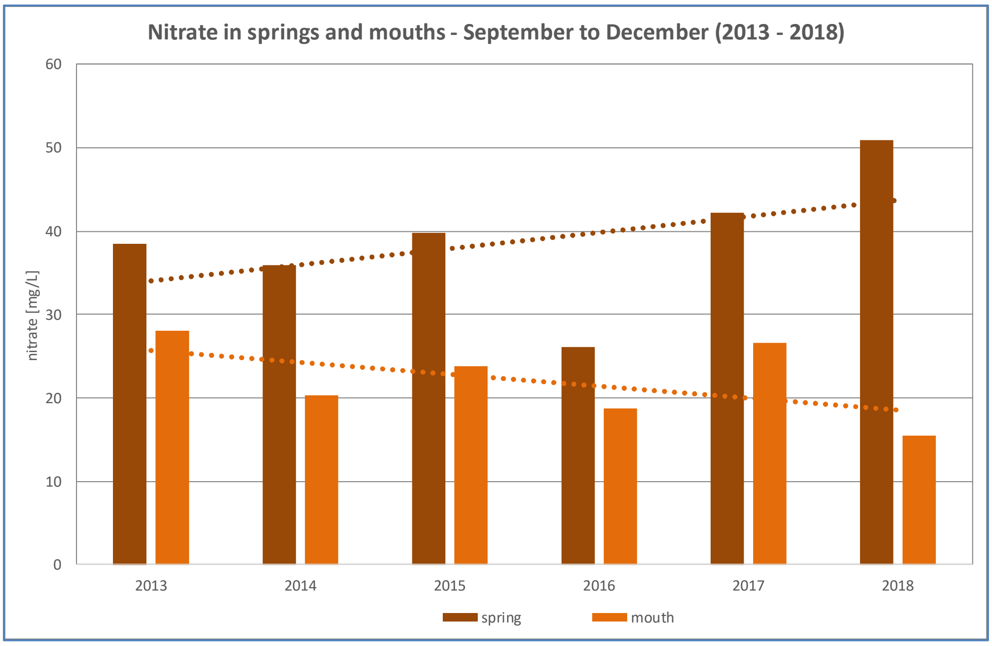

figure 30 :Average of nitrate concentration over the years in springs and mouths of the tributaries in autumn (river Our and Sauer)

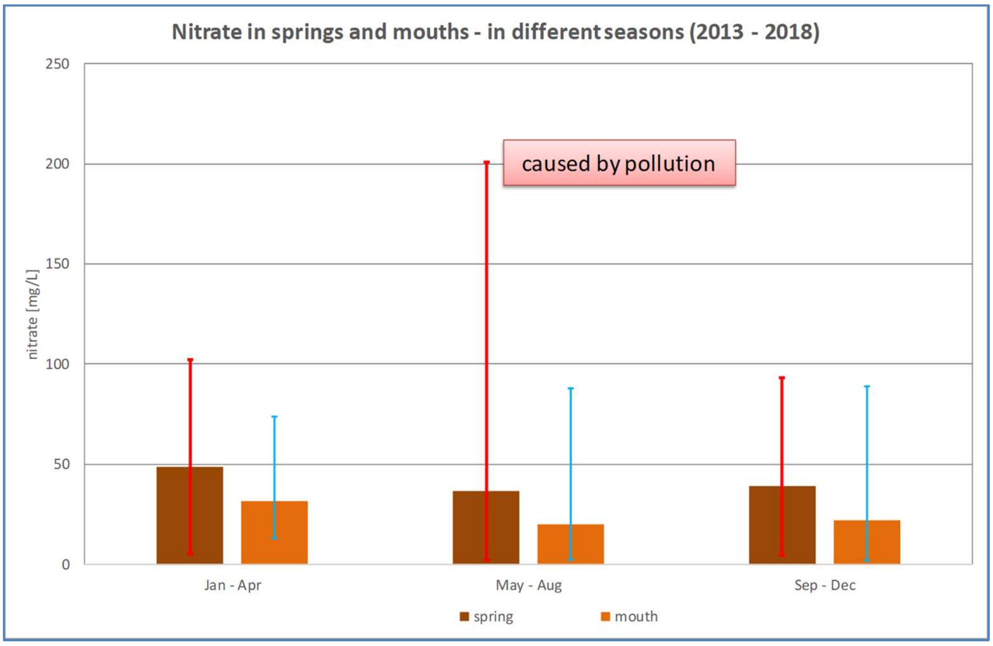

figure 31 :Average of nitrate concentration over the years in springs and mouths of the tributaries (river Our and Sauer)

The range of the nitrate concentration seems to be independent of the season. In summer 2018 there was a pollution with fertilizer next to the spring area. The Adminstration of Water was informed.

6 Pesticides in selected springs 2013 to 2018

Samples from different springs were analyzed by the administration of water from 2013 to 2018. Several parameters such as pesticides, ions and heavy metals were analyzed. In average 11 samples were analyzed.

In 2013 and 2014 no degradation products of Metazachlor and Metolachlor were monitored. But after the pesticide accident in Belgium (autumn 2014) the administration started to detect the degradation products as well. In most of the samples Metazachlor ESA was detected (see figure 32). The highest concentration was seen in Stolzebuerger Akescht in the year 2015. Stolzebuerger Akescht had in total a high concentration of pesticides in all the years.

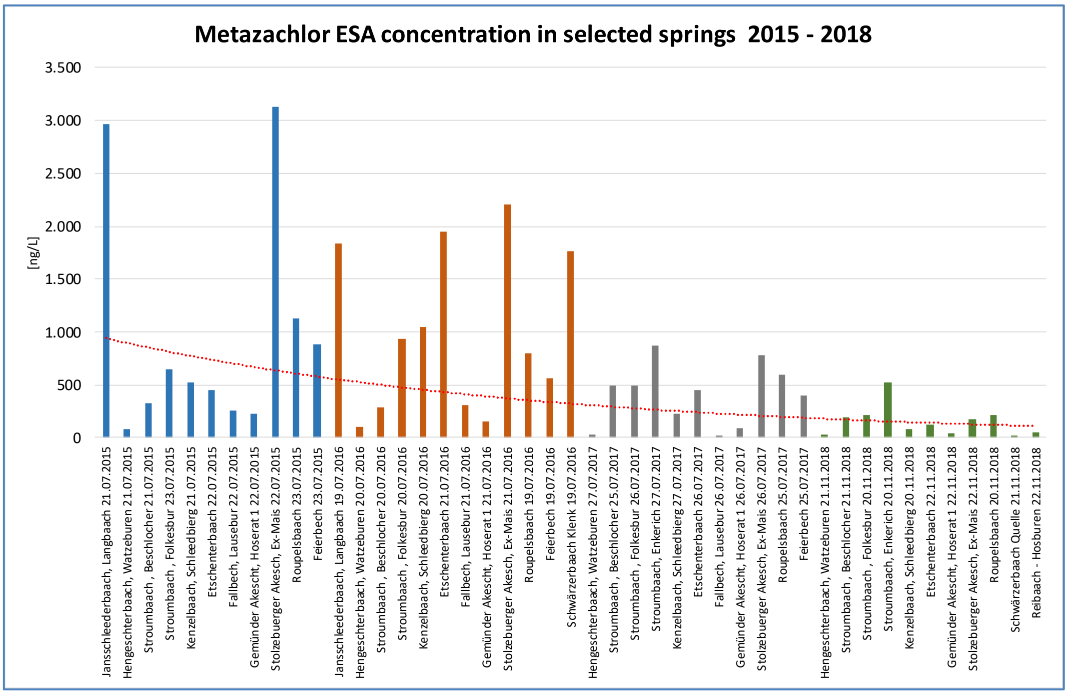

figure 32: Metazachlor ESA in springs – 2015 to 2018

Four springs (Folkesbur, Gemünder Akscht, Stolzebuerger Akescht, Janschleder- Roupelsbaach, see figure 33) are polluted by the degradation products of Metolachlor that is used for maize production. Since 11th February 2015 the application of Metolachlor is forbidden in Luxembourg all over the country. The concentration of the products is decreasing which lead to the assumption that the products are washed out. Metolachlor itself was not detected.

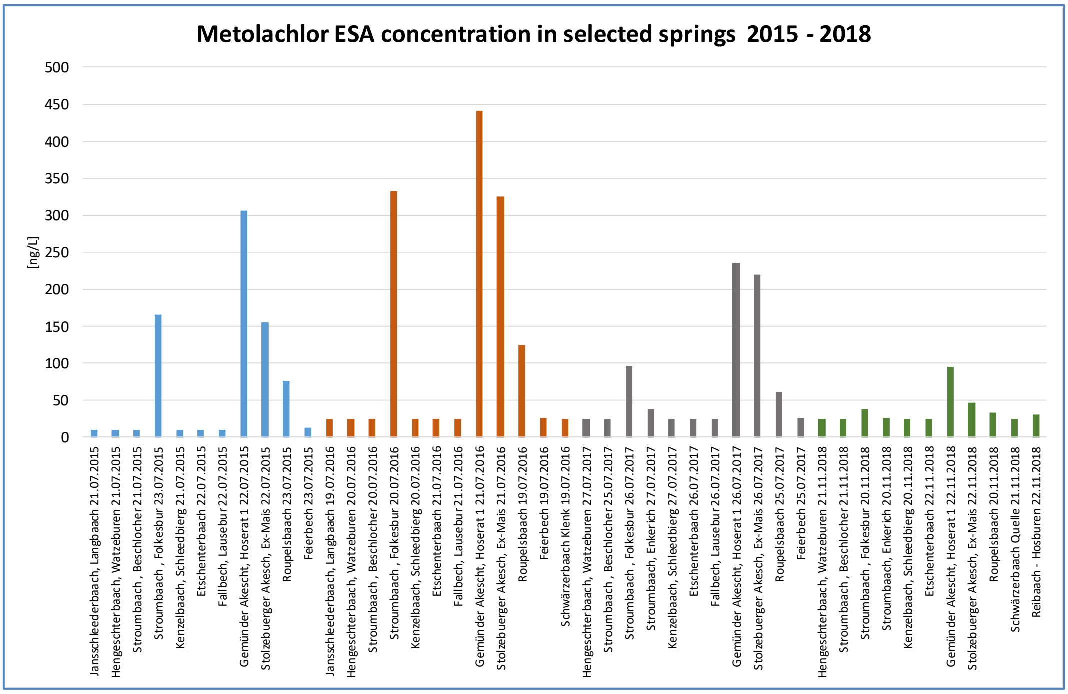

figure 33: **Metolachlor ESA in springs – 2015 to 2018**

In sample Kenzelbaach (Schleedbierg) Dichlorbenzamide is found (see figure 34). Dichlorbenzamide is a degradation product of Dichlobenil, which is not approved in Luxembourg. However Casoron is a widespread used herbicide in Luxembourg, not only in agriculture. However, the concentration is decreasing over the years.

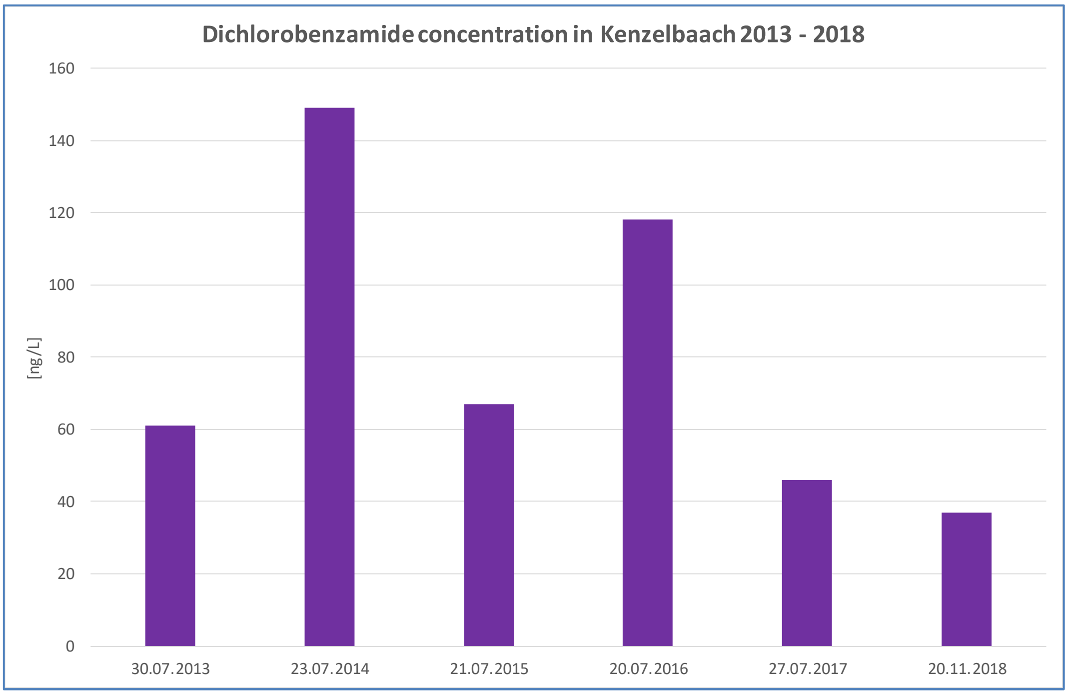

figure 34: **Kenzelbaach – Dichlorobenzamide 2013 to 2018**