Influence of Storm ”Kyrill” Induced Deforestation on the Silicon Supply of the Sorpe Dam

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The storm ”Kyrill” in 2007 fell an huge amount of timber in North Rhine-Westphalia, Germany and produced areas with uncovered soil. It is assumed that bare soil leads to an increased leaching of minerals, which could influence the reason Si concentration in the receiving waters. We were able to proove this by finding a slight positive correlation between the relative area of Kyrill clearances and the Si content of the draining streams on several forest covered areas on the western shore of the Sorpe dam. In catchment areas with 44 % Kyrill clearances the Si content of the draining streams increased about 1.1 mg/L (SiO_2), that is about 0.25 mg/L (SiO_2) for each 10 % of deforestation. This additional silicon load could possibly have a positive effect on the diatom development in the dam.

1 Introduction

In the night of january 18th, 2007, a storm with maximum velocities of more than 225 km/h drew over Europe. The associated depression and the storm were named ”Kyrill”. More than 37×10^6 m^3 of timber fell in Germany alone (Bundesregierung 2007), almost 50 % of that figure only in North Rhine-Westphalia: 18×10^6 m^3 on an area of 31102 ha (areas smaller than 0.25 ha are excluded in this calculation) (ASCHE et al. 2007). A decrease in trees is followed by a decrease in evapotranspiration, which has as consequence an increased surface and subsurface flow (ELLIOT et al. 1999), what means an increased leaching of minerals. Removing vegetation and forest coverage causes erosion and a run off of nutrients which can lead to a loss of up to 0.6 kg of soil m^{-2} yr^{-1} (DOUGLASS/GOODWIN 1980).

This observation raises the question wheather or not clearances in the forest due to Kyrill could remarkebly increase the elution of Silicon and influence the population growth of diatomaceous algae in the Sorpe dam.

2 Investigated area

The Sorpe reservoir forms part of the dams which supply the Ruhr industrial region with water (fig. 1). The reservoir lies in the mountains of the Sauerland (North Rhine-Westphalia, Germany) in a catchment area of about 100 km^2, of which 66.7 % are forested. It consists, similar to the remaining dams of the Ruhr region, of a pre- and a main basin.

The purpose of the pre-basin is the reduction of nutrients to keep the main basin and the subsequent waters of the river Ruhr in nutrient poor state. It measures about 1 km both in length and width and has a maximum depth of 9 m. It is separated by a barrier from the main basin. At maximum level the barrier lies about 1 m under the surface, so that the uppermost layer is common to both basins in the time, when the reservoir is filled to maximum. The pre-basin receives the effluents from two streams rich in nutrients, running mainly through agriculturally used area. The nutrient status of the pre-basin is highly eutrophicated.

The waterbody of the main basin forms a slightly curved bow of 6.2 km length and 700 m width (measured at the north end), orientated from south to north-east. Its surface spreads over 3.38 km^2, the maximum depth is 57 m, while the mean depth measures 21 m. The total volume is 70.8×10^6 m^3. The theoretical filling time is 1.53 years. It receives the waters of the pre basin and the nutrient poor waters of contributing small streams arranged around the main basin. The nutrient status is oligo- to mesotrophic (LAWA 1990). In 2007 the trophic rating increased from 1.5 to 1.8 according to LAWA 2001 (RUHRVERBAND 2008).

The majority of the flora of both basins are diatoms. In the pre-basin *Asterionella formosa* and *Synedra acus* dominate, whereas in the main basin *Asterionella formosa*, *Melosira (Aulacoseira) varians* and *Fragilaria crotonensis* are the most common diatoms.

The catchment area of the dam is situated in the Arnsberg beds, which are a part of the Renish Shist Mountains. The parent material are grey to black upper arbonic greywacke, clay and silt stones and sandstones (cn1 in fig. 2), partly conglomeratic. The pre dam and the southern parts of the catchment area contain lower carbonic lime parts (cdk) together with dark clay and alum shists (cdn). The valleys contain alluvic alteration and loess silts (dl). The majority of the forests on the slopes of the Sorpe valley is composed of *Picea abies*, together with a small fraction of *Fagus sylvatica*. The diameter of the trees is about 30 cm.

3 Methods

To obtain an overview of the damages Kyrill made to the landscape, the forestry department of the North Rhine-Westphalian government mapped the forests by means of

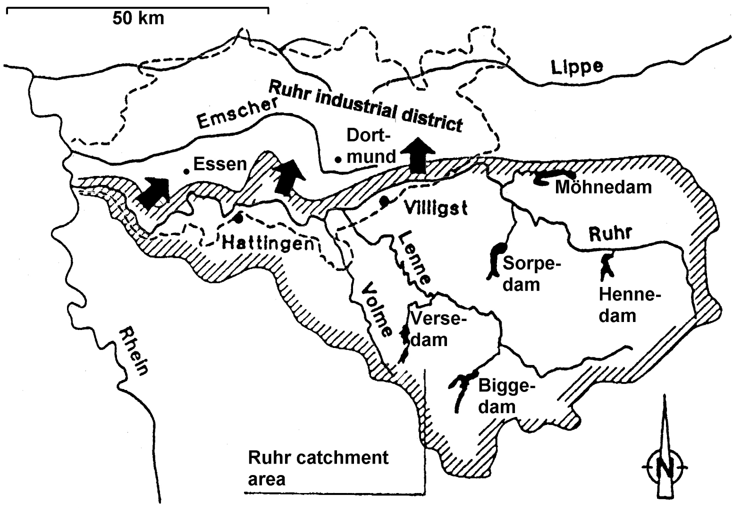

Figure 1: Reservoirs in the Ruhr catchment area (from RISSLER 1997, modified)

aerial infrared photographs (LDS 2007). These maps were the prerequisite to determine where water of the draining streams should be sampled to examine silicon content and conductivity (κ). Ten sampling points (fig. 2) were choosen according to accessibility and differences in the fraction of Kyrill clearances in respect to the total catchment areas of the draining streams. The Kyrill fractions ranged from 4.4 to 41.6 %. (An example is shown in fig. 4). Each station was sampled in total three times, on the Jan. 14th, Jan. 21st and March, 3rd, 2008, three days with precedented rainy periods (fig. 3). An WTW conductivity meter (Cond 315i, with automatical correction to 20 °C) and the Macherey-Nagel visocolor silicon test for water analysis (914224), together with Macherey-Nagel photometer PF-10, were used. Results were plotted against relative Kyrill area and regression curves were obtained using the spreadsheet module of the OpenOffice.org software package (version 2.4). Significance was calculated by correlation analysis.

4 Results

The ten streams draining the catchment areas were examined as close to the dam as possible, depending on accessibility. The results are found in table 1. With the data of the three visits of the sampling sites pooled, regression analysis shows a correspondence between silicon content of the streams and the relative area of Kyrill clearances (fig. 5). An increase of the vegetation free area to 40 % lead to an increase of the silicon content of afflux of env. 1 % mg/L (SiO_2). (The correlation coefficient is about r = 0.38, which states significance at $\alpha = 0.05$).

Assumed an average loss of 20 % forestry area due to Kyrill in the total catchment area (100 km^2) of the Sorpe dam, this would match an increase of 0.5 mg/L SiO_2 in the contributing waters. With an annual influx of 52×10^6 m^3 this makes 26000 kg of SiO_2,

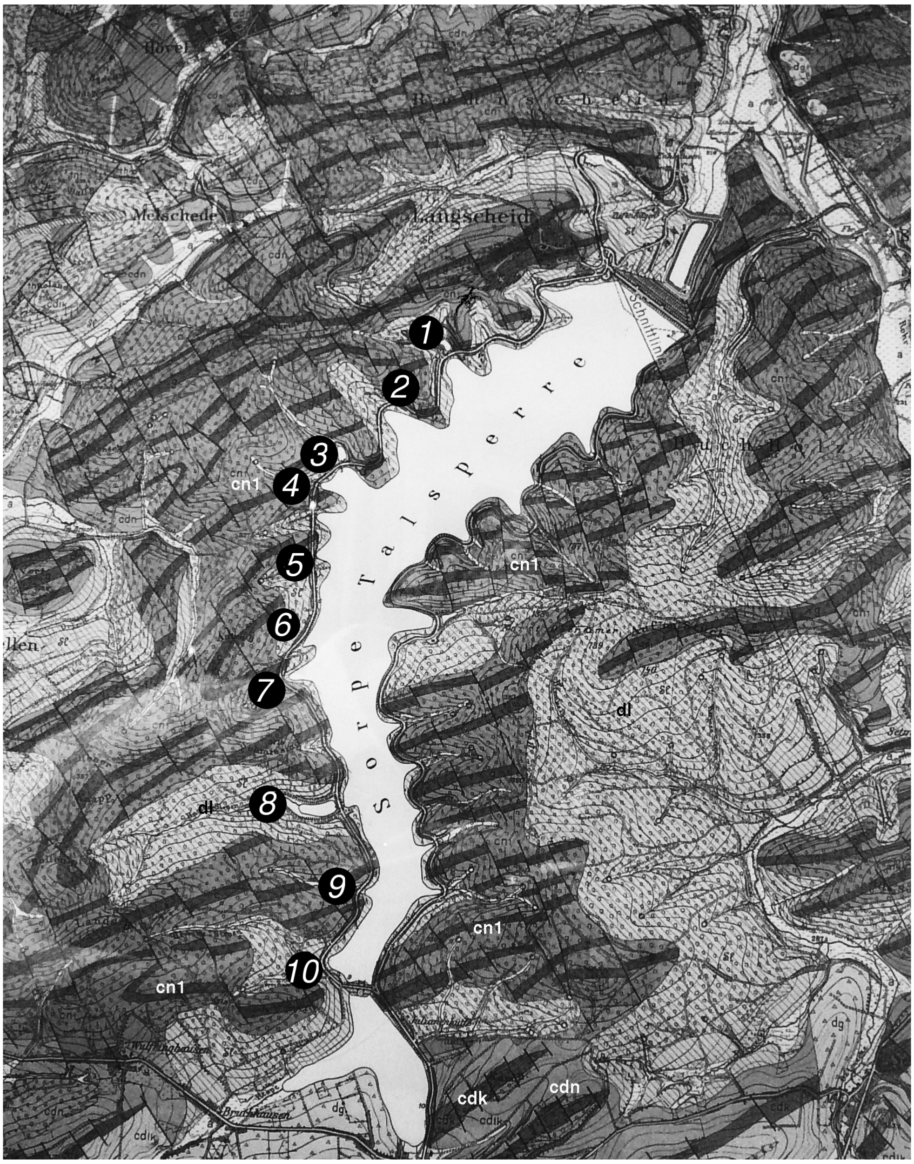

Figure 2: Geological situation around Sorpe dam (from Preussische Geologische Landesanstalt 1938) with sampling sites

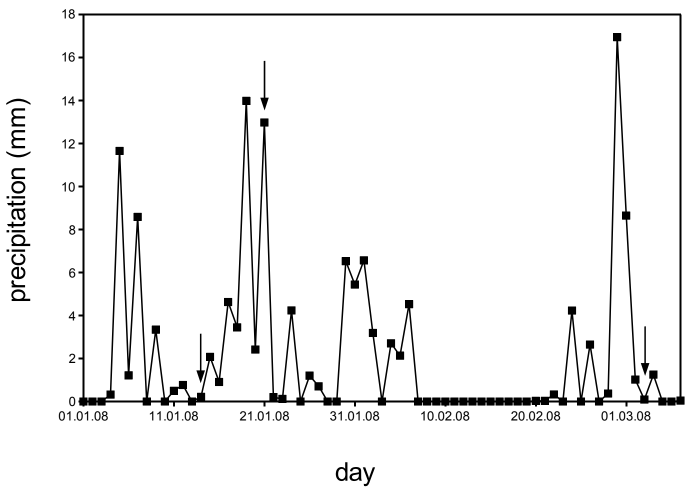

Figure 3: Squares: Precipiation (mm) (LANUV 2007, measured in Menden-Lendringsen, about 20 km north-west of Sorpe dam). Arrows indicate sampling times.

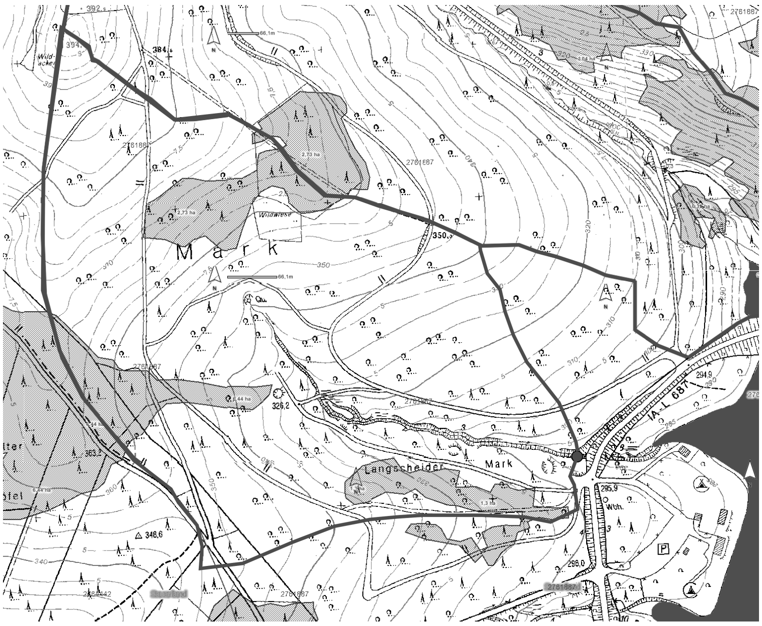

Figure 4: Map of catchment area "Marker Bach" (32.9 ha, surrounded by thick line) with Kyrill clearances (4.4 ha, shaded), showing sampling point no. 4, indicated by dot (made using data from LDS 2007)

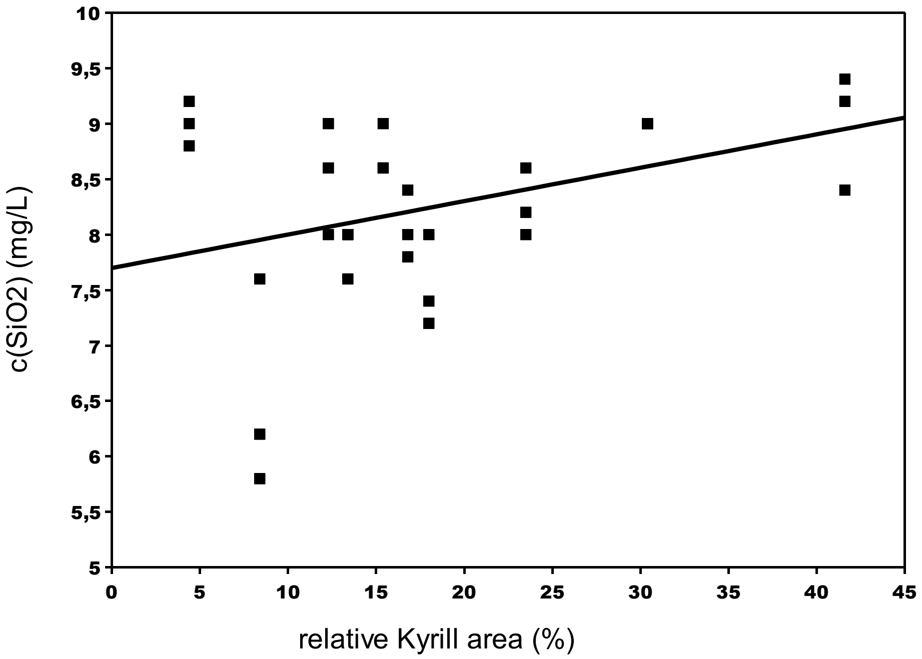

Figure 5: Silicon content of the draining streams in relation to the Kyrill fraction of their catchment areas, with linear regression

what equals to an additional silicon load of 11400 kg. It is possible, that this additional load leads to additional diatom biomass. But since it does not take long until clearances are vegetation covered again, the momentary state is only transitionally.

No.	Area (total) (m^2)	Area Kyrill (m^2)	Area Kyrill (%)	Jan. 14th, 2008 c(SiO_2) (mg/L)	Jan. 14th, 2008 κ (µS/cm)	Jan. 21th, 2008 c(SiO_2) (mg/L)	Jan. 21th, 2008 κ (µS/cm)	March 3th, 2008 c(SiO_2) (mg/L)	March 3th, 2008 κ (µS/cm)
1	166648	14115	8.4	5.8	602*	6.2	264	7.6	263
2	382441	58866	15.4	9.0	129.2	8.6	116.5	8.6	116.6
3	563935	95009	16.8	8.4	114.5	7.8	106.4	8.0	105.1
4	329962	44211	13.4	7.6	90.5	8.0	87.5	8.0	86.9
5	154268	27785	18.0	8.0	153.6	7.2	136.6	7.4	136.2
6	170145	70536	41.6	8.4	97.2	9.2	94.0	9.4	93.2
7	277433	65142	23.5	8.0	104.9	8.2	103.2	8.6	105.4
8	1298190	394752	30.4	9.0	133.5	9.0	134.4	9.0	136.9
9	226583	10080	4.4	9.0	105.9	8.8	104.4	9.2	103.9
10	746526	92014	12.3	9.0	104.3	8.6	100.6	8.0	98.6

Table 1: Si concentration and conductivity of streams in some Kyrill areas on the west shore of Sorpe dam (*: Increased conductivity due to de-icing salt)

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