Water Quality Laboratory Analyses and Data Interpretation

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1. Introduction

The absolute pure water rarely exists in nature. Actually, water is commonly found to carry a wide variety of constituents. Thus, this phenomenon causes the water needs to be described by many parameters that have a large or essential influence on the water (Water, 1978). This is water quality, which refers to the chemical, physical, biological, and radiological characteristics of water. Due to these constituents' circulation in the natural situation and human activities affect, water quality has different characteristics in different places. Therefore, it is necessary to analyze water quality and study its changes in time and space.

The objective of this report is to analyze water quality in the vicinity of Delft and studying the changes in water quality between different spots. We place emphasis on potential contamination by nutrients and organic matter, which are the most common water quality issues worldwide.

All the students were divided into three groups to analyze water quality around Delft and study the changes in water quality. All three groups took samples from three representative sites (city canal, lake, and farm canal), and did experiments and data analysis to achieve the objective of the assignment. These three sites are on behalf of three typical parts in Delft. The city canal point represents the water in the city, which its quality is influenced by human activity and domestic wastewater. Lake point represents the natural situation. Farm canal point represents the water in the agriculture system, which has quality influenced by farming activity and agriculture wastewater.
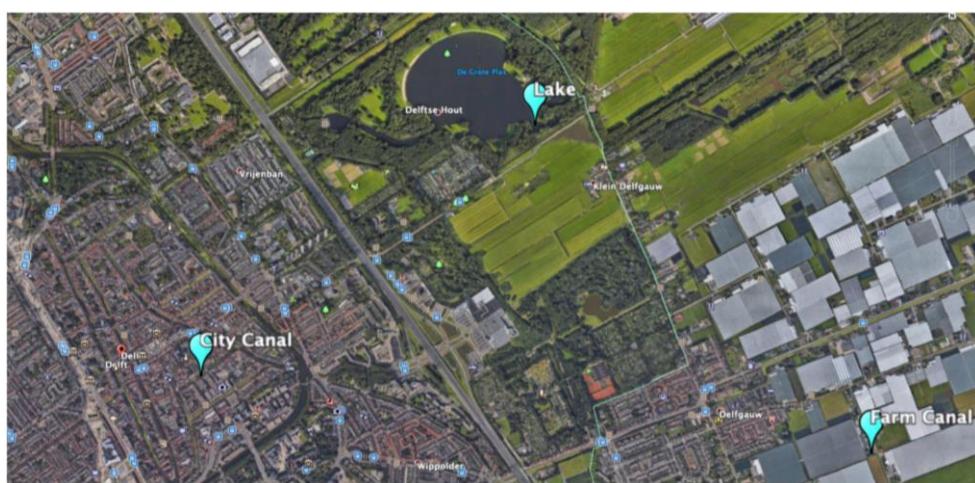
Figure 1 the three sites for sampling

2. Methodology

The whole process of the experiment is as follows. The first step is taking samples in different sites and doing situ analyses to get values of parameters that are easily changed

during transporting and storage. Second, after transporting samples to the laboratory, we analyze other parameters, mainly the ions in water. Finally, we analyze the data of field and laboratory testing and give the interpretation of them.

2.1 Sample collection

Our requirement of sampling is to keep no change of the sample properties from the specific collection point to the laboratory. We used the chemically neutral plastic bottle as our sampling bottle. Firstly, we used the bucket to take some water from the river. And then, we rinsed the bottle by water from the bucket to ensure the sample is only from the river. After rinsing, we filled the sampling bottle with water with exactly no air in the bottle in case unexpected reactions between air and water happen during the transport. Finally, the label should be attached to the bottle. On the label, the sampling time, location, sample number, and sampler should be recorded.

2.2 Water analysis

2.2.1 Field measurements

2.2.1.1 Dissolved oxygen (DO)

We used a dissolved oxygen meter to measure the amount of oxygen dissolved in water. The method of dissolved oxygen meter is easy. We just put the probe into water and wait for the temperature on the screen to stop changing, and then we can read the dissolved oxygen. For the meter we used, dissolved oxygen can be reported in milligrams per liter (mg/L) and the percent of air saturation. The relation between two ways is: O_2 mg/L = (Measured % DO) *(saturate DO value for specific situation). (Fondriest Environmental, 2013). After the measurement, we cleaned the probe with pure water to keep the sensor clean and undamaged.

2.2.1.2 Electrical conductivity (EC)

The electrical conductivity meter tested the electrical conductivity. The using method of electrical conductivity is similar to the dissolved oxygen meter. We put the probe into water and waited for the temperature on the screen to stop changing, and then we can read the electrical conductivity. We also need to clean the sensor after measuring it.

2.2.1.3 pH

We used a pH meter to test the pH of water. The most process is the same as the measuring processes of DO and EC. However, in pH measurement, we set temperature as water temperature, which is from the measurements of DO and EC, instead of waiting for stable temperature. Another difference is that the probe needs to keep moist generally. So, after cleaning, we put the probe into a rubber tube filled with a specific liquid.

2.2.1.4 Temperature

Temperature is a base parameter of water quality. The value of temperature is measured by the sensor of meters of DO and TC.

2.2.1.5 Turbidity

It is better to measure turbidity before taking the sample in case the clays at the bottom of the river are removed, increasing the turbidity. We used the turbidity tube to measure the turbidity. First, we filled the tube with water. And then we looked through the tube toward the target disk on bottom. If we can see the disk, we recorded the turbidity is greater than the length of the tube. If the disk was not visible, we released water till the

disk can be seen and then recorded the turbidity.

2.2.1.6 Transparency

The transparency of water depends on its color and turbidity. The Secchi disk was used to measure water transparency. Secchi disk is a white disk with 30 centimeters in diameter. The Secchi disk reading is the depth that the disk disappears with lowing it slowly and vertically into the water.

2.2.2 Laboratory measurements

2.2.2.1 Chloridion (Cl)

We used the titration way to determine the concentration of Chloridion. K_2CrO_4 was chosen as an indicator solution. When titrating chlorine with $AgNO_3$, since the solubility of AgCl was less than that of $AgCrO_4$, the chloride ions were completely precipitated first, and then the chromate was precipitated in the form of $AgCrO_4$ which produces brick red, indicating the end of the titration. The steps are as follows.

1. Transfer 50.00mL sample to an Erlenmeyer flask

2. Add 1 ml 5% K_2CrO_4 indicator solution

3. Titrate with 0.015 mol/L $AgNO_3$ until a reddish-brown color persists.

4. Carry out a blank by taking 50.00 mL distilled water instead of the sample

2.2.2.2 Ammonium (NH_4^+-N)

We use spectrophotometry to measure the ammonium concentration in samples. Spectrophotometry is a method for quantitative analysis of a substance by measuring its absorption at a specific wavelength or within a certain wavelength range. The instruments and reagents used are shown below. Follow the instructions on the kit step by step to get the results of ammonia nitrogen.

Figure 2 Instruments and reagents for spectrophotometry

2.2.2.3 Nitrate (NO_3^--N)

Spectrophotometry is also used to measure nitrate. The process is the same as the process of ammonium.

2.2.2.4 Phosphate (PO_4^{3-})

Spectrophotometry is also used to measure nitrate. The process is the same as the process of ammonium.

2.2.2.5 Other ions

Other ions needed to analyze were tested by the laboratory staff, which includes

sulphate (SO_4^{2-}), total organic carbon (TOC), total nitrogen (TN). While total organic nitrogen can be calculated by the difference between total nitrogen and the sum of ammonium and nitrate.

2.3 Data analysis

There are three parts of data analysis. The first one is to analyze the data of our samples by analyzing the differences between duplicate results and comparing data of our group with other groups. The second part is to compare results with historical data from Delfland Water Authority. The third part is to compare results with water quality in the Netherlands.

3. Results

3.1 Sample analysis results

3.1.1 Group 1 results

The results of the situ analysis are as follows. As the table is shown, the parameters did not have much change except dissolved oxygen and EC. The dissolved oxygen concentration is highest in the lake, and in the farm canal, the concentration is also high, while that in the city canal is lower than the concentration of the places with exuberant water plant. Accordingly, EC is highest in the city canal with lower values in the lake and farm canal.

Table 1 The data of situ analysis in group 1

Sample	Latitude	Longitude	Temp (°c)	Oxygen Saturation (%)	Oxygen Concentration (mg/L)	EC (µS/cm)	pH	Turbidity (TU)	Transparency (cm)
1	52°00'38.33"N	4°21'44.34"E	6	74.2	9.48	987	8.18	5-6	greater than 112
2	52°01'16.5"N	4°23'9"E	6	97.4	12.27	688	8.56	<5	greater than 55
3	52°00'34.99"N	4°24'20.21"E	7	93.6	11.53	596	7.94	5	greater than 30

The following table is the data of laboratory analysis in group 1. The differences between the duplicate values of nitrate and ammonium are small, while for phosphate, we did not do the duplicate measuring. The differences in chlorine are worth paying attention to. The error of chlorine is more distinct. During the titration, we visually measure the color changes to determine the end of the titration, which is not accurate. So, titration can cause more errors than spectrophotometry.

Table 2 The data of laboratory analysis in group 1

Sample	Trial	Cl^-(mg/L)	Average Cl^-(mg/L)	NO_3^--N (mg/L)	Average NO_3^--N	PO_4^{3-} (mg/L)	NH_4^+-N (mg/L)	Average NH_4^+-N
1	I	132.9375	120.7	3.51	3.43	0.516	0.211	0.209
	II	108.477		3.34		-	0.207	
2	I	60.6195	64.9	2.11	2.11	0.336	0.165	0.166
	II	69.1275		-		-	0.167	
3	I	70.191	65.4	3.43	3.43	0.59	0.268	0.268
	II	60.6195		-		-	-	

3.1.2 Comparing results with other groups

The values of DO, EC, pH, TOC, TN, and SO_4^- in all three groups are similar. We think these parameters are credible. The other parameters (Cl-, NH4+, NO3-, and PO43-) in

group 1 are higher than the other two groups. Compared with the IC value given by the laboratory, we find the values measured are higher. We titrated too fast causes we did not end at the exact time of all chlorine precipitating and added more AgNO₃. So the values measured were higher. For ammonium values, we knew the group 2 took wrong testing, so our results can be seen as the true values. However, when measuring nitrate and phosphate, we wrote the label on the glass tube, which affected the ability to penetrate light. So, the data of nitrate and phosphate are not considered credible.

Table 3 The data of water analysis in all the groups

Group	Sample	pH	DO (%)	DO (mg/L)	EC (μS/cm)	Temperature (C)	Cl⁻ (mg/L)
G1	S1	8.2	74	9.5	987	6	121
G2	S1	7.8	75	11.5	983	6	114
G3	S1	8.2	75	9.5	969	5.9	79.2
G1	S2	8.6	97	12.3	688	6	64.9
G2	S2	8.6	97	12.3	688	6	85.1
G3	S2	8.2	94	11.9	688	6	59.6
G1	S3	7.9	94	11.5	596	7	65.4
G2	S3	8.1	105	13.6	706	6.7	71.3
G3	S3	7.6	83	9.8	686	7.5	25.0

Group	Sample	TOC (mg/L)	TN (mg/L)	NH₄⁺-N (mg/)	NO₃⁻-N (mg/L)	PO₄³⁻-P (mg/)	SO₄²⁻ (mg/L)
G1	S1	14.1	1.66	0.21	3.34	0.52	129
G2	S1	12.5	1.50	<0.015	2.13	0.06	125
G3	S1	15.0	1.71	0.03	1.86	0.07	128
G1	S2	11.7	0.99	0.17	2.11	0.34	132
G2	S2	11.4	0.96	0.02	0.71	<0.05	132
G3	S2	12.9	1.14	0.05	0.68	<0,05	131
G1	S3	10.3	1.61	0.27	3.43	0.59	111
G2	S3	11.5	1.46	<0.015	1.78	0.44	129
G3	S3	9.67	2.97	0.34	2.55	0.71	57.8

* Red values do not give indication because of the wrong method of measuring

3.2 Comparing results with historical data from Delfland Water Authority

The following tables describe group 1 results compared with historical data in all three sites. All the parameters are in the range of historical data and near the average of historical data. And most of the parameters are between the minimum and maximum of the winter historical values except total nitrogen, which is lower than the minimum of winter historical data in all three sites.

Table 4 Group 1 results compared with historical data in the city canal

City Canal	Temp (C)	DO (mg/L)	NH₄⁺-N (mg/L)	NO₃⁻N (mg/L)	TN (mg/L)	PO₄³⁻-P (mg/)	SO₄²⁻ (mg/L)	TOC (mg/L)
Group1	6.0	9.5	0.21	1.61	1.66	<0.3	129.0	14.1
History_min	0.6	0.2	0.03	0.03	0.89	0.0	40.6	8.9
History_max	22.8	20.0	0.90	2.20	4.80	2.6	141.0	18.3

	Temp (C)	DO (mg/L)	NH₄⁺-N (mg/L)	NO₃⁻N (mg/L)	TN (mg/L)	PO₄³⁻-P (mg/)	SO₄²⁻ (mg/L)	TOC (mg/L)
History_ave	13.1	5.7	0.22	0.37	2.25	0.6	73.3	12.9
Winter_min	0.6	6.4	0.14	1.35	2.40	0.1	94.9	9.8
Winter_max	9.5	10.9	0.90	2.20	4.80	0.6	135.0	9.8
Winter_ave	4.3	8.3	0.35	1.84	3.51	0.2	119.0	9.8

Table 5 Group 1 results compared with historical data in the lake

Lake	Temp (C)	DO (mg/L)	NH₄⁺-N (mg/L)	NO₃⁻N (mg/L)	TN (mg/L)	PO₄³⁻-P (mg/)	SO₄²⁻ (mg/L)	TOC (mg/L)
Group1	6.0	12.3	0.17	0.42	0.99	<0.3	132.0	11.7
History_min	0	4.5	0.03	0.03	0.8	0.005	127	10.7
History_max	24	18.3	0.80	0.59	4.5	0.686	3700	14.5
History_ave	13	10.2	0.15	0.17	1.58	0.105	223	12.1
Winter_min	0	7.5	0.03	0.345	1	0.005	127	10.7
Winter_max	8.7	17.1	0.54	0.592	2.5	0.23	142	10.7
Winter_ave	5.0	11.6	0.20	0.487	1.6	0.08	136	10.7

Table 6 Group 1 results compared with historical data in farm canal

| Farm canal	Temp (C)	DO (mg/L)	NH₄⁺-N (mg/L)	NO₃⁻N (mg/L)	TN (mg/L)	PO₄³⁻-P (mg/)	SO₄²⁻ (mg/L)	TOC (mg/L)
Group1	7.0	11.5	0.27	1.63	1.61	<0.3	111.0	10.3
History_min	1.8	1.5	0.03	0.242	1.3	0.322	32	-
History_max	23.6	20	6.9	16	40	11	186	-
History_ave	12.5	8.9	0.97	4.64	9.95	2.24	78.2	-
Winter_min	1.8	3.72	0.18	2.99	4	0.4	32.3	-
Winter_max	9.4	20	3.5	5.44	40	6.8	151	-
Winter_ave	5.6	10.18	0.89	3.94	11	1.7	86.9	-

3.3 Comparing results with water quality in the Netherlands

In the report, Water quality in the Netherlands, the unit to describe the concentration of nitrate is NO_3^-/L. So, we need to convert our results into NO_3^-/L. They are 7.13, 1.86, 7.22 NO_3^-/L in the city canal, lake, and farm canal. From figure 3 and figure 4, we can know the concentration of nitrate keeps a decreasing trend from 1992. And our measured data are in parallel with this trend. If we extend the curve on the two graphs to 2020, our data will be included in the curve. In figure 5, there are light blue spots around Delft, which means the concentration of nitrate is from 2 to 10 mg/L. This is also consistent with our measured data, which proves the rationality of our data from another aspect.
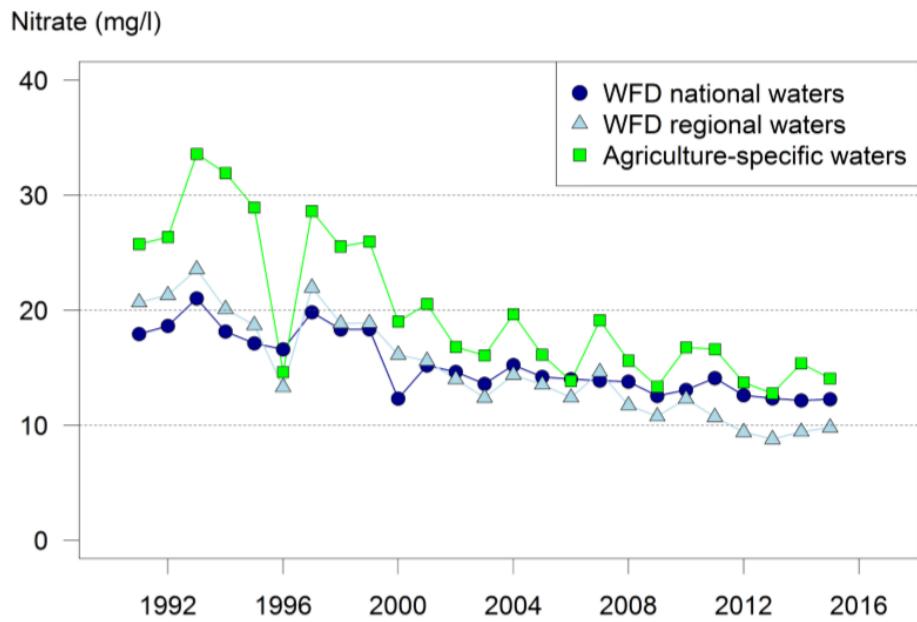
Figure 3 Nitrate concentration (winter average of NO3 in mg/l) in fresh surface waters in the period 1990-2015

(B.Fraters, 2017)
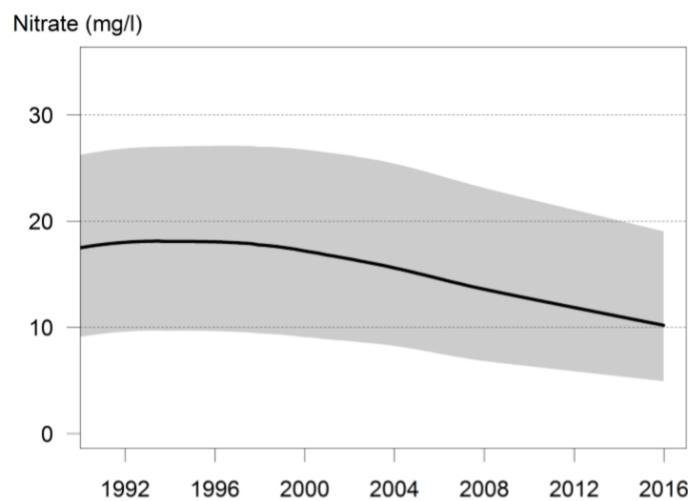
Figure 4 Calculated trend in the nitrate concentration (winter measurements; as NO3 in mg/l) for agriculture-specific waters; median trend (continuous line) and the area between the 25th and 75th percentile trends (grey area)

(B.Fraters, 2017)
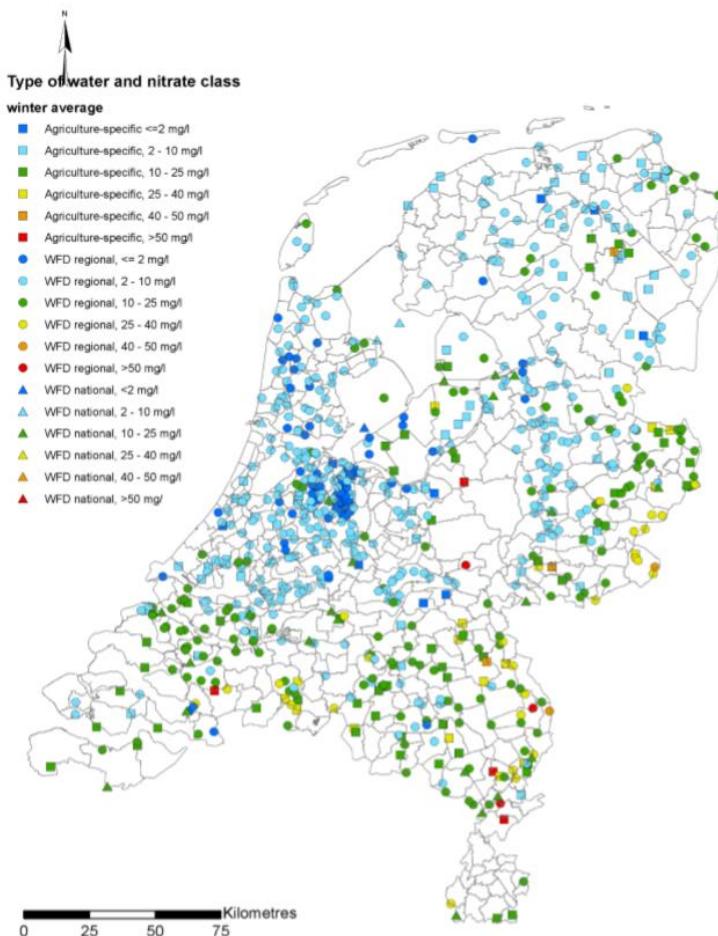
Figure 5 Winter average nitrate concentration in Dutch fresh waters per measurement location in the period 2012-2015

(B.Fraters, 2017)

4. Interpretation

Because the temperature in winter is low, the saturated concentration of dissolved oxygen is high. And in areas where vegetation is abundant, the concentration of dissolved oxygen will be higher than in areas where aquatic vegetation is scarce because of plant photosynthesis. Therefore, dissolved oxygen concentrations were high in all three sites, with the highest concentration in the heavily vegetated lakeside and the lowest in the urban water intake site.

Under the condition of oxygen enrichment, due to the REDOX reaction, the existing form of nitrogen in water will be mainly nitrate, while the content of ammonia will be small. The influence of sewage and the use of fertilizers increase the input of organic nitrogen into the nitrogen cycle, while aquatic plants and wetland systems absorb nitrogen from the water. Thus, total nitrogen concentrations are higher in the city canal and on farms than in lakes, and nitrogen is present mainly in the form of nitrates, which have the same trend with total nitrogen in the distribution of spatial scale.

In terms of phosphorus input and output, phosphate in water may increase with the use of chemical fertilizers and decrease with the absorption of aquatic plants. So phosphoric acid would be high on the farm, low in the lake. Chlorine ions are high in cities due to

the use of disinfectants and the influence of factories. And because chlorine is essential for plant growth, it can be reduced in densely vegetated areas. Therefore, among the three sampling points, the urban water body had the highest chlorine content, and the farm had the lowest chlorine concentration.

Our results of dissolved oxygen and nitrogen make sense as the interpretation above, while some parts of chlorine and phosphorus do not make sense. The analysis results of phosphorus are relatively high, and the concentration of chlorine on the farm is also relatively high, which should be lower than the results of the lake and city canal. This is due to the error in titration and the wrong labels in the spectrophotometry process.

5. Recommendations

The analysis results of group 3 at the farm canal were significantly different from those of the first two groups because of the different locations of the water intake point on the farm. This suggests that water quality on the farm is strongly influenced by location. Therefore, I suggest that Delfland record the specific sampling location when sampling on the farm and increase the sampling point on the farm to two, one near the greenhouse and the other at the outlet of the farm area, so as to better monitor the water quality.

The total nitrogen we measured was all less than the historical winter minimum, which is worth Delfland's attention. Three bodies of water can be recently re-measured to see why this is the case.

In the case of sufficient funds, Delfland may consider increasing the parameters of the measurement. Our results show that the changes in chlorine ions in different positions are relatively large, which is worth paying attention to. In addition, the total carbon can also be considered to increase the measurement frequency, because the current data of total carbon is too small to carry out an effective analysis.

6. References

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