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Learning Through Exploration and Research

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Abstract: Potable water, one of the crucial natural resources, is becoming increasingly affected by pollution, which is putting people's health at risk. As part of the extra-curricular activity Chemistry Club, we tackled the investigation of water resources in the vicinity of our school. Research that is integrated into the learning process should come to resemble real scientific research. Exploration and research provide the student with an opportunity to form knowledge in an active learning process – through research work, while they also help us achieve a major contemporary educational goal, that is the development of natural sciences literacy. Through research assignment we focused on brooks and water wells, where we measured chemical attributes of water. With the help of the colorimetric method we established the concentration of nitrates, nitrites, ammonium ions and phosphates as well as the pH value. We found out that chemical water attributes did not exceed the permitted levels set by regulations for potable water.

Keywords: Chemical water attributes, Research assignment

Introduction

Importance of Water in Slovenia

We are usually reminded of water's significance only after it is gone or when it gets contaminated. Because potable water does not pose a major problem in Slovenia, Slovenians are not conscious of the fact that water is a natural resourse whose supplies are most limited. Population growth, climate changes, and, above all, our water management could lead to a great global crisis. Although more than 70% of the world's surface is covered by water, only 2,5% of it is fresh water, and as much as 70% of the latter is in a frozen state. People can thus consume less than 1% of water on our planet.

In Slovenia, most water is used for supplying households and in the industry. Slovenia has lots of available water, but its quality is not satisfactory. Central sources of potable water supply, such as zones of soil water and Karstic springs, are also polluted.

In Slovenia, 70 % of water is used in the energy industry for cooling, 16 % is used as drinking water, and 14 % as process water. In households, drinking water is used for: bathing and body-washing (32 %), sanitation (32 %), laundry (14 %), dishwashing (7 %), cleaning (4 %), cooking (7 %) and other things.

Slovenia has continental climate with great temperature differences between summer and winter, except for the coastal part of the country, where we find Mediterranean climate with mild winters and warm summers. The distribution of precipitation is not even; in eastern Slovenia, most rainfall is in the summer, while in the rest of the country, rainfall is concentrated in autumn, due to the influence of the Mediterranean Sea. As far as the amount of rainfall is concerned, the annual average for the Bohinj area is more than 3000 mm, while it is less than 800 mm for the Prekmurje region; for the coastal region, it is 1000 mm. Particular areas can also be distinguished by various types of torrential rain which differ in terms of duration and amount. In the high mountains and highlands of Alps and in the Dinaric Mountains, the downpours are long and heavy. The rain can also be heavy in the coastal area and in the hills of Brda, while the downpours are short-lived in the eastern part of Slovenia. (see Fig.1)

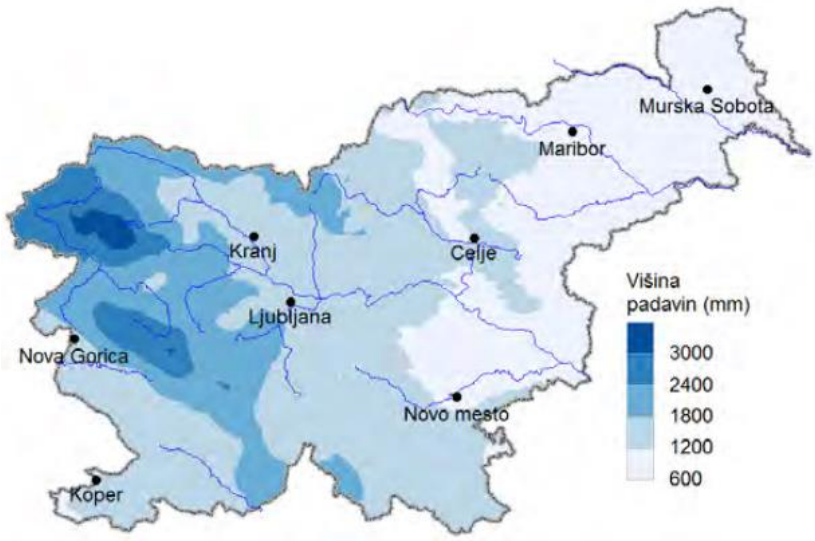

Figure 1. Precipitation in Slovenia in 2017 (source: revija Ujma)

Chemical Parameters

The health adequacy of drinking water is determined by microbiological and chemical parameters.What follows is a list of some chemical parameters set for drinking water in accordance with Rules on drinking water (Official Gazette of the Republic of Slovenia, No 19/04, 35/04, 26/06, 92/06, 25/09, 74/15, 51/17).We have also added the description of the phosphate parameter, which is absent from the above mentioned Rules.

pH value indicates the acidity or alkalinity of water. Very low or very high pH values in drinking water may be a result of accidents, mistakes in water treatment or release from materials in contact with water (e.g. cement pipes). Water with extremely low or high pH values causes irritation to the eyes, mucous membranes and skin as well as tissue damage, and the pH value indirectly affects the materials in contact with water.

Nitrates and nitrites are sources of nitrogen in the environment. They are well soluble in water. We are exposed to nitrates and nitrites through food and water. Nitrates and nitrites are harmful to human health, as they disrupt the oxygen flow around the body. In Rules on drinking water, the limit value for nitrate is 50 mg/L, and for nitrite, it is 0,50 mg/L.

Phosphates are not usually found in the natural environment. In watercourses running through agricultural areas, the values rise to 0,25 mg/l and more. Excessive quantities of phosphates cause mass spread and growth of plants, especially green algae and cyanobacteria. Phosphates are nutrients for plant growth, but greater concentrations signal water pollution. Concentrations of 1000 - 1200 mg/l may produce laxative effects. Rules on drinking water do not set any limit values.

Methods

Experimental work

This article presents an example of writing a research paper undertaken by students aged between 14 and 15 years. Before we set to writing the research paper, we took a look at the school's surrounding area and made enquiries about any streams or wells in the vicinity of our homes. After locating several streams in close and far proximity to the school, we began planning our research.

Our essential research method was laboratory work. We decided that we would do chemical analyses at school, in the framework of Chemistry Club, since all the required laboratory equipment and reagents were at our disposal. As part of laboratory analyses, we conducted chemical analyses, by which we determined the concentration of nitrates (NO_3^-), nitrites (NO_2^-), phosphates (PO_4^{3-}) as well as pH value.

In the experimental part we set three hypotheses. First hypothesis: Nitrates and nitrites do not exceed limit values. Second hypothesis: pH values are between 6,5 - 9,5. Third hypothesis: The values of chemical parameters are lower in wells than in streams.

Sampling points

Sampling points are presented on the map below. (see fig. 2)

Figure 2. Sampling points

We decided to analyse water in eight streams (sample number: 1, 2, 3, 4, 6, 7, 8 and 11) and three wells (sample number: 5, 9 and 10), where we did the sampling of water and took field measurements.

Laboratory equipment

For our experiments we needed the reagent case for water analysis Machery Nagel visocolor ECO Analysenkoffer and thermometer for measuring the temperature of water at sampling points.

The work procedure

Analyses were based on the colorimetric method, set out on the enclosed leaflet with a colour-comparing scale and manufacturer's instructions. The intensity of the sample's colour is compared to a ready-made colour scale with the help of which we read off ion concentration in the sample.

For example, here is the procedure for determining phosphates.

First, we washed the two containers with samples. We then filled them with sample water to the 5 mL mark. One container was left for comparison. We added 6 drops of reagent PO_4-1 into the second container, stoppered the container, and shook it well. Then we added six drops of reagent PO_4-2, stoppered the container, shook it well and left it to stand for 10 minutes. After ten minutes, both containers were put on the colour scale. At this point, we compared them and read off the concentration of ions. Depending on the concentration of phosphates, the water showed a more or less intense blue colouring.

Results and discussion

Nitrates in water

The results of nitrate analysis in water samples are shown in the following diagram:

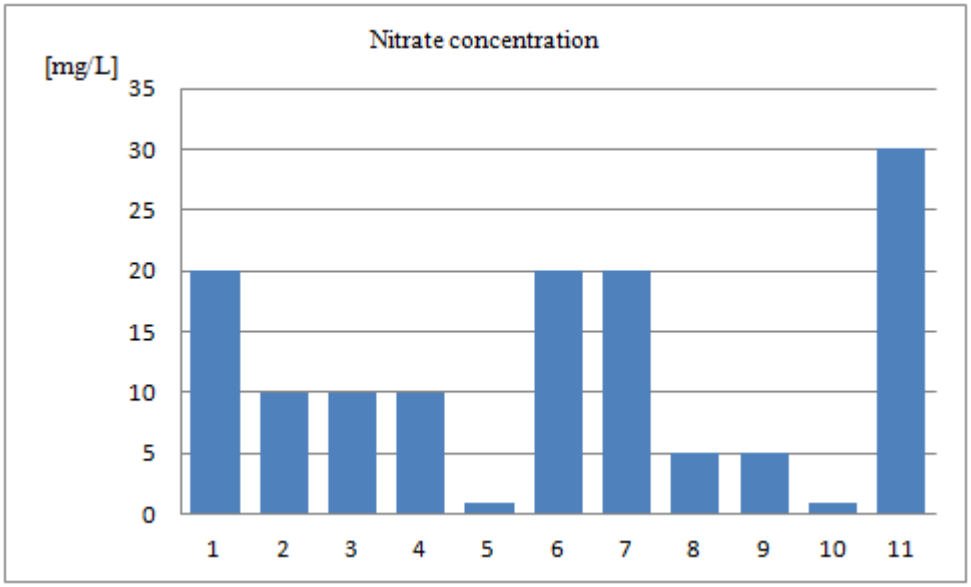

Figure 3. Nitrate concentration in water samples

According to Rules on drinking water, the limit value for nitrate is 50 mg/L.We found that least nitrates were present in sample 5 and sample 10 the concentration was 1 mg/L. The highest concentration was determined in sample 11. (see fig. 3)

Nitrites in water

The nitrite concentration in individual water samples are shown in the table below:

Table 1. Nitrite concentration in water samples

The water sample number	The concentration of nitrites NO_2^- [mg/L]
1	0,05
2	0,02
3	0
4	0
5	0
6	0,03
7	0
8	0
9	0
10	0,02
11	0,05

In Rules on drinking water, the limit value determined for nitrite is 0,50 mg/L.The results of analyses show very low nitrite concentrations in all samples and they did not exceed 0,05 mg/L.

Phosphates in Water

The results of phosphate analysis in water samples are presented in the following diagram:

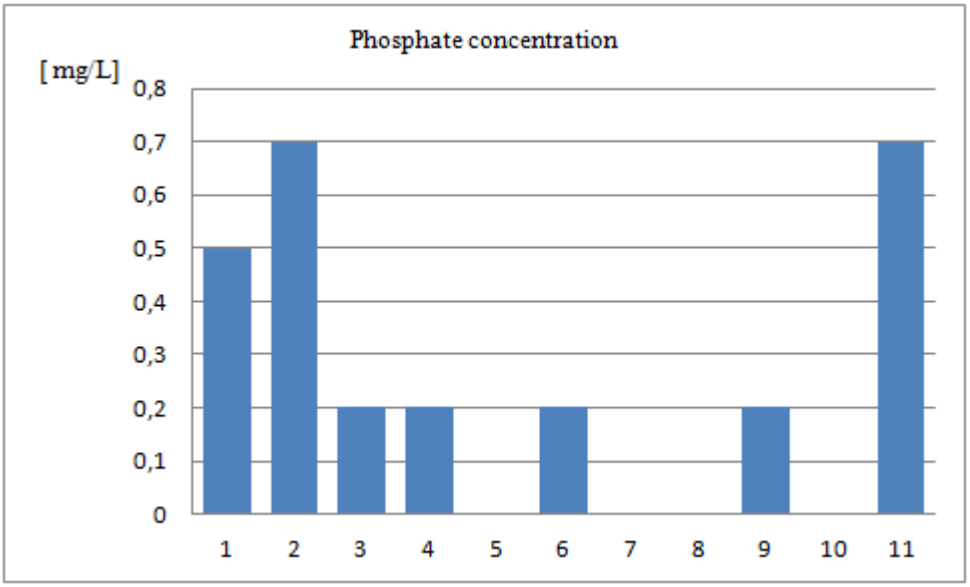

Figure 4. Phosphate concentration in water samples

The results of the analyses indicate that four of the samples (samples number 5, 7, 8 and 10) did not contain phosphates at all, while in other samples the concentrations ranged from 0,2 to 0,7 mg/L. Rules on drinking water do not prescribe a limit value for phosphates. (see fig.4)

pH value

The results of pH value analyses in water samples are presented in the table below.

Table 2. pH value in individual water samples

The water sample number	pH value
1	8
2	8
3	7
4	7
5	8
6	8
7	7
8	8
9	8
10	8
11	8

To sum up the findings, the majority of samples had a pH value of 8, while three samples had a pH value of 7. (Table 2) For pH values, Rules on drinking water set the limit value between 6,5 and 9,5.

Conclusion

The results of experiments showed us that the concentration of nitrates and nitrites does not exceed their limit values in any of the analysed water samples, which confirms the first hypothesis *(Nitrates and nitrites do not exceed limit values).* The pH values of analysed samples ranged from 7, 0 to 8, 0, which supports the second hypothesis *(pH values vary between 6,5 and 9,5).* In the samples from three wells, sample 9 was used to determine the presence of nitrates and phosphates, sample 10 for establishing the presence of nitrites while in sample 5 the presence of nitrates, nitrites and phosphates was not detected. In all samples, the values were very

low. The third hypothesis (*The values of chemical parameters are lower in wells than in streams*) was thus partially confirmed. In some water samples from streams, particular concentrations of the same parameters were the same or occasionally even lower than in water from wells.

The pollution of potable water is caused above all by farming, decrepit and uncontrolled sewerage systems and the failure of proper waste disposal, which contaminate potable water.

This report presents an example of research activity which at all levels of education has recently become very relevant and pertinent.Such literacy should enable today's students and future citizens to actively participate in the emergent technological society. In order to become ready for this task, students have to recognize the practical usefulness of their knowledge in everyday life, acquaint themselves with the procedures and methods of scientific research as well as respect nature and learn about the capabilities and limitations of current science.

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