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SET OF STUDIES FOR ECOLOGICAL ASSESSMENT OF THE RIVER WATER BY THE SCHOOL CHEMICAL LABORATORY

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SUMMARY

SET OF STUDIES FOR ECOLOGICAL ASSESSMENT OF THE RIVER WATER BY THE SCHOOL CHEMICAL LABORATORY

Looking at the environmental realities of our time, we realize that environmental education should be among the main educational areas of modern youth. Therefore, the **purpose of our work** is to select a set of studies of the ecological state of river water, which is potentially used to meet the drinking, household and other needs of the population.

Since the beginning of the Russian aggression, the issue of surface water quality in Ukraine has become, without exaggeration, of vital importance. Air strikes and shelling continue to destroy or damage industrial facilities, oil depots, landfills and waste storage facilities across Ukraine, contaminating soil and water resources through leakage of hazardous substances. People are forced to consume potentially unsafe water from centralised water supplies, take water from wells and rivers, exposing themselves to the risk of waterborne infectious diseases, as well as increasing the risk of non-communicable diseases and poisoning. Thus, water that may contain hazardous components requires additional research and identification of clean and contaminated water sources in war-affected areas.

The object of research in our work is the water of the Pripyat and Dnipro rivers, Which are the main sources of meeting the drinking, household and other needs of the Ukrainian population.

The subject of the study is a set of parameters of the ecological state of water and their importance in creating an ecological picture of the research object.

The relevance of the work lies not only in highlighting the list of studies, research results and their methodology, but also in showing the possibility of carrying out these studies by secondary school students. The proposed set of studies is of great relevance in the context of martial law, as it allows for operational monitoring of surface water quality.

The paper has three main parts: "Peculiarities of sampling for research", "Express research", "Laboratory research".

The first part describes a STEM expedition as a way to obtain research samples. The second part of the paper is devoted to rapid analyzes, and the third part proposes laboratory detection of cations and anions (for example, ferrous cations and nitrate anions) in samples taken during the expedition.

Key words: complex of researches, ecological state of river water, STEM-expedition, rapid research, possibilities of school chemical laboratory.

CONTENT

A LIST OF CONVENTIONAL ABBREVIATIONS

CF	civilian fleet
DAC	digital analytical complex
FEC	photoelectrocolorimetry
IW	inland waterways
LSR	Life safety rules
MCP	maximum permissible concentrations
pH	indicator of the level of H^+ protons (acidity)
SM	small craft

SHORT BIOGRAPHY OF THE PARTICIPANT

Oleksandr Tromsa, was born on October 14, 2006, in Poltava region.

In 2013, I entered the 1st grade of Kalynivka lyceum, Fastiv district, Kyiv region, where I am currently in the 11th grade.

I am interested in all disciplines. I have repeatedly won school subject competitions at the district and regional levels. My most favorite subjects are chemistry, English, biology, physics, geography, astronomy, and mathematics. I have a talent for mechanics, engineering and design.

I have been practicing judo since early childhood. As a result became an all-Ukrainian judo champion, a prize-winner of the Open European Judo Tournament, a prize-winner of the Ukrainian Championship, and a multiple winner and prize-winner of the Kyiv region in judo.

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INTRODUCTION

There is no corner of the world that is not affected by environmental issues. Today, the ecological state of our habitat is an acute issue on a global scale. After all, the ecological state depends on a large number of factors. The destruction of the overall ecological balance begins when we disrupt at least one of them.

One of these factors is river water. They play an important role in ensuring ecological balance and the viability of ecosystems. However, they are extremely vulnerable to pollution from various sources. In particular, from man-made emissions, agricultural activities, fishing and other human activities. The ongoing military operations on the territory of Ukraine have a separate impact

Solving the problem of river water pollution requires a comprehensive approach. First and foremost, it is necessary to determine the fact of water pollution, analyse the factors that led to the pollution, and identify the source of pollution. Specialized expert companies deal with these issues in their laboratories. However, there are many places where pollution occurs, and the number of such places is growing every year.

As a rule, no one orders or conducts such studies for In today's conditions, the experience described in the paper I am presenting may be one of the ways out of this situation.

Objective of the research is to create a set of studies that would make it possible to formulate a general description of the environmental state of the object, identify the main pollutants of this object, localize the place where the pollutant enters the river water, and identify the source of pollution.

The object of research of the complex in my work is the ecological state of the water of the Pripyat and Dnipro rivers.

The novelty in my work is that this complex covers studies with not very complicated, but sufficiently accurate, methods of implementation. The materials used in the research are not expensive and are available on the Ukrainian market. The necessary laboratory equipment and utensils are standard for a school chemistry classroom. It should also be noted that the proposed complex is dynamic, meaning that experiments can be removed or added depending on the object of study.

The relevance of my work lies in the implementation of this experience in the educational process in the form of material for student research projects or for use in STEM education. The proposed set of studies is of great relevance in the context of martial law, as it allows for operational monitoring of surface water quality.

CHAPTER 1. PECULIARITIES OF SAMPLING FOR RESEARCH

There is a well-known saying: "You can't step into the same river twice". Therefore, it is safe to say that the accuracy of the results of an environmental study is inversely proportional to the time that has passed from sampling to the start of laboratory research. Therefore, in order to improve the accuracy of the results, it is necessary to reduce the time that passes from the moment water is extracted from the ecosystem to the moment the study begins. Thus, it was decided to combine the whole range of studies into two stages:

- express research;
- laboratory testing.

Therefore, to obtain the research materials, the administration of our lyceum initiated a STEM-expedition (hereinafter referred to as the expedition) consisting of two students and a teacher - the scientific supervisor of the work. The responsibilities for preparing for the expedition, during the expedition, taking water samples, conducting rapid tests, conducting laboratory analyses and drawing conclusions are assigned to the members of the student team in equal numbers.

1.1 Preparation for the expedition

Because the expedition involved an autonomous voyage of 7 days, this event required careful preparation.

1.1.1 Rules of conduct for health and safety during the expedition

During the week, as part of the preparation for the expedition, we had ten briefings, which covered

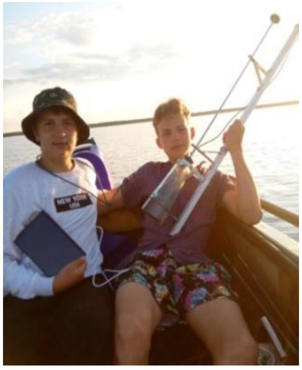
- rations for autonomous sailing;
- paramedical actions in emergency situations;
- rules for using rescue equipment;
- fire extinguishing methods;
- studied the location of the expedition area;
- rules of use of crane and mooring equipment;
- technical features of the propulsion system;
- features of radio communication;
- rules for using pyrotechnic warning devices;
- navigation on the water.

1.1.2 Design and manufacture of the necessary equipment

The chemistry room of our lyceum, although equipped with a large number of devices, including a modern DAC, lacks special devices for narrowly focused research. Therefore, to determine specific parameters of the river, we came up with some devices, which we then manufactured ourselves. For example, to determine the speed of the river flow, we used the Photo Finish module, which is included in the list of DAC sensors, and combined it with a counting wheel (Pic 1.11).

Pic. 1.11

A nylon thread is wound around the counting wheel, with a weight and float attached to the end. Knowing the number of counting spokes in the wheel and the circumference of the wheel, it is easy to calculate the unwinding speed of the thread, which will be equal to the speed of the river.



Pic. 1.12

Given that the water surface may contain a large amount of impurities of both natural and man-made origin (garbage, leaves of trees and bushes, bird and plant fluff, fuel or fuel oil stains, etc.), it is advisable to take samples for analysis not from the surface, but from a certain depth. To do this and avoid diving into the water every time, we designed and manufactured a special device (Pic 1.12). To draw water, just immerse it to the mark indicating the desired depth and open the valve by pulling the handle. When you run out of water bubbles, close the valve. This way, the water in the tank is from the exact depth we have chosen and is not mixed when the tank is brought up from the depth.

Pic. 1.13

One of the parameters we need to assess the ecological state of the water is the turbidity of the water in the river. We also designed and manufactured a device to determine it ourselves. The principle of this device is based on the absorption of light by the medium. The cleaner the water, the less light it absorbs. Thus, at the end of a 50 mm diameter plastic sewer pipe, an LED is installed, which is protected from water penetration. At the other end of the pipe there is a light-sensitive element that can convert light energy into direct electric current (Pic. 1.13). This current is recorded by the DAC's DC sensor and displayed on the screen in the form of a graph and digital values. To get the data as a percentage of absorbed light, we wrote a program that inverts the luminous flux into a percentage of water turbidity (Pic. 1.14).

Pic. 1.14

SECTION 2. RAPID RESEARCH

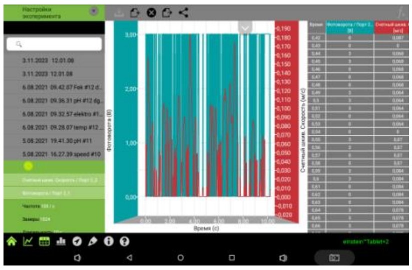
The first group of "express research" included experiments that can be carried out with mobile equipment. This type of equipment includes the laboratory of our lyceum's chemistry class, which is equipped with a DAC, and we also need a set of areometers to determine the density of liquids.

Pic. 2.1

2.1 Determining the velocity of a river

The flow rate of a river is an important characteristic of a body of water. Moreover, this parameter greatly affects other parameters of the river. Therefore, we consider this parameter first to determine the impact it has on other water characteristics. Using the instrument described above (see 1.1.2)

Determine the flow velocity. Let the float with the weight float freely (Pic. 2.1). The thread wound on the counting wheel unwounds freely by rotating it. The DAC records the number of counting pulses and displays them on the screen (Pic. 2.2).



Pic. 2.2

After processing the indicators obtained during the measurements and analyzing the data, we enter them into the summary table 2.1.

Table 2.1

Table of average river flow rates ($\upsilon_{(r.f.)}$)

measuring point	$\upsilon_{(r.f.)}$ **(m/s)**	**measuring point**	$\upsilon_{(r.f.)}$ **(m/s)**	**measuring point**	$\upsilon_{(r.f.)}$ **(m/s)**	**measuring point**	$\upsilon_{(r.f.)}$ **(m/s)**	**measuring point**	$\upsilon_{(r.f.)}$ **(m/s)**	**measuring point**	$\upsilon_{(r.f.)}$ **(m/s)**	**measuring point**	$\upsilon_{(r.f.)}$ **(m/s)**
1	*0,84*	**5**	*0,78*	**9**	*0,65*	**13**	*0,69*	**17**	*0,09*	**21**	*0,12*	**25**	*0,62*
2	*0,87*	**6**	*0,88*	**10**	*0,62*	**14**	*0,51*	**18**	*0,0012*	**22**	*0,12*	**26**	*0,68*
3	*0,82*	**7**	*0,83*	**11**	*0,57*	**15**	*0,43*	**19**	*0,01*	**23**	*0,21*	**27**	*0,51*
4	*0,80*	**8**	*0,75*	**12**	*0,78*	**16**	*0,22*	**20**	*0,11*	**24**	*0,58*	**28**	*0,71*

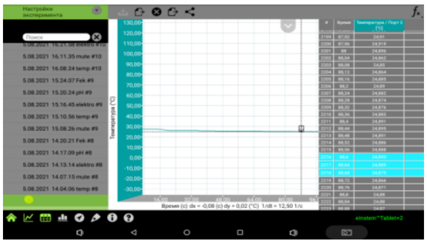
The following conclusions can be drawn from the table:

- In the upper reaches of the Pripyat and Dnipro rivers, the flow rate is much higher than in the lower reaches;
- the river flow rate depends on the width and depth of the river
  - the narrower the river, the higher the flow velocity;
  - If there are bends in the riverbed, the flow velocity also increases;
  - the deeper the river and the wider it gets, the speed decreases;

- Below river engineering structures (dams, weirs), the flow depends on the condition and operation of the water control sanders.

2.2 Determination of water temperature depending on depth

For order to determine the temperature of different layers of river water, we use a DAC with a temperature sensor that can operate underwater. This sensor is mounted on a folding probe. This probe has marks at 10 cm intervals. The first measurement is taken in air, near the water surface. Each measurement takes place within 15 seconds. This time is enough for the sensor to respond to temperature changes and stabilize its readings (Pic. 2.3). After processing the digital data using the "signal points" principle, we create a table of average temperature values by dive intervals.



Pic. 2.3

Table2.2

Table of average temperature values in ℃ by depth intervals

Measuring point	**Depth of the sensor (cm.)**								
	0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**
1	27,44	25,85	25,54	25,21	25,18	25,07	24,88	24,80	24,21
2	27,43	25,84	25,53	25,18	25,05	24,89	24,56	24,02	23,89
3	27,47	25,86	25,85	25,22	25,07	24,84	24,54	24,11	23,87
4	27,46	25,79	25,65	25,19	25,05	24,87	24,53	24,20	23,74
5	27,40	25,61	25,58	25,11	25,04	24,79	24,34	24,01	23,79
6	27,45	25,64	25,57	25,10	25,04	24,76	24,40	24,09	23,69
7	27,48	25,65	25,53	25,08	25,02	24,84	24,41	24,03	23,71
8	27,46	25,51	25,43	25,06	24,94	24,68	24,53	24,04	23,68
9	27,51	25,91	25,63	25,22	25,15	25,02	24,92	24,89	24,32
10	27,54	25,96	25,44	25,12	25,02	24,87	24,56	24,33	23,97
11	27,53	26,01	25,76	25,24	25,05	24,88	24,47	24,31	23,68
12	27,50	25,89	25,43	25,13	25,01	24,81	24,54	24,04	23,76
13	27,46	25,87	25,44	25,10	24,97	24,67	24,32	24,01	23,77
14	27,31	25,75	25,40	25,09	24,91	24,53	24,34	24,03	23,79
15	27,59	25,76	25,37	25,08	24,87	24,47	24,45	24,12	23,85
16	27,60	25,93	25,41	25,11	24,90	24,46	24,12	24,02	23,67
17	27,58	25,87	25,38	25,09	24,86	24,52	24,21	24,03	23,58
18	27,36	26,59	26,47	26,38	26,25	26,04	25,82	25,76	25,17
19	27,40	26,40	25,62	25,59	25,03	24,89	24,59	24,13	23,54
20	27,42	26,12	25,68	25,50	25,02	24,78	24,46	24,09	23,67

21	27,48	25,98	25,41	25,31	24,96	24,63	24,11	24,03	23,55
22	27,51	25,87	25,37	25,30	24,98	24,67	24,10	24,01	23,77
23	27,53	25,85	25,36	25,15	24,87	24,56	24,39	24,03	23,59
24	27,21	25,12	25,08	24,88	24,52	24,31	24,01	23,93	23,12
25	27,24	25,22	25,11	24,97	24,57	24,33	24,03	23,67	23,09
26	27,32	25,37	25,16	24,89	24,49	24,31	24,02	23,87	23,21
27	27,42	25,61	25,47	25,04	24,96	24,81	24,67	24,48	24,22
28	13,45	-	-	-	-	-	-	-	-

The following conclusions can be drawn from the table:

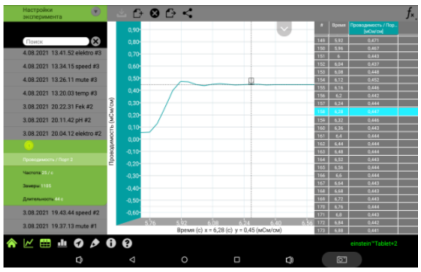
- - the water is generally warmed up in the 0.8 m layer to an average temperature of 24-25 °C;
- - the temperature decreases on average by 1.5 - 2.0 °C in the water layer 0.8 m from the surface, depending on the immersion;
- - water temperature is inversely proportional to the river flow rate;
- - this temperature is favorable for the life and reproduction of unicellular and multicellular organisms.

2.3 Determining the electrical conductivity of water

Pic. 2.4

We know from our 9th grade chemistry course that distilled water does not conduct electricity. With a sufficiently sensitive DAC sensor, we can determine the electrical conductivity of river water. Based on this data, we can assume that the water contains electrolytes, which, when dissociated in water, form ions, which in turn cause the electrical conductivity of aqueous solutions.

Pour a portion of the sample taken from a depth of 0.8 m into the measuring cylinder. Immerse the conductivity sensor in the sample (Pic. 2.4). The DAC records the readings and displays them on the screen (Pic. 2.5).



Pic. 2.5

As you can see from the graph and data table, the sensor in the free state has some potential. This is the sensor's own internal error. Since this error is constant and individual, it can be neglected. After all, we use this particular sensor for all measurements, and this potential is negligible compared to the useful data.

Having processed the indicators obtained during the measurements and having analyzed the data, we enter them into a summary table. Table 2.3 shows some examples of such data.

Table 2.3

Table of average values of electrical conductivity of river water ($E_{(r.w.)}$)

Measuring point	$E_{(r.w.)}$ (mSm/cm^3)	Measuring point	$E_{(r.w.)}$ (mSm/cm^3)	Measuring point	$E_{(r.w.)}$ (mSm/cm^3)	Measuring point	$E_{(r.w.)}$ (mSm/cm^3)	Measuring point	$E_{(r.w.)}$ (mSm/cm^3)	Measuring point	$E_{(r.w.)}$ (mSm/cm^3)	Measuring point	$E_{(r.w.)}$ (mSm/cm^3)
1	*0,447*	**5**	*0,462*	**9**	*0,651*	**13**	*0,584*	**17**	*0,876*	**21**	*0,551*	**25**	*0,461*
2	*0,451*	**6**	*0,553*	**10**	*0,613*	**14**	*0,498*	**18**	*0,743*	**22**	*0,512*	**26**	*0,458*
3	*0,449*	**7**	*0,449*	**11**	*0,593*	**15**	*0,510*	**19**	*0,701*	**23**	*0,479*	**27**	*0,510*
4	*0,564*	**8**	*0,552*	**12**	*0,578*	**16**	*0,962*	**20**	*0,628*	**24**	*0,480*	**28**	*0,637*

The table shows that almost all river water has a consistently low electrical conductivity. Only a few points showed a significant increasing of this parameter. We have put these points under control and will monitor peak changes of other parameters in them.

In general, we can draw the following conclusion:

- In general, the river water that has been studied does not contain a significant amount of electrolytes.
- There are places where there is a significant increase of the amount of electrolytes, which may be the cause of pollution with both mineral and organic substances.

2.4 Determination of water density

Based on the fact that the density of distilled water is a constant and has a tabulated value of 1 g/cm^3, it is possible to perform a comparative analysis with the sample under investigation and make assumptions about the presence of impurities in this sample. To determine the density of river water, we use an areometer with a measuring range of 0.950 to 1.050 g/cm^3. After taking a portion of the sample into a chemical cylinder, we immerse the areometer in it (Pic. 2.6). Holding the chemical cylinder vertically, we find the moment when the areometer does not touch the walls of the cylinder and has stabilised its position relative to the water surface. We read the density value from the scale of the areometer, taking into account the lower meniscus of the liquid, since the river water wets the chemical glass from which both the cylinder and the areometer are made. The results of the experiment are recorded in the logbook. Table 2.4 shows the results of determining the density at some sampling points.

Pic. 2.6

Table 2.4

Table of river water density values ($\rho_{(r.w.)}$)

Measuring point	**$\rho_{(r.w.)}$ (g/cm^3)**	**Measuring point**	**$\rho_{(r.w.)}$ (g/cm^3)**	**Measuring point**	**$\rho_{(r.w.)}$ (g/cm^3)**	**Measuring point**	**$\rho_{(r.w.)}$ (g/cm^3)**	**Measuring point**	**$\rho_{(r.w.)}$ (g/cm^3)**	**Measuring point**	**$\rho_{(r.w.)}$ (g/cm^3)**	**Measuring point**	**$\rho_{(r.w.)}$ (g/cm^3)**
1	*1,013*	**5**	*1,017*	**9**	*1,015*	**13**	*1,018*	**17**	*1,092*	**21**	*1,015*	**25**	*1,010*
2	*1,015*	**6**	*1,012*	**10**	*1,016*	**14**	*1,017*	**18**	*1,084*	**22**	*1,013*	**26**	*1,010*
3	*1,016*	**7**	*1.014*	**11**	*1,014*	**15**	*1,018*	**19**	*1,075*	**23**	*1,016*	**27**	*1,008*
4	*1,014*	**8**	*1,015*	**12**	*1,015*	**16**	*1,098*	**20**	*1,049*	**24**	*1,011*	**28**	*1,009*

In general, the following conclusions can be drawn:

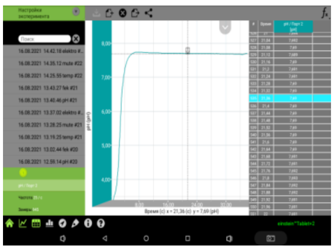
- river water contains a small amount of impurities in almost the entire study area, but there are several places where this value deviates significantly from the other average values;
- the water of the Prypiat river, on average, has a slightly lower density than the water in the Dnipro river;
- analysing the results of the studies of electrical conductivity and water density, it can be assumed that there are impurities in the water, mostly compounds of organic non-polar origin.

2.5 Determination of water pH

As you know from the 9th grade biology course, living organisms are inherent in a certain environment that has a set of parameters for normal existence. If at least one of these parameters changes, living organisms face a deterioration in their living conditions. One of these parameters is the acidity of the environment. According to the results of studies published in [2], the usual acidity (pH) for river water is between 6.5 and 8.5. According to MCP [1].

Pic. 2.7

For the rapid determination of pH, we will again use a DAC with the appropriate sensor (Pic. 2.7). We take a portion of the sample into the chemical cylinder and immerse the measuring part of the pH meter sensor into it. The device reads the data and displays the result (Pic. 2.8). After processing the readings, enter the average values in the table. Table 2.5 shows examples of pH values for some samples.



Pic. 2.8

Table 2.5

Table of pH values of river water ($pH_{(r.w.)}$)

Measuring point	**$pH_{(r.w.)}$**	**Measuring point**	**$pH_{(r.w.)}$**	**Measuring point**	**$pH_{(r.w.)}$**	**Measuring point**	**$pH_{(r.w.)}$**	**Measuring point**	**$pH_{(r.w.)}$**	**Measuring point**	**$pH_{(r.w.)}$**	**Measuring point**	**$pH_{(r.w.)}$**
1	*7,691*	**5**	*7,654*	**9**	*7,721*	**13**	*7,712*	**17**	*9,012*	**21**	*7,769*	**25**	*7,681*
2	*7,595*	**6**	*7,668*	**10**	*7,698*	**14**	*7,715*	**18**	*8,584*	**22**	*7,688*	**26**	*7,677*
3	*7,613*	**7**	*7,691*	**11**	*7,689*	**15**	*7,688*	**19**	*8,031*	**23**	*7,687*	**27**	*7,688*
4	*7,637*	**8**	*7,704*	**12**	*7,683*	**16**	*9,250*	**20**	*7,982*	**24**	*7,678*	**28**	*7,584*

Having analysed the data, the following conclusions can be drawn:

- the water of the Dnipro River, from the northern border to Kyiv, and the water of the Pripyat River, from the town of Chornobyl to the point of its confluence with the Dnipro River, has approximately the same acidity, which is in line with the norms;
- the river water in the area of the southern part of Kyiv has a significant increase in pH, which is significantly higher than normal;
- the point at which a significant violation of the pH norm is observed coincides with the point at which deviations from the average values of river water density and electrical conductivity were observed.

2.6 Determination of water turbidity

One of the obvious parameters of the ecological state of river water is turbidity. To determine the degree of water turbidity and its change with depth, we will use a DAC with a homemade turbidity sensor.

Pic. 2.9

Water measurements were taken directly from the SM (Pic. 2.9). The depth step was 10 cm. The measurement time was 15 seconds, which is sufficient to stabilize the indicators. The obtained data were processed and displayed on the DAC screen (Pic. 2.10).

The graph above shows that the percentage of turbidity (light absorption) of water naturally varies depending on the depth of immersion of the sensor. But the difference in absorption levels increases with depth. This may indicate that the level of turbidity in the river water is not the same vertically, and increases with decreasing depth. Table 2.6 shows the results of several study points.

Pic. 2.10

Table 2.6

Table of average values of water turbidity (%) by depth intervals

Measuring point	Depth of the sensor (cm.)					Measuring point	Depth of the sensor (cm.)				
	10	**20**	**30**	**40**	**50**		**10**	**20**	**30**	**40**	**50**
1	*1,34*	*13,14*	*25,74*	*42,9*	*53,36*	**15**	*1,32*	*15,52*	*26,78*	*47,37*	*56,92*
2	*1,24*	*12,87*	*25,56*	*41,87*	*54,56*	**16**	*1,35*	*16,02*	*26,91*	*47,58*	*57,10*
3	*1,31*	*14,21*	*26,23*	*42,48*	*56,13*	**17**	*1,34*	*15,69*	*26,70*	*46,34*	*56,68*
4	*1,26*	*15,16*	*25,72*	*41,34*	*54,81*	**18**	*1,59*	*14,01*	*26,35*	*45,27*	*54,26*
5	*1,28*	*14,89*	*25,59*	*42,04*	*55,62*	**19**	*1,47*	*14,65*	*26,69*	*45,61*	*54,79*
6	*1,30*	*14,78*	*25,94*	*43,01*	*56,48*	**20**	*1,43*	*14.87*	*26,72*	*45,78*	*54,80*
7	*1,27*	*12,94*	*24,89*	*42,67*	*55,12*	**21**	*1,42*	*15,01*	*26,94*	*46,02*	*55,03*
8	*1,28*	*13,01*	*24,78*	*43,57*	*56,04*	**22**	*1,43*	*15,23*	*27,21*	*46,27*	*56,45*
9	*1,30*	*12,92*	*25,22*	*46,15*	*53,02*	**23**	*1,45*	*15,22*	*27,26*	*46,31*	*56,51*
10	*1,29*	*13,12*	*25,58*	*45,98*	*54,60*	**24**	*1,21*	*12,41*	*23,13*	*41,96*	*52,14*
11	*1,31*	*14,22*	*25,71*	*45,72*	*55,03*	**25**	*1,22*	*12,46*	*23,07*	*41,75*	*25,26*
12	*1,32*	*15,67*	*26,12*	*45,93*	*56,13*	**26**	*1,23*	*12,52*	*23,12*	*41,89*	*25,34*
13	*1,28*	*14,59*	*25,37*	*46,04*	*55,69*	**27**	*1,31*	*13,27*	*25,34*	*42,96*	*52,81*
14	*1,31*	*15,34*	*26,21*	*47,13*	*56,72*	**28**	*1,00*	-	-	-	-

Having analysed the research data, the following conclusions can be drawn:

- the water in the Prypiat river has a lower degree of turbidity than in the Dnipro river;
- water turbidity in the vertical section of the Prypiat river differs less by layers than in the same section of the Dnipro river.

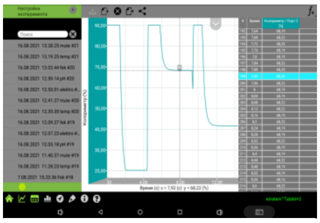
2.7 FEC analysis of water

Pic. 2.11

As can be seen from the previous study, insoluble impurities are present in river water, which cause an optical effect. We see it as the color of the water. To determine this color, we will use the FEC module, which is connected to the DAC (Pic. 2.11). The FEC determines the level of absorption of light with a certain wavelength. For this purpose, the device uses three light filters with different colors, namely red (R), green (G), and blue (B). This is the order in which we conducted the study (RGB).

Pic. 2.12

A certain amount of water is poured into a special cuvette (Pic. 2.12), which is then put into the FEC itself. Switch on the device and calibrate its zero point. Then insert a red light filter in the light path between the source and the cuvette. The measurement takes 10-12 seconds. This time is enough to stabilise the readings. Remove the red light filter and insert the green, then blue. Thus, on the screen (Pic. 2.13) we see stable indicators in the RGB sequence. The narrow vertical columns are the moment the light filter changes.



Pic. 2.13

Analysing the obtained graphs, we see that the light of the green spectrum has the highest permeability, followed by the blue and red spectrum with the lowest permeability. Table 2.7 shows the results for some of the research points.

Table2.7

Table of average photoelectrocolourimetry values (%) of water

Measuring point	**Light filter**			**Measuring point**	**Light filter**		
	R	**G**	**B**		**R**	**G**	**B**
1	*<20*	*68,22*	*41,43*	**15**	*20,13*	*65,22*	*42,25*
2	*<20*	*68,56*	*40,22*	**16**	*21,15*	*60,13*	*43,08*
3	*<20*	*67,94*	*38,35*	**17**	*21,42*	*61,50*	*40,32*
4	*<20*	*65,65*	*39,20*	**18**	*21,82*	*59,07*	*36,45*
5	*<20*	*67,42*	*40,56*	**19**	*20,25*	*60,21*	*35,17*
6	*21,03*	*68,29*	*41,38*	**20**	*20,74*	*61,59*	*41,73*
7	*21,12*	*69,13*	*41,94*	**21**	*21,63*	*62,15*	*40,72*
8	*20,14*	*68,79*	*40,31*	**22**	*22,38*	*60,24*	*38,19*
9	*<20*	*65,32*	*45,26*	**23**	*21,17*	*59,48*	*39,05*
10	*21,24*	*64,98*	*44,72*	**24**	*22,42*	*59,90*	*37,11*
11	*20,08*	*65,12*	*43,69*	**25**	*22,33*	*62,69*	*41,62*
12	*22,10*	*65,03*	*45,12*	**26**	*22,47*	*64,12*	*45,38*
13	*21,54*	*64,34*	*42,43*	**27**	*22,35*	*64,56*	*42,63*
14	*20,04*	*64,28*	*41,07*	**28**	*22,37*	*21,12*	*<20*

Having analyzed the results, the following conclusions can be drawn:

- the water of the Prypiat and Dnipro rivers is dominated by green and blue colors, which may indicate the presence of blue-green algae;
- the color intensity in the Prypiat River water is much lower than in the Dnipro River water.

SECTION 3. LABORATORY TESTS

The water samples taken at the specified points were immediately transferred to vacuum-sealed chemical beakers with lapped lids (Pic. 3.1). The beakers were numbered and stored in the hold of the SM, where the temperature is equal to the temperature of the river water and no sunlight is allowed to enter (Pic. 3.2). At the end of the expedition, all samples were transferred to a dark room at the temperature of the river water, where they remained for a short period of time before laboratory analysis began.

Рис. 3.1

The volume of chemical beakers for storing samples is 250 ml. This amount of water is enough for a certain number of tests. For example, we decided to do only two analyses - one for cations and one for anions.

Having in the arsenal of the FEC chemistry room a KFO-4 (photoelectric single-beam colorimeter) and analytical balances of the VA-200 type, we selected the methods in which it is advisable to use such equipment [3].

Рис. 3.2

3.1 Qualitative and quantitative determination of cations in test samples

3.1.1 Determination of the total concentration of iron cations

It is known that iron is found in natural waters in the form of ferrous iron and trivalent cations. We will use the method of determining iron by the formation of a thiocyanate -complex with subsequent quantification using FEC, described in [4].

After conducting all the studies according to the above method, we obtained the results, an example of which is given in Table 3.1.

Table 3.1

Table of concentration values (C) of Fe^{2+} and Fe^{3+} in river water

Measuring point	**$C_{(Fe\ gen.)}$ (mg/dm^3)**	**Measuring point**	**$C_{(Fe\ gen.)}$ (mg/dm^3)**	**Measuring point**	**$C_{(Fe\ gen.)}$ (mg/dm^3)**	**Measuring point**	**$C_{(Fe\ gen.)}$ (mg/dm^3)**	**Measuring point**	**$C_{(Fe\ gen.)}$ (mg/dm^3)**	**Measuring point**	**$C_{(Fe\ gen.)}$ (mg/dm^3)**	**Measuring point**	**$C_{(Fe\ gen.)}$ (mg/dm^3)**
1	*0,21*	**5**	*0,23*	**9**	*0,19*	**13**	*0,27*	**17**	*0,32*	**21**	*0,21*	**25**	*0,17*
2	*0,20*	**6**	*0,31*	**10**	*0,19*	**14**	*0,24*	**18**	*0,20*	**22**	*0.22*	**26**	*0,19*
3	*0,20*	**7**	*0,27*	**11**	*0,21*	**15**	*0,26*	**19**	*0,21*	**23**	*0,17*	**27**	*0,22*
4	*0,21*	**8**	*0,21*	**12**	*0,23*	**16**	*0,48*	**20**	*0,19*	**24**	*0,18*	**28**	*0,81*

According to MCP [1] ferrum cations are 0,3 mg/dm^3.

Having analyzed the data, the following conclusion can be drawn:

- The amount of iron in the water of the Pripyat and Dnipro rivers is almost the same and is within the environmental norm [1, 2].

3.2 Qualitative and quantitative determination of anions in the research samples

3.2.1 Determination of nitrate anion concentration

To determine the content of nitrate ions in the samples, we also used colourimetric analysis. Using the method described in [5], we first prepared calibration solutions. The results of our samples were obtained by comparing the calibration solutions with our samples [6]. An example of these results is shown in table 3.2. According to MCP [1] nitrate anions are 45,0 mg/dm^3.

Рис. 3.3

Table 3.2

Table of values of NO_3^- concentration (C) in river water

Measuring point	**$C_{(NO_3^-)}$ (mg/dm^3)**	**Measuring point**	**$C_{(NO_3^-)}$ (mg/dm^3)**	**Measuring point**	**$C_{(NO_3^-)}$ (mg/dm^3)**	**Measuring point**	**$C_{(NO_3^-)}$ (mg/dm^3)**	**Measuring point**	**$C_{(NO_3^-)}$ (mg/dm^3)**	**Measuring point**	**$C_{(NO_3^-)}$ (mg/dm^3)**	**Measuring point**	**$C_{(NO_3^-)}$ (mg/dm^3)**
1	*18,20*	**5**	*18,34*	**9**	*9,26*	**13**	*12,81*	**17**	*24,24*	**21**	*21,93*	**25**	*21,40*
2	*19,31*	**6**	*15,52*	**10**	*9,12*	**14**	*13,83*	**18**	*23,12*	**22**	*22,45*	**26**	*23,54*
3	*20,12*	**7**	*11.49*	**11**	*10,10*	**15**	*13,27*	**19**	*23,02*	**23**	*23,14*	**27**	*24,37*
4	*19,10*	**8**	*11,04*	**12**	*12,57*	**16**	*26,65*	**20**	*22,20*	**24**	*22,85*	**28**	*5,17*

Based on the data obtained, the following conclusions can be drawn

- the content of nitrate ions in water at different locations is quite different, although it is within ecological limits [1, 2];
- the fact that the increase in nitrate ion levels is observed close to the shores with signs of agricultural activity suggests that this increase is anthropogenic.

CONCLUSIONS

Thus, our work has experimentally proved that this set of studies of the ecological state of the river is not something complicated and unattainable. On the contrary, it is scientifically cognitive and interesting for secondary school students. We recommend using it in environmental and STEM education classes for students in grades 8-9.

Also during the expedition, thanks to rapid analyses and laboratory tests, we discovered a section of the Dnipro River that is potentially environmentally hazardous. In this area, the river water has a significantly increased density, high electrical conductivity and a fairly high pH, which is significantly higher than the environmentally acceptable levels. By analyzing the products manufactured by the surrounding enterprises and taking into account the technological processes of these enterprises, it is possible to make an assumption which enterprise is the source of the river pollution.

We also observed a gradual decline in the overestimated values when testing the water at points below the likely point of pollution. Having analyzed these data, we can make a forecast of the extent of the pollution in the area.

In my opinion, in this paper we have achieved our goal and proved the effectiveness and efficiency of the proposed set of studies of the river's ecological state. We have also demonstrated that the capabilities of a school chemistry laboratory are sufficient to carry out these studies.

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