The estimate of the current state of the river Chulman in the area of activity of the limited liability company (LLC) “Kolmar”

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Abstract. The fact of pollution of the rivers Dezhnevka and Chulman, running in the zone of activity of the LLC "Kolmar" was recorded in May 2018. According to the results of the ecological surveys of the named above watercourses carried out by Ministry of Nature Protection of the Republic of Sakha (Yakutia), it was established that the main pollution was the result of the mine water discharge from the hydraulic system and industrial site JSC GOK “Denisovsky”. As part of the integrated ecological monitoring the hydrochemical investigations of the river Chulman were carried out at 7 observation points in August of 2018. There were chemical and analytical works with the use of methods of potentiometry, titration, gravimetry, capillary electrophoresis, atomic absorption spectrometry, photometry and fluorimetry.

1. Introduction

Kolmar Company was founded in 2004 and today and it is a large holding company uniting industrial enterprises for the mining and processing of coking coal located in the territory of the Neryungri District of the Republic of Sakha (Yakutia). The core business of Kolmar company is development of stone coal deposits in South Yakutia and efficient production and processing of stone coal. The balance reserves of the Kolmar company amount more than 1 bln tons of coal, most of which are deficient premium grades of coking coal possessing a unique set of physical and chemical properties. Kolmar incorporates production and processing capacities, open-pits and underground mines, coal processing plants, sales and logistical units. Today, Kolmar is the leader among Russian companies in terms of room-and-pillar mining efficiency, which is applied at Denisovskaya mine (GOK Denisovskiy). Room-and-pillar method was not used at deposit below 200 meters in Russia; Kolmar is the first company to obtain permission to use this technique and has applied this method for mining coal at deeper deposits. JSC GOK Denisovskiy develops the reserves of Denisovskiy stone coal deposits (Central and Eastern part) within the license areas. GOK Denisovskiy includes: Denisovskaya mine (operational), Denisovskaya Eastern mine (under construction), Denisovskiy open pit (operational) and Denisovskiy Eastern area [1].
2. Models and Methods
The main large watercourse, running in the zone of activity of the JSC "GOK Denisovsky" is the river Chulman – the left inflow Timpton (Figure 1).

The length of it is 109 km (with the Right Chulman it’s 166 km long). It begins running from the Northern slopes of the Stanovyi crest. It takes 15 inflows which are more than 10 km long. There are more than 60 lakes in the river basin. It opens in the first decade of May and freezes in the middle of October.

![Figure 1. The river Chulman.](image)

The river Chulman belongs to small mountain rivers of the East-Siberian type. More than 88 inflows flow into the Chulman, 11 rivers from which being from 20 to 68 km long and 77 streams being about 10 or less kilometers long. The largest inflows are the river Kabakta (68 km), the Right Chulman (57 km) and the Small Chulman (48 km), which don’t fall into the area if field development.

The watercourse is characterized as fishery reservoir of the 1st category. The investigated plot is of a typically mountain character with rapids interspersed with sandbars. The width of the river varies from 70-100 m to 150-200 m in places with islands. The depth on rapids at their deepest is from 0,7 to 0,8 m, and on sandbars it reaches 8 m [2].

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| Observation points | Designation | Place of selection                        |
|--------------------|-------------|------------------------------------------|
| 1                  | SY -1       | Above Neryungry town                     |
| 2                  | SY -2       | Neryungry town                           |
| 3                  | SY -16      | Above the mouth of the Dezhnyovka stream |
| 4                  | SY -15      | Below the mouth of the Dezhnyovka stream |
| 5                  | SY -11      | Below Chulman village                    |
| 6                  | SY -12      | Above Chulman village                    |
| 7                  | SY -4       | The river mouth                          |

As part of the integrated ecological monitoring the hydrochemical investigations of the river Chulman were carried out at 7 observation points (Table 1) in August of 2018. There were chemical and analytical works in the accredited laboratory FBUZ “Center of hygiene and epidemiology” in Neryungry district of the Republic of Sakha (Yakutia), as well as in the laboratory of physical and chemical methods of analysis Scientific research institute of applied ecology named after D D Savvinov of the North-Eastern Federal University named after M K Ammosov with the use of methods of potentiometry, titration, gravimetry, capillary electrophoresis, atomic absorption spectrometry, photometry and fluorimetry.
3. Results and Discussion
During the period of the investigation the river Chulman above Neryungry town is characterized by small mineralization with neutral environment and very soft water. The ionic composition of water by O.A. Alekin’s classification (1953) [3] is prevailinglly bicarbonate-sulphate-calcium. The content of suspended solids in the investigated water reaches 15.3 mg/dm$^3$. Exceeding the maximum permissible concentration (MPC) standards is noted for manganese up to 1.2 times, for common iron up to 1.4 times and for copper up to 13.1 times. On the other indicators exceeding the MPC standards is not observed.

At the point below Neryungry town the investigated watercourse has small mineralization with neutral environment and very soft water. The ionic content of water is also mainly bicarbonate-sulphate-calcium. The concentration of the suspended solids in the studied water reaches 16.5 mg/dm$^3$. Exceeding the MPC standards were recorded for manganese up to 1.4 times, for common iron up to 2.2 times and for copper up to 5.1 times. On the other indicators exceeding the MPC standards is not observed.

At the point above the mouth of the stream Dezhnyovka water of the river Chulman is characterized by small mineralization with neutral environment and very soft water. The content of water is bicarbonate-sulphate-calcium. The concentration of the suspended solids reaches 7 mg/dm$^3$. Exceeding the MPC standards were recorded for manganese up to 2.6 times, for copper up to 6.5 times and for common iron up to 14 times. On the other indicators exceeding the MPC standards is not observed.

Below the mouth of the stream Dezhnyovka, water of the river Chulman has small mineralization with neutral environment and soft water. The content of water remains bicarbonate-sulphate-calcium of the class of the group of calcium as well. The concentration of the suspended solids reaches 57.6 mg/dm$^3$. Exceeding the MPC standards were noted for manganese up to 3.4 times, for copper up to 9.4 times, for common iron up to 16 times and for total petroleum hydrocarbons up to 4.4 times. On the other indicators exceeding the MPC standards is not observed. At this point the increased turbidity can be noticed, which has a direct link with the increase of the amount of the suspended solids in water in comparison with the point above the confluence of the stream Dezhnyovka.

Water of the river Chulman above Chulman village is characterized by small mineralization with neutral environment and very soft water. The content of water is bicarbonate-sulphate-calcium. The concentration of the suspended solids reaches 7.5 mg/dm$^3$. Exceeding the MPC standards were recorded for copper and common iron up to 6.5 and 1.3 times correspondingly. On the other indicators exceeding the MPC standards is not observed.

Below Chulman village the investigated water has also small mineralization with neutral environment and very soft water. The content of water is prevailinglly bicarbonate-sulphate-calcium of the class of the group of calcium. The concentration of the suspended solids reaches 12.3 mg/dm$^3$. Exceeding the MPC standards were recorded for copper up to 4.9, for common iron up to 1.2 and for manganese up to 1.4 times. On the other indicators exceeding the MPC standards is not observed.

In the mouth part of the river Chulman the water is characterized by small mineralization with neutral environment and very soft water. The content of water is prevailinglly bicarbonate-calcium. The concentration of the suspended solids reaches 19.3 mg/dm$^3$. Exceeding the MPC standards were recorded for manganese and copper up to 1.4 and 7.8 times correspondingly. On the other indicators exceeding the MPC standards is not observed. During the period of rainfall flood the sharp increase of the suspended solids is recorded – more than 5000 mg/dm$^3$, as well as the 2.5-fold decrease of the concentration of the common iron (above Chulman village) and the 4-fold reduction (below Chulman village).

As a whole, the increase in the amount of mineralization and the measure of turbidity can be recorded, as well as the increase of the concentration of suspended solids in the river Chulman after the confluence of the stream Dezhnyovka (Figure 2).
Figure 2. The dynamics of the mineralization index, turbidity and concentration of the suspended solids in the water of the river Chulman (August, 2018).

Figure 3. The dynamics of the change of concentration of microelements and total petroleum hydrocarbons in the water of the river Chulman (August, 2018).

As it can be seen from Figure 3, the increase of the concentrations of manganese, copper, common iron and total petroleum hydrocarbons is noted in the water of the river Chulman after the confluence of the stream Dezhnyovka.

Thus, the increase of the concentration of manganese, common iron, copper and total petroleum hydrocarbons and the content of the suspended solids, as well as the increase of such indicators as mineralization and turbidity testify about the influence of the stream Dezhnyovka on the chemical content of the river Chulman. Besides, heavy precipitation makes the suspended solids enter the water of the river Chulman from the catchment area.

Bottom sediments of the investigated watercourses have neutral and slightly alkaline environment, the average organic matter content is 2.3 % of masses.

The microelement content of the bottom sediments of the investigated watercourses is represented in table 1 and to characterize it they were compared to the local geochemical background of the mobile forms of microelements, extracted with 1 N nitric acid, which is calculated for the surface watercourse of the basin of the river Chulman (n=16).
Table 2. Microelement composition of the bottom sediments of the investigated watercourses, mg/kg.

| Place of selection | Pb  | Ni  | Mn  | Cd  | Co  | Cr  | Zn  | Cu  | As  | Fe  |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Local background   | 2.12| 0.33| 101.9| 0.02| 0.60| 0.47| 5.55| 1.23| 0.12| 2.07|
| SY-1               | 0.91| 0.25| 37.5 | 0.027| 0.63| 0.55| <2.5| 0.72| <0.05| 1.52|
| SY-2               | 1.98| 0.99| 123.5| 0.024| 0.94| 0.56| 4.09| 1.26| 0.07| 1.68|
| SY-16              | 2.14| 0.51| 169.7| 0.018| 1.24| 0.76| 5.90| 1.39| 0.13| 2.79|
| SY-15              | 2.41| 0.45| 130.2| 0.021| 0.72| 0.54| 4.59| 2.08| 0.19| 4.16|
| SY-11              | 1.63| 0.43| 197.1| 0.020| 0.86| 0.80| 37.23| 1.17| 0.13| 0.86|
| SY-12              | 1.82| 0.78| 200.4| 0.023| 1.40| 0.88| 5.74| 2.24| 0.13| 3.53|
| SY-4               | 1.80| 0.38| 106.1| 0.018| 0.74| 0.36| 4.37| 1.52| 0.09| 1.46|

The bottom sediments of the investigated watercourses by the calculated concentration factors (Kk) have different manifestation of the increased concentrations of the whole number of chemical elements relative to local geochemical background. (Table 3).

Table 3. Factors of the concentration of the microelements in the investigated bottom sediments.

| Place of selection | KpPb | KpNi | KpMn | KpCd | KpCo | KpCr | KpZn | KpCu | KpAs | KpFe |
|--------------------|------|------|-------|------|------|------|------|------|------|------|
| Local background   | 2.12 | 0.33 | 101.9 | 0.02 | 0.60 | 0.47 | 5.55 | 1.23 | 0.12 | 2.07 |
| SY-1               | 0.4  | 0.8  | 0.4   | 1.5  | 1.0  | 1.2  | -    | 0.6  | -    | 0.7  |
| SY-2               | 0.9  | 3.0* | 1.2   | 1.3  | 1.6  | 1.2  | 0.7  | 1.0  | 0.6  | 0.8  |
| SY-16              | 1.0  | 1.5  | 1.7   | 1.0  | 2.1  | 1.6  | 1.1  | 1.1  | 1.1  | 1.3  |
| SY-15              | 1.1  | 1.4  | 1.3   | 1.2  | 1.2  | 1.2  | 0.8  | 1.7  | 1.6  | 2.0  |
| SY-12              | 0.9  | 2.4  | 2.0   | 1.3  | 2.3  | 1.9  | 1.0  | 1.8  | 1.1  | 1.7  |
| SY-11              | 0.8  | 1.3  | 1.9   | 1.1  | 1.4  | 1.7  | 6.7  | 1.0  | 1.1  | 0.4  |
| SY-4               | 0.9  | 1.1  | 1.0   | 1.0  | 1.2  | 0.8  | 0.8  | 1.2  | 0.8  | 0.7  |

4. Conclusion
By coefficient values of the concentration the microelement cumulative series were built characterizing the content of the bottom sediments in the water bodies, located in the area of the activity of JSC “GOK Denisovsky”:
SY-1 - Cd<sub>1.5</sub>
SY-2 - Co<sub>1.6</sub><Ni<sub>3.0</sub>
SY-16 - Ni<sub>1.5</sub><Cr<sub>1.6</sub><Mn<sub>1.7</sub><Co<sub>2.1</sub>
SY-15 - As<sub>1.6</sub><Cu<sub>1.5</sub><Fe<sub>2.0</sub>
SY-12 - Cu<sub>1.8</sub><Cr<sub>1.9</sub><Mn<sub>2.0</sub><Co<sub>2.3</sub><Ni<sub>2.4</sub>
SY-11 - Mn<sub>1.6</sub><Zn<sub>0.7</sub>
SY-4 – no exceed

As a whole, the bottom sediments of the river Chulman are enriched with the number of elements, such as cobalt, nickel and manganese.

The pollution index of the water was calculated in the period of the rainfall flood for the river Chulman in Table 4.
Table 4. The pollution index of the water of the river Chulman (August, 2018).

| Watercourse                        | The pollution index of the water | Quality class          |
|------------------------------------|----------------------------------|------------------------|
| The river Chulman above Chulman    | 210                              | Class 7, “extremely dirty” |
| village                            | (at the suspension >5000 mg/dm³) |                        |
| The river Chulman below Chulman    | 210                              | Class 7, “extremely dirty” |
| village                            | (at the suspension >5000 mg/dm³) |                        |

* according to the data of the accredited laboratory FBUZ CH & E in Neryungry district; the background on the suspended particles was adopted as 4 mg/dm³ – on the river Kabakta.

Thus, during the period of the rainfall flood due to the extremely high content of the suspended solids in the investigated water of the river Chulman on the areas above and below Chulman village the quality class of the water refers to 7 – “extremely dirty”.

As a whole, in August, 2018, the increase of the concentration of copper, manganese, common iron, total petroleum hydrocarbons and suspended solids are noted, also the increase of the amount of mineralization and turbidity factor at the point below the mouth of the stream Dezhnyovka can be noticed, which indicates the influence of the stream water on the chemical content of the water of the river Chulman.

During the rainfall flood due to the high concentrations of the suspended solids in the investigated water of the river Chulman on the areas above and below Chulman village the quality class of water corresponds to the 7-th – “extremely dirty”. The largest range of the cumulative series is observed at the points above the mouth of the river Dezhnyovka and above Chulman village. The characteristic elements in the bottom sediments of the river Chulman are nickel, manganese and cobalt.

References

[1] The official site of «KOLMAR», LLC., [http://www.kolmar.ru/](http://www.kolmar.ru/)
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[3] Alekin O A 1953 Basics of hydrochemistry (Leningrad: Gidrometeoizdat) p 122