Determination of Formation Water Toxicity with the Use of Wheat Seeds (*Triticum*)

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Abstract. The article is devoted to the study of the toxic properties of formation and model waters prepared in accordance with their chemical composition. The assessment of hazardous properties was carried out by phytotesting using wheat seeds (*Triticum*) as a test object. Two varieties of wheat – “Salavat Yulaev” and “Omskaya-35” were used for the experiments. The study analyzed such indicators as seed germination, the seedling underground and aboveground parts length, the total length of the seedling. Research results showed good responsiveness of seeds to this toxicant. The acute toxicity of the studied model medium and formation water was revealed. A comparative toxicity analysis showed a slight deviation between the tested aqueous media. The studies show the importance of taking into account the toxic properties of oil waters for environmental monitoring and in the recultivation of water resources and land.

1. Introduction

Currently the global economy requires a huge amount of energy carriers, the main is oil. It is expected that oil production in Russia in 2018–2020 will be about 553 million tons per year according to the Ministry of Economic Development [1]. The development of oil deposits, oil production, refining and transportation has a negative toxically effect on the environment what was evidenced by a large number of publications [2-5]. However it is not considering that all this processes are usually accompanied by formation water pumping from productive reservoir during the flooded products mining [6]. Formation waters include reservoir waters of the aquiferous complex where the deposit is located and injected waters used to maintain reservoir pressure [6]. These two types of water are a mixture of salts, so they leads decrease of soil fertility and salinization of soils and aquifers.

The purpose of this work is to study the phytotoxicity of formation waters and model waters prepared in accordance with their chemical composition. Wheat seeds of the varieties “Omskaya-35” and “Salavat Yulaev” were used.

2. Practical part

The composition of model water is given in the table 1.
Table 1. The composition of the model formation water.

| Components            | Content (mg/kg) |
|-----------------------|-----------------|
| Sodium chloride       | 86000           |
| Calcium Chloride      | 10500           |
| Magnesium chloride    | 5200            |
| Sodium Sulphate       | 4000            |
| Sodium Bicarbonate    | 400             |

The experiment was carried out according to the certified method of PND F T 14.1: 2: 4.19-2013 in the laboratory [7, 8].

30 wheat seeds were fit to the filter paper in a Petri dish. Then different dilutions (1: 2, 1: 4, 1: 8, 1:16 and 1:32) were produced from the formation water. Distilled water was used for dilution and as a control medium. It was made three replications of each dilution and control sample. The samples with model saline solution were prepared similarly. 5 ml of native medium and prepared dilutions were added to each dish with seeds. On the seventh day after sowing, seed germination (%), the underground and aboveground parts of the seedling (mm) and the average dry weight (mg) of the seedling were measured.

Statistical data processing was performed using the program “Statistica 5.0 for Windows” [7].

3. The experimental results

The seeds of both wheat varieties began to germinate with 8-fold dilution. However, seed germination of the “Salavat Yulaev” variety in model water exceeds the germination value in the formation water of deposits. It varies in dilutions 8-32 about 87.8-97.8% and 84.4-86.6%. The seed germination of “Omskaya” variety between the analyzed waters differ slightly. It is between 93.3-95.9% and 92.2-93.3%, respectively.

The length of the underground, aboveground parts of the wheat seedlings and its total length of are shown in the Table 2.

The underground part of the seedlings length of both varieties increases with decreasing of formation water concentration. The aboveground part of the seedling responds to changes in the concentration of formation water in the samples similarly to the underground. The aboveground seedling length increases with the concentration decrease. The aboveground length of seedling of both varieties is higher in model water than in oil deposit. Such length difference of “Salavat Yulaev” variety for 8-fold dilution about 69.1%, in 16-fold dilution is 36.46%, in 32-fold dilution is 7.66%. The same parameters for the “Omskaya” are 68.6%, 22.34%, 5.64%, respectively. The total length of the seedling reacts to changes in the concentration of formation waters in a similar manner.

The length of the underground, aboveground parts of the wheat seedlings and its total length of are shown in the Table 2.

The underground part of the both varieties of wheat seedlings in model water exceeds the underground part of the seedling in oil deposit water. The length difference for “Salavat Yulaev” is 31.5% for 8-fold dilution, 19.0% for 16-fold dilution, 9.5% for 32-fold dilution. The difference for “Omskaya” variety is 33.02%, 5.14% and 8.37%, respectively (Table 2).
Table 2. The average value of the analyzed parameters.

| Dilution ratio | Wheat “Salavat Yulaev” | Wheat “Omskaya” |
|----------------|-------------------------|-----------------|
|                | Model water             | Oil deposit water | Model water | Oil deposit water |
| Native medium  | 0                       | 0               | 0           | 0               |
| 1:2            | 0                       | 0               | 0           | 0               |
| 1:4            | 0                       | 0               | 0           | 0               |
| 1:8            | 29.85                   | 20.46           | 31.07       | 20.81           |
| 1:16           | 71.94                   | 58.17           | 70.4        | 66.78           |
| 1:32           | 79.48                   | 71.92           | 86.46       | 79.22           |
| Control        | 102.57                  | 111.55          |             |                 |

Aboveground part of the seedlings (mm)

| Dilution ratio | Wheat “Salavat Yulaev” | Wheat “Omskaya” |
|----------------|-------------------------|-----------------|
| Native medium  | 0                       | 0               | 0           | 0               |
| 1:2            | 0                       | 0               | 0           | 0               |
| 1:4            | 0                       | 0               | 0           | 0               |
| 1:8            | 15.18                   | 4.69            | 23.25       | 7.3             |
| 1:16           | 58.39                   | 37.1            | 60.48       | 46.97           |
| 1:32           | 63.32                   | 58.47           | 77.87       | 73.48           |
| Control        | 72.25                   | 80.52           |             |                 |

Underground part of the seedlings (mm)

| Dilution ratio | Wheat “Salavat Yulaev” | Wheat “Omskaya” |
|----------------|-------------------------|-----------------|
| Native medium  | 0                       | 0               | 0           | 0               |
| 1:2            | 0                       | 0               | 0           | 0               |
| 1:4            | 0                       | 0               | 0           | 0               |
| 1:8            | 45.02                   | 25.15           | 54.32       | 28.11           |
| 1:16           | 130.33                  | 95.27           | 130.88      | 113.75          |
| 1:32           | 142.79                  | 130.39          | 164.33      | 152.69          |
| Control        | 174.82                  | 192.07          |             |                 |

Total seedling length (mm)

The "Omskaya" variety showed the greatest responsiveness in the model water, which is confirmed by a reliable correlation coefficient for all analyzed parameters (Table 3).

Table 3. The analyzed parameters dependence on the dilution ratio.

| Analyzed Parameters | Wheat “Salavat Yulaev” | Wheat “Omskaya” |
|---------------------|-------------------------|-----------------|
|                     | Model water             | Oil deposit water | Model water | Oil deposit water |
| Seed germination (%)| 0.60                    | 0.20            | 0.12        | 0.07            |
| Underground part of seedling (mm) | 0.75* | 0.88 | 0.89 | 0.86 |
| Aboveground part of seedling (mm) | 0.72 | 0.94 | 0.91 | 0.95 |
| The total length of the seedling (mm) | 0.74 | 0.92 | 0.90 | 0.91 |

* Values of correlation coefficients are reliable at P> 0.95

A reliable positive dependence between the dilution ratio of the samples and the analyzed parameters was found for the underground, above-ground and total length of the seedling.
It is necessary to calculate the safe dilution ratio to compare the toxicity degree of model water and oil deposit water. It is the safe dilution ratio at which the analyzed parameter equals the value in the control sample; this parameter can be calculated using regression equations (Table 4).

### Table 4. The regression equations and the safe dilution ratio.

| Analyzed Parameters | Wheat “Salavat Yulaev” | Wheat “Omskaya” |
|---------------------|------------------------|-----------------|
|                     | Model water            | Oil deposit water | Model water | Oil deposit water |
| Underground part of seedling (mm) | Y=26.07+1.84X | Y=13.58+1.96X | Y=23.04+2.12X | Y=14.59+2.2X |
|                      | X=41.58                | X=45.40         | X=41.75     | X=40.0          |
| Aboveground part of seedling (mm) | Y=12.71+1.76X | Y=-5.99+2.11X | Y=14.56+2.11X | Y=-5.59+2.6X |
|                      | X=33.83                | X=37.08         | X=31.26     | X=33.12         |
| The total length of the seedling (mm) | Y=38.79+3.60X | Y=-7.59+4.07X | Y=37.6+4.23X | Y=8.64+4.8X |
|                      | X=37.79                | X=41.09         | X=37.47     | X=38.21         |

The safe dilution ratio was selected according to the maximum value from the table 4. The safe dilution ratio for the “Salavat Yulaev” variety in the model water is 41.58 and in oil deposit water is 45.40. This parameter for the “Omskaya” is 41.75 and 40.0 respectively. The model water is less toxic than water from oil deposit. However, deviations of model water toxicity from water from oil deposit is about 8% for the “Salavat Yulaev” variety and 4% for the “Omskaya” variety.

### 4. Summary

The experiments show good responsiveness of both wheat varieties and the possibility its using wheat as a test object for determining of formation water toxicity. The results indicate the acute toxicity of model and formation oil water. A comparative analysis of model and oil deposit water toxicity showed a slight deviation, which indicates the same chemical composition of the tested types of water.

The research data show the importance of considering of the formation water toxic properties, which can get into the water and soil with oil. It is necessary to consider this factor for environmental monitoring and for the recultivation of water and soil resources.

### 5. References

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