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Constant concentration of chemical components in produced water is an important requirement when using them as hydromineral raw materials

***M. V. Reva** *(Taras Shevchenko National University of Kyiv)*, **D. F. Chomko** *(Taras Shevchenko National University of Kyiv)*

SUMMARY

The article considers one of the criteria for the possibility of using the produced water (PW) of oil and gas fields as hydromineral raw materials. For example, the authors study the PW of the Lelyakivskoye field, which has a long history of development and is in its final stages. The article defines the criteria for the use of these waters as hydromineral raw materials. The main criterion is the concentration of chemical components. However, an important issue regarding concentrations is their consistency throughout the field development period. The authors determined exactly what chemical components and their conditions in terms of content should be in the PW so that in the future they could be used as hydromineral raw materials. Bromine and magnesium are of industrial value at the Lelyakivsky deposit. This article analyzes the dynamics of concentrations of these chemical components. Bromine and magnesium concentrations were investigated during 1964-2017. The authors found that the concentrations of these components in PW throughout the period met the condition requirements. Also during this period there is a dynamics of concentrations within 10 percent.

Introduction

The development of oil and gas fields in the Eastern Oil and Gas Region of Ukraine at the present stage is taking place with a fairly high degree of flooding of extracted raw materials. This raw material is a so-called emulsion, consisting of hydrocarbons and produced water (PW). These waters are mostly formation waters surrounding the oil deposit, and by their nature are highly mineralized brines.

According to modern methods of development of hydrocarbon deposits, PW is costly component in economic point of view. Because the increase in their production leads to a decrease in the volume of commodities (oil or gas), as well as increases the cost of extraction companies for their disposal. But if we consider these extracted waters as secondary raw materials that can be used, the PW from the consumable component becomes profitable. The use of PW as a secondary raw material, namely as a hydromineral, at the present stage of development of the oil industry is a promising area (*Chomko et al., 2017*).

Theory

Produced water in oil and gas fields in the Eastern oil and gas region of Ukraine have high mineralization, sometimes it`s brines, respectively. This waters with a high content of macrocomponents, which primarily include bromine, iodine and boron. There are also high levels of lithium, strontium, hafnium and others *(Tereshhenko, 2015; Chomko et al., 2016; Havryliuk, 2012; Gal'chenko & Osipova, 1963)*. Therefore, due to the high content of chemical components of PW in Eastern oil and gas region of Ukraine can be considered as a hydromineral raw material. For the further possibility of using PW as hydromineral raw material, one criterion for high concentrations is not enough, since the volumes of PW and the constancy of concentrations of chemical components in it must be predicted. Thus, the study of this issue is one of the main areas of development of this valuable resource.

In effectively use PW as hydromineral raw material, it is necessary to rely on existing processing technologies. According to the existing processing technologies and hydrogeochemical properties of PW boron, bromine, iodine, lithium, magnesium and other elements can be extracted from them. At the present stage, the most economical way to extract iodine. This element already has a long history of extraction from hydromineral raw materials. Ukrainian scientists have proposed a technology for its extraction from PW (*Nimets, 2019*). But the most promising today is the possibility of extracting lithium from PW. According to the existing technologies for the cost-effective use of PW, the main criteria remain the concentrations of chemical components, promising components and their concentrations (Table 1). If the PW meet these criteria then they need to be examined by others, which are discussed in this article.

Table 1*Conditions for hydromineral raw materials*

Component	**Boron**	**Magnesium**	**Lithium**	**Iodine**	**Bromine**
Minimum condition, mg/dm³	10	500	10	10	200

In order for PW to have a positive economic effect during the development of oil and gas deposits, it is advisable to use it as hydromineral raw material. Appropriate substantiation of PW is carried out according to the following criteria:
- Staged development of the field (according to the water cut);
- Geochemical features of formation or produced waters;
- Compliance of PW with technological requirements.

We conducted such an analysis on the prospects of using PW as hydromineral raw material, for example, Lelyakivskoye field.

The field is located in Pryluky district of Chernihiv region, belongs to Eastern oil and gas region of Ukraine. Paleozoic, Mesozoic and Cenozoic deposits take part in the geological structure of the deposit. Oil is found in Lower Permian Upper Carboniferous deposits, the main reserves are in limestones, dolomites and sandstones of Upper Carboniferous and Lower Permian ages. The deposit was discovered in 1962, operated from 1967 to the present day, formation waters are highly mineralized.

The field has been in operation for over 50 years and according to the flood rate, today it belongs to the fourth stage. This is confirmed by the graph (Fig. 1), which is based on observations of the Water cut of the extracted fluid (*Prylutskyi litsei №10 - Rozrobka pozaklasnoho zakhodu. (n.d.*).

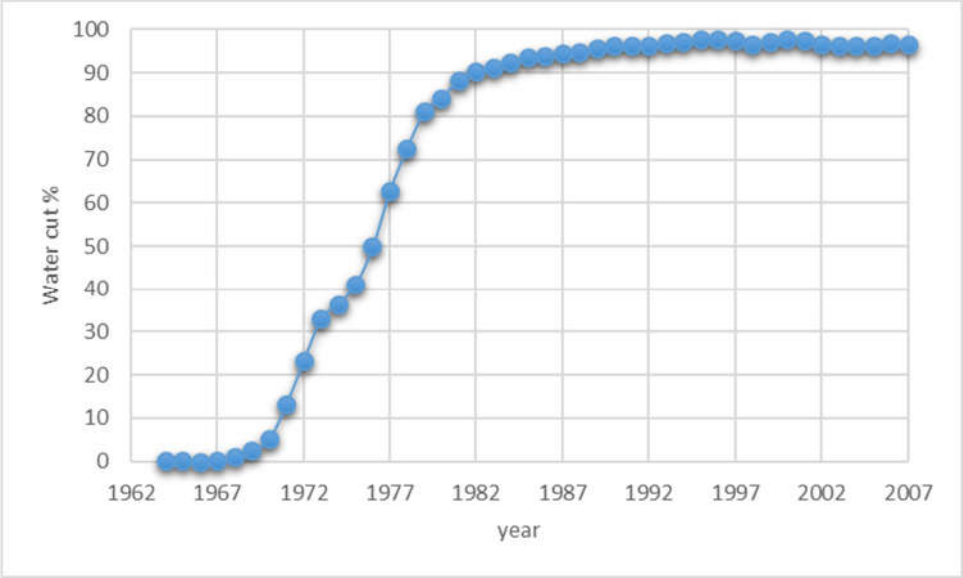

Figure 1 *The graph of the Water cut in extracted fluid at Lelyakivske field.*

The Water cut in extracted products at this field is approximately 96%. This indicates that one volume unit of oil produces 24 volume units of PW. Given that the Lelyakivskoye field produces about 150 tons of oil per day, it produces about 4445,0 m^3 of PW.

The next indicator that was analyzed at this field is the geochemical characteristics of formation waters. The analysis was conducted on the basis of initial information for the period 1964–2017, which is contained in stock sources and in the authors' research. During the study, the average contents of chemical components in the field were determined (Table 2), and the dynamics of changes in concentrations over time was traced (Figure 2.3).

Table 2 *Concentration of components in the PW at the Lelekivskoye field*

Component	Mineraliz.	Sodium	Magnesium	Chlorine	Boron	Iodine	Bromine	Lithium	Strontium
Concentration, mg/dm³	157307	52014,9	1614,7	95708,7	11,8	9,6	213,4	9,5	159,1
Minimum condition, mg/dm³			500		10	10	200	10	

From table 2 we see that from the PW in this field, in accordance with the technological requirements shown in table 1, it is advisable to extract magnesium and bromine. Components such as iodine and lithium are on the verge of profitability, and therefore for a particular component production will not be profitable, but in the complex of their production will be appropriate.

In order to justify the feasibility of using this PW, it is necessary to emphasize the stability of concentrations of chemical components. During the analysis, the change in time concentrations of bromine and magnesium in the formation water of the productive horizon as the main technologically oriented components was investigated.

Analysis of bromine content. The results indicate that the boron concentration is approximately 223 mg/dm^3 and varied between 1963 and 2017 within 13%. The dynamics of changes in concentrations are shown in Figure 2.

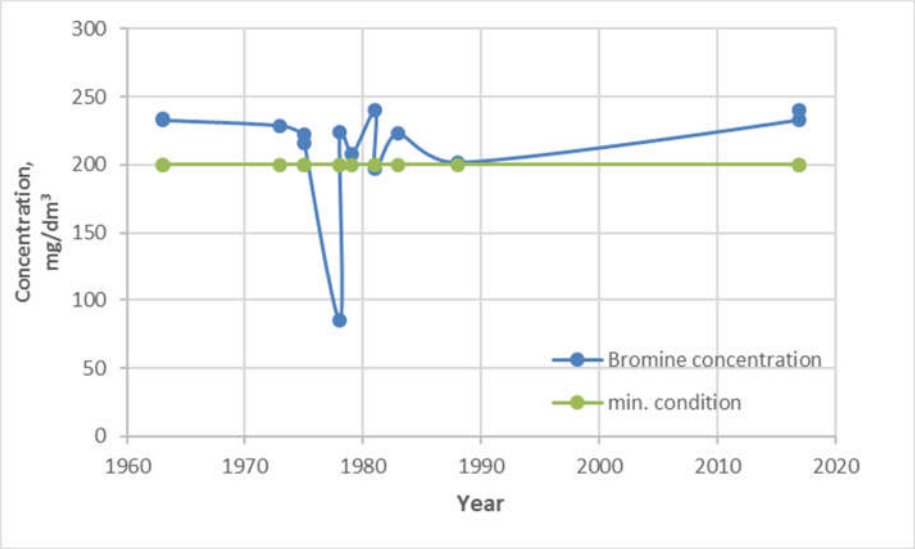

Figure 2 *Graph of changes in bromine concentrations at the Lelyakivske field.*

Analysis of magnesium content. It is established that the concentration of magnesium in the period 1963–2017 has an average value of 1669.3 mg/dm^3, the minimum recorded value is 851.0 mg/dm^3, and the maximum is 2675 mg/dm^3. Due to the minimum technical concentration of 500 mg/ dm^3, industrial production of magnesium will be possible even at its minimum values.

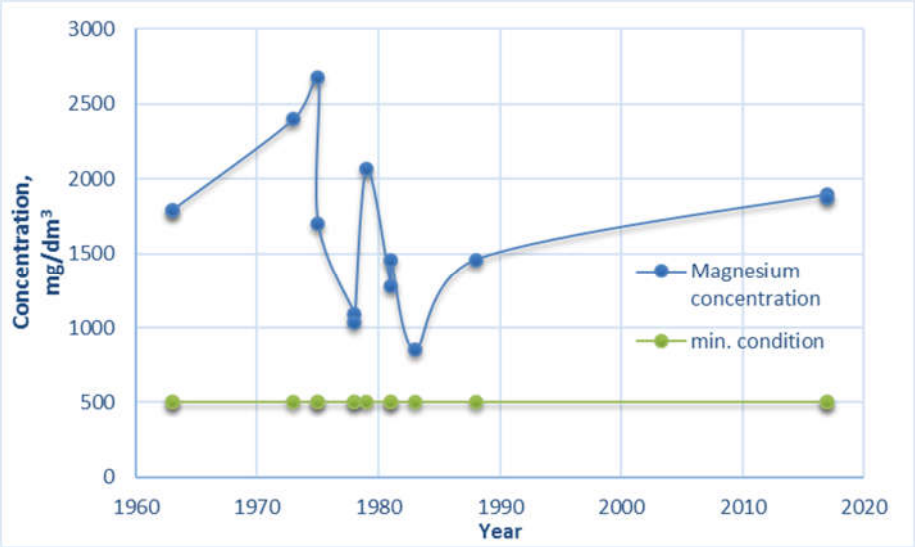

Figure 3 *Graph of changes in magnesium concentrations at the Lelyakivske field.*

From the above graphs we can conclude that the concentration of components in formation waters is maintained throughout the life of the field, and the deviation from the average value is within acceptable limits, which are determined by specific geological and hydrogeological conditions of wells, method of operation and others.

Other components present in the Lelyakivskoye field behave in the same way as demonstrated. As a result, we can say that the dynamics of changes in the concentrations of valuable chemical components in PW is predictable. Therefore, when studying the possibility of using PW as a hydromineral raw material, the issue of stability of concentrations recedes into the background.

Conclusions

The use of PW in oil and gas fields is an economically promising area of development of the oil industry. These waters can be considered as hydromineral raw materials. Because their condition corresponds to existing processing technologies. This study considers an important issue regarding the dynamics of concentrations of chemical components in PW. This issue has substantiated on the example of the development of the Lelyakivsky deposit. As during the whole period of development the concentration of chemical components was within the conditional norms and had fluctuations within 10 percent.

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