

HEALTH AND ENVIRONMENT

The problems of urban areas upon development of oil and gas fields (with reference to Boryslav)

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The article analyzes the scientific works regarding the research area in question. It contains the findings of research of gas pollution in Boryslav and shows the results of hydrocarbon concentration measurements taken in the basements of houses in the territory of Boryslav. The authors have worked out and suggested the measures for reduction of the level of gas pollution.

Boryslav oil field is a unique natural and man-made system having no analogue in the world.

The first mention of oil in Boryslav is dated back to the second half of the eighteenth century. In 1810 the Government of the Austrian Empire issued a Decree of the Court House, pursuant to which oil was recognized as a mineral and the state monopoly for oil and wax extraction was established. To extract oil, it was required to obtain a license from the Department of Mining, which was located in Drogobych. That same year the first permits for oil extraction were issued. Due to significant oil manifestation on the surface from Vorotyshche and Polyany Neogene sediments of Boryslav hollow folds, the field development with manholes and then with shallow wells was started. The boring of deep wells in the deposits started in 1886. The major horizon oil field is Boryslav sandstone of Boryslav hollow folds, discovered in 1887. At present, there are more than 2,000 wells and more than 20,000 pits in the city [1-3].

The long-lasting oilfield activity used to be, and nowadays is accompanied by worsening of the environmental situation. The main cause of environmental issues are the natural and man-made geochemical anomalies caused by high content of hydrocarbon gases in the soil layer, resulting in considerable accumulation of hydrocarbon gases in some basements of residential buildings and other structures, creating hazardous situations.

The researches of gas pollution of Boryslav are conducted by a number of research teams, including IHHHK of the NAS of Ukraine, UkrDGRI, CASDZ of the Institute of Geological Sciences of Ukraine and others. Despite this, the level of gas concentration in recent years has not changed significantly. The research has shown that the major cause of gas concentration is discharge of the deep fluid systems in the permeable areas, i.e. blasted zones, which are the most active today.

According to the research of gas concentration in Boryslav performed by the experts of NIPI of UkrNafta PJSC from 2006 to 2012, it was established that the most problem gas pollution areas are located in the downtown area, near dense residential development, including outside the mining allocation (Fig. 1). The most intensive emission of hydrocarbon gases occurs in the area of Vesniana Street (City Market), Chornovola (house 10, 12, 14), Mickiewicz (house 34, 36), Hrushevskoho 1 (City Culture Department). At the same time, in the areas where the intensive exploitation of hydrocarbon is conducted, such issues are less frequent. In particular, in the area of the existing wells the hydrocarbon gas emanations are negligible. This is also confirmed by the results of aerospace surveys conducted in 2001-2002 by scientists of CASDZ V. Lalko and A. Mychak.

The research Boryslav soil contamination conducted by I. Dudok and A. Romaniuk established that the soils located near ozokerite mine in the Potik microdistrict and in the downtown area in the floodplain and bed of the river Tysmenytsia the are the most polluted with petrochemicals (Fig. 1 and 2). Meanwhile it was noted that the oil content in selected samples exceeded the allowable temporary concentration (ATC - 4000 mg/kg) 2 to 8 times. In addition, the authors found that in areas with a high content of oil the increased (2-4 times compared with background values) content of heavy metals such as Cu, Zn, Co, Cd is also observed.

The situation in the field is complicated by the fact that the location of the great part of mines (unsealed pits, wells built in the late 19th and early 20th century) is unknown and is located in the area of residential development. Today some of the found wells and boreholes are not only in poor condition, polluting the environment, but also threat to the life of Boryslav residents (see Fig. 2).

Now the oil production volumes from most of the shallow wells of Boryslav deposits are minor, but Boryslavnaftogas OGPD, a structural unit of UkrNafta PJSC, is forced to continue the operation of such wells to prevent the uncontrolled outputs of reservoir and in the downtown area in the floodplain and bed of the river Tysmenytsia the are the most polluted with petrochemicals (Fig. 1 and 2). Meanwhile it was noted that the oil content in selected samples exceeded the allowable temporary concentration (ATC - 4000 mg/kg) 2 to 8 times. In addition, the authors found that in areas with a high content of oil the increased (2-4 times compared with background values) content of heavy metals such as Cu, Zn, Co, Cd is also observed.

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Викопірування
з топооснови м. Борислава в М 1: 2 000
схеми розміщення дегазаційних свердловин, шурфів-колодязів,
які заходяться за межі гірничого відводу



Figure 1. Layout of degasification wells, pit wells and areas of gas contamination outside the mining allotment of Boryslav oil field



Figure 2. Abandoned mine workings of the past: a- Destroyed oil pit near house 12 at Chornovola Street; b- mouth of the liquidated hole in the bed of the Tysmenytsia branch

The extraction of hydrocarbons from Boryslav field is essential for the city, which will greatly help to reduce the level of gas concentration. This is proven by the situation with Boryslav well 494, which was drilled by shock yet in 1897 and deepened in 1905. This well is located near house 1 at Nafta Street. Due to the probable jam of the casing and folding of tubing it was decommissioned. The wellhead is equipped with a rocking machine, the electric connection of which was disconnected from the mains. On February 15, 2012 the uncontrolled release of the oil mix from the well and oil spill about the adjacent area occurred (Fig. 3, a). After oil removal the rocking machine

was dismantled and the work related to revision of the technical condition of well columns and elimination of the eventual cause of ejection was conducted. The probable cause of the oil and gas mixture release was the termination of hydrocarbons extraction from well 494 and insufficient oil extraction from adjacent wells due to freezing of exhaust lines. The committee for inquiry proposed to perform the well overhaul and transfer the same to the degasification fund subject to its connection to the vacuum line. During renovations, on July 16, 2012 the gas-oil mixture spewed from the well, resulting in contamination of the land and penetration of a small portion of the oil mixture into the unnamed stream (Fig. 3, *b*). In addition, due to leaks in the plumbing the petrochemicals penetrated into the Boryslav water supply system, having deprived many people of the only source of drinking water.

Another key way to minimize the level of gas pollution of the areas is the presence of two vacuum compressor stations (VCS) and vacuum pipeline network through which the mixture of hydrocarbon gas emissions is removed from the existing, inactive wells and pits. It is testified by researches carried out by us. During the period from the 12th to 14th of June 2010 we conducted sampling of gas and air mixtures in some observation spots of Boryslav field after switching off the vacuum gas collection system. During the investigated period, in degasification well 14 at 36 Danylo Galytsiy Street and well 29 at 12 Chornovola St., as well as in the hole at 46 Hrushevskoho St. reached its maximum content of hydrocarbon gases starting from 2006, namely in well 14 - 31214.9 mg/m³ (during 2006-2009 - 16.873 to 11,513.04 mg/m³), the volume fraction of methane - 3.3%, in well 29 - 75861.15 mg/m³ (during 2006-2009 - 209.861 to 57,718.24 mg/m³), the volume fraction of methane - 8.67%, in hole 46 - 31819.6 mg/m³ (in 2006-2009 - 15.98 to 6447.7 mg/m³), and the volume fraction of methane - 4.7%. Based on the above, we can make assumptions about the relationship between the increasing concentrations of hydrocarbon gases in these points and VCS stop. However, the unambiguous interpretation of this phenomenon requires more prolonged and thorough investigation.

As it was noted already, outside the mining allotment of Boryslav deposit there are geochemical anomalies of uncontrolled exits of reservoir fluids in the form of oil and gas to the surface in certain areas of residential development (Fig. 4).

Especially dangerous is the area around house 12 at Chornovola Street and around the ozokerite mine of the mine group (Fig. 1 and 5). Here, the Company drilled many degasification wells to reduce the gas pollution by discharge of hydrocarbon gases in the atmosphere, and we conducted the monitoring of the environment condition. During observations we repeatedly found unauthorized oil manifestation in the basement of the house and surrounding area. For example, the oil and gas mixture was released near well 25 to the surface on December 17, 2012. In our opinion, this is a testimony of the fact that these measures are insufficient, since, as it was noted already, the most effective method of gas elimination from the territories is improvement of the vacuum network for gas mixture extraction from wells and other mining wells and near-surface layers. However, according to Article 17 of the Law of Ukraine on Subsoil, "...the use of subsoil outside the mining allotment is forbidden."

There is a strange situation; on the one hand, the Company doesn't have the moral and legal right not to deal with reduction of gas concentration, and on the other there is no legal ground for extraction of hydrocarbons outside the mining allotment.

In order to ensure the ecological balance and gradual elimination of adverse social and environmental consequences of the long-term development of Boryslav deposits, the biggest part of which is located in the city of Boryslav, UkrNafta PJSC provides financing of the relevant programs over the past few decades. Thus, only the implementation of the Program of Urgent Measures for Prevention of Aggravation of the Environmental and Social Situation in Boryslav for 2001-2005, approved by the Cabinet of Ministers of Ukraine dd. 29.11.2001 No. 544-r, the financing of which is assumed by the state and oblast budgets and UkrNafta PJSC, the amount of funding of measures by UkrNafta PJSC totaled UAH 27.2 million at the planned UAH 26.7 million (fulfilled by 101.8%).

At the same time, the state and regional administrations fulfilled their obligations by 3.2 and 38.5%, respectively.

Since 2005 till presently the issues of gas pollution in Boryslav have been dealt by UkrNafta PJSC almost solely, while spending large amounts of money. The numerous appeals to the state government to develop the state target program to reduce the gas pollution of Boryslav found no support.

Only now the problems of Boryslav are considered at the state level. Verkhovna Rada of Ukraine passed the Law of Ukraine on the All-State Target Program of Protection of Population and Territories from Emergency Situations of Man-Made and Natural Character for the Years of 2013-2017 on June 7, 2012, which approved the program activities and the tasks to implement the All-State Target Program of Protection of Population and Territories from Emergency Situations of Man-Made and Natural Character for the Years of 2013-2017. The said law entered into force on January 01, 2013.

These measures include the elimination of the environmental and social consequences of long-term oil and wax extraction in the city of Boryslav in Lviv oblast, including the transfer of secondary school No. 7 outside the dangerous area, transfer of buildings of Boryslav Central Hospital beyond the oil and wax fields, survey of the area of oil and wax deposits in order to establish the boundaries of the territory from which the residents shall be resettled etc. The main administrator of budget funds to meet the objectives shall be the Ministry of Emergencies of Ukraine, Ministry of Energy and Coal Industry of Ukraine and Lviv Oblast State Administration.



Figure 3. 3. Emergency situations which have occurred at well 494-Boryslav: a- February 15, 2012; b- July 16, 2012



Figure 4. Natural manifestations of hydrocarbons in the surface: *a*- griffons in the territory of Boryslav TSBVO; *b*- Oil spill in the bed of Tysmenytsia River at Chernovola Street

It should be noted that this problem did not arise by itself. In addition to natural factors, it was reinforced by enterprises and local residents, since the decision on construction in residential houses, including the high-rise ones, in the territory of oil and gas deposits has been a gross violation of rules of the settlements development. For various reasons this trend is still present. The housing and other social infrastructure is constructed nearby and sometimes even on the oil and gas extraction facilities, which is very dangerous to humans and the environment. There are the following questions: can the permission to build housing on the wells be issued? Why is the mining allotment of oil and gas deposits constructed, etc.

Another important factor affecting the condition of gas pollution of Boryslav is the inactivity of the mine group as regards wax extraction or proper conservation of the mine. Due to the stop, the shaft tunnels got with water, which stopped their ventilation. In addition, the hydrocarbon gases are emitted due to the damage to the municipal gas pipeline network, biogas emission from the water and sewage system etc.

It is also required to pay attention to the situation with traffic in the city. In view of the fact that the bridge over the Tysmenytsya destroyed by floods in the summer of 2008 has not been repaired yet, all transit traffic is sent to the city center. Consequently, the dynamic load on the soil is increased, which leads to the formation of additional migration of hydrocarbons to the surface. In addition, the significant emission of pollutants from motor vehicles falls exactly in the epicenter of gas contamination, thereby further deteriorating the quality of life of the residents and the atmospheric air condition.

With a view to resolving the situation, according to the authors, it is required to:

1. Create a steering committee composed of the Lviv oblast state administration, local self-government, territorial bodies of the MOE, Derzhgirpromnagliad, Ministry of Environment, Ministry of Energy, UkrNafta PJSC.

2. Develop a long-term national program to eliminate the effects of long-term production of hydrocarbons in Boryslav. The program shall provide for the following measures:

increase in the intensity of selection of hydrocarbon from deposits in Boryslav oil field. Consider the regulatory support of drilling additional wells to extract hydrocarbons within residential developments, including the use of technologies aiming at inclined and horizontal drilling and hydraulic fracturing used in the extraction of shale gas;

in order to study the dynamics of change in gas concentration in time and space, conduct the aerospace research of Boryslav oil field, wax mine and adjacent areas of Boryslav deposit;

based on the research findings, create the database of the most polluted areas of the surface layers, establish the proper level of public awareness about gas pollution of the city;

resettle the residents of individual houses from the most dangerous areas;

establish the local automated system for preventing gas explosion in the basement of residential buildings and other facilities located in the most polluted areas of Boryslav by installation of mechanical ventilation;

development and implementation of measures for decontamination of utility facilities, i.e. water and sewage, heat and other networks. Construction of new wells, repairs and maintenance of the existing system of ventilation wells; establishment of a special service for supervision of gas concentration in the city with involvement of Stebnytskyi mountain and rescue point of Ivano-Frankivsk specialized militarized mountain rescue unit for servicing of the local automated system for prevention of gas explosion in the basement of residential buildings and other facilities of Boryslav and surveillance of wax mine.



Figure 5. of gas pollution with degasation wells nearby house 12 at Chornovola St., a – overview; b – oil griffon near the degasation well 25

3. Develop and adopt a regulation prohibiting the construction, reconstruction, improvement and use of basements in the areas of gas pollution.

4. For degassing the surface layers, develop and take on the state level the regulatory documents which allow the extraction of hydrocarbons in the territory of polluted areas outside the mining allotment of Boryslav without special permits for subsoil plot and payment of rental. Equip the tunneling for all hazardous areas of Boryslav oilfield, mine group and surrounding areas with a vacuum network. Consider tax incentives for such businesses, or even a grant.

5. Unload the city center from the bus transportation. To do this, complete the construction of a bridge across the river of Tysmenytsia at Girna Street and arrange the bypass road for vehicles etc.

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