AGH DRILLING, OIL, GAS • Vol. 32 • No. 4 • 2015

http://dx.doi.org/10.7494/drill.2015.32.4.723

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AN ASSESSMENT OF THE INFLUENCE OF THE MAIN OIL INDUSTRY TECHNOLOGICAL PROCESSES ON THE ENVIRONMENT

1. INTRODUCTION

The production of oil, gas, and condensate is one of the most important issues among the sectors of the national economy of the Ukraine. Furthermore, a negative influence on the environment is an essential part of the process of formation fluids production. Besides, as the USA shows, the production processes of the oil production industry also contain a considerable amount of potential environmental risks [1]. The ecological situation in Ukraine in regions where oil and gas are produced is not completely studied; besides, such studies are not systemic. Hence, there appears a necessity for a detailed analysis of the negative factors that may provide a negative influence on the environment, their classification, and assessment of their influence consequences.

Oil production in Ukraine has a very ancient history and it dates back to the middle of the 19th century. Oil has been the main source of income of the Western Ukraine population for almost two centuries. Oil deposits were discovered mainly in the places of oil seepage. Oil production was conducted with the help of the so-called well pits, some of which were 100 m deep. These methods of oil production were changed into the first wells that were drilled with the help of the cable tool percussion drilling method. The well pits were abandoned and the essence of the abandonment reduced to the fact that the wellhead was covered with wooden boards and filled up by clay. The process of construction of the well pits was not controlled and it was carried out chaotically, nobody kept record of such wells. In the first wells that were drilled in the fields of the Prykarpattya, the annular space was not cemented. It happened very often that wells were drilled into the deposits with high formation pressure that led to oil gushers and fires that sometimes couldn't have been eliminated for several months. Thousands tons of oil were emitted into soils and natural waters, millions of cubic meters of gas and combustion products of formation fluids got into the atmosphere. Consequently, oil production has been accompanied by environmental pollution even since those times. Ecological aspects

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were not paid a significant attention. Furthermore, the availability of work and incomes facilitated settlement of people directly within the territory of oil and gas fields – Boryslavske, Bytkiv-Babchynske, Dolynske, Pivnichno-Dolynske, Bohorodchanske, Ripnianske, Pidliaske etc. Consequently, in such fields there formed industrial urban agglomerations, existence of which is dangerous due to the negative environmental consequences of the inefficient production of formation fluids and violation of norms of relative position of industrial and accommodation facilities. A good example of such a situation can be the Boryslavske oil field [2, 3].

Eventually, the processes of oil production had been improved and oil industry activities took place in the following order: construction of wildcat, exploratory, and production wells; extraction of oil and gas; transportation and the gathering of well production in its treatment places; the treatment of oil, gas, and condensate and their delivering to the customer; utilization of formation waters by burying them into underground water-bearing horizons or in the reservoir pressure maintenance systems.

2. PRESENTATION OF THE MAIN MATERIAL

Ecological aspects of each of the mentioned technological processes are different, so we will consider them for each individual element of oil production.

The drilling of wells involves allocation of a land plot for the construction of wells. Furthermore, before beginning drilling operations on the land plot that is allocated for well construction, the fertile soil layer is removed, a drilling site is designed, and drilling equipment is installed. During the process of drilling, the following main environmental influences are possible: the generation of drilling wastes, the formation of drilling wastewaters, air emissions from the operation of internal combustion engines, drives of the drilling rig and drilling mud pumps, diesel generator, heating boiler houses, tanks for diesel fuel storage, etc. Drilling wastes include used drilling mud and drill cuttings. The drilling mud is a complex colloidal system that contains different chemical agents such as: surface active agents, oil, formation water, alkalies, caustic soda, organic acids, and even salts of heavy metals. After being used, the mud is removed into the mud pit (in case of sumpless drilling – into the metal tanks), where it is stored until the end of the drilling. Depending on the well depth and complexity of the geological conditions, the contruction process may last for 4–5 years. During this time, mud pits (tanks) are a potential source of contamination of soils and underground water-bearing horizons. After drilling operations are completed, the liquid phase (drilling wastewaters) is separated from the drilling mud and the drilling wastes are buried on-site or (in case of the sumpless drilling) taken away for burying into special sludge tanks or into landfills for domestic solid wastes. Drilling wastewaters, after being treated, are reused during the process of well construction or disposed into the formation water flow for further utilization in the reservoir pressure maintenance system.

In the case of diesel drilling, the drilling site is characterized by significant amounts of discharges of polluting substances and greenhouse gases into the atmosphere. In particular, the atmospheric air is polluted by the products of diesel fuel combustion of the drilling rig, diesel generator, and heating boiler house drives – carbonic oxide, hydrocarbons, sulfuric anhydride, nitrogen oxide and dioxide, benzapyrene, solid particles (soot), greenhouse gases (carbon dioxide, methane) – that make up the main portion of the drilling site pollutant emissions and products of evaporation from the fuel and wastes storage tanks – these are mainly hydrocarbons. In the case of electrical drilling, atmospheric air pollution during the process of well construction

is minimized. It should be noted that, from the point of view of environmental influence duration, the influence onto the atmospheric air is relatively short-term; at the same time, the consequences of contamination of the underground waters and soils can hold true for decades.

Thus, the main danger for the environment during well construction consists in the formation of significant amounts of drilling wastes and wastewaters that can be potential pollutants of the soil and underground waters when they are stored, as well as considerable volumes of air emissions when conducting diesel drilling operations.

The second stage of the oil production cycle is the oil production from a well with the help of the pumps or free-flow production. When producing oil and gas, the environment can be polluted by the formation fluids due to the equipment leakage or occurrence of different emergency situations. It should be noted that the production of formation fluids is continuously accompanied by performing different technological operations that include production stimulation (acid treatment, hydraulic fracture etc.). Production stimulation technological operations include the utilization of chemical agents such as acids, alkalies of surface active agents etc. that can be potentially dangerous for the environment. Furthermore, the substances mentioned above are used in low-concentrated forms.

Besides, it is necessary to take into account the fact that the formation hydraulic fracturing takes place as a result of high pressure injection of special solutions into the hydraulic fracture zone and this, in turn, can cause leakage of the annular space cementing. Well workover and maintenance operations include running-out of the downhole equipment, its cleaning, repair or replacement. If these operations are not properly performed, the oil products that accumulated in the pipes can penetrate into the soils. The downhole equipment cleaning products are mainly resinous paraffin depositions that cannot be treated further, so they are removed into the specially equipped sludge tanks of the oil-and-gas production enterprises, where they are stored for a long time.

Transportation of the well production to the gathering and processing stations is mainly conducted with the help of the pipeline system. We believe that the pipeline system itself constitutes the most potential danger for the environment. The oil well production is a mixture of unstable oil and highly mineralized formation water and, in the case of the pipeline integrity loss, there occurs the simultaneous salt and oil pollution of the waters and soils. Taking into account the fact that the formation water is an aggressive environment, pipeline corrosion can occur tenfold faster than in other environments. Pipeline pressure loss can occur as a result of the pipe clogging by salt depositions. The occurrence of emergency situations on pipelines is a result of combined action of these two factors. Salt and oil soil pollution can lead to a violation of soil structure, destruction of soil microflora, thus the withdrawal of the land plot from the agricultural utilization system for a long time. The soil renewal process can last for decades depending on the pollution level.

Besides, gas transportation by pipelines is accompanied by emissions of significant volumes of gas combustion products from the operation of the gas pumping units [4].

Processing of oil, gas, and condensate includes storage of well production in the reservoirs; furthermore, hydrocarbon gases are discharged through relief valves into the environment. Besides, when the technological process is carried out normally, the air is polluted by the gas combustion products from the technological equipment that is used for processing of the formation fluids (heating a boiler house, heaters etc.). In the case of emergency situations or maintenance operations, a great deal of gas that fills the equipment can be emitted

into the air. Such an emission takes place through the specially equipped stacks or flaring systems of the oil production enterprises. If gas is emitted through the stack, the hydrocarbon gases get directly into the air; when gas is discharged via the flare, its combustion products get into the air. In most cases, discharge of relatively small gas volumes is conducted through stacks and great volumes of gas are emitted via flare systems.

It should be noted that not all the well production processed meets the condition requirements – stable oil emulsions, which are considered to be production wastes, form at the enterprises as a result of this. Such wastes contain water, salts, and oil products; they are removed for storage into the sludge tanks.

Sludge tanks for the storage of oil industry wastes are mostly open mud pits with the installed watertight screens (clay, concrete, polymer, etc.). From the point of view of the environmental influence, the sludge tank is a plane source of pollutant emissions into the atmospheric air with a relatively big area of oil products evaporation. Concerning the influence onto the soil and underground waters, we would like to state that such an influence is possible under conditions of low watertight screen quality or its destruction and as a result of an overflow of the sludge tank content because of cave-ins, in cases when atmospheric precipitations are not sufficiently withdrawn or the tank is overflowed. It should be noted that most sludge tanks at the oil-and-gas production field facilities are operated for decades without any control of the watertight screen quality, so the problem of pollution of the underground waters and soils in the region of location of such facilities is very important.

In order to maintain reservoir pressure in a field, formation water separated from oil is mostly used. In cases when there is not enough water, additional underground or surface water intakes are constructed. In order to prevent formation pores clogging, the water is processed after having been separated from oil. The essence of processing consists in the separation of hung particles and oil products that are later removed into the sludge tanks for the storage of oil-containing wastes. After leaving the waste treatment plant, the water is supplied with the help of water pipelines into the reservoir pressure maintenance system well under the pressure of 10–22 MPa. In the case of emergency situations – pipeline leakage or well casing integrity loss, salt waters can penetrate surface waters or underground water-bearing horizons and saline soils. Taking into account high injection pressures, the scales of such accidents are quite significant and the elimination of environment saline contamination is a complex long process.

Based on the results of the conducted analysis, we developed a classification of characteristic influences of the main oil industry technological processes onto the environment. This classification is provided in Table 1.

3. CONCLUSIONS

Thus, the main dangerous environmental influence factors of the oil-and-gas production industry on the environment were determined as a result of the conducted studies. At present, the real ecological consequences and ecological situation in the region of location of oil-and-gas industry facilities in the Ukraine are not sufficiently studied. Besides, each facility of the potential influence can have its own peculiarities and each of them can provide a different influence on the environment under different conditions. Correspondingly, there arises the necessity in carrying-out of monitoring studies that would allow us to assess the scales of the technogenic environmental pollution when producing oil and gas.

Table 1

Classification of characteristic influences of main oil industry technological processes onto the environment

Stage	Nature of influence	Environment of influence	Technological process / emergency situation	Environmental influence
Construction of wells	technological	atmosphere	actuation of the diesel drive, drilling mud pump	emissions of fuel combustion products
			well development	emissions of combustion products from flare operation
		water	well washover	generation of drilling wastes
				formation of drilling wastewaters
		soils	well washover	generation of drilling wastes
				formation of drilling wastewaters
			drilling site design, drilling equipment installation	mechanical soil devastation, withdrawal of the land plot from the main purpose utilization
	emergency	atmosphere	flowing	emissions of hydrocarbon gases, combustion products
		water	flowing	emissions of oil products, formation waters
		soils	flowing	emissions of oil products, formation waters
Production	technological	atmosphere	–	absent
		water	–	absent
		soils	paraffin removal from tubing	generation of wastes – paraffin depositions
	emergency	atmosphere	flanges,	pollutant emissions due to equipment integrity loss
		water	hydraulic fracturing of formation	leakage of the annular space cementing > cross-flow between layers > salinization of underground waters
			acid treatment	possible overflows of acids, chemical agents
		soils	workover	inflow of oil products from the downhole equipment onto the surface
			acid treatment	possible overflows of acids, chemical agents

Stage	Nature of influence	Environment of influence	Technological process / emergency situation	Environmental influence
Transportation	technological	atmosphere	pumping	pollutant emissions from pumping units
		water	–	absent
		soils	–	absent
	emergency	atmosphere	pipeline pressure loss	emissions of hydrocarbon gases
		water	pipeline pressure loss	overflow of oil, formation water
		soils	pipeline pressure loss	overflow of oil, formation water
Gathering and treatment	technological	atmosphere	storage of oil, condensate	emissions of hydrocarbon gases through the reservoir relief valves
			treatment of oil, gas, condensate	emissions of hydrocarbon gases through the equipment relief valves, emissions of combustion products from pipe heaters, emissions of auxiliary substances (deemulsifying agents, hydrate inhibitors etc.)
		water	treatment of oil, gas, condensate	generation of wastes – stable oil emulsions that are stored in sludge tanks
		soils	treatment of oil, gas, condensate	generation of wastes – stable oil emulsions that are stored in sludge tanks
	emergency	atmosphere	equipment pressure loss	emissions of hydrocarbon gases
		water	equipment pressure loss	overflow of oil, formation water
		soils	equipment pressure loss	overflow of oil, formation water
Reservoir pressure maintenance system	technological	atmosphere	–	absent
		water	treatment of water	generation of oil-containing wastes
			reservoir pressure maintenance	water intake for reservoir pressure maintenance from the surface or underground sources in case of insufficient volume of formation waters
		soils	treatment of water	generation of oil-containing wastes
	emergency	atmosphere	–	absent
		water	pressure loss of tanks, water pipelines, other equipment, well casing integrity loss	salinization of underground and surface waters
		soils	pressure loss of reservoirs, water pipelines, other equipment, well casing integrity loss	soil salinization

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