The Use Of Foamed Concrete For Oil Spill Treatment And Carbon Capture

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Abstract. The paper presents analyses the pollution and the spills distribution and presents the results of the experiment on the use of the oil spill elimination means with the foam concrete application. The studies have shown that in the medium term the pipeline transportation accidents, the number of spills and the environmental pollution increase is expected. In addition, studies have shown that the application of the foam concrete with a D 600 density is considered to be the most effective way of the oil spill elimination.

1. Introduction
One of the major environmental problem of our time is the oil-polluted land surface as a result of the low-quality operations implementation and the emergency situations in the hydrocarbon extraction and transportation. The oil pollutions influence the geological environment, causing a great damage to the soil surface layer, surface-and-groundwater, endangering people's health and jeopardizing the existence of entire ecosystems [1, 2].

According to the technical regulations, the soils and the subsoils are considered to be oil-contaminated if the oil and petroleum products concentration reaches the point when the negative ecological changes in the environment occur, such as: the violation of the ecological balance in the soil ecosystem, the soil biota loss, productivity reduction or loss of plants, change in the morphology and hydrophysical soils’ properties and diminishing of soil fertility. The big danger is the pollution of groundwater and surface water as a result of oil leaching from the soil or ground and further dissolution in the water [3,4].

The article analyzes the pollution and the spills distribution and presents the results of the experiment on the use of the oil spill elimination means with the foam concrete application [5, 6].

2. Materials and methods
The analysis of the empirical material about methods oil spill treatment and carbon capture covering the period 1965 – 2015. Conducting experimentation with simulated oil spills have been covered by the foam concrete of different density: D 300, D 400, D 500, D 600, D 700, D 800.

3. Results and Discussion
In recent years, with the offshore petroleum production volume increase the oil pollution of the World ocean has grown. For the last 20 years, the number of the world's major offshore deposits discoveries exceeded the corresponding onshore index and the offshore petroleum production has reached 30% of the world total [7].
The main sources of the pollution include both the oil spills from the floating drilling units and the offshore fixed platforms in the process of continuous drilling, the oil production and transportation and the spills during the accidents. The overall spills volume is approximately 1% of the oil entering the World ocean total amount. Analysis of the World ocean pollution sources by 2014 is presented in the Table 1.

| Source                        | mln. t/year |
|-------------------------------|-------------|
| Marine freight                | 1.83        |
| Accidental spill              | 0.30        |
| River run-off including urban | 1.90        |
| Coastal area waste waters     | 0.80        |
| Atmospheric fallout           | 0.60        |
| Natural oil wells             | 0.60        |
| Offshore petroleum production | 0.08        |

Most of the oil and oil products losses and as a result the pollution are carried out in the process of water, railway, automobile and pipeline transportation [8,9]. The enormous length of pipelines, which is more than 200,000 kilometers in the Russian Federation, and the severe operating conditions provide for the high rates of the accidents and the pollution volume. Figure 1 is a graph showing the density (intensity) oil and oil products transportation through pipelines in the RSFSR and the Russian Federation.

![Figure 1](image-url) - The main pipelines and oil-product pipelines length and the pumping in the RSFSR and the Russian Federation.

As it can be observed, since 1995 the pump volume has had a clear increasing trend while the length of the main pipelines and oil-product pipelines almost unchanged, that means the operational piping load increase and, consequently, the risk of accidents and pollution increase.
The main causes of oil spills during the oil pipeline operation are: the underground corrosion, the construction works defects, the tube defect, mechanical damages, the operational imperfection, internal erosion and corrosion, natural disasters, equipment defect and others [10]. The main oil pipelines in the places of crossing the artificial and natural obstacles (roads, railways, rivers, lakes) are the most dangerous, for example the under water lines. Lots of pipelines, located underneath the shipping lanes or in the channels, are more susceptible to the serious mechanical damages as a result of natural causes such as the erosion of the shallows, the bottom creep, and the anchor relocation in the process of dredging.

Table 2 – The pipeline system accident rates from 2010 to 2014

| Parameter                              | 2010 | 2011 | 2012 | 2013 | 2014 | The average value 2010-2014 |
|----------------------------------------|------|------|------|------|------|---------------------------|
| The number of accidents                | 13   | 17   | 21   | 12   | 8    | 14 ± 4                    |
| The long pipelines, 1000-km.           | 232.6| 237.5| 245.2| 245.8| 248.1| 242 ± 6                   |
| The specific intensity of accidents (1/1000 km/year) | 0.06 | 0.07 | 0.09 | 0.05 | 0.03 | 0.06 ± 0.02 |
| The freight turnover, billion tons km.  | 2382 | 2422 | 2453 | 2513 | 2423 | 2439 ± 43                 |
| The specific frequency of accidents per year, 1/(trillion tons km) | 5.5  | 7.0  | 8.6  | 4.8  | 3.3  | 5.8 ± 1.8                 |
| The total damage accidents              | 146.0| 161.5| 154.8| 318.9| 96.5 | 174 ± 74                  |
| The average damage for one accident, mln. rub. | 11.2 | 9.5  | 7.4  | 26.6 | 12.1 | 13 ± 7                    |

According to the given table we can observe that the figures are not stable and do not have a clear trend, which is a negative factor in the prediction of further development of the petroleum industry. The vectors of the country development, mapped out by the Government of the Russian Federation in 2015 indicated the further oil production and transportation volume increase. However, the appropriations released for the purpose of petroleum industry development, show a downward trend, which may directly affect the equipment reliability rate and as a consequence, the number of accidents followed by the environmental pollution.

Thus, in the medium term the pipeline transportation accidents, the number of spills and the environmental pollution increase is expected.

In the process of the oil spill elimination the different methods and means are used, the choice of which is based on the performance and the contaminated area availability. The most common methods include the use of the foam concrete due to its low cost, the operating conditions and efficiency. In the process of the foam concrete behavior investigation and the effectiveness evaluation of the petroleum product removal, the sandy soil contaminations were made in the laboratory conditions. The simulated oil spills have been covered by the foam concrete of different density: D 300, D 400, D 500, D 600, D 700, D 800. The height of the foam concrete rise was measured visually after 1 and 4 days. On the 7th day it was possible to see how the foam absorbs the oil. The obtained data are represented in Table 3 and Figure 2 and 3. After the results analysis, it can be concluded that D 600 foam concrete has the maximum oil products removal efficiency.
Table 3 – Oil products removal efficiency

| Foam concrete grade | The height of the oil products rise, cm | Oil products removal efficiency, % |
|---------------------|---------------------------------------|-----------------------------------|
|                     | 1<sup>st</sup> day | 2<sup>nd</sup> day | 3<sup>rd</sup> day | 4<sup>th</sup> day |                                    |
| D 300               | 0.5                   | 0.86                 | 1.0               | 1.0               | 70                                 |
| D 400               | 0.7                   | 1.00                 | 1.5               | 1.9               | 80                                 |
| D 500               | 0.8                   | 1.30                 | 1.5               | 2.6               | 90                                 |
| D 600               | 0.9                   | 1.20                 | 2.7               | 3.6               | 99                                 |
| D 700               | 0.6                   | 1.00                 | 1.8               | 2.6               | 99                                 |
| D 800               | 1.0                   | 1.30                 | 1.4               | 1.6               | 98                                 |

Figure 2 – The dependence of the efficiency of removal of oil from the density of foam concrete.
The experiments with the crude oil, exhaust and clean industrial oils, fuel oil have been conducted to find out what types of different fractions petroleum products can be removed from the surface the most effectively. In almost all cases, except the fuel oil, the spill has been removed successfully with the help of the foam concrete by 80-90%. The data of the experiments are represented in Figure 4.

**Figure 3** – Oil products removal efficiency dependence on the foam concrete density.

**Figure 4** – Oil products removal efficiency dependence on the fractions.

### 4. Conclusion

Thus, conducted contaminants distribution analysis showed that the most emergency petroleum industry objects are the objects of pipeline transport infrastructure. Currently, the operating pipelines have a high extent of wear and a high risk of breakthrough. In the medium term the environmental pollution increase can be expected with the further increase in the production volumes and the investment decrease. In this case, the application of the foam concrete with a D 600 density is considered to be the most effective way of the oil spill elimination.
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