Landscape conditions of oil contaminations along oil fields piles network in West Siberian northern taiga

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Abstract. The results of the analysis of accident occurrence and oil contaminations area along the oil pipelines are compared with the length of the pipelines for landscapes of the West Siberian northern taiga. The possible influence of landscapes on the relative frequency of accidents and contaminated areas are discussed.

1. Introduction
Oil pollution is the most common negative consequence of oil production and transportation, including due to accidents of low-pressure oil fields pipelines. When reduce of the accident rate of oil pipelines is the subject, the most attention is paid to the properties of pipes and first of all to corrosion resistance [1]. The influence of landscape environments are not highly estimated [2], and usually not analyzed. The purpose of our work was to analyze the possible influence of different northern taiga landscapes of Western Siberia on the frequency of oil pollution occurrence and their distribution along oil fields pipelines.

2. Materials and methods
We used the inventory information of contaminations on some oil fields including already recultivated areas as data of accidents. Also we used results of local ecological monitoring including maps of vegetation and soils (scale 1:25000) as data of landscapes and information on oil pipe networks of oilfields was used as well.

The study area includes central part of Siberian Uvals (chain of hills) and adjacent parts of planes – northern areas of Surgut Polesie and southern areas of the Pur-Nadyrn accumulative plain all within the zone of the northern taiga [3]. Forest and bogs landscapes prevail here, and the following are most typical. On loamy sediments, the most drained areas are covered by zonal vegetation with larch (with dark coniferous species and small-leaved species) forests with dwarf shrub-moss ground cover [4] on podzols [5]. The drained sandy sediments are covered by intrazonal pine dwarf shrub-lichen forests on podzols. With deterioration of drainage these forests are replaced by pine dwarf shrub-sphagnum communities (ryam) which usually surround sphagnum bogs. Bogs cover the central parts of the local watersheds and mainly are represented by permafrost palsas [6], thawed sphagnum bogs and ridge-pool complexes [7] on peat soils. Mesotrophic bogs are elongated along the drainage of bog adjoining to the bog creeks and also to rivers with floodplain series of vegetation on alluvial soils. The probable influence of these landscapes on the accidents of oil pipe networks was analyzed.

The weight (rate) of the number and area of 220 contaminated sites and the weight (rate) of the length of the pipeline networks for each terrain were determined for the analysis of the influence of
different landscapes. The influence of the landscape was estimated as the ratio of the weight of the number and area of contaminants and the weight of the length of the pipes within this each landscape. If there was no influence these ratios were expected near 1, i.e. the number of sites and the area of contamination was equal to the length of the pipes crossing the landscape, with values less than 1 – relatively less accidents, and more than 1 – greater accident rate.

3. Results

Almost all of the analyzed oil pipelines are underground; the above-ground parts near the stop valves are less than 0.17 % of the total length of the pipes. Depths of oil pipelines is from 0.30 to 2.20 m, depths of 1.00-1.10 and 1.50 m prevailed. The average depth was 1.18 ± 0.10 m, and was the same in different landscapes. Pipes with a diameter of 114, 159 and 219 mm predominated. The age of the oil pipelines was from 1983 to 2010, during investigation the majority of pipes were exploited from 1986 and earlier.

As the analysis of oil pipeline networks distribution shows the main part of it (69%) is located in the most drained landscapes in forest communities on podzols soils (Table 1) while the bog areas in the subzone of the northern taiga covers about 40%. In the area of investigation in the basins of rivers Piakopur and Nadym the bog cover reaches about 70% [3]. This distribution of oil pipe networks is associated with the convenience of construction and maintenance in the most drained areas. As a rule all communications of oil fields, including roads and pipes networks are associated with the same sites when possible. 24 % only of the oil pipelines passed through the bog landscapes, and 7% only passed through the elongated mesotrophic bogs and floodplains of local rivers crossing them perpendicularly.

| Landscapes                          | Relative share | Pipe lengths | Relation to the pipe lengths |
|-------------------------------------|----------------|--------------|-------------------------------|
|                                     | Number | Square | Number | Square |                         |                         |
| Pine dwarf shrubby-lichen forests   | 0.11   | 0.09   | 0.26   | 0.42   | 0.34                      |                         |
| Zonal larch dwarf shrub-moss forests | 0.38   | 0.28   | 0.43   | 0.88   | 0.66                      |                         |
| Pine dwarf shrub-sphagnum forests  | 0.05   | 0.03   | 0.05   | 1.00   | 0.56                      |                         |
| Ridge- pool bog complexes           | 0.06   | 0.07   | 0.04   | 1.60   | 1.98                      |                         |
| Sphagnum bogs                       | 0.18   | 0.18   | 0.09   | 1.96   | 1.99                      |                         |
| Permafrost palsa                    | 0.10   | 0.13   | 0.06   | 1.68   | 2.25                      |                         |
| Mesotrophic bogs                    | 0.06   | 0.10   | 0.03   | 1.94   | 3.02                      |                         |
| Floodplain series of vegetation     | 0.06   | 0.11   | 0.04   | 1.53   | 2.74                      |                         |

The distribution of contaminated areas was significantly different in different landscapes. The number of contaminations relative to the length of the pipes in the most drained pine shrubby lichen forests on sandy podzols was the smallest, more than 2 times less than expected independent distribution of contaminations, and somewhat less than expected in zone larch shrubby-moss forest.

In semi-hydromorphic conditions of pine sphagnum ryam, the number of contaminations was nearly close to expected, and their area was almost less than expected in two times.

In all bog landscapes the number of contaminations was in 1.5 - 2 times higher than expected, and their area was more than expected in 2 to 3 times. Probably increased number of contaminations in the bog landscapes is connected with cryogenic processes which are especially pronounced in hydromorphic conditions and lead to mechanical effects on oil pipelines increasing their accidents. Also oil spills in the permafrost bog complexes with numerous hollows and small lakes is capable of rapid spreading.
The landscapes of mesotrophic bogs and river floodplains showed even more relative contamination. In both cases it is probably associated with directed flows downstream, which largely contributes to the spread of oil pollution.

4. Conclusions
Generally the analysis shown that the probability of accidental contamination along oil fields pipelines as higher as more hydromorphic conditions they cross. As for the number of contaminations and their area the bog landscapes and river floodplains are the most polluted. The best conditions for the spread of oil pollution are in the landscapes of permafrost and especially mesotrophic bogs and river floodplains.

5. References
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