EXPRESS ASSESSMENT OF RECULTIVATION EFFICIENCY OF DISTURBED TUNDRA SOILS IN NATURAL GAS PRODUCTION AREA

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It is known that motor vehicles used for exploration, drilling wells and construction of gas production fields in the Far North conditions may mechanically affect the soil and vegetation of tundra. The soils partially of completely lose their vegetation and organogenic layer; mineral horizons come up to the ground surface and cryogenic situation changes [1]. Therefore the key attention is paid to the tundra soil researches particularly in Tazovsky peninsula (68°09'N/76°02'E), where Gazprom dobycha Yamburg LLC carries exploration works, constructs and develops new fields, produces gas (more than 31% of total Russian gas), gas condensate and arranges their treatment [2]. Tazovsky peninsula locates in the north of the West Siberian Plain in Yamal-Nenets Autonomous Okrug between the Ob Bay (the sea gulf) in the west and the Taz Bay in the east (Fig. 1). The flat surface of the peninsula is covered with numerous small lakes and bogs. It has a slight slope towards the Taz Bay in the east and massive cliffs by the Ob Bay in the west. The peninsula itself is a moss, lichen and shrub tundra which is totally used by indigenous people for rain deer grazing to the present days (Fig. 2).

Production activity of Gazprom dobycha Yamburg LLC is based upon principles of sustainable development that means a balance between its economic, social and ecological components [2]. At the same time one of the environmental guideline principles is minimization of technogenic impact within the area of production activity of Gazprom dobycha Yamburg LLC and preservation of the environment. It is realized in particular in recultivation (restoration of fertility) of disturbed tundra soils. For example the peat and sand mixture layer (in the ratio 1:4 and thickness up to 5-6 cm) are applied to the soils striped of their organogenic top. It hastens restoration of vegetation and therefore soil itself [1]. However only in decades to come it will be possible to evaluate (by the regeneration of initial vegetation) the effectiveness of this soil reclamation technique in severe conditions of tundra. Therefore it is crucial to develop a method of prior express assessment of effectiveness of disturbed tundra soil recultivation by some mean via laboratory tests conducted in controlled hydrothermic conditions and application of key indicators of soil fertility formation. One of these indicators is a dehydrogenase enzyme activity produced by microorganisms and plants and widely applied for characteristic of soil types, fertility assessment and degree of soil recultivation, effectiveness of agricultural methods and etc. [3].

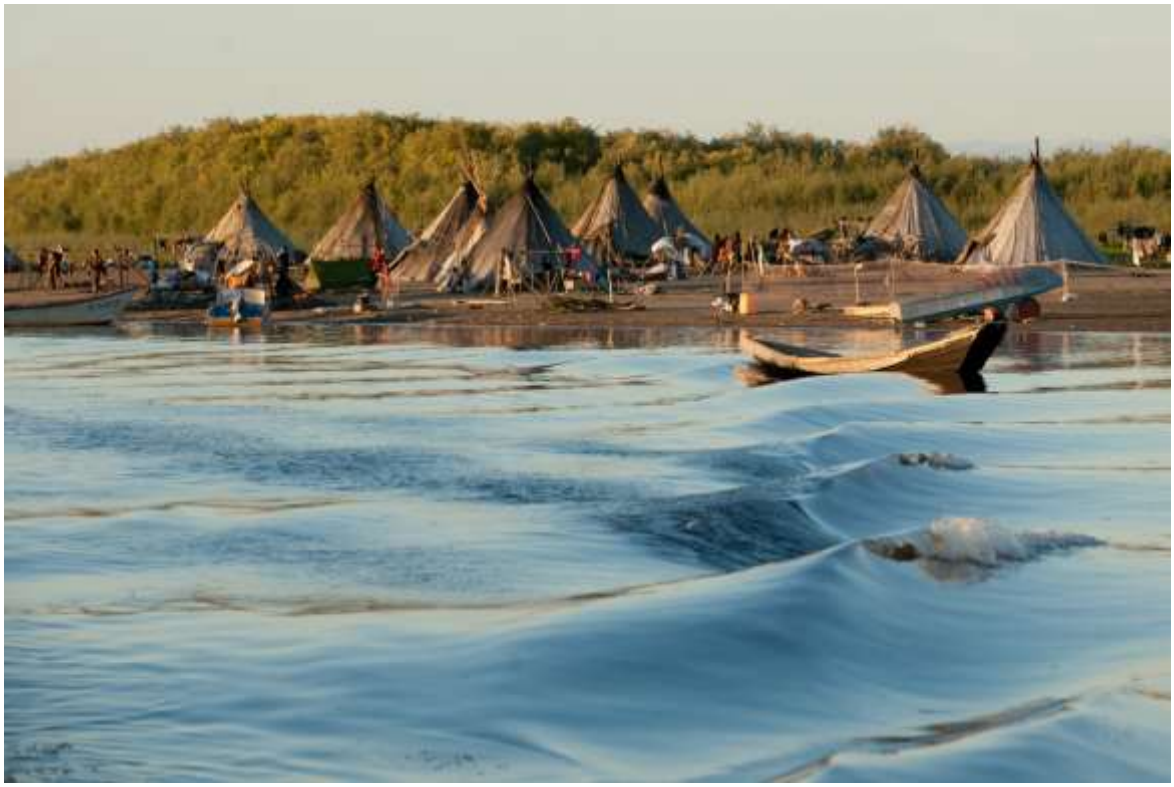

Fig. 1. Costal tundra area by the Taz Bay.

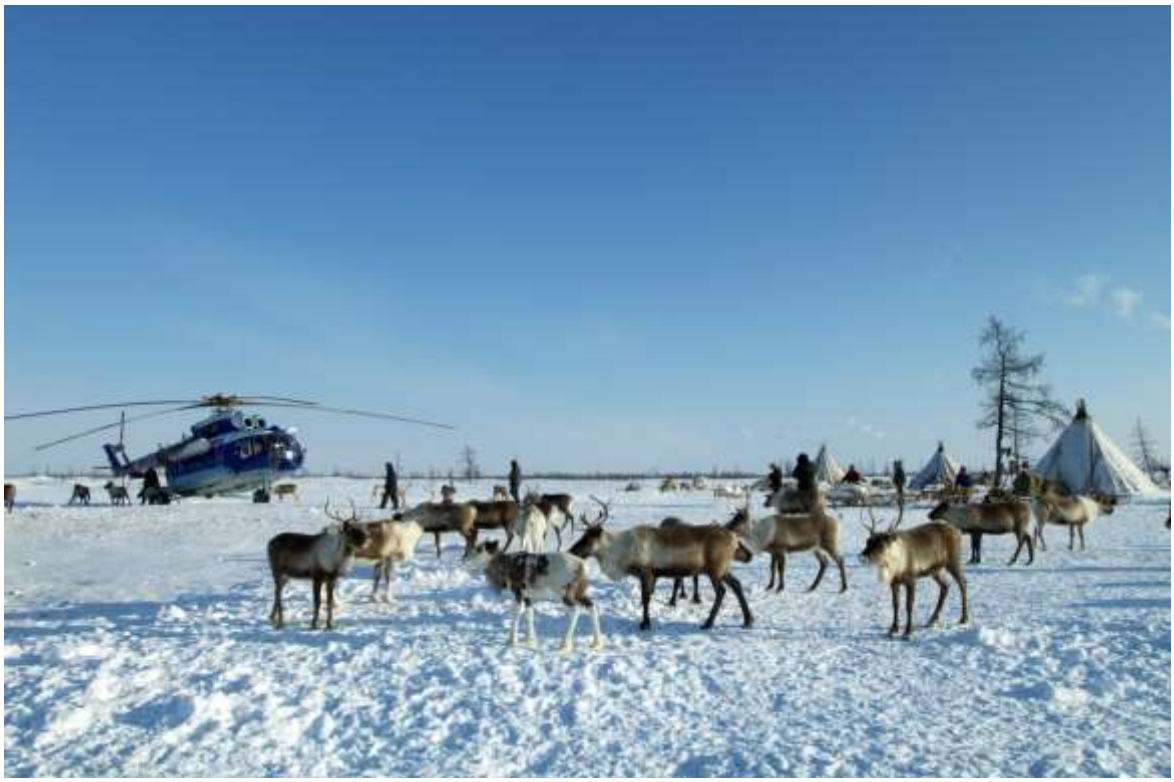

Fig. 2. Reindeer herder’s camp.

The dehydrogenase significance implies catalysis of dehydrogenating activity (hydrogen abstraction) of organic substances (carbohydrates, alcohols, organic acids and etc.) as its substrates accompanying the plant remains.

The target of the work is to estimate recultivation efficiency for disturbed soils of Tazovsky peninsula by application of peat and dehydrogenase activity test.

The averaged samples from the top layer (0-6 cm) of disturbed tundra soil (aggregate-size distribution – cohesive sand with 5-10% clay content) nearby the Comprehensive Gas Treatment Units were taken for research (Fig. 3). One section of the soil was free of vegetation the other one had fragments of restored vegetation such as grass and herbage cultures and mosses. The soil free of vegetation contained 0.2% of C_{org} and the soil with vegetation cover – 0.9% of C_{org}. Recultivation tests involved application of 54% ash content peat to the soil in the ratio 1:4. Organogenic top (0-10 cm) of typical tundra peaty-gleezem soil of 39% ash content was used as a standard. Physicochemical properties of soil and peat test samples are listed in Table 1.

Fig. 3. Overview of the Comprehensive Gas Treatment Unit.

Table 1.

Physicochemical properties of soil and peat samples

Sample	Density or volume weight g/sm^3	Moisture equivalent, %	Total moisture capacity, %	pH_{water}
Typical tundra peaty-gleezem soil	0.39	216	315	5.1
Peat	0.40	216	420	5.4
Disturbed soil without vegetation	1.71	25	32	5.9
The same + peat, 4:1	1.04	66	80	5.1
Disturbed soil with vegetation cover	1.54	37	43	5.1
The same + peat 4:1	0.89	78	102	5.3

The 50g samples (with and without peat) moisten to 70% were incubated into Petri dishes at thermostat temperature 30ºC to assess effectiveness of disturbed soils recultivation. Over time of 5, 10, 20 and 30 days the activity of dehydrogenase in different test samples was analyzed under technology protected by RF patent [4].

Dehydrogenase activity was calculated using triphenyltetrazolium chloride (2, 3, 5-TTC) $C_{19}H_{15}N_4Cl$. TTC is a colorless substance which, accepting hydrogen mobilized by dehydrogenase, in the soil turns into 2, 3, 5-triphenylformazan (2,3,5-TPF) $C_{19}H_{16}N_{4,}$ the substance of red color [3]:

$$C_{19}H_{15}N_4Cl + H_2 \rightarrow C_{19}H_{16}N_4 + HCl$$

The dehydrogenase activity analysis: a lot of soil (peat) of 1g weighting is placed into the modified Erlenmeyer flask of 20 ml capacity with cranked side arm of 3ml capacity filled with thins. A lot of 0.1 g calcium carbonate and then consistently 1 ml of 1% water solution of glucose and 1 ml of 2, 3, 5-TTC are added to the same flask. The flask content is mixed and 2.5 ml of saturated alkaline pyrogallol prepared with usage of potassium hydroxide is syringed into cranked arm. Hermetically closed flask and its cranked arm is placed into thermostat at the temperature 30^{o}C for 24 hours for incubation. After that, generated in the soil (peat) 2, 3, 5-TPF is multiply extracted by ethyl alcohol until colorless extract is obtained. The painted extract after paper filtration enters the volumetric tube. The intensity of coloration of integrated filtrates of ethyl alcohol is measured by spectrophotometer at a wave length equal to 490 nanometers and 2, 3, 5-TPF concentration is calculated. Dehydrogenase activity is expressed in μg or mg 2, 3, 5-TPF/(g·days).

The data from Table 2 show that peat addition significantly increase dehydrogenase activity of the disturbed soils without vegetation: 11.4% against 23.4% (without peat) and with vegetation: 29.1% against 51.9% correspondingly.

Table 2.

Dynamics of dehydrogenase activity in disturbed soils recultivated by peat

Sample	Dehydrogenase activity in % of standard tundra peaty-gleezem soil			
	days			
	5	10	20	30
Peat	128.5	100	96.7	101.2
Disturbed soils without vegetation	9.2	6.7	7.6	5.9
The same + peat, 4:1	32.6	23.9	19.0	23.7
Disturbed soils with vegetation	18.6	13.6	15.1	11.9
The same + peat, 4:1	70.5	58.6	59.9	41.0

It signifies that the high effectiveness of disturbed soil recultivation is confirmed by increase of their dehydrogenase activity. Peat dehydrogenase activity matched the corresponding activity of standard peaty-gleezem soil taken as a standard and 5 first days was up by 28.5%.

Correlation and regression analysis proved the validity of dehydrogenase activity method in assessment of recultivation effectiveness of disturbed soils by peat. So the calculation of correlation ratio (r), pointing at a direction and degree of conjugacy in

mutability of properties revealed a strong correlation dependence between dehydrogenase activity and specific gravity (weight by volume) of samples (r = -0.95), dehydrogenase activity and capillary moisture capacity (r = 0.95), dehydrogenase activity and total moisture capacity (r = 0.95). The equations of linear regression corresponding to these correlations make possible to find how the effective attribute (*y*) quantitatively changes at change of factorial attribute (x). It has the following form:

$$y = 76.9 - 44.4x; \qquad y = 2.74 + 0.28x; \qquad y = 7.71 + 0.15x$$

It turned out that the smaller the specific gravity (weight by volume) and the larger the capillary and total moisture capacity determined by its organic component in the samples the higher the dehydrogenase activity. The importance of moisture in the dehydrogenase activity is based on the fact that moisture determines the standard physiological state of microorganisms and plants as enzyme producers in the soil and at the same time it keeps enzymes and their substrates (carbohydrates, alcohols, organic acids and etc.) in reaction state.

The conducted researches proved that dehydrogenase activity analysis in laboratory conditions gives possibility to estimate in the short-term the effectiveness of disturbed tundra soil recultivation by peat. The integrity of using dehydrogenase activity for estimation of effectiveness of disturbed soil recultivation is confirmed by presence of strong correlation dependences between the key fertility indicator and basic physicochemical properties of soils.

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