Modeling of salt-water migration through spod-podzolic soils under the field and laboratory conditions

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Introduction

Salt affected soils are widely spread throughout the world. Various regions with different climatic conditions are exposed to the risk of salinization. The formation of salt-affected soils is not only related to climate factors but also caused by anthropogenic activities, such as agriculture, oil and gas production. Formation of salt addicted soils is a complex process of the drastic chemical and physical properties changes. Therefore the chain of the laboratory and field experiments should be done in order to assess the main factors promoting highly mineralized water migration. In addition to it modelling is a good way to understand and evaluate main chemical and physical transformations in soils.

Objects and methods

The main goals of the work were to evaluate the rate of salt water movement through soils and to estimate velocity of the desalinization process.
The experimental sites are located in Kaliningrad region. The climate is moderate marine. The average annual precipitation is 760 mm. Evapotranspiration is about 550 mm. Soils of the experimental sites are spod-podzolic. Bulk density of the top horizons is 0.8 g/cm^3.
The textural class is silt loam. Soil pH values ranged from 4.9 to 8.3. Salinization of soils and soil solution is 0.2 g/l and 0.4 g/l correspondingly.
The field experiment was conducted in June. Soil samples were collected in periods of 1 week, 3 month and 1 year after the spill. Samples were taken at each site at the depth of 0-110 cm every 10 cm. The top horizons of non-saline spod-podzolic soil were taken for the laboratory experiment.

fig. 1. Area of study

fig. 2. Experimental sites

Field experiments

4 salt affected sites
2 pure sites
20*25 cm measured
5 liters of salt water per site
mineralization 100 g/l

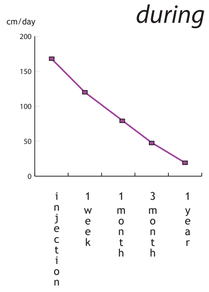
fig.3. Field experiments on salt water migration

Laboratory experiments

14 salt affected columns
2 pure soil columns
10*4 cm measured
104 mm of salt water per column
mineralization 100 g/l

fig. 4. Laboratory experiments on salt water migration

Changes in water movement velocity during laboratory experiments



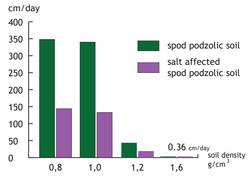


fig.6. Changings in velocity during the laboratory experiments with different soil bulk density

fig. 5. Changings in water movement velocity during the laboratory experiments

Changes in soils chemical properties and structure which were caused by prevailing salinization processes lead to decrease in water migration velocity. The velocity was 170 cm/day after the salt water poured into the column. The value of water movement was 17 cm/day at the end of the experiment. Moreover the findings of the experiments with varying soil bulk density showed the significant reduction in the velocity.
As the velocity decreased the soil bulk density increased.

Results

Changes in mineralization during laboratory and field experiments

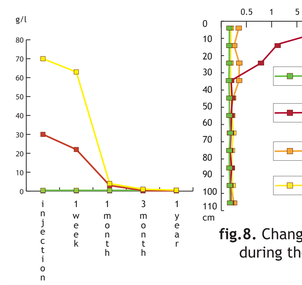


fig. 7. Changings in mineralization during the laboratory experiments

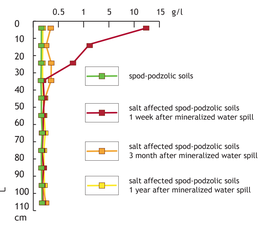


fig.8. Changings in mineralization during the field experiments

Growth of soil salinization level was recorded immediately after the salt water spill. The mineralization reached 70 g/l in soil solutions and 30 g/l in soils during the laboratory experiment.
The outcomes of the field experiment showed the twice less salinization (12.5 g/l) of soils then at the lab experiment. These can be described by prevailing of horizontal flow over the vertical. However the speed of desalinization was similar in both experiments. The mineralization reached natural values 3 months after the spill.

Changes in pH during laboratory and field experiments

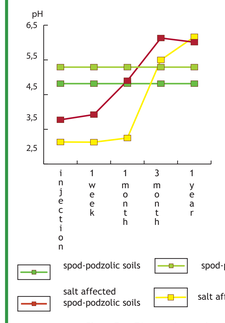


fig. 9. Changings in pH during the laboratory experiments

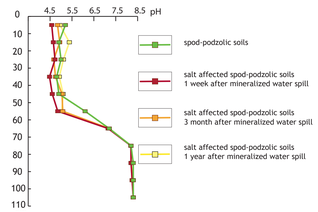


fig.10. Changings in pH during the field experiments

Changes in pH were registered instantly after the salt water injection. The decrease of pH was observed both in field and lab experiments. The actual acidity lessened by about 1 unit after the salt water spill. The slight growth of the pH was recorded during the experiments. Moreover the pH did not reach natural values in laboratory experiment.

Conclusion

Changes of soil chemical and physical properties due to salinization lead to slow down of water movement velocity in more than 10 times.
The tremendous growth of the mineralization took place. Maximum values in soil solutions and soils reached 70 g/l and 30 g/l respectively.
The acidification of soils was recorded immediately after the salt injection.
On the one side, the pH exceeded natural values even at the end of laboratory experiment. On the other, the pH slowly went up and reached natural values in field experiment.
The reduction of salt concentrations in soils occurred in the period 3 months 1 year after the spill.