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National Scientific Center

**“Institute of Soil Science and Agrochemistry Research
named after O.N. Sokolovsky”**



Recovery of soils biodiversity on reclaimed drilling pads of oil-gas wells in East Ukraine

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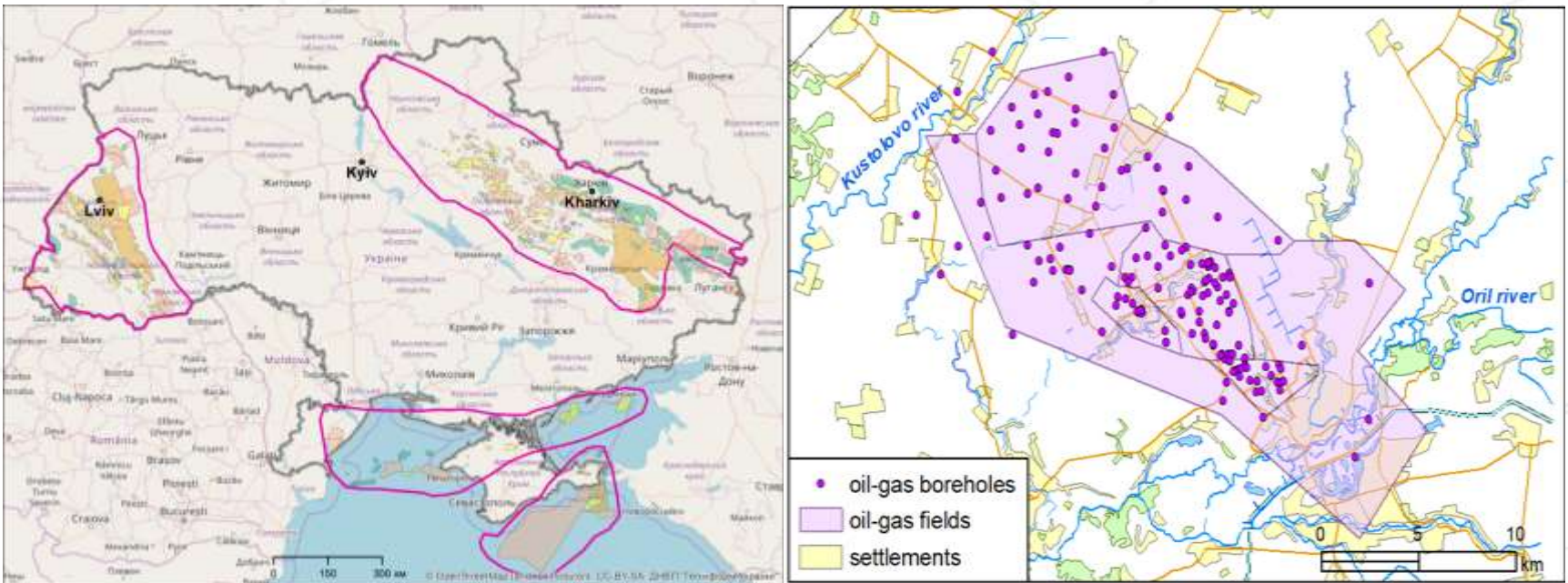
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Introduction



The total number of oil and gas fields in Ukraine – 350

Average number of boreholes in one oil and gas field – 30-40

Area of disturbed soil on one borehole 5-15 ha
(sometimes up to 40 ha per borehole)



Objectives

The objective of the study is to assess impacts of technical reclamation on soil biodiversity (microorganisms and invertebrates) and estimate its recovery rates.



Methodology

We studied reclaimed and background soils on drilling pads on Ignativka and Rudenkivka fields in southern part of Eastern oil-gas-bearing basin of Ukraine. Terms of drilling and soil reclamation were different for all studied boreholes.

Belonging sites to the fields and the age of technical reclamation

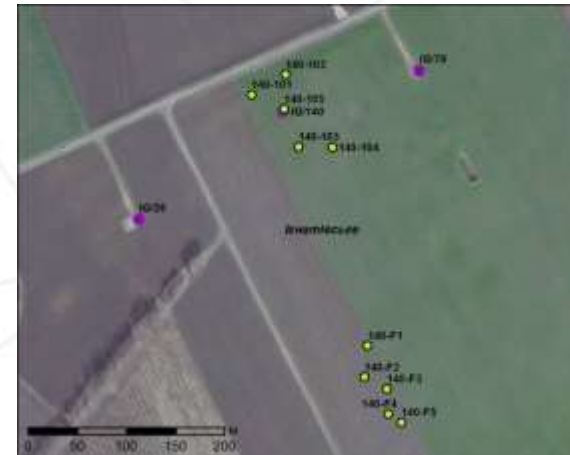
Borehole	Terms of reclamation, years ago
Borehole 23, Ignativka field	35
Borehole 134, Ignativka field	7
Borehole 103, Rudenkivka field	3
Borehole 140, Ignativka field	Less than 1



Location of soil sampling points on boreholes sites



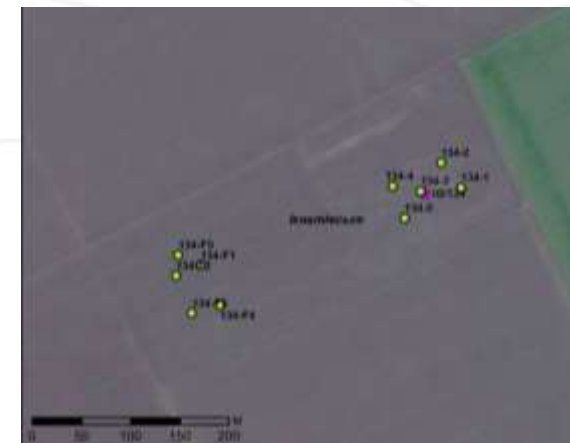
a) borehole 23 (reclaimed 35 years ago)



b) borehole 140 (reclaimed less than 1 years ago)



c) borehole 103 (reclaimed 3 years ago)



d) borehole 134 (reclaimed 7 years ago)



Microbiological research method

Number of soil microorganisms of main ecofunctional and taxonomic groups was determined by sowing dilutions of soil suspensions on dense nutrient media with fourfold repetition: each soil sample was sown on each nutrient medium in 4 parallel Petri dishes (ISO 7847: 2015).



Different ecological-trophic and taxonomic groups of microorganisms on dense nutrient media



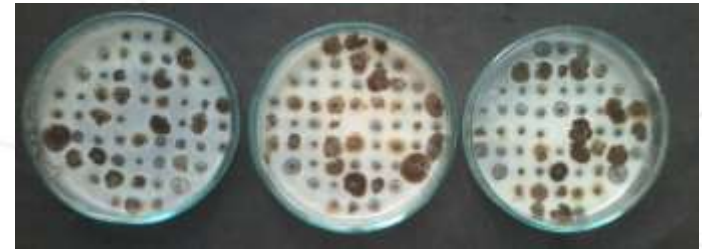
Organic nitrogen assimilating bacteria on MPA



Mineral nitrogen assimilating bacteria and actinomycetes on SAA



Fungi on Rihter's media



Azotobacter on Ashby's media



Olygotrophs on SA

MPA - meat-peptone agar;
SAA - starch-ammonia agar;
SA – starvation agar.



Soil invertebrates were collected by soil excavation. Twenty samples (25×25×30 cm) were taken at each study (reclaimed soil) and control (undisturbed soil) plots. They were associated with the location of soil analysis samples: 4 excavations around one place of soil analysis. The soil was sorted out in the field; the invertebrates found in each sample were preserved separately in 75% alcohol or 10% formalin (earthworms) and identified in laboratory conditions.

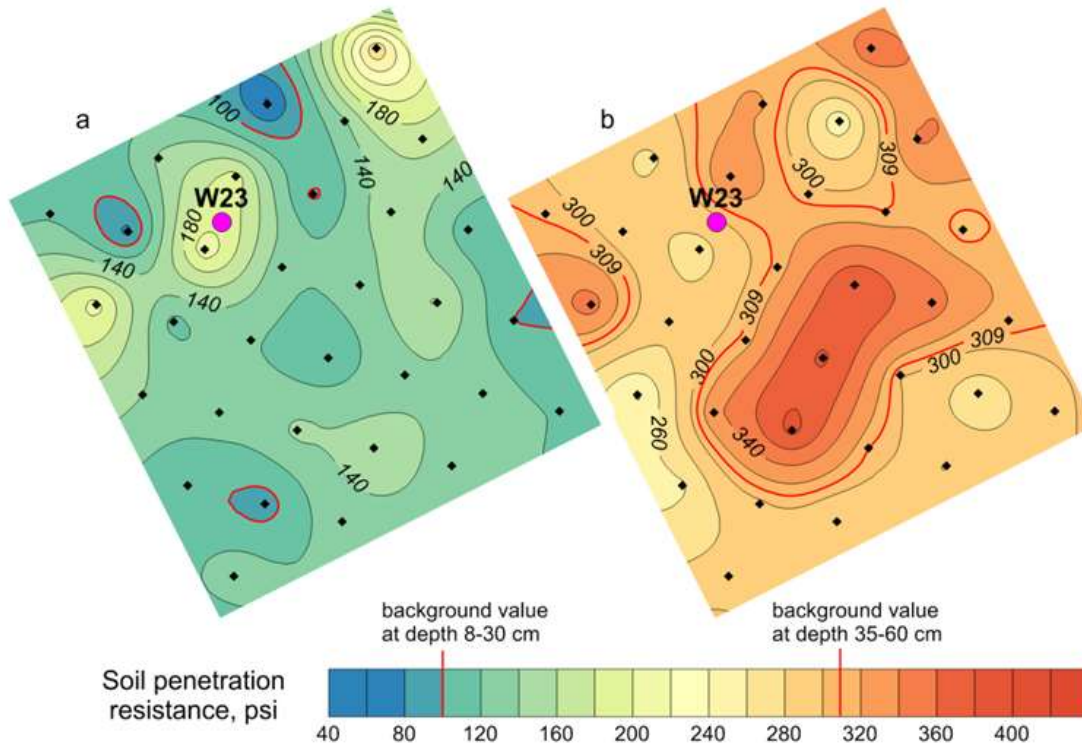


Method for studying soil invertebrates



Results and Discussion

Soil properties (term of reclamation 35 years, borehole #23)

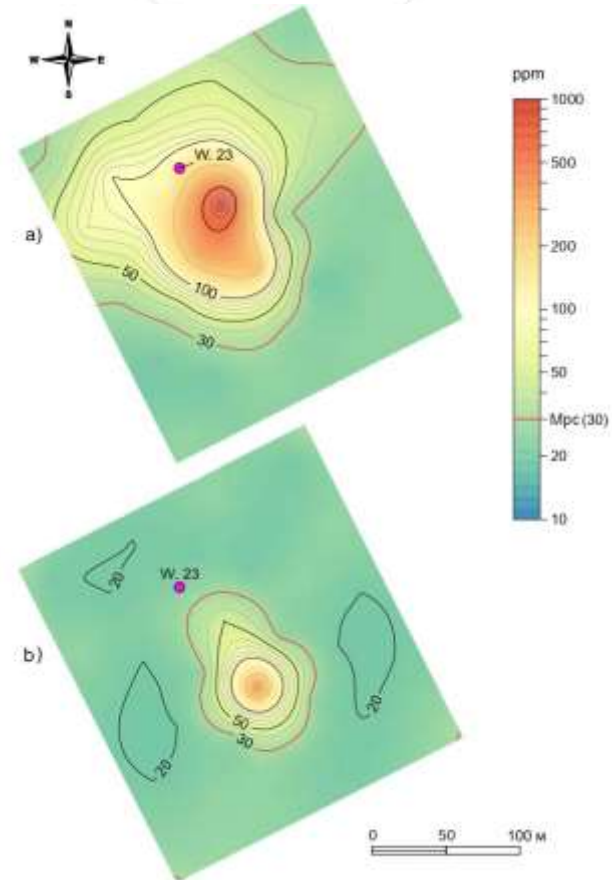
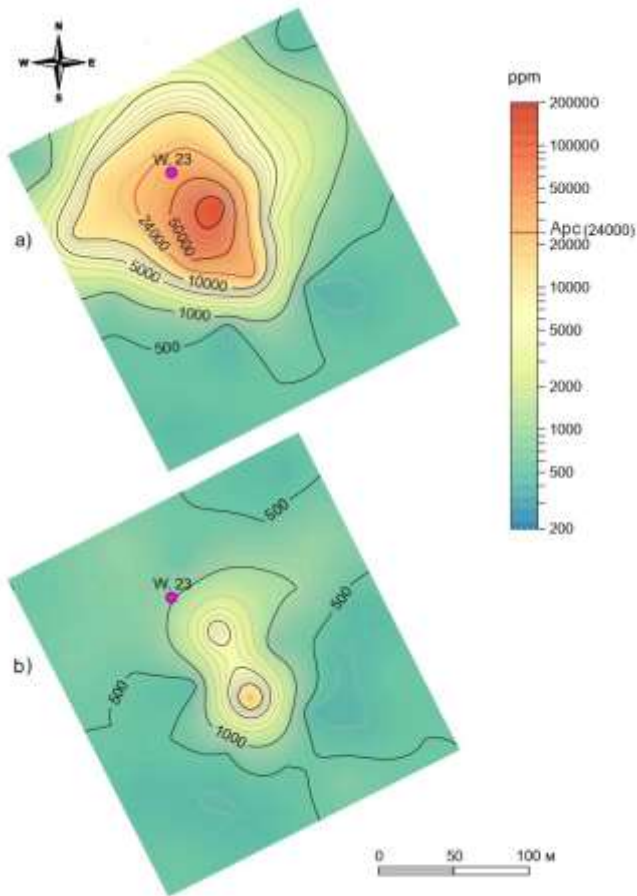


Soil penetration resistance at depth 8-30 cm (a) and 35-60 cm (b) on the reclaimed drill pad

Soil profile of the reclaimed drill pad



Soil properties (term of reclamation 35 years, borehole #23)



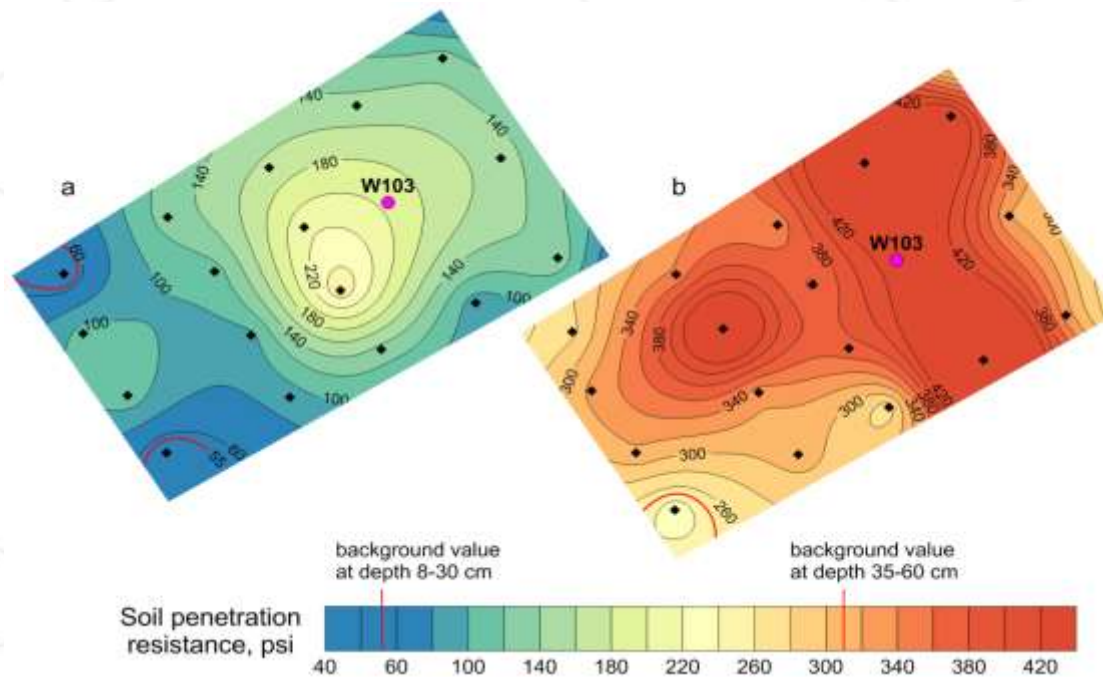
Concentration of Ba

a) 0 - 30 cm
b) 30 - 60 cm

Concentration of Pb



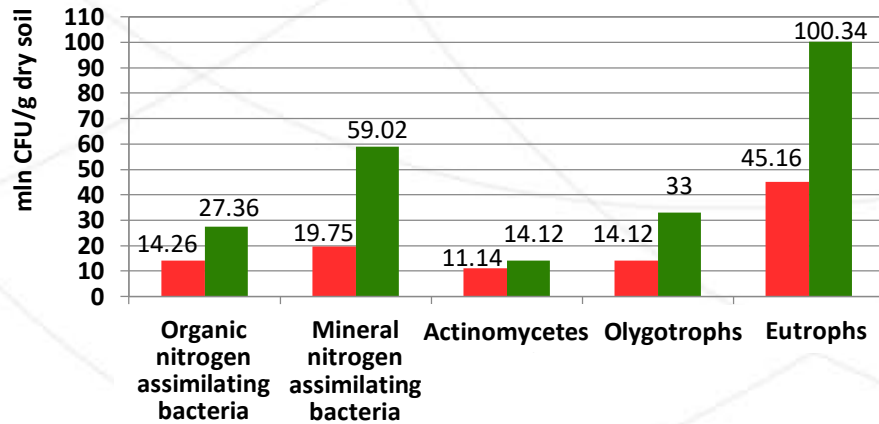
Soil properties (term of reclamation 3 years, borehole #103)



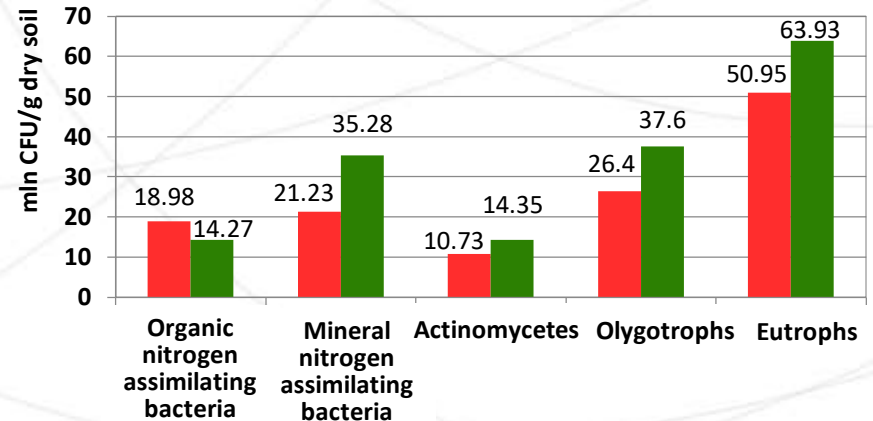
Soil penetration resistance at depth 8-30 cm (a) and 35-60 cm (b) on the reclaimed drill pad



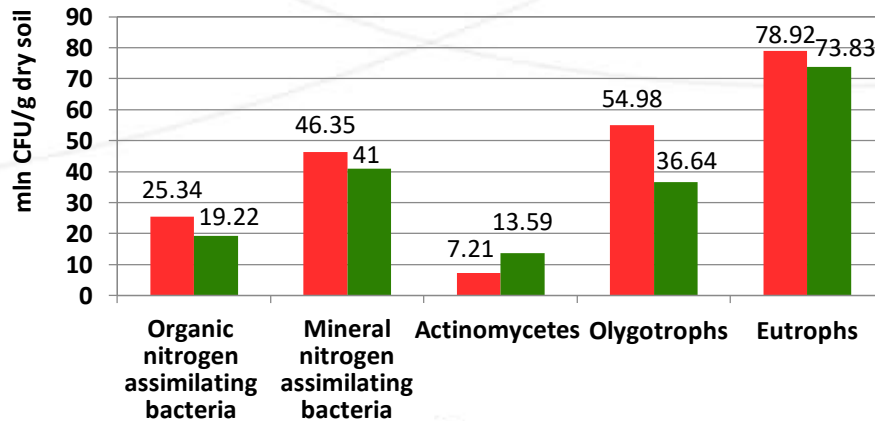
The number of microorganisms belonging to main trophic and taxonomic groups



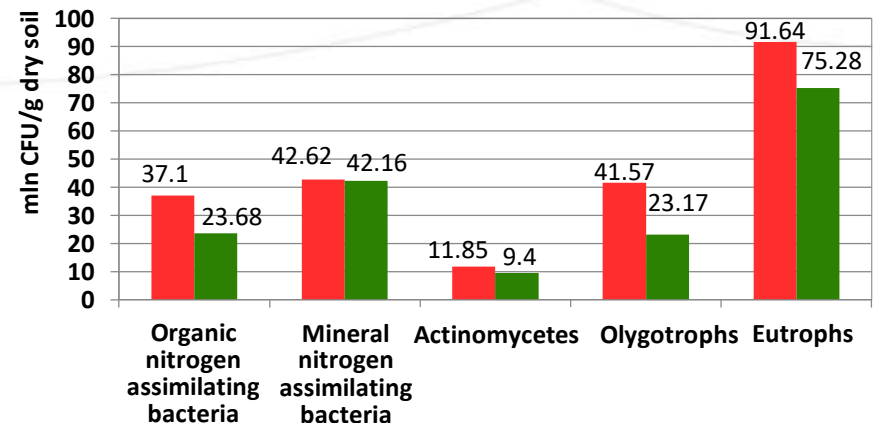
Borehole No 140 (1 year ago reclaimed)



Borehole No 23 (35 year ago reclaimed)



Borehole No 103 (3 year ago reclaimed)



Borehole No 134 (7 year ago reclaimed)

■ Reclaimed soil ■ Background soil

Note:
CFU – colony forming unit

The degree of disturbance of the state of microbial communities depends on the age of technical reclamation and the duration of the biological stage of reclamation, as well as on the presence or absence of soil pollution.

Recently reclaimed soil (borehole **140**) had much lower microorganisms number comparing to background values: organotrophic bacteria by 48 % (1.9 times), mineral nitrogen consumers – by 58 % (2.4 times), fungi – by 40 % (1.7 times), oligotrophic – by 57 % (2.3 times). Deviation rate of microorganisms in reclaimed soil corresponds to **moderate level of biological degradation**.

The number of microorganisms at the site **reclaimed 3 years ago** (borehole **103**) did not differ significantly from background values except for actinomycetes. Their number was twice lower in the reclaimed soil (49 % or 1.9 times).

Similarly, no significant difference in microorganisms number was found on the site reclaimed **7 years ago** (borehole **134**).

In the soil **reclaimed 35 years ago** (borehole **23**) microorganisms' number for almost all studied groups was significantly lower than in background soil. For instance, for mineral nitrogen consumers it was 32–47 % lower. Such soil condition can be defined as **moderate level of biological degradation**.



Changes in soil invertebrate assemblages depending on time since technical reclamation



Background soil



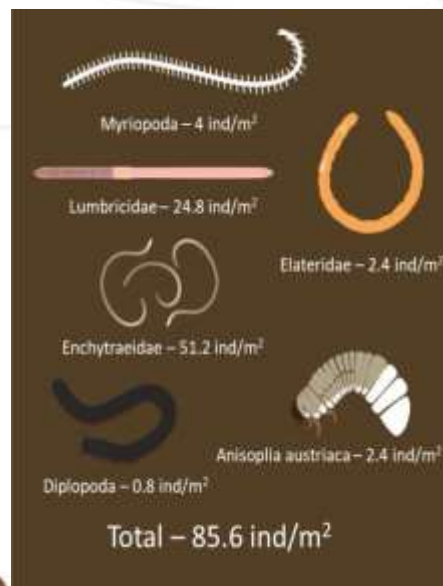
1-year reclaimed soil



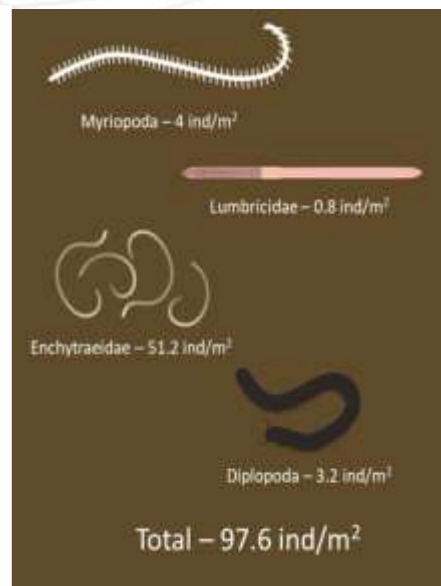
Background soil



3-years reclaimed soil



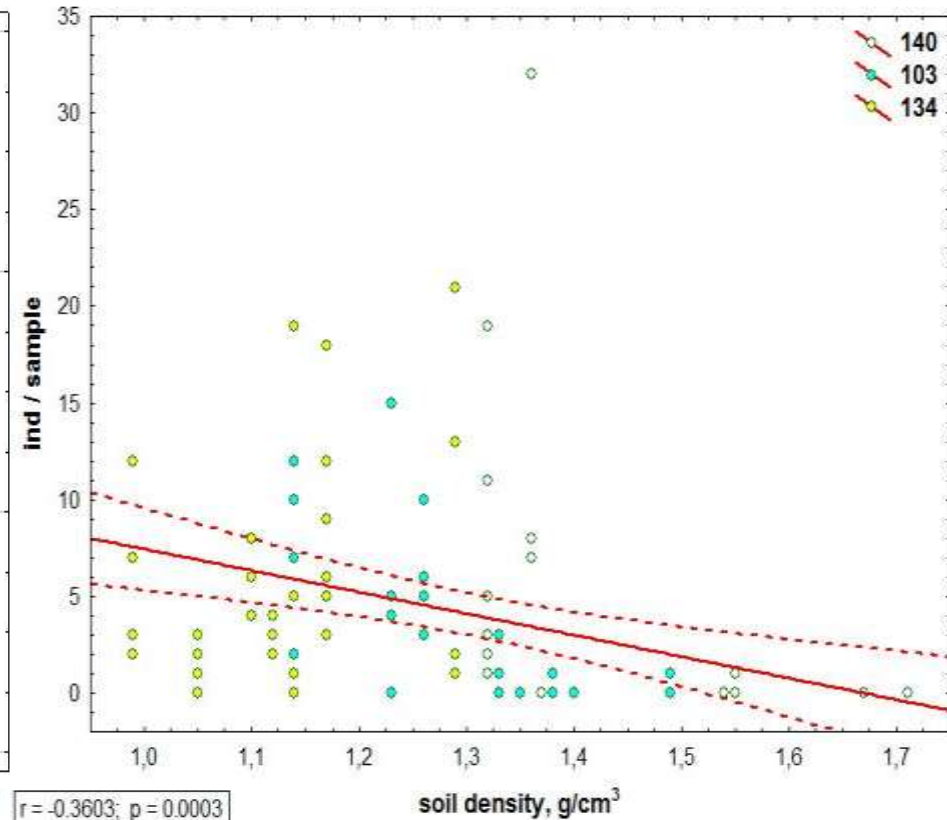
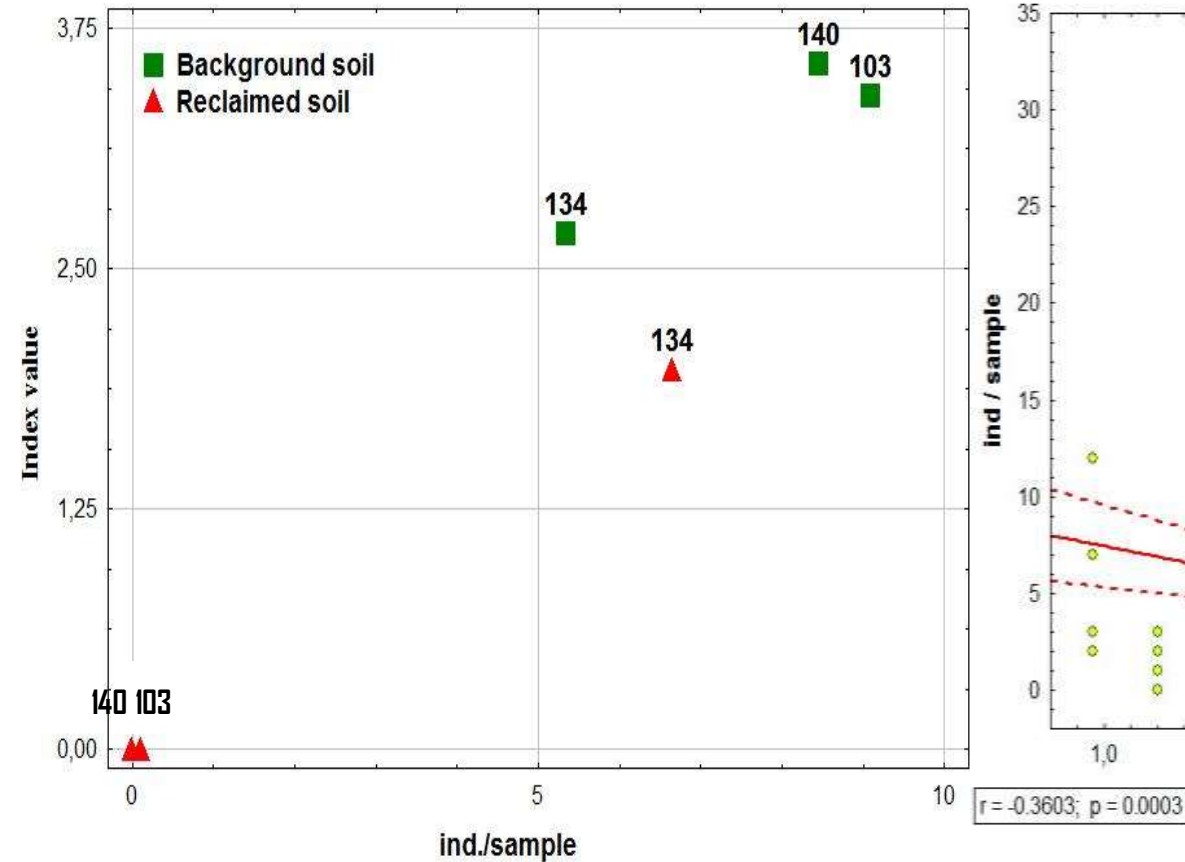
Background soil



7-years reclaimed soil

Soil invertebrate diversity (Shannon index) in reclaimed and undisturbed soils

Correlation between the number of soil invertebrates and soil density



Boreholes: 140 – 1 year after the reclamation; 103 – 3 years; 134 – 7 years



Conclusions

- Microbiological and zoological indicators of reclaimed soil condition depend on quality of soil reclamation and duration of residual effects of soil disturbance.
- Technical stage of land reclamation has a detrimental effect on the soil biota. Number of soil microorganisms and invertebrate fauna has positively correlated with soil humidity and negatively with soil compaction and heavy metals concentration.
- Re-colonization of disturbed soil begins in the second year by the larvae of phytophagous insects. The biodiversity recovery is slow and approaching initial values after seven years of reclamation. The most vulnerable are the earthworms. The Oligochaeta worms (Lumbricidae, Enchitraeidae) are recommended as indicators of the soil reclamation adequacy.



Suggestions

Microbiological and zoological indicators immediately react to changes of chemical and physical properties of soil and adequately reflect alterations rate. Therefore there is a need to include them in the system of indicators for reclaimed soils monitoring.





Thanks a lot for Your attention!

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