Soil redox potential as a predictor of benthos species composition in an intertidal zone

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Abstract

Soil redox potential measurements can be done without much physical effort in a short amount of time, whereas measuring benthos species diversity involves more effort and time. This study explored if soil redox potential can be used as a sole predictor of the abundance of benthos species. Both variables were measured at an intertidal zone at Schiermonnikoog at a transect from salt marsh to mudflat. Inundation was expected to be influential in species composition, and to correct for this, benthos species and redox values were obtained from two depths at each site. It was found that redox potential alone cannot be used as predictor of species composition.

Introduction

> He who does not expect will not find out the unexpected, for it is trackless and unexplored (Heraclitus)

Species composition is one of the first and most vital pieces of data a field-based ecological research needs to gather. Any way to reliably conclude the same information with less work will save researchers both time and resources. One piece of information that is easy to obtain is a soil its redox potential. Redox potential is not just a passive abiotic factor; it is a value is of biological importance instead. Among others, redox potential can be a measure of oxygen in the soil, and it is known that plant roots can raise the oxygen level in the soil (and thus its redox potential) [4]. This positive correlation, however, is not always correct, because at least one other study finds a negative correlation [5]. As far as I know, using redox potential as a predictor of species being present or not, has not yet been investigated. It might be so, because no relation is expected. Would this relation be found, those expectations were incorrect.

This study investigates if soil redox potential can be used as a sole predictor of benthos species abundance. Or: would it be that some species abundances are distributed normally around a certain redox potential?

Materials and method

This study was carried out at the intertidal zone of Schiermonnikoog. In the Southwest of this island, a 2400 meter long transect was set up, from salt marsh to mudflat. The elevations of the transect range from 270 cm to -80 cm NAP. All measurements were done at September 9th and 10th. At those days, inundation times of the sample sites ranged from from 1-80% of a tidal period.

Soil samples of 20 cm deep were taken at different distances. The top 5 cm was separated. Both parts of the soil sample were scored for species.

Redox values were measured by a potentiometer using 4 platinum-tip electrodes and a solution of KCl as a reference. The electrodes were put in at two depths: 2 cm and 10 cm, in this sequence. The potential read is the value that remained constant, when placing or changing the electrodes. The values read were transformed to use earth as a reference point, using the formula $V = 1.8847 \cdot V_{measured} - 53.201$.

In this study, the redox potential at 2 cm depth is coupled to the benthos species diversity at depth 0-5 cm, where the potential at 10 cm depth is coupled to the diversity of depth 5-20 cm.

Of all collected species, only species with at least 3 individuals at both depths were taken into account. The minimum value of 3 was chosen, because it is the minimum number to test for normality. The requirement for a species to be at two depths is to disrupt the effect of inundation, as there can be similar redox potentials for different inundation times.

For each species, a Shapiro-Wilk normality test was used to determine if abundance is distributed normally around a certain redox potential. This test is chosen, as it has the best power for a given significance [1].

The script to analyze the data is written in R and can be downloaded at `https://github.com/richelbilderbeek/EvoEcoResearchCourse2014`.

Results

The redox potentials measured can be seen in figure 1.

863 individuals of 18 different species were collected at the site (see figure 1). Of these species, 8 species had at least 3 individuals at both depths. Out of these 8 species, only 4 could be used, as not all sites had their redox potential measured. From the 4 species left, only the 2 species occurring at multiple redox potentials were analyzed. These two species were *Hydrobia ulvae* and *Nereis diversicolor*. Figure 2 shows the abundance of both species at different redox potentials. A Shapiro-Wilk normality test shows that both species have a significant probability of not following a normal distribution ($p_{Hydrobia} < 0.001$, $p_{Nereis} < 0.05$, see table 2 for exact values).

Species name	Depth: 2 cm	Depth: 10 cm
Arenicola marina	12	1
Bathyporeia	2	0
Carcinus maenas	3	14
Cerastoderma edule	5	22
Crassostrea gigas	4	6
Eteone longa	0	5
Gammarus locusta	1	3
Hemigropsus takanoi	4	11
Heteromastus filliformis	1	13
Hydrobia ulvae	131	369
Lanice conchilega	2	31
Littorina littorea	11	51
Macoma balthica	0	31
Mytilus edulis	7	78
Nereis diversicolor	14	10
Nereis virens	3	0
Scoloplas armiger	1	16
Scrobicularia plana	1	0

Table 1: All 18 species and the number of individuals found per species per depth.R

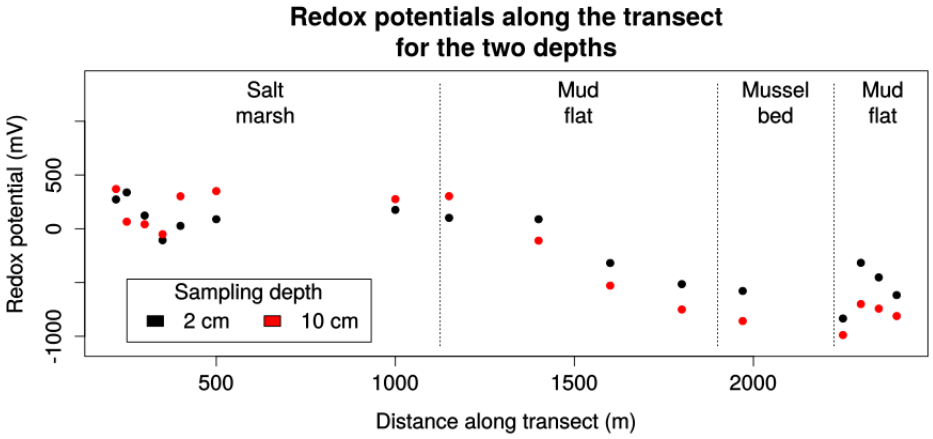

Figure 1: Redox potentials along the transect.

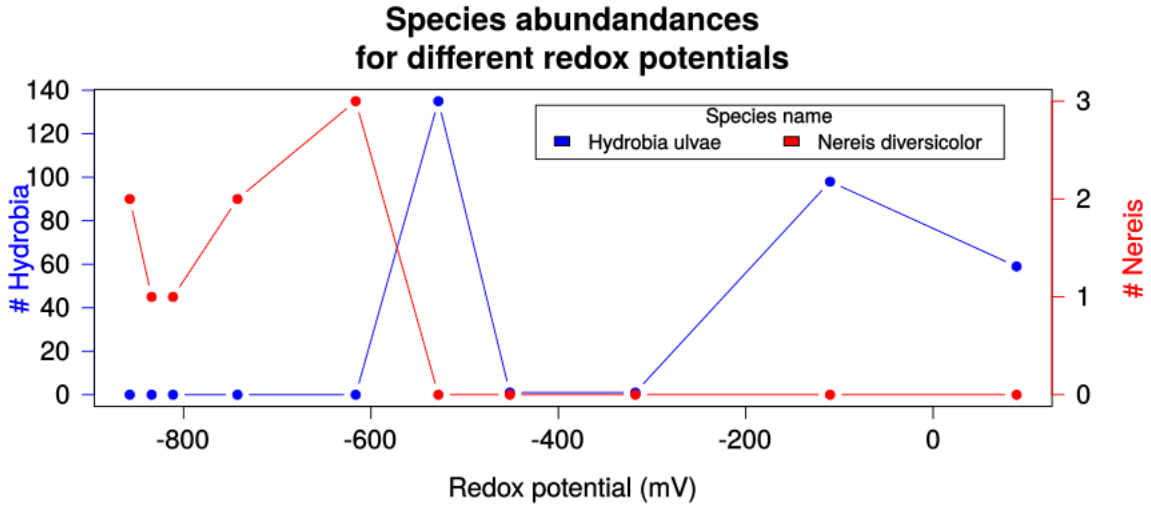

Figure 2: Number of individuals at the different redox potentials.

Name	n	p	significance
Hydrobia ulvae	294	$<$ 2.2e-16	***
Nereis diversicolor	9	0.04965	*

Table 2: Shapiro-Wilk normality test of the species abundances on redox potential. n: number of individuals. p: chance the species abundances do not follow a normal distribution for a redox potential.

Distance	Orderedness
220	LTH
250	UNO
300	UNO
350	LTH
400	LTH
500	LTH
1000	UNO
1150	LTH
1400	HTL
1600	HTL
1800	HTL
1970	HTL
2250	HTL
2300	HTL
2350	HTL
2400	HTL

Table 3: The way the redox potentials are ordered when measuring a redox potential at 2, 5 and 10 cm in this order. LTH: low-to-high (the lowest redox potential was measured at 2cm deep, the heighest at 10 cm), HTL: high-to-low, UNO: unordered.

Conclusion

Given a certain redox potential, the abundances of both *Hydrobia ulvae* and *Nereis diversicolor* can not be predicted, when assuming their abundance are distributed normally around a certain redox potential.

Discussion

This study makes a strong case that soil redox potential cannot be used to predict species abundances, for both *Hydrobia ulvae* and *Nereis diversicolor*.

As *Hydrobia ulvae* is an epibenthic grazer [2], it seems rather obvious that is not influenced by the oxygen level of the soil underneath it. Less obvious is that individuals were found in benthos 5 cm below the surface. This finding appears not to be an experimental error, as *Hydrobia ulvae* is found in deeper soil samples at multiple distances. It might be that the *Hydrobia ulvae* found in the deeper soil were not individuals, but only the shells left.

Nereis diversicolor creates burrows in the mud and is a predator and scavanger [6]. As it does not live in the soil itself, nor does it feed on something in the soil itself, it is not surprising that also this species is unaffected by soil redox potential.

Coupling a redox potential at a single depth to species abundances at a

range of depths may have been too much of a simplification. Redox potential changes when probing at different depths in the soil, but whether this change is monotonous was unknown. After drawing the conclusions, the change of redox potential was analyzed for its orderedness. Because in the experiments also the redox potential at 5 cm deep was measured, it could be tested if redox potential changes monotonously for depths 2, 5 and 10 cm. It was found that this was the case in 10 out of 13 locations (see table 3). Thus, in 3 out of 13 cases, the redox potential at intermediate depth was the heighest or lowest value measured at that location. There can be two explanations for this unexpected pattern: (1) the soil redox potential is a complex abiotic variable that does not follow a monotonic change, or (2) the noise in the redox measurement is higher than the change in 'true' redox potential between depths.

References

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