

Title: Soil redox potential as a predictor of endobenthos species composition in an intertidal zone

Author: Richèl Bilderbeek, Community and Conservation Ecology, University of Groningen, r.j.c.bilderbeek@rug.nl

Running title: Redox potential versus species composition

Keywords: relation soil redox potential endobenthos benthos species composition intertidal mudflat

Type of article: Letter

Number of words in abstract: 107

Number of words in main text:

Number of words in text boxes: 0

Number of references:

Number of figures: 2

Number of tables: 3

Correspondence address: Richèl Bilderbeek, COCON, P.O. Box 11103, 9700 CC Groningen, University of Groningen, +31 50 363 6133, r.j.c.bilderbeek@rug.nl

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

Richèl Bilderbeek

September 29, 2014

Abstract

Soil redox potential measurements can be done without much physical effort in a short amount of time, whereas measuring endobenthos 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 endobenthos. 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, species abundances and redox values were obtained from two depths at each site. It was found that redox potential alone cannot be used as predictor of endobenthos composition.

Introduction

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 of biological importance. 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) [Blossfeld et al. 2011]. This positive correlation, however, is not always correct, because at least one other study finds a negative correlation [Dong et al. 2014]. As far as I know, using redox potential as a predictor of benthos species being present or not, has not yet been investigated.

As redox potential is positively correlated with soil oxygen concentration, and all animals need oxygen for respiration, I expect some benthos animals to respond to soil redox potential. The most likely candidates are animals that live in the soil and breathe through their skin, as these animals might choke from a too low oxygen concentration and will probably move to a habitat with a higher oxygen concentration instead. Additionally, it might be that

microbenthos serving as prey aggregates at a certain oxygen concentration, which might cause its predator to follow this distribution.

The hypothesis tested is if soil redox potential can be used as a sole predictor of endobenthos species abundance, when assuming species distribute themselves normally around a certain redox potential. This study makes a strong case that this hypothesis should be rejected.

Material and methods

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 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 three depths: 2, 5 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 [Razali & Wah 2011].

The script to analyze the data is written in R and can be downloaded at <https://github.com/richelbilderbeek/EvoEcoResearchCourse2014>, or viewed in the appendix.

Results

The redox potentials measured can be seen in figure 1.

863 individuals of 18 different benthos 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 were measured for redox potential. From the 4 species left, only the 2 species occurring at multiple

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

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

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.

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

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).

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 [Newell 1965], 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*

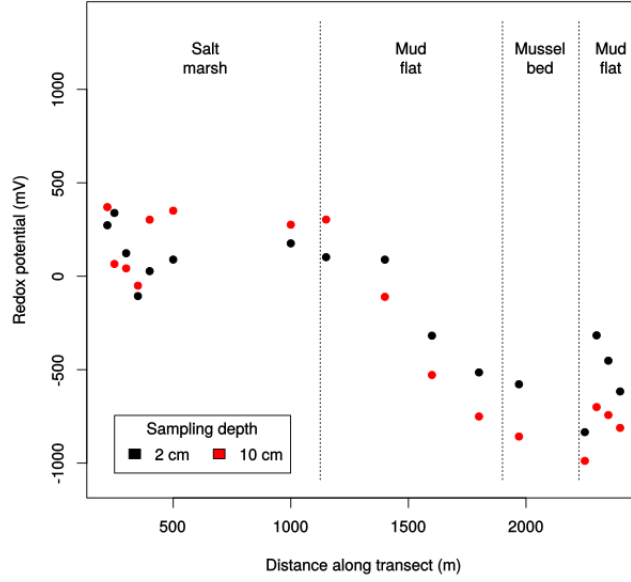


Figure 1: Redox potentials along the transect.

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.

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

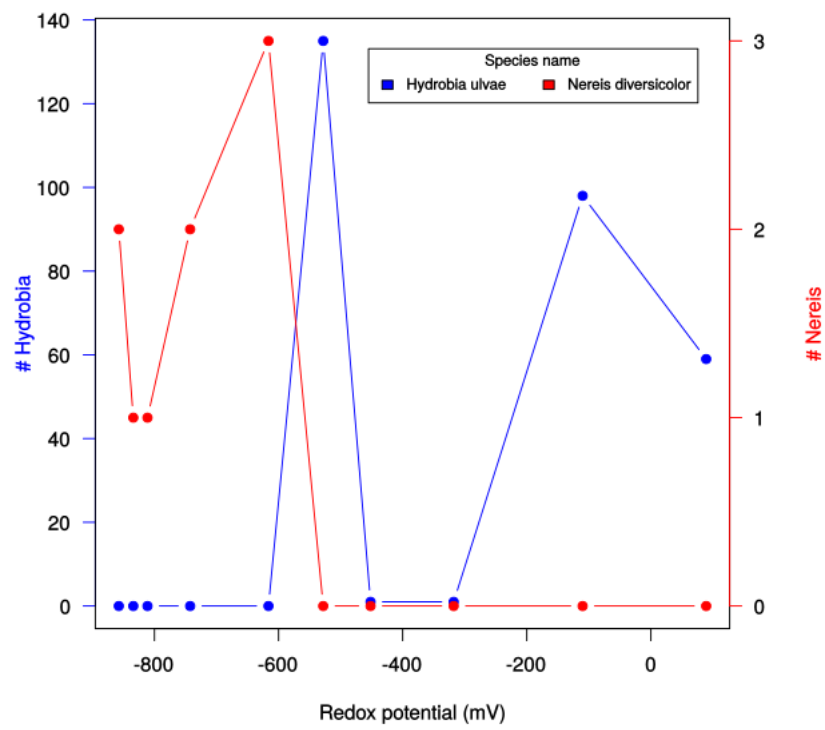


Figure 2: Number of individuals at the different redox potentials.

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 scavenger [Witte & Wilde 1979]. 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 highest 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

- [Blossfeld et al. 2011] Blossfeld, S. Gansert, D. Thiele, B. Kuhn, A.J. Lösch, R. (2011). The dynamics of oxygen concentration, pH value, and organic acids in the rhizosphere of *Juncus* spp. SOIL BIOL BIOCHEM 43:1186-1197.
- [Dong et al. 2014] Dong, B. Han, R. Wang, G. Cao, X. (2014). O₂, pH, and Redox Potential Microprofiles around *Potamogeton malaianus* Measured Using Microsensors. PLOS ONE. 9(7): e101825. doi:10.1371/journal.pone.0101825.
- [Newell 1965] Newell, R.C. (1965). The role of detritus in the nutrition of two marine deposit-feeders, the prosobranch *Hydrobia ulvae* and the bivalve *Macoma balthica*. P ZOOL SOC LOND. 144. 25-45.
- [Rauschenplat 1901] Rauschenplat, E. (1901). Ueber die Nahrung von Thierier aus der Kielerbucht. HELGOLAND WISS MEER, 5(2), 85-151.
- [Razali & Wah 2011] Razali, Nornadiah. Wah, Yap Bee. (2011). Power comparisons of Shapiro–Wilk, Kolmogorov–Smirnov, Lilliefors and Anderson–Darling tests. JOSMA. 2 (1). 21–33.
- [Witte & Wilde 1979] Witte, F. Wilde, de, P.A.W.J. (1979). On the ecological relation between *Nereis diversicolor* and juvenile *Arenicola marina*. NETH J SEA RES. 13(3/4). 394-405.

Appendix

```
# Manuscript , script to generate figures and tables for the Evolution & Ecology  
# Research course 2014  
# Copyright (C) 2014 Richel Bilderbeek
```