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OBSERVATION ON REDOX POTENTIAL IN FRESHWATER POOLS ON ALDABRA

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ABSTRACT

In comparison with most values reported in the literature for freshwaters, small freshwater pools on Aldabra were found always to have values for redox potential which were low, the great majority lying below + 200 mV at a standard pH of 7.0, using a correction of 58 mV per unit pH difference from the standard pH. Values were especially low in pools in *Casuarina* forest, where readings below + 50 mV were recorded frequently. Typical freshwater pools on Aldabra combine a well oxygenated environment with low redox potential, an environmental combination which has received little investigation in the literature.

INTRODUCTION

In a previous study of the chemistry of freshwater pools on Aldabra (Donaldson and Whitton, 1976), it was found that most of the inorganic nitrogen present was apparently in the form of ammonia rather than nitrite or nitrate. This occurred in spite of the fact that the pools were often highly super-saturated with oxygen by daytime. The only other observations in the literature reported a similar (apparent) loack of nitrification are those made by Ganning and Wulff (1969) in brackish rockpools by the Baltic Sea. These latter authors suggested that some inhibitory substances might be present in the pools which hindered oxidation of ammonia.

Since the previous account of the pools on Aldabra, the present authors have had the opportunity to collect further data from the atoll which would help account for any lack of nitrification. A full report of these will be published elsewhere, but a summary of observations on redox potential in the pools is given here in order that it may be read together with the previous account. These observations were all made during the period December 1974 - January 1975.

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METHODS

The system used for naming the pools has been described in the previous account (Donaldson and Whitton, 1976).

Measurements of redox potential were made using a PYE UNICAM portable meter model 293 with PYE UNICAM combined redox electrodes, these consisting of a platinum indicator electrode and a silver / silver chloride reference system. Cleaning and buffering of the electrode was made at frequent intervals during sampling. The Pt indicator electrode was first cleaned by rubbing gently with emery paper and then immersing in concentrated, chlorine-free HNO_3. It was then rinsed and calibrated against a redox buffer. Measurements of pH were taken at the same time as redox potential, using a similar meter, but with a pH electrode. Data on redox potential is reported here both as a direct reading (Eh) and one "corrected" to pH 7.0 (Eh_7). Due to wide diurnal fluctuations in pH, it is essential to make some initial comparison of results with redox potential values corrected to a standard pH value. The correction value of 58 mV per unit pH used in the earlier literature was used here. Where simple tests of adding acid or alkali to samples of pool water were carried out, these did in fact indicate that this was a reasonable choice of correction value.

It was unfortunately not possible to take measurements of dissolved oxygen simultaneously with those of redox potential due to loss of equipment on route to the atoll. However observations on ammonia, nitrite, nitrate, phosphate and algal vegetation indicated that the behaviour of the pools was in general very similar during the present period of study to that during the previous period.

RESULTS

Of the 20 pools whose chemistry was described by Donaldson and Whitton (1976), six were chosen for detailed study of redox potential changes with depth and time on 17 January 1975. Part of the data obtained is summarized in Table 1. As the sediment surface tends to be both ill-defined and a region of rapid change, not too much attention should be paid to small differences between readings taken immediately above the sediment surface.

In addition to these readings, measurements were taken in other small pools on 17 January, and also in a range of pools on other dates. These somewhat extended the upper range of redox potential values, the highest being a small pool filled with *Oedogonium:*

	t	pH	Eh	Eh_7
0950 h	28.9	7.50	+ 245 mV	+ 274 mV

All freshwater pools found with an Eh_7 value in the water near the surface of the pool lower than + 50 mV (including W7, W8, W9) were associated with the *Casuarina* Forest, and had waters coloured a pale brown.

DISCUSSION

These data are obviously fragmentary, and any conclusions should be treated with caution until a more intensive study has been carried out on them. Nevertheless they do indicate the probability of several features of interest.

1. All the pools showed marked variations in redox potential during the day. As repeated readings at any one time were consistent, and as the pattern of changes was quite different in different pools, it seems unlikely that these variations were associated with any sort of instrument error. It may be pointed out that the pool which showed an increase between successive readings during the day, W2, is also the pool for which Donaldson and Whitton (1976) reported a late afternoon peak in nitrite and nitrate values.

2. In comparison with data for soils and lake sediments, the literature on values for redox potential in freshwaters is rather sparse. It would however seem clear from the literature available (Baas-Becking *et al.*, 1955; Hutchinson, 1957) that in comparison with most oxygenated waters, the values for pools on Aldabra are low, and those for the pools in the *Casuarina* Forest remarkably low.

3. If freshwaters behave in a manner similar to soils (Pearsall, 1938; Reddy and Patrick 1975), then the redox potential measurements recorded for the majority of Aldabra pools correspond with environments which do not favour nitrification. If the values quoted by Pearsall (1938) are corrected to Eh_7 values, then he found that with only three exceptions, all soils studied where nitrate predominated over ammonia had an Eh_7 greater than + 234 mV, and soils lacking nitrates had an Eh_7 less than 204 mV. The three exceptions found by Pearsall were all soils receiving drainage from stream waters containing nitrate.

These observations would provide an explanation for the rarity of detectable nitrate in Aldabra pools. In most instances the redox potential values correspond to an environment which is sufficiently reducing that nitrification would not be expected to occur. Further, pool sediments were always found to be markedly reducing, and as the sediments are in many cases disturbed frequently by the activity of crabs, any chemical changes taking place in the sediments may be expected to have a marked effect on the chemistry of the water above the sediment.

It is less clear what are the probable agents responsible for bringing about these low redox potential measurements. The fact that all the pools in the *Casuarina* Forest had low values suggests that the brown materials leaching from the debris of "needle" and other fallen parts of the tree may here be partly responsible. However the variations taking place during a single day within one pool suggest that some other quite different factors must play a role. Disturbance of the sediments and release of excreta by crabs would seem likely such factors.

ACKNOWLEDGEMENTS

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Table 1 Temperature (°C), pH and redox potential (mV) values for six pools (see text)

Position in pool and time of day	W2				W3				W4				W7				W8				W9			
20 mm below surface of pool	t	pH	Eh	Eh_7	t	pH	Eh	Eh_7	t	pH	Eh	Eh_7	t	pH	Eh	Eh_7	t	pH	Eh	Eh_7	t	pH	Eh	Eh_7
0820-1030	25.8	6.25	+100	+57	28.8	7.35	+120	+140	29.8	8.39	+172	+253	29.9	6.20	+225	+179	28.4	6.31	+78	+38	28.0	6.58	+80	+56
1425-1455	33.4	7.95	+100	+155	40.2	9.35	-85	+51	37.2	10.18	+15	+199	41.5	7.80	-60	-14	31.7	6.22	-48	-93	31.7	6.76	+58	+44
1810-1850	32.8	7.8	+180	+226	32.2	8.60	+45	+138	34.2	10.0	-10	+164	35.1	7.60	+10	+45	29.2	8.0	-130	-72	29.6	7.65	-80	-42
over surface of sediment																								
0820-1030	25.2	5.58	+45	-37	28.5	7.40	-80	-57	29.2	7.90	+165	+217	28.2	6.22	+75	+30	28.3	5.90	+25	-39	28.2	6.25	+105	+62
1425-1455	32.2	7.10	-95	-89	32.3	7.10	-95	-89	40.2	7.25	-182	-167	40.8	7.53	-58	-27	31.3	6.09	-92	-145	30.8	6.70	-15	-32
1810-1850	30.8	7.4	-140	-117	32.4	8.70	+10	+109	33.8	9.6	-40	-111	35.8	7.80	-40	+6	29.2	8.0	-180	-122	29.4	7.80	-160	-114
100 mm below surface of sediment																								
0820-1030	25.8	5.15	-395	-502	28.2	6.35	-248	-286	29.3	6.25	-15	-59	28.3	6.25	-45	-84	28.1	5.98	-120	-178	28.3	5.96	-85	-145
1425-1455	30.2	6.45	-338	-370	38.2	6.82	-208	-218	32.8	7.20	-148	-136	36.9	6.65	-192	-212	31.3	6.10	-183	-235	29.9	6.75	-182	-197
1810-1850	30.2	7.0	-260	-260	33.6	8.65	-192	-96	33.8	9.2	-180	-52	35.2	7.80	-240	-194	29.3	7.65	-240	-182	29.0	7.68	-260	-221