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MARSH BULLETIN

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The Effect of Sesarma boulengeri(Calman) Crab Burrows on Surrounding Pore Water Chemistry in the Shatt Al-Arab NW Arabian Gulf

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Abstract

The result of the present study has shown that presence of chemical elements concentration in the pore water surrounding the crab burrow depends on the distance from or depth of the burrow. After analyzing the samples in the laboratory, the results have demonstrated that the concentration of ammonium and phosphate decreases as we move away from the burrows edge, and there is also a significant difference with regard to the ammonium and phosphate concentrations. With respect to phosphate, there is no important significant difference, but the concentration of sulfide has increased with the distance from the burrow edge. Its highest concentration is at a distance of 12cm, such that there is a noticeable difference between the various samples. But there no change in the proportion of salinity and redox with the distance or depth from the burrow edge. The results have, also, that the crab burrows affect the pore water present in the sediments surrounding the burrows, to a distance that approaches 12 cm from the burrows opening . There, the activity of the crab burrows has increased the heterogeneity of the sediments in the area of study.

Key ward : crab burrows, pore water, water chemistry, intertidal flat

1- Introduction

The ocypodidae constitute most of the mangrove where crabs occur in nearly all tropic and sub tropic regions of the world (Crane, 1975 ; Jones, 1984). They inhabit salty marshes e.g. mangrove zones ,mudflats and sandy beaches (Walrath,1992). The crabs live in mixed–sex colonies on intertidal mud flats (Bacwell and Passmore,1996)) and they live in high densities and a copy of small overlapping home ranges that are centered around the important resources of their burrows (Hemi and

Zeil,2003).

Intertidal flats are generated in geographical areas where wave actions are moderate and river inputs are small .They are the manifestation of progradation of sediments derived from marine sediment sources and can occur in lateral accreting tidal-dominated estuaries or wave dominated inner parts of estuaries (Navas *et al*.,2002).

Previous studies have demonstrated that the crab burrows can affect the sediments in an intertidal flat (Genoni,1991) . The mechanisms affecting pore water sulfide and nutrients with an increased burrow density have been speculated by (Harvey *et al.*, 1995).

Furthermore, the chemical processes that crab burrows facilitate within marsh sediments have been speculated by (Koretsky et al.,2003) and (Pvan,2003).

A few studies have applied mult-dimensional millimeter-scale profiles to determine the effects of burrow structures on sediment pore water (Luther *et al.*,1998) that created three-dimensional maps oxygen and manganese concentration surrounding a worm burrow (Nielson et al.,2003), and created radial micro-proiles of sediment chemistry which surround fiddler crab burrows within mangrove sediments. Even though a few studies have examined pore water surrounding various animal burrows, these studies have been done on a micro – scale and did not extend to more than 30mm from the burrow edge. Also they have focused on metal ions and did not question the effects of the burrows on pore water nutrients. There is still much to be examined to determine the extent to which burrows and other bioturbation structures affect the chemistry of surrounding pore water.

The aim of this study is to determine the scope of influence of individual fiddler crab burrowing on surrounding pore water chemistry (cm^2 scale) in a intertidal flats.

Study area:-

The main locality of the present study is the Intertidal flat of Shatt Al- Arab river in the north of Arabian Gulf (fig 1). The remarkable feature of this area is the straightness of the water line and the flatness of its surface.

The width of the intertidal flat is between 10-25m and the tides are of semi-durnalin nature with the mean tide ranging from (0.5-3)m.

2-Methods and material

In an intertidal flat 6 crab burrows (1.5-3 cm diameter) were randomly chosen from intertidal flat .These burrows were distributed over $25m^2$ area of the study. Each burrow was at least 20cm apart. Six transects were established radially from each burrow in the six compasses. Pore water was collected at distances of 4, 8 and 12cm from the edge of each burrow and at a depth of 15cm using a sampling probe. The pore water sampling probe design is Berg and Mc Glathery (2001).The sampling probe was inserted vertically into the sediment by using PVC pipe at a depth of 15cm. The end of the pipe was placed at the edge of the burrow to measure correctly the distance from the burrow edge.

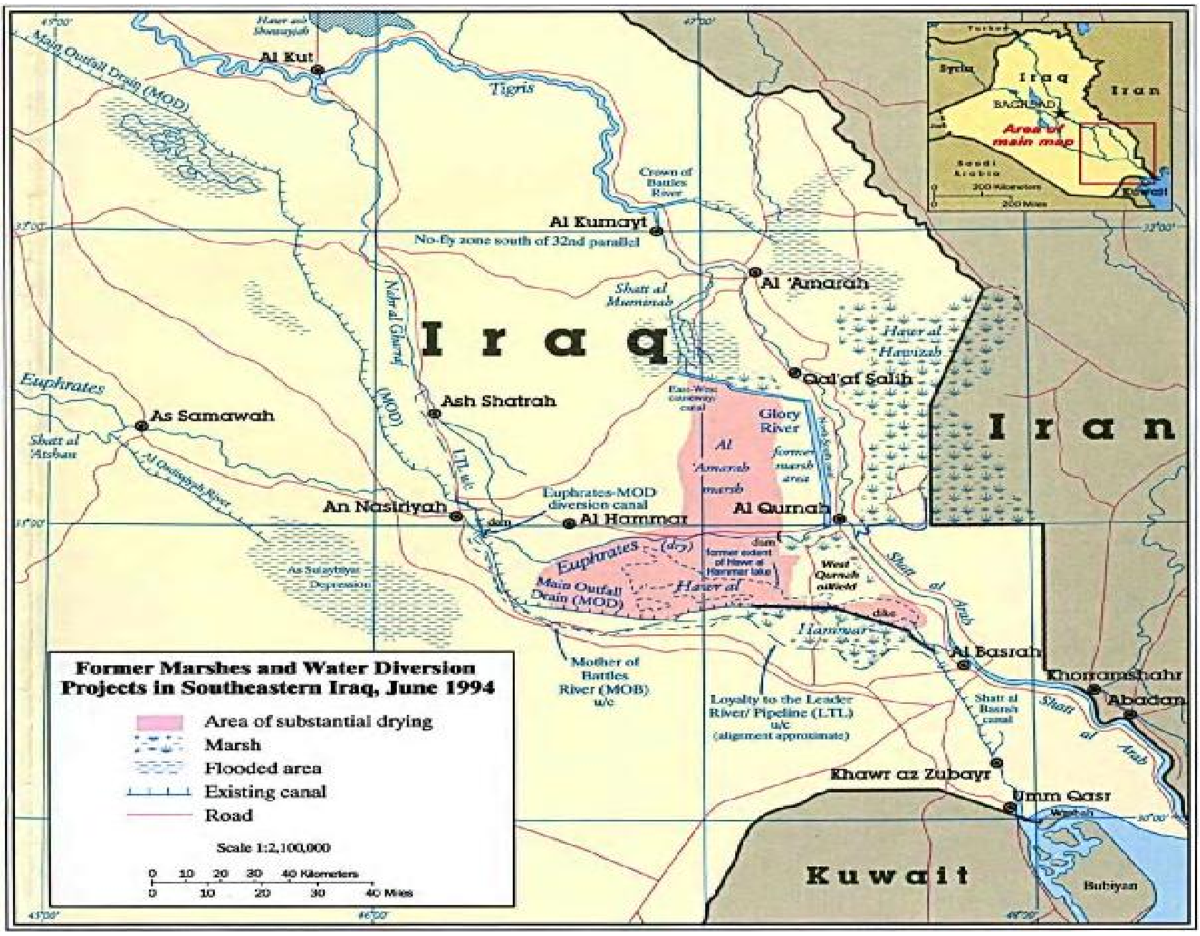

Fig (1)

A small piece of Tygon tubing was tightly placed around the probe to mark the depth to which the probe is to be inserted (Berg and Mc Glathey 2001). To collect a pore water sample using the probe, the open end of the sampling was connected to the length of Tygon tubing which was connected to a stainless steel 3-way stop cock.

The samples collected were kept in ice until they were analyzed in the laboratory as soon as returning from the field, the pore water was analyzed for ammonium, phosphate, and sulfide concentrations, redox potential, and salinity. Ammonium, phosphate, and sulfide concentration were determined in the lab calorimetrically. Ammonium concentrations were measured using the method of Parsons et al.(1984). Phosphate concentration were measured using an ammonium molybdate method (Strickla and Parsons, 1972). Sulfide concentrations were measured using the method described in Cline (1969) . Redox potential was determined by injecting the sample into an anaerobic chamber and measuring the oxidation-reduction with a Beckman waterproof Eh-Ph probe .Salinity was measured using Vista refractometer.

Bulk density and porosity were measured to determine if the pore space and porosity were the same near each of the burrows at a depth equivalent to the depth of the pore water samples collected by the probe. Three cores were taken near the burrow. The cores are were 30cm long with an inner diameter of 4.0cm and were dug into the sediment to a depth of 20cm. The cores were removed from the ground when the sediment was logged with water. The cores were filled with sea water to the top and the end was opened and then closed to create suction that enables the core to be removed from the ground without losing the sediment. Cores were kept on ice until they were returned to the laboratory. The sediment plugs obtained from the cores were longer than 15cm.

Two sediment slices of 1 cm in thickness were removed from the middle of each core at depths of 14-15cm and 15-16 cm respectively. The wet weight of each slice was measured; the slices were dried at 60 C until constant weights were obtained, and then the slices were reweighed. Bulk density was calculated from the dry weights of the slices and their volumes, porosity (volumetric water content) was calculated from the difference between weight and dry weights divided by the volume of each slice. Sediment porosity was analyzed to determine the volume of the sediment from which the pore water samples were extracted. The data were analyzed using the statistical Analysis system (SAS 1999-2001). Pore water was analyzed using a nested analysis in a General linear Model (GLM). The burrow and transect were treated as random effects, and the sample point was treated as a fixed effect; transect was nested within the burrow, and sample point is used as a continuous variable. When significant differences were determined among sample points for a dependent variable, a TUKEY test was used to determine which sample points differed from the other. For the sample point mean, least squares and standard error were calculated by making the sample point a class variable; these are the means and standard errors presented in this paper. The bulk density and porosity data were analyzed for differences among the ten burrows using an analysis of variance (ANOVA) based on the mean values from each burrow. The sediment samples obtained from each burrow area were used as replicates to represent each burrow.

3-Results

This study carried out in spring 2007 .This study has shown that the sediments surrounding the ten sample crab burrows were similar to each other in chemical or physical properties or both the experiment. Bulk density (a mean value of 1.95 g/cm^3±0-001(n=10) showed no significant difference among the ten burrows..Likewise, Porosity (mean of .394 ml/cm2+-0.005(n=10))showed no significant differences among the ten burrows. The sediment was relatively uniform, as the spatial variance of bulk density and porosity among burrows was similar to the variation among cores surrounding individual borrows(Table 1).

Pore water nutrients sulfide concentrations and salinity did not show the coordinated decreases near burrow expected; nor did redox potential show a concurrent inverse pattern. Instead, while sulfide concentration did decrease near the burrow ammonium and phosphate concentrations increased , redox potential and salinity were unchanged. Ammonium concentration significantly decreased with the distances between burrows (p=0.0041). The 4cm and 12cm samples poinx were significantly different from each other and the 8cm sample point was not significantly different from the other two (Fig 1).

The concentration of phosphate does not show a significant difference among sample points (p=0.0820). There was a trend of decreasing concentration with distance from the burrow (Fig 2). Sulfide concentration has significantly increased with the distance from burrow (p=0.0 178). The 4cm and 12cm sample point were significantly different from each other and 8cm sample point was not significantly different from the other two (Fig 3).

Redox potential did not exhibit a significant difference among sample points, and there was no evident trend with the distance from burrow (Fig 4). Salinity did not show a significant difference among sample points, and there was almost no difference with distance from burrows (Fig 5).

Table 1: bulk density and porosity (means ± SE) by burrow and among all burrows.

Burrow No.	n	Bulk density (g/cm^2)Mean ± SE	Porosity (ml/cm^2)Mean ± SE
1	5	1.671 ± 0.021	0.392 ± 0.014
2	5	1.754 ± 0.013	0.377 ± 0.028
3	5	1.699 ± 0.010	0.391 ± 0.012
4	5	1.701 ± 0.038	0.353 ± 0.023
5	5	1.721 ± 0.032	0.381 ± 0.014
6	5	1.784 ± 0.001	0.376 ± 0.008
All burrows	30	1.686 ± 0.052	0.364 ± 0.006
Among burrows	5	1.784 ± 0.007	0.362 ± 0.001

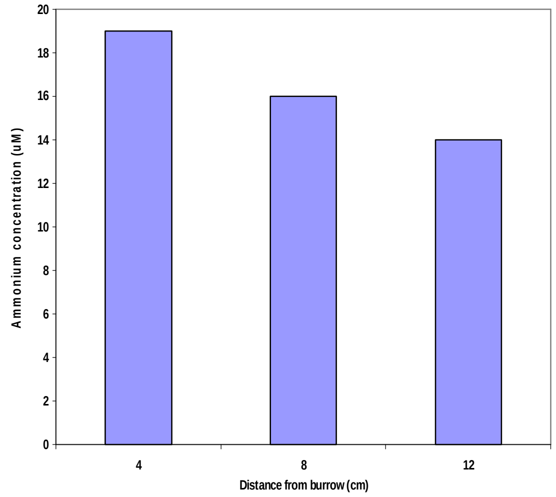

Fig 1: The relation between Ammonium concentration with distance from burrows (mean ± SE, n=6)

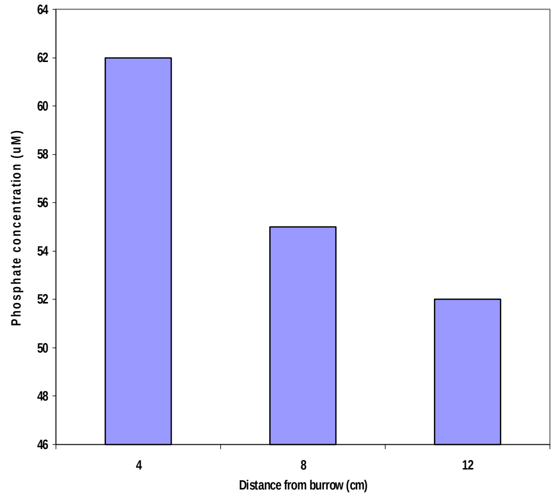

Fig 2: The relation between Phosphate concentration with distance from burrows (mean ± SE, n=6)

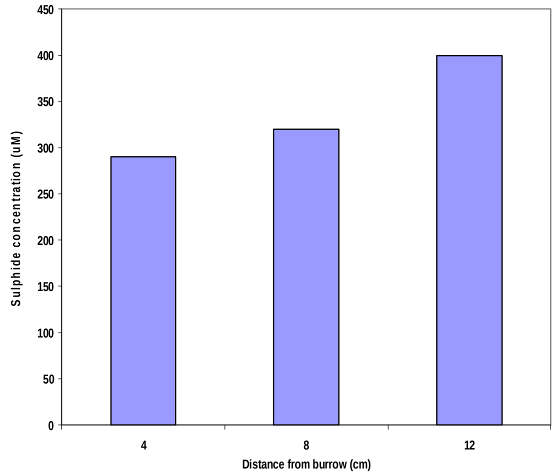

Fig 3: The relation between Sulfide concentration with distance from burrows (mean ± SE, n=6)

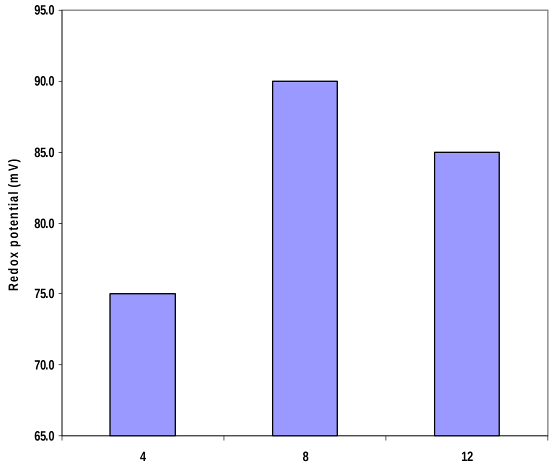

Fig 4: The relation between Redox potential with distance from burrows (mean ± SE, n=6)

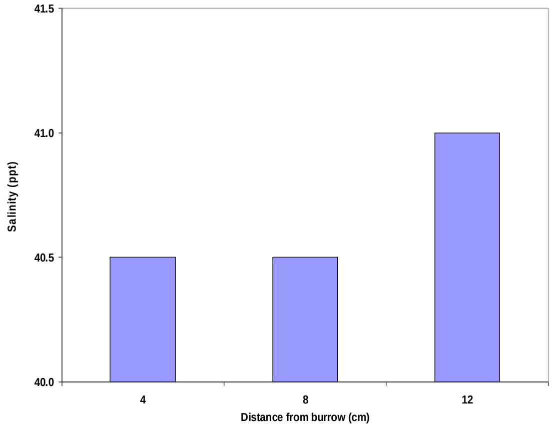

Fig 5: The relation between salinity with distance from burrows (mean ± SE, n=6)

4-Discussion

. Typically it is believed that the presence of crab burrows aerates sediments, increases the redox potential and releases hydrogen sulfide (Bertness andMiller,1984, Walsh ,1998).

The chemical reactions that occur in water logged beach sediment are quite different from the reactions that occur in well drained sediments (Howarth,1993). The increase of oxygen supply inside the burrow may be a reason for the elongation of the burrow towards winter (Birgit,1992). Ammonium phosphate, and sulfide concentration were affected more dramatically than redox potential and salinity, while the predicted increase of sulfide concentration with distance from the burrows did occur, the observed decreasing in concentration ammonium and phosphate which was unexpected. The nutrient concentrations may have been higher near the burrow and lower when far from it because organic matter from the sediment surface could have fallen into the burrows increasing mineralization within the burrows (Hines and Jones,1985).

As the organic matter content of the sediments was relatively low, the addition of this new organic matter could have effected the organic matter reduction rates. The burrows were drained and exposed to air during low tide which would allow aerobic organic matter oxidation to occur at higher rates. Crab-excretion could also account for the higher ammonium concentrations near the burrow fecal Matter could also have fallen into the burrow from the sediment surface.

The intertidal flat floods from the bottom up therefore, seawater with low ammonium concentration would not enter the sediment from the sea above the hole.

Interstitial water from the water table and below ground could have flooded the intertidal flat from underneath. Therefore, the water surrounding the bottom of burrows where there is more mineralization could have occurred, would have moved upward around the burrows as the tide rose. The flushing of ions away from the burrows was not a major mechanism because of these intertidal flat floods underneath. The absence of any pronounced flushing plus the low sulfide concentration near the burrow, indicates that the proportion of sulfate reduction relative to other pathways was lower and/ or sulfide oxidation occurred simultaneously. Sulfate reduction did not appear to be dominant in this area, therefore, other pathways of reduction of other elements, such as (oxygen, nitrate and iron) may have been utilized (Thomas,2003).

(Howarth,1993)found that different processes may have increased the rate of organic matter oxidation within the sediment. The increased availability of organic matter can stimulate sulfate reducing bactria and shift the type of oxidation reaction to sulfate reduction, decreasing the rates of the other pathways of reduction material from the sediment surface with higher organic content could have fallen into the newly formed artificial burrows (Berner and Westrich,1985; Fenchel et al.,1998; Thongthan,2003).

Iron sulfide (pyrite) concentration in the sediment would indicate the proportion of iron and sulfate that was unavailable, because they represent the end products of sulfate reduction, and are only reactive with O_2 oxidation (Koch et al.,1990; Naline and Kreistensen,2003). Ammonium is an end product of the nitrate reduction. The increasing in the rate of nitrate reduction may account for the significantly higher ammonium concentration near the burrow. Phosphate had a higher concentration near the burrow, but the difference according to the distance from the burrow was not significant. The higher phosphate near the burrow may have been thoroughly due to an increased organic matter oxidation, this effect may not have been great enough to yield a noticeable in the phosphate concentration along the distance gradient. It was surprising that redox potential did not have a significant difference with the change distance from burrows because redox potential usually has a close inverse relationship to sulfide concentration (Naline and Kristensen,2003). Redox potential was highly variable, since it is possible that the method used for measuring redox potential may not have been sensitive enough to show any change in redox according to distance from burrow.

The concentration of the measured components which are of water fill the burrows ,as well as ,the chemical composition of the surrounded sediments,can not tell us how long the crab inhabited the burrows had been present and whether they were currently inhabited might have helped explain why redox potential did not show a trend or significance with distance from the burrow. The elapsed time could be taken consideration to see how the chemistry pore water changes with the presence of burrow for longer periods .The creation of three dimensional pore water profiles composed of nutrient, metal, and other ion concentrations with a top 15 cm of the sediment throughout a 0-25 cm^2 area surrounding each burrow would likely further illustrate the effects of individual burrows at different spital scale (mm-cm).

Conducting this study over a certain timescale would give another dimension to the data. The shapes of the burrows could be determined after the water was collected and a spatial and temporal model of the chemical changes in the sediment could be made. Examining the effect of crab burrows on different spatial scales and through time would increase the understanding of how bioturbators affect the system that they inhabit.

5-Conclusion

Borrows are important for crabs in several ways: in this study the results confirm that there is a significant correlation between the pore water and crab burrows. The sediment characteristics of intertidal flat is an important contributing factor in deterring the effect of crab burrows on pore water chemistry .

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تأثير حفر السرطانات على كيميائية الماء المسامي المحيط بها في شط العرب – شمال الخليج العربي

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الملخص

أظهرت نتائج الدراسة الحالية أن هناك علاقة بين حفر السرطانات والماء المسامي المحيط بفتحة الحفرة. حيث وجد أن تركيز الفوسفات والامونيوم يقل كلما ابتعدنا عن حافة الحفرة. أما تركيز الكبريتات فانه يزداد مع زيادة البعد عن حافة الحفرة ويصل إلى أعلى تركيز له عنــد البعد 12سم عن حافة الحفرة. أما تركيز الملوحة وجهد الأكسدة والاختزال فأنها لا تتأثر مع البعد أو المسافة.