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The Effects of Fiddler Crabs (*Uca* sp) on C/N Ratio and Redox Potential of Soil in Mangrove Ecosystems

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ABSTRACT

Research has been done in Ketapang mangrove area of Probolinggo city in months of September-November 2015. The objectives are to observe the fiddler crab community stucture and to analyze the effects of fiddler crabs on C/N ratio and redox potential of soil in mangrove ecosystems. The samples of fiddler crabs were taken during the low tides at 4 station (20 transects with sizes of 1 m^2). Data of the fiddler crabs were measured from the soil digging insides the transect. The soil samples were taken from these crab holes wall (at the surface and at the depth of 20 cm), under the holes at the depth of 40 cm as well as from the locations that undwells by these animals at the same depth. The fiddler crab identified are *U.* Triangularis between 2 – 6 ind/m^2, U paradussumieri 1 – 3 ind/m^2, U perplexa 14 – 32 ind/m^2, U dussumieri 12 – 27 ind/m^2 and U. Tetragonon 3 – 6 ind/m^2. The diversity is moderate (H = 1.7) and the dominance index was low (C = 0.37). C/N ratio soil were inhabited by fiddler crab between 6 – 14, the undwelled area were 14 – 20. Soil C/N ratio was inhabited by the fiddler crab at the surface and depth of 20 cm in average of 9 cm while at 40 cm in avergae of 12. The low of C/N ratio at surface and depth of 20 cm causing the organic matter turnover faster because the high nitorgen content. Soil potential redox (Eh) the undwelled areas was found –0.647 mV, meanwhile the soil Eh in the dwelled areas was positive (0.68 till 0.87 mV). This mean, the decomposition was occured during aerobic condition and will produce untoxic subtances.

Key words : fiddler crab, C/N ratio, redox potential

INTRODUCTION

The concept of ecosystem engineers was introduced more than a decade ago by Jones, Lawton and Shachak (1994). Organism is called as ecosystem engineers if they can change the material or energy flow and imfluence the number of other species in the ecosystem (Gilad et al., 2004), influence the biogeochemical reaction by changing the availibility of the resources (Gutiérrez and Jones, 2006), create, modify and maintain the environment for theemselves and for other organisms. Based on the mechanisms it can be differenciate (1) autogenic engineers change the environment through (caused by) physical structure, for example a big tree, (2) allogenic engineers change the environment through their activities, for example beaver (*Castor canadensis*) which uses kinds of logs and branches to build a dam (Miller, Johnson, and Smith, 2008).

Ecosystem engineers are also found in mangrove area, for example fiddler crab (*Uca*). This organism is thought to be allogenic engineer, its activity among others is (1) change detritus becoming humus through feeding habit. Detritus changes becoming humus can be shown from C/N ratio soil organic matter. According to Miller (2000) if C/N ratio of organic matter >30, then immobilisation will happen, between 17 – 33 will stabilize immobilisation and mineralization and <17 mineralization will happen, and (2) creating aerob condition in the soil through digging habit for its residency. The existence of burrow possibly provide oxygen in the soil when high and low tide come, which can be detected from the soil redox potential. According to DeLaune and Reddy (2005) in the aerob condition with abundant oxygen, redox potential will be positive and high, can reach up to +400 mV. In the other hand, if there is no oxygen, redox potential is zero or negative. In this kind of condition, nitrate, iron and manganese is in reduced condition, sulphate is stable and there is no sulfite.

Aim of research are study fiddler crab community, analyze the influence of fiddler crab towards soil C/N ratio, and analyze the influence of fiddler crab towards soil redox potential in mangrove area in Ketapang, Probolinggo.

RESEARCH METHOD

This research was done in mangrove area Ketapang Probolinggo on October 2015. The sample taking of fiddler crab was done when it was low tide, 20 transects with each 1 m^2 size. The total density obtained by digging the burrow, then identified and calculated the diversity and dominance.

In the station which is occupied by the fiddler crab, the soil samples were taken from the upper side of the burrow (in the surface), from the burrow wall (depth of 20 cm) and in the bottom of the burrow (depth of 40 cm). Meanwhile in the station that was not occupied, the soil sample was taken from surface area, at depth of 20 and 40 cm. The soil sample was analyzed its texture, C/N ratio and redox potential.

RESULT AND DISCUSSION

Research Location's Condition

The research location geographically located in 7˚.28.'48"-7˚.57'.00"S and 113˚.10'.48"-113˚.25'.00"E, wide ±2.051 km^2, coast length ±921 m, wide mangrove area ±6,13 ha and fishpond ± 5,6 ha (Figure 1). Soil texture is sandy loam and loamy sand (Table 1).

Table 1. Soil Texture Mangrove Area in Ketapang Probolinggo, October 2015.

St	Sand	Silt	Clay	Texture
	%	%	%	
1	64	25	11	Sandy loam
2	59	35	6	Sandy loam
3	88	6	6	Loamy sand
4	87	3	10	Loamy sand

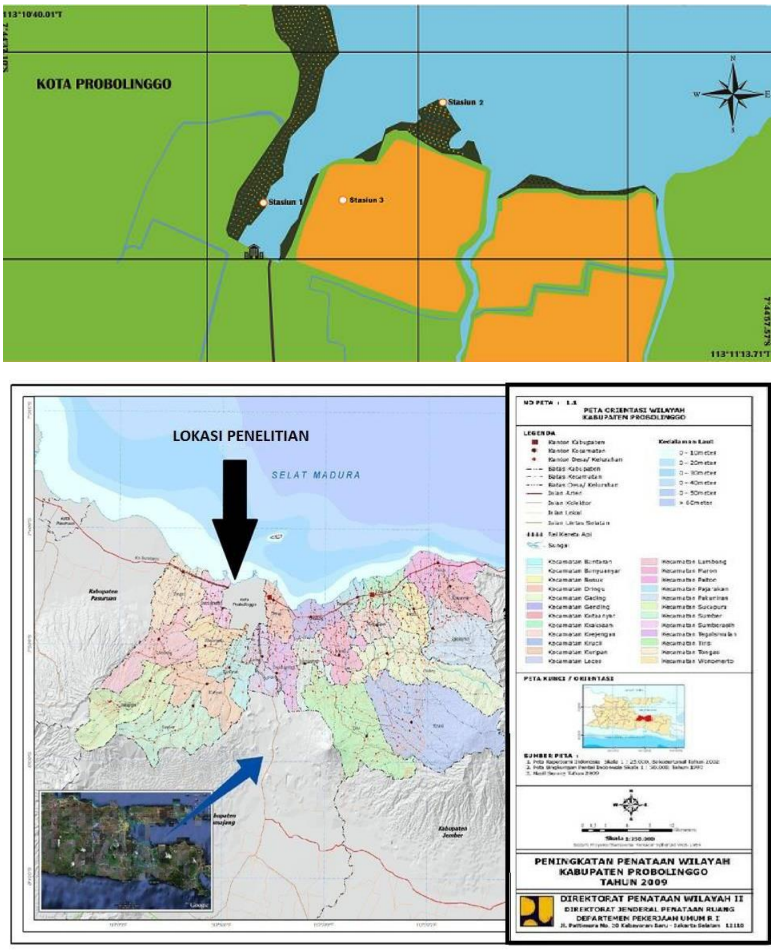

Figure 1. Research Location Map

Fiddler Crab Community

Fiddler crabs which found in land up to the sea were (a) *Uca triangularis*, (b) *U. paradussumieri,* (c) *U. perplexa*, (d) *U. dussumieri* dan (e) *U. tetragonon* (Figure 2).

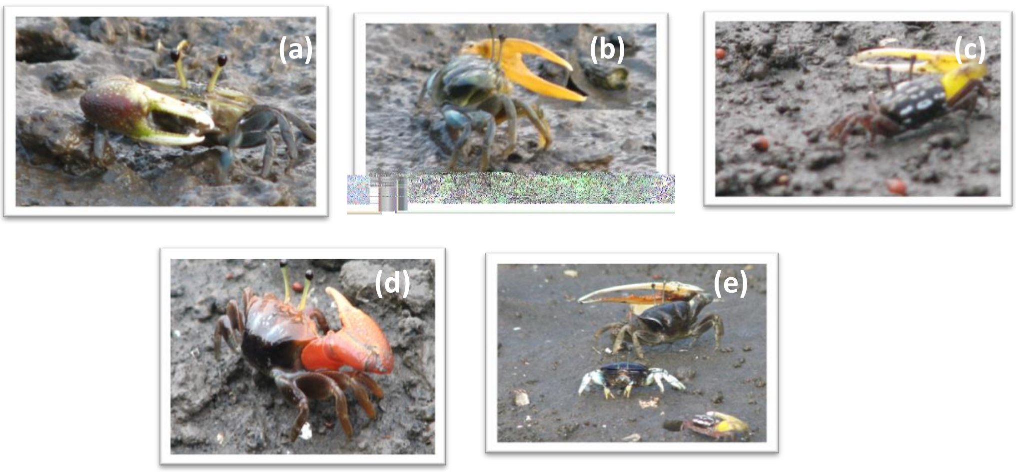

Figure 2. Identified Fiddler Crabs

As seen from the density, sequencially from the most one (Figure 3) : (1) *U. perplexa* 42%, near the land (beach 1) found 32 ind/m², towards the sea (beach 4) lesser 14 ind/m², (2) *U. dussumieri* 38%, near the shore 12 ind/m², towards the sea (beach 3) more 27 ind/m². According Crane (1975) *U. perplexa* and *U. dussumieri* geographically spreaded throughout beach area in Indonesia, (3) *U. tetragonan* 3 – 6 ind/m², (4) *Uca triangularis* 2 –6 ind/m². These two crabs can survive as long as there is sea water, therefore many of them are found near land (beach 1 and 2), (5) *U. paradussumieri* are found the least 1 – 3 ind/m², towards the sea, is nearly not found.

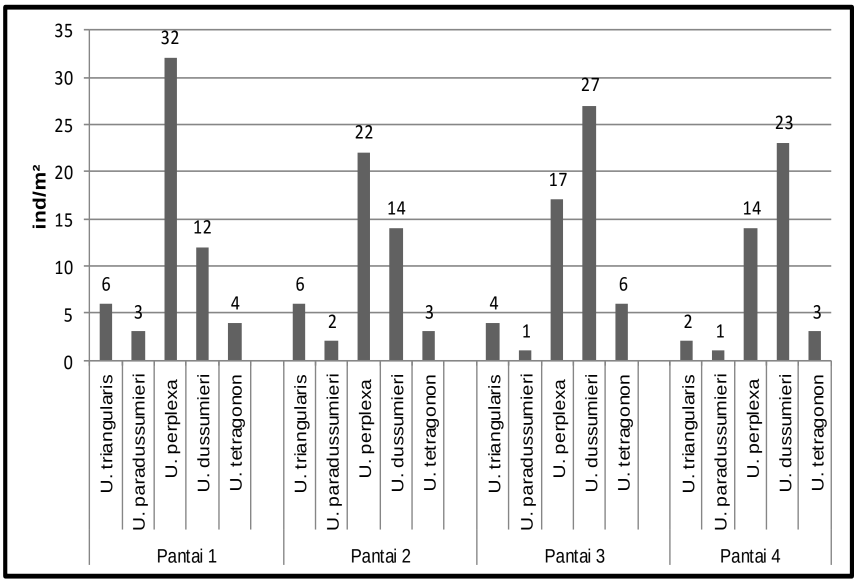

Figure 3. Fiddler Crab Composition

The diversity of fiddler crab in this area is medium and none of them are dominance. This is based on the Shannon-Wiener Diversity Index H’ = –3,32 ∑pi log pi = 1,7 and Dominance Index C = ∑pi² = 0,37.

Carbon Nitrogen Ratio

Carbon nitrogen ratio (C/N ratio) is the comparison between the total of carbon and nitrogen in organic matter, that can be used as indicator of nitrogen availability in the soil. Total carbon is the measurement of the whole organic and inorganic carbon in organic matter. Total nitrogen includes all kinds of nitrogen form, such as N-organic, ammonium-N (NH_4-N) and nitrate-N (NO_3-N). Nitrate is commonly contained in low concentration in organic matter which have not been experienced detritus, and can increase in humus and detritus result (Jones, 2002).

From the research result can be identified that soil C/N ratio location that were occupied by fiddler crabs is quite low around 6 – 14, average 10. In the area that were not occupied by fiddler crab is higher 14 – 20 average 17 (Figure 4). Towards the sea (beach 4) C/N ratio is the lowest. This is because of the influence of tidal wave and the high and low tide which contribute in accelerating detritus process of organic matter. The high C/N ratio in the soil that were not occupied by fiddler crab shows that organic matter in the soil is not used by that organisms, and the carbon content is still relatively.

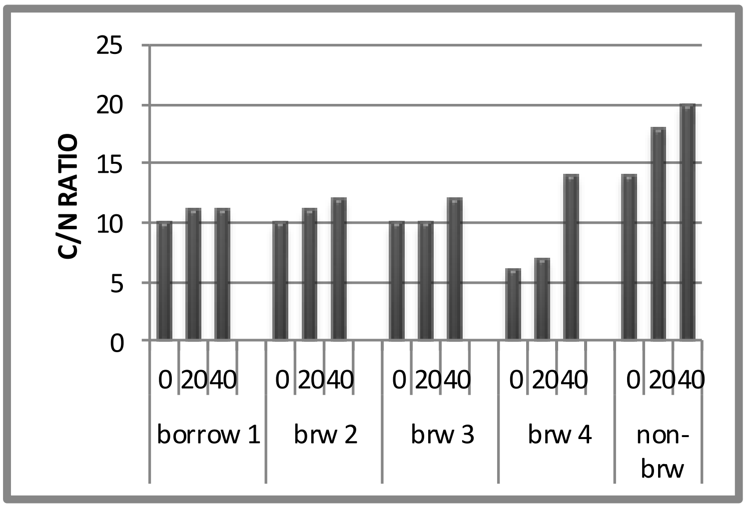

Figure 4. Carbon Ratio – Fiddler Crab burrow's Nitrogen

Soil C/N ratio is vertically for area that were occupied by fiddler crab, in the surface and depth 20 cm average 9, depth 40 cm average 12. The low C/N ratio in the surface and depth 20 cm can trigger organic matter decomposition faster because of its nitrogen content is higher.

The value of C/N ratio vertically shows the difference between burrow's wall soil condition and soil under the burrow. This proves that the location of fiddler crab's burrow effects the quality of soil organic matter.

Microorganism (bacteria) needs nitrogen to build its body tissue and multiply, where 16% from the protein is nitrogen (Miller, 2000). In the soil with high C/N ratio, bacteria which works in the organic matter detritus process will take the nitrogen from the material which detritused and the short comings will be taken from soil nitrogen storage. This can cause the deficiency of nitrogen, as a result the soil fertility will decrease.

Detritus process rate of organic matter and the number of humus which formed is related to C/N ratio from residue. If the other condition is balance, then the increase of detritus rate, causing C/N ratio become smaller. Humus which formed from detritus will contain more or less 50% carbon and 5% nitrogen, in other words, C/N ratio dari humus is 10 : 1 (Soils Agron 305, 2012).

The low C/N ratio in area that were occupied by fiddler crab causes detritus process of organic matter become faster, becauses the bacteria which is working in the detritus process grow and breed faster. As the information taken from cenevada@ucdavis.edu (2011) bacteria uses carbon as energy and nitrogen for building its cell. Optimal comparison from those two elements which needed by bacteria average 30 part of carbon and 1 part of nitrogen or C/N ratio 30. If the C/N ratio is less than 30, bacteria will grow faster and of course the organic matter detritus will also be faster.

Redox Potential

Redox potential (Eh) of soil horizontally from the highest tide area towards the sea (beach 1 until 4), is taken from three depths, the surface, depths 20 and 40 cm, all are measured in mVolt. Location that were occupied by fiddler crab, the oxidation condition with Eh value is average positive.

In the highest tide area (beach 1), Eh = –,82 until +1,78 (average +0,68), next is towards the sea (beach 2) –0,48 until +1,07 (average +0,403), (beach 3) –0,82 until +2,19 (average +0,87), (beach 4) –1,2 until +1,07 (average +0,203. In the area that were not occupied by fiddler crab, the reduction condition with Eh –1,32 until +0,1 (average –0,647) (Figure 5). Average value Eh for location that were occupied by fiddler crab even it is positive, it is relatively small, because the depth 40 cm is a sampel which taken from the soil under the burrow of the crab, the reduction condition or anaerobic.

The low redox potential in the location that were not occupied by fiddler crab indicates that the sediment is reductive, this is because of there is no rinsing by sea water intensively and also there is no air exchange. While in the location that were occupied by fiddler crab, the redox potential is higher, which means this sediment is oxydative, showing how intensive the exchange of water and air. This corresponds to Ponnamperuma's opinion (1978) that the oxydative condition is shown with Eh value which is high and positive, and the reductive condition is shown with Eh value which is low and negative. According to Delaune and Reddy (2005) in Eh = +400 mV oxygen is very rich, while in Eh = 0 mV oxygen and nitrate is not available, iron and manganese in reduction condition, sulphat in stable condition and there is sulfit production, which poisonus to the plant.

One of fiddler crab's activities is always digging holes, then some of the hole are left behind. In high tide, rinsing happens and when the water is low oxygen exchanges. This allows the availibity of oxygen so the sediment will be more oxidative. this corresponds to Krauskopf's opinion (1967) that generally the strongest oxydation agent in nature is oxygen. This condition is different with are which is not inhabited by fiddler crab. While there is tide, the soil pores is filled with water, but rinsing does not occur, and when the water is low, there is air exchange, so some of the soil layers is oxugen less. In this anaerob condition, facultative microorganism will use inorganic oxydant as electron acceptor and it forms reductive condition in the soil. According to Patrick and Reddy (1978 in Basir–Cyio. 2008) the oxydant is NO^{3-}, Mn^{4+}, Fe^{3+}, CO_2, N_2 and H^+, which then will be reduced as N_2, Mn^{2+}, Fe^{2+}, H_2S, CH_4, NH^{4+}, and NH_2. According to Krauskopf (1967) in

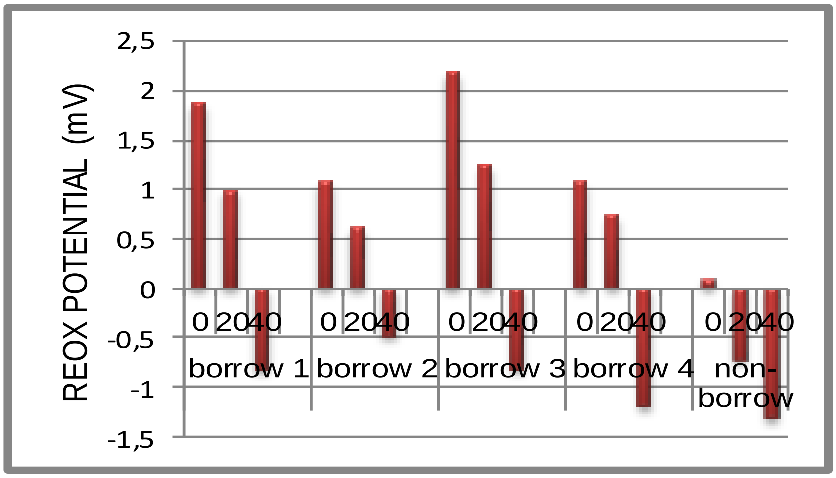

Figure 5. Redox Potential Fiddler Crab Burrow

reductive condition bacteria's activity stimulate the ion *ferri* changes Fe^{3+} becomes ion *ferro* Fe^{2+}, pH enhancement, Eh reduction. In this anaerob condition according to Ponnamperuma (1976) there is a release of CO_2, CH_4 and H_2S.

Redox potential of soil vertically for inhabited area by fiddler crab, in the surface 1,07 until 2,19 (average 1,55), depth 20 cm –0,62 until 1,24 (average 0,75), depth 40 cm –0,82 until 0,41 (average –0,33). In the beach, the surface 0,37 until 1,98 (average 1,26), depth 20 cm –0,61 until 1,21 (average 0,90), depth 40 cm (under the burrow) –0,48 until –1,2 (average –0,83). Under the burrow of fiddler crab contains water, and the soil under it is reductive, showing that does not contain oxygen. This corresponds to Kristensen's opinion *et al*. (1995) that aerobic oxydation happen near the sediment's surface, around the burrow and along the surface of mangrove's root which rich with oxygen. Ponnamperuma (1972 in De Datta 1981) states that oxydation reaction related to the soil condition with a good drainage, while the reduction reaction realted to soil condition with a bad drainage or if there is excess water. Waterlogging can cause reduction condition and reduce the soil Eh value.

CONCLUSION

Conclusion

1) Fiddler crabs found are *Uca. triangularis* 2–6 ind/m², *U. paradussumieri* 1–3 ind/m², *U. perplexa* 14–32 ind/m² (mostly 42%, towards the sea the density declines), *U. dussumieri* 12–27 ind/m² (towards the sea more abundant), *U. tetragonon* – 6 ind/m². Diversity index 1,7 and domination index 0,37.
2) The existence of fiddler crabs can decrease the soil C/N ratio. The location that were occupied by fiddler crab has low (10), while location that were not occupied is higher (17). In the surface and depth of 20 cm (9), depth of 40 cm (12).
3) The existence of fiddler crabs can increase the soil redox potential. The location that were not occupied by fiddler crabs Eh = – 0,647, occupied ones Eh = + 0,539 mV. In the surface +1,55, depth of 20 cm +0,75, depth of 40 cm –0,33.

Suggestion

Through the activity of planting mangrove is strongly considered to have introduction about fiddler crab in the planting area. It is to help accelerating the organic matter decomposition.

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