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The Effect of Urbanization on The Stand Structure of A Mangrove Forest in Likas Bay, Sabah Malaysia

(Dampak Urbanisasi pada Struktur Tegakan Hutan Mangrove di Teluk Likas, Sabah, Malaysia)

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ABSTRACT

The aims of this study were to determine the effect of urbanization on species composition, change to stand structure and tree species on the mangrove stand between the housing development and the river. Two (2) plots were established, with five (5) subplots each measuring 10m x 10m. Simpson's Index, Shannon-Weiner Index, Shannon evenness and Important Value Index (IVI) were used to determine the diversity and abundance of tree species. There are 4 species found in both plots which are Avicennia alba, Avicennia marina, Rhizophora mucronata and Rhizophora apiculata. The most abundant species is the R. apiculata with an IVI of 86.99 percent (%). The Simpson's Index value calculated for the forest was 0.75, while the value for the Shannon-Weiner (H') was 1.38. This indicates the area has low diversity in mangrove trees. The Shannon evenness (E) was 0.99. This means the area is completely covered in standing trees. In this study, the stand structure was measured using tree Diameter at Breast Height (DBH), height and crown size. The data indicates that mangrove trees approaching the housing developments experienced a steady decrease in DBH, height, and crown size. Trees in the middle of the forest had the largest DBH and height. The DBH and height of trees approaching the river steadily decreased but had larger crowns compared to the other subplots. Whereas, water quality and the presence of sediments were two other additional aspects used to measure the impact of housing developments on mangrove forests. Urbanization projects do not leave any noticeable impact on the clearness of water in mangrove forests, but does for sediments. As a conclusion, urbanization project such as housing development do leave an impact on mangrove forests in the Likas bay, Malaysia. More future studies will shed more light on how housing developments impact mangrove forests.

1. Introduction

Likas is situated on the west coast of Sabah. It is sub-urban of Kota Kinabalu, 5.983° latitude and 116.067° longitude. Sabah is 73700 km^2 in total area out of which 341,000 hectares is the total land area of mangrove forests in Sabah (Ong and Petol, 2007). Mangrove forests cover a greater area in Sabah compared to other Malaysian states. It is mostly found along the eastern and southeastern coasts of the state. The mangrove forest covers an area smaller than that of inland forests, but in terms of value per unit area, mangrove forests are much higher in value than that of inland forests. Mangrove forests occur in muddy shores, lagoons and estuaries of tidal rivers. The most common tree species are *Rhizophora* sp., *Avicennia* sp., *Bruguiera* sp., *Sonneratia* sp., *Xylocarpus* sp. and *Nypa* sp. It is rich in biodiversity.

Urbanization allows an opening of new land where it is use for the housing, industrial, and tourism development sector. The reason for carrying out public housing projects is due to the increasing population, especially in urban areas. Shortage of affordable housing and other types of accommodation is a serious problem, especially in the state capital, Kota Kinabalu, and other major cities like Sandakan and Tawau. This makes land conversion a very attractive option, particularly for mangrove forests in Likas (Verus, 1989).

Due to urban pressure, most of the mangrove forests in the Likas area has already been reduced following growing developments such as public housing projects. The north-eastern part of the city around Likas Bay once contained an extensive mangrove forest, but most of the mangrove forests have disappeared because of development. Mangrove forests are in great danger and has been said to be one of the world's most threatened tropical ecosystems (Science daily, 2006). Many mangrove forests are not managed well and have been harvested without any future plans of sustainability.

The aims of this study were to determine the effect of housing development projects on mangrove tree species composition, the change of stand structure along the mangrove forest, and change in species composition along the mangrove stand between the river and housing developments in the Likas mangrove area).

2. Materials and Methods

Plots were established for sampling. Two plots were prepared with five subplots measuring 10x10m each. They were established across the mangrove forest near a public housing development. The distance from one subplot to the nearest subplot was 10m. The beginning and ending points of the plots were randomly determined and five subplots per plot were then arranged along the starting and ending points. The species, DBH, crown size, and total height of the mangrove trees were recorded for analysis

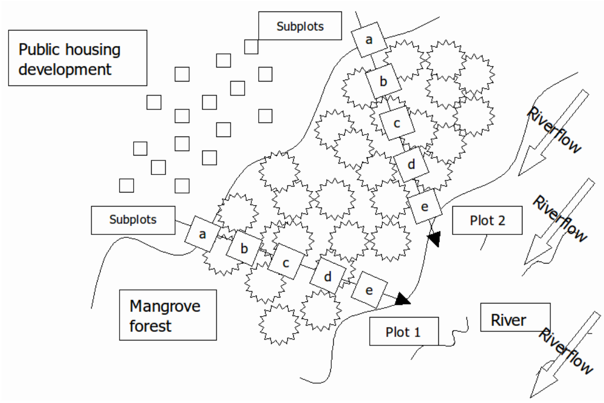

Figure 1. Plot sampling layout at Likas Bay

3. Results and Discussion

Species composition can be measured or can be understood through the Importance Value Index (IVI) calculation which was developed by Curtis and McIntosh (1951). This calculation involves summing up three values which are the relative abundance, the relative dominance and the relative frequency value. Through this method, the dominant species can be determined.

From the data that was gain through the study, the Importance Value (IV) was calculated and shown in Table 1. The most abundant species among all mangrove tree species in the Likas bay area was the *R. apiculata*. This species was found widely throughout the disturbed mangrove area in Likas. *R. apiculata* was the dominant species with the highest IVI of 86.99. This species grows in the area where the level of the high tide is at its lowest, and consist of soft and muddy soil. The second most abundant species based on the IVI calculation is *R. mucronata* at 83.37, followed by *A. alba* with 71.38. The species lowest in abundance was *A. marina* at 58.62

The forest environment influences species diversity, and can be used to determine the variety of species in one area compare to other areas. In this study, two diversity indices were used. They are the Shannon-Weiner Index and Simpson's Index. The value of the two indices is shown in the Table 2

Table 1. The tree species in the Likas mangrove area ranked by the Important Value Index (IVI) Species Diversity

Rank	Species	Relative dominance (m2/ha), %	Relative abundance (n/ha), %	Relative frequency, %	IVI, %
1	*Rhizophora apiculata*	41.31	22.22	23.46	86.99
2	*Rhizophora mucronata*	31.81	29.63	21.93	83.37
3	*Avicennia alba*	16.28	25.93	29.17	71.38
4	*Avicennia marina*	10.6	22.22	25.44	58.26
1 to 4					300.00

Table 2. Diversity indices of the Likas Mangrove area

Diversity Index	Likas Mangrove Area
Shannon-Weiner Index, H'	1.38
Simpson's Index, 1-D	0.75

The Shannon-Weiner Index was 1.38. This value may indicate low species diversity, but it is actually a common value for mangrove forests when compared to the study by Lu Chang-yi *et al*, (2008), which was 1.44.

Through applying Simpson's Index on the data, a value of 0.75 was obtained. This shows diversity in this area was slightly higher with reference to a study performed by Mojiol *et al*. (2008) on two virgin mangrove forests at 0.70 and 0.54 respectively. This means although the mangrove forest is low in species diversity, it is comparable to mangrove species diversity in other regions.

According to Magurran (1988), evenness indices standardizes abundance and range from near 0 which assumes each individual tree is a unique tree species; to close to 1, when all individual trees belong to the same tree species. Shannon evenness was also taken into account in this study. From the entire plot, the Shannon evenness was calculated and the value is 0.99.

The Shannon evenness value was 0.99. This value is higher compared to the study performed by Mojiol *et al*. (2008) which was 0.92 and 0.80 respectively for two virgin mangrove forests. This shows Likas mangrove area is nearly homogeneous in species diversity. Stand structure was also considered a factor in this study. Three measurements were used to represent stand structure. They were DBH, crown size, and tree height.

In both plots, there were a total of 456 tree stands that were measured. Only 4 species were found in both plots which were the *A. alba*, *A. marina*, *R. mucronata* and *R. apiculata*. The data is summarized Table 3.

Table 3. Results on the number of trees of each species of the Likas mangrove area study

No.	Species	Plot		Plot 1 + Plot 2
		Plot 1	Plot 2	
1	*Rhizophora apiculata*	54	53	107
2	*Rhizophora mucronata*	45	55	100
3	*Avicennia alba*	71	62	133
4	*Avicennia marina*	42	74	116
Total		212	244	456

Overall, *A. alba* was most common with 133 individuals. In other words, the areas was dominated by this species. In contrast, the least common species in the total area sampled was *R. mucronata* with 100 number of individual. As a whole, the species in the study areas were evenly distributed.

Data on stand structure measurement was collected. Table 4 shows the average of the data collected on tree DBH, crown size and tree height of the mangrove trees in Plot 1.

Table 4. Results on average of tree DBH, tree height and crown size in each subplot of plot 1

Plot 1	Subplot 1a	Subplot 1b	Subplot 1c	Subplot 1d	Subplot 1e
Average DBH, mm	9.99	22.92	55.02	31.03	62.93
Average height, m	0.67	3.01	8.96	5.80	4.92
Average crown size, m^2	0.43	0.85	2.23	1.09	1.77

Table 5. Results on average of tree DBH, tree height and crown size in each subplot of plot 2

Plot 2	Subplot 2a	Subplot 2b	Subplot 2c	Subplot 2d	Subplot 2e
Average DBH, mm	17.28	18.59	516.3	33.43	115.18
Average height, m	1.91	1.74	4.14	5.26	10.87
Average crown size, m^2	0.97	1.22	4.16	3.51	6.30

Table 5 shows the average of data collected on tree DBH, crown size and tree height of mangrove trees in plot 2.

From the data that was analysed, several graphs were generated that showed nearly the same pattern in tree DBH, tree height, and crown size.

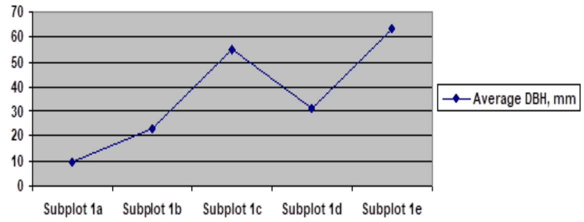

Figure 2. Average DBH of Plot 1

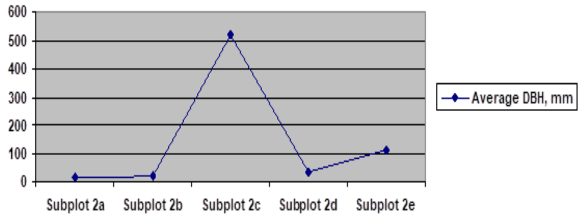

Figure 3. Average DBH of Plot 2

The average DBH of the mangrove trees increases the further they are from the housing development. Average tree height reaches a peak in the middle of the mangrove forest in Subplot 1c and Subplot 2c.

Average tree height then sharply decreases with increased distance from the middle of the mangrove forest towards the river. Tree DBH then continues to climb.

The data also shows an immense spike in the DBH of trees in Plot 2c. Plot 2c lies upriver and is also in the middle of the mangrove forest. Plot 1c lies in the middle of the forest as well. Perhaps the difference could be a result of differing levels of anthropogenic activity, or the erosion and higher water level brought about by tidal waves from the sea at high tide, which flows upstream into the river.

The data shows that most trees of the greatest DBH can be found in the middle of a mangrove forest.

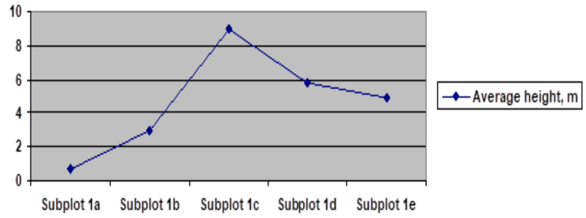

Figure 4. Average height of Plot 1

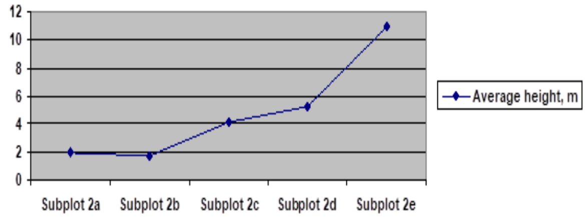

Figure 5. Average height of Plot 2

The average height of the mangrove trees differs in value in Plot 1 and Plot 2. Plot 1 shows that there is an increase in tree height up to Subplot 1c, but then decrease in value up to Subplot 1e. For Plot 2, there is a steady increase in height up to Subplot 2 where a steep increase in average tree height was found in Subplot 2E.

The 2 plots differ completely in pattern where a rise and fall pattern in Figure 4 is contrasted with a steadily rising graph in Figure 5.

The difference may be due to different levels of construction activity of the housing projects. Mechanical factors, such as differing levels of erosion, current speed, and sedimentation may lead to different variations in growth.

It is possible that tidal waves have a greater influence than expected, where water rushes upstream from the sea at high tide. This effect is weak in the upper regions of the river; but significant in the lower regions. It is also possible that the strength of the river current contributes to changes in tree growth.

Human-led activity can also explain the variations in the graph, where harvesting activities may have been carried out at Plot 2, resulting in lesser tall trees in the middle of the mangrove forest.

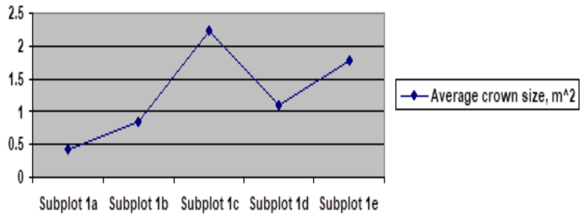

Figure 6. Average crown size of Plot 1

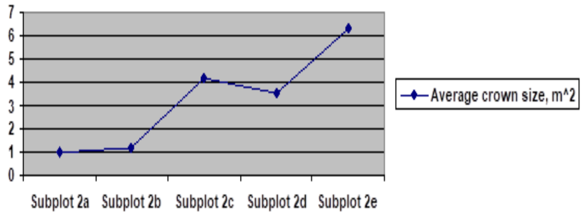

Figure 7. Average crown size of Plot 2

For the change in tree crown size, both Plot 1 and Plot 2 experience the same pattern of change as can be seen in *Figure 6* and *Figure 7*. Crown size is smallest when nearest to the housing development, experiences a peak in the middle of the mangrove forest, decrease in size again in Subplot d, then increases when nearing the river.

Because the average crown size appears to correlate with the data for average DBH, this may indicate that crown size is a result of DBH size, or that the crown is influenced by similar factors influencing tree DBH.

Water quality is important for the organisms either living in the mangrove waters, or organisms who obtain food from it. In this study, the apparatus used to indicate the quality of the water was the turbidimeter. The greater the reading of the turbidimeter, the murkier the water is. The data collected during the study is shown in Table 7.

Table 7. Turbidimeter readings for Plot 1 and Plot 2 in the studied area

Subplot	Plot 1, NTU*	Plot 2, NTU*
a	2	5
b	3	4
c	6	5
d	20	9
e	30	5

NTU = Nephelometric Turbidity Units

The turbidimeter shows that water is nearly clear in both Plot 1 and Plot 2, with the very low readings in all fields but Subplot 1d and Subplot 1e. This suggests a housing development project does not affect the clarity of a river. Sedimentation was another factor studied to observe the impact of housing development project on the mangrove area. The depth of the sediment layer was measured. The data is shown in Table 8.

Table 8. Sediment thickness of Plot 1 and Plot 2 in the studied area

Subplot	Plot 1, cm	Plot 2, cm
a	5.0	9.2
b	4.8	2.4
c	6.2	2.5
d	1.0	1.5
e	0.6	1.0

When a land is converted for commercial usage, it is likely to result in soil erosion. This is the most likely explanation for the trend of thicker sedimentation the closer the mangrove area studied is to housing development projects. When there are sediments on the riverbed, the organic substance becomes obscured, which makes it difficult for seedlings to grow on. This means housing development projects are capable of influencing the soil profile of mangrove forests.

4. Conclusion and Recommendations

There were four species of mangrove trees found in both plots, which were the *Avicennia alba*, *Avicennia marina*, *Rhizophora mucronata* and *Rhizophora apiculata*. The most abundant species in the area studied is the *R. apiculata* with an IVI of 86.99 percent (%). The Simpson's Index value for the forest was 0.75, while the Shannon-Weiner Index value for the forest was 1.38.

With a value of 1.38, the Shannon-Weiner Index indicates low mangrove tree species diversity in the area studied, but this may actually be a common value for mangrove forests. The Simpson's Index value of 0.75 while low, was comparable to mangrove species diversity in other regions. The Shannon evenness value was 0.99, which indicates the mangrove area studied is nearly homogeneous in species diversity.

Urbanization project such as housing development do leave an impact on mangrove forests in the Likas bay, Malaysia. There is a noticeable decrease in the DBH, tree height, and crown size of the mangrove trees studied. This points to the disruptive nature of human activity on mangrove forests. Perhaps illegal harvesting activities have also been carried out, which would explain the absence of tall trees in the middle of the mangrove forest in Plot 2c.

Water clarity was not affected by housing developments, although this does not prove that pollution has not occurred. Sedimentation was increasingly greater though, the closer the mangrove forest is to the housing development.

Specific studies on how exactly housing developments affect mangrove stand structure need to be carried out to further understand the affect anthropogenic activities have on the mangrove forest

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