Organic matter and macrobenthos dynamics analyzed with stable isotopes in the anthropogenically transformed mangrove ecosystem of Batan Bay Estuary, Philippines

（フィリピン、バタン湾の人為改変されたマングローブ生態系における安定同位体を用いた有機物とマクロベントスの動態）

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Coastal areas receive considerable attention as ecosystems with high ecologic and economic importance due to their substantial contributions to ecosystem services. However, coastal areas have been placed under threat by extensive anthropogenic impacts. This study was carried out in Batan Bay Estuary, in the Philippines, where mangrove deforestation due to aquaculture pond construction has taken place on a large scale. For several decades, mangrove plantations have been established. However, insufficient ecological research has been conducted in Batan Bay Estuary under such disturbed conditions. Here, stable isotope analyses of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) were used to survey organic matter flows with a focus on primary producers, sediment organic matter and the macrobenthic community. The objective of this thesis was to understand the effects of anthropogenic impacts on organic material flows, especially on macrobenthic communities, which are important environmental indicators and ecosystem engineers (Chapter 1).

Chapter 2 outlines the stable isotope ratios of carbon and nitrogen from primary producers for use in the analyses of subsequent chapters. In addition, the interspecific and intraspecific variability of mangrove species that were collected in sufficient numbers were analyzed. Clear interspecific patterns were not detected, although intraspecific variation of δ13C with water salinity was shown.

Chapter 3 clarifies sediment organic matter sources in Batan Bay Estuary, where most of the mangrove area has been deforested. First, Batan Bay Estuary was classified into three ecological zones based on environmental factors and the δ13C, δ15N and C/N of sediment organic matter. Then, ratios of sediment organic matter sources (mangrove, microphytobenthos, and phytoplankton) were calculated using a mixing model. Results showed a high contributionof mangrove organic matter in Batan Bay Estuary, while phytoplankton and microphytobenthos were also found to make complementary contributions, depending on the classified zone.

Chapter 4 examines anthropogenic impacts on macrobenthic community structure. Macrobenthic organisms were collected from natural mangroves, tidal flats, Rhizophora mucronata plantations and abandoned aquaculture ponds. In addition, stable isotope analysis was conducted to reveal food sources. Results showed high biodiversity and a wide food web structure at natural sites, with poor biodiversity and simple food webs at anthropogenic sites.

Chapter 5 compares the ecological positions of R. mucronata plantation with natural mangrove forests. Forest structure, biomass and productivity were measured in both forest types. The results showed that although plantations had high biomass and productivity, they were vulnerable to strong winds due to their homogenised, overcrowded planting. In addition, the darkness of the forest floor inhibited microphytobenthos. It could be suggested that R. mucronata plantations are not suitable for ecosystem restoration.

Chapter 6 provides a conclusion for all chapters to correspond with the research aims of “understanding the effects of anthropogenic impacts on organic material flows”. The expansion of homogenous environments such as R. mucronata plantations and abandoned aquaculture ponds in tropical coastal areas will simplify organic matter flow.