

A STUDY ON THE EFFECTS OF CARBON DIOXIDE,  $p\text{CO}_2$   
ON CORAL HEALTH

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**A STUDY ON THE EFFECTS OF CARBON DIOXIDE,  $p\text{CO}_2$  ON CORAL  
HEALTH**

**By**

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## LIST OF ABBREVIATIONS

nm	-	nanometer
rpm	-	rates per minute
$\mu\text{mol.kg}^{-1}$	-	micromole per kilogram
$\mu\text{g.L}^{-1}$	-	micrometer per liter
$\mu\text{atm}$	-	micro atmosphere
kPa	-	kilopascal
$\text{CO}_2(\text{aq})$	-	free carbon dioxide in aqueous form
$p\text{CO}_2$	-	carbon dioxide partial pressure
$\text{HCO}_3^-$	-	bicarbonate ion
$\text{CO}_3^{2-}$	-	carbonate ion
$\text{Ca}^{2+}$	-	calcium ion
$\text{CaCO}_3$	-	calcium carbonate
$\text{H}_2\text{CO}_3$	-	carbonic acid
CCM	-	carbon concentrating mechanism
$\%.\text{day}^{-1}$	-	percentage per day
$\text{mgO}_2.\text{cell}^{-1}$	-	milligram of oxygen per cell
$\text{mgCO}_2.\text{cell}^{-1}$	-	milligram of carbon dioxide per cell
$\text{cell.cm}^{-2}$	-	cell per centimeter
$\text{mg.cells}^{-1}$	-	milligram per cell
$\text{mgCaCO}_3.\text{L}^{-1}$	-	milligram of calcium carbonate per litre
$\text{mgCO}_2.\text{L}^{-1}$	-	milligram of carbon dioxide per litre
$\text{mgCaCO}_3\text{eq.L}^{-1}$	-	milligram of calcium carbonate equivalent per liter
NOAA	-	National Oceanic and Atmospheric Administration

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## ABSTRACT

Effects of air-sea interaction of carbon dioxide in the sea are highly speculated with ocean acidification and alteration of seawater chemistry. This research studied the effects of elevated carbon dioxide,  $p\text{CO}_2$  towards health of scleractinian corals, *Porites cylindrica* and *Galaxea fascicularis* by inspecting photosynthesis rate, chlorophyll content, zooxanthellae cell density and calcification rate. Normal free  $\text{CO}_2$  (aq) in seawater ranged from 23.34 - 38.65  $\mu\text{mol.kg}^{-1}$  while the elevated free  $\text{CO}_2$  (aq) was 67.32 - 109.44  $\mu\text{mol.kg}^{-1}$ . Daily, monthly and seasonal variation affects the  $\text{CO}_2$  level depending on the geographic region, wind velocity and tidal range. Net photosynthesis corresponds with high chlorophyll content resulting significant increase in productivity for both species in elevated  $p\text{CO}_2$ . High photosynthesis activity causes high metabolism in algal cells. Zooxanthellae adjust to external stress and facilitates uptake of elevated  $p\text{CO}_2$  causing cell density in *P. cylindrica* and *G. fascicularis* to decline 26.80% and 69.85% respectively. At high  $p\text{CO}_2$ , mitotic cell division increases in *G. fascicularis* from 4.14% to 6.47% but decrease in *P. cylindrica* from 2.31% to 0.95%. Species-specific reactions retard zooxanthellae reproduction in *P. cylindrica* while *G. fascicularis* shows stress-related response by increasing mitotic division to replenish significant cell loss. Effects of elevated  $p\text{CO}_2$  show species-dependant response in calcification by promoting dissolution rate in *P. cylindrica* but facilitate carbonate precipitation rate in *G. fascicularis*. Calcification rate decline with time suggest the interacting effects of seawater carbonate chemistry could affect calcification in marine calcifying organism such as planktonic pteropod, foraminifera, echinoderm and coccolithophorid as predicted in future.

# KAJIAN KESAN KARBON DIOKSIDA, $p\text{CO}_2$ TERHADAP KESIHATAN BATU KARANG

## ABSTRAK

Interaksi antara atmosfera dan laut dalam konteks karbon dioksida di udara merupakan isu utama yang merangkumi kesan asidik terhadap laut dan perubahan dalam proses kimia lautan. Kajian ini memberi fokus kepada kesan peningkatan karbon dioksida,  $p\text{CO}_2$  terhadap batu karang, *Porites cylindrica* dan *Galaxea fascicularis* dalam aspek kadar fotosintesis, kandungan klorofil, kepadatan sel zooxanthellae dan kadar pengapuran kedua-dua spesies tersebut. Julat  $\text{CO}_2$  (aq) dalam lingkungan normal adalah 23.34 - 38.65  $\mu\text{mol.kg}^{-1}$  manakala kepekatan  $\text{CO}_2$  (aq) yang ditingkatkan adalah dalam julat 67.32 - 109.44  $\mu\text{mol.kg}^{-1}$ . Variasi harian, bulanan dan musim mempengaruhi kadar  $\text{CO}_2$  bergantung kepada kedudukan geografi, halaju angin dan pasang surut. Fotosintesis bersih meningkat dengan kenaikan ketiga-tiga pigment fotosintetik. Metabolisme zooxanthellae adalah tinggi sebagai adaptasi terhadap perubahan persekitaran menyebabkan kepadatan sel zooxanthellae dalam *P. cylindrica* dan *G. fascicularis* menurun 26.80% and 69.85% masing-masing. Mitosis alga digalakkan dalam *G. fascicularis* dari 4.14% kepada 6.47% untuk menggantikan kehilangan sel tetapi merencatkan mitosis alga *P. cylindrica* dari 2.31% kepada 0.95% apabila  $p\text{CO}_2$  tinggi. Kadar enapan kalsium karbonat berkurangan dalam *P. cylindrica* tetapi mencatatkan pertumbuhan dalam kadar enapan *G. fascicularis* maka menunjukkan  $p\text{CO}_2$  memberi kesan spesies-spesifik dalam karang. Kadar enapan yang menurun memberi implikasi terhadap organisma berkalsium karbonat seperti yang telah diramal untuk masa depan.