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Short Communication: Coral reef lifeform variation around power plant activity: Case study on coastal area of Paiton Power Plant, East Java, Indonesia

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Abstract. *Saptarini D, Mukhtasor, Rumengan IFM. 2017. Coral reef lifeform variation around power plant activity: Case study on coastal area of Paiton Power Plant, East Java, Indonesia. Biodiversitas 18: 116-120.* Heat water, a waste, generated by industries activity near coastal area had generally higher temperature than sea water. It affected to marine organism which used coastal area as their habitat. Coral reefs as one of coastal productive ecosystem had stenotolerant adaptive nature. That nature made them relatively stay on narrow spanning upon environment changing factors. This study obtained to understand various composition of coral lifeform around steam power plant at district of Paiton in Probolinggo, East Java province. Both coral reef and water observed in five area based on distance of heat water distribution and coral presence. Line transect method was unfold in 30m for sampling. Certain parameter like coral coverage area, diversity, and water temperature were collect as data barrier factor for it presence. The percentage of coral coverage area resulted among 48.37-75.33%, it ranked at middle till good level. ANOVA analysis gave significant different toward inter-location coral lifeform and observation location. The ecosystem consisted as massive (CM), foliose (CF), encrusting (CE) and *Acropora* branching coral (ACB) were dominantly coral types who living over there.

Keywords: Cooling water, coral branching, lifeform, temperature

INTRODUCTION

Hermatypic coral species, otherwise known as reef-building or hard corals, are often the dominant component of tropical reef systems. They were belongs to productive coastal ecosystem that had stenotolerant adaptive nature. It made them had narrow adaptation ability for environment factor changes. Diversity, distribution, and coral growth influenced by environment factors. Light intensity, level of exposure, water temperature, current, water turbidity, salinity, and suspended solid were physic-chemical factor that affected corals life (Supriharyono 2000; Mukhtasor et al. 2015). Corals with higher light environments providing faster growth conditions compared to growth of the same species in lower light environments. Light and levels of exposure are considered to be the key drivers of colony morphology as well as growth, although across global spatial scales, temperature also plays a role.

Distinguished from their colony morphologies or lifeform, coral grouped into *Acropora* and non *Acropora*, where they differed morphologically like coral branching, coral massive, coral encrusting, coral foliose, coral tabulate, mushroom (English et al. 1994; Tomascik et al. 2003; Suharsono, 2010). Certain coral lifeform was able to dominate in a kind of habitat, it depended on environment condition or habitat. The various corals colony morphologies provide the physical complexity that characterizes coral reefs

Coastal areas as reef habitat receive much heat water generated from industrial activity. Recently the most abundance waste discards of heat water produced by electric power plant activity. Amount 20 million meter cubic of it, more than 12^{o}C than sea water temperature, discharged by 1000 MW power plant (Mukhtasor 2007).

One of them was (total capacity >1000 MW) Paiton power plant at Paiton district, Probolinggo, East java province. The heat water reached 175 m^3/second for maximum discharge. It had amount average number and high temperature (around 6-8°C) compared with the sea water temperature (Saptarini and Muzaki 2010). It potentially destroyed marine organism, especially tropical organisms which were they live in tolerance temperature limit.

Coastal resources that affected by rising water temperature of the cooling water in Paiton district was coral reef. Coral reef susceptible threatened upon water temperature rising. They responded using physiological (feed declining response, decreasing photosynthetic comparison, and respiration), interactive and also response because indirect impact (Smith and Buddemeier 1992).

Coral colonies morphologies or coral life form rates of which vary greatly between species and between environments factor. The purpose of the present study is to understand coral lifeform various composition around power plant and cooling water outfall. The outcome used to consider cooling water management systems in coastal area, particularly with coral reef ecosystem in it.

MATERIALS AND METHODS

Area of study

Data sampling collected from five stations (sta-1 7°42'51.32"S; 113°35'59.46"E, station 2 $7^0$42’53.96”S; $113^0$35’48.86”E, station 3 7°42'39.37; $113^0$35’33.08”E, station 4 7°42'39.10S; 113°35'12.99 E, station 5 7°42'4.53"S; 113°34'23.96”E), around power plant at Paiton Sub-district, Probolinggo District, East Java, Indonesia. The sampling location determined by heat water extended spread over Paiton coastal (Mukhtasor et al. 2015). The location captured geographically in Figure 1.

Methods

The investigation method for coral reef is Line Intercept Transect (LIT). Field surveying of coral lifeform composition and coverage was conducted on May-August 2015. The Line Intercept Transect (LIT) method (English et al. 1994) was used to assess the community of the reefs. The community is characterized using lifeform categories which provide a morphological description of the reef community. The LIT is used to estimate the cover of a lifeform or group of lifeforms within a specified area. LIT method required coral lifeform determination skill so it could complete information related to coral community. It was use to array coral community structure based on hard coral, death coral (with algae), types of substrate, algae, others organism (sponge, soft coral) presence coverage (English et al. 1994; Ministry of Environment 2001).

On each station, we measured 20 m line intercept transects, with five transect at a depth of 3-5 m using fiberglass measuring tapes. At each point where the coral lifeform changed, the transition point in centimeters and the code of the life form was recorded. All hard corals intercepted by the transect were recorded and their maximal projected length were measured. An individual colony of a hard coral was defined as any colony growing independently of its neighbours. The intercept of each lifeform encountered under the transect is the difference between the transitions points recorded for each lifeform.

Water temperature is measured every month during the time of observation. The temperature was observed at the location of the reef and conducted at three depths are on the surface, water column and bottom.

Data analysis

LIT method describes the coral community structure by calculating the percent cover (% cover) substrate randomly. The composition of coral species used to determine variations of coral species and lifeform formed the community.

Every lifeform based on each category was calculated by formula:

$$\% \text{ coral coverage} = \frac{pk}{pt} \times 100\%$$

Pk is the total length of each coral life form category, consisted of hard corals. Pt is the total length of transect.

All categories of lifeform were calculated by formula:

$$ni = \frac{li}{L}$$

Ni is percent of all the coral life form coverage. Li is the total length from all categories of reef. L is the total length of transect

Coral coverage criteria referred to the Republic Indonesia Minister for Environment No. 04/2001 about standard for coral reef damage (Table 1).

Table1. Damage criteria for coral reef

Life coral coverage	Criteria
0-24.9 % living coral cover	Poor
25-49 % living coral cover	Fair
50-74 % living coral cover	Good
75-100 % living coral cover	Excellent

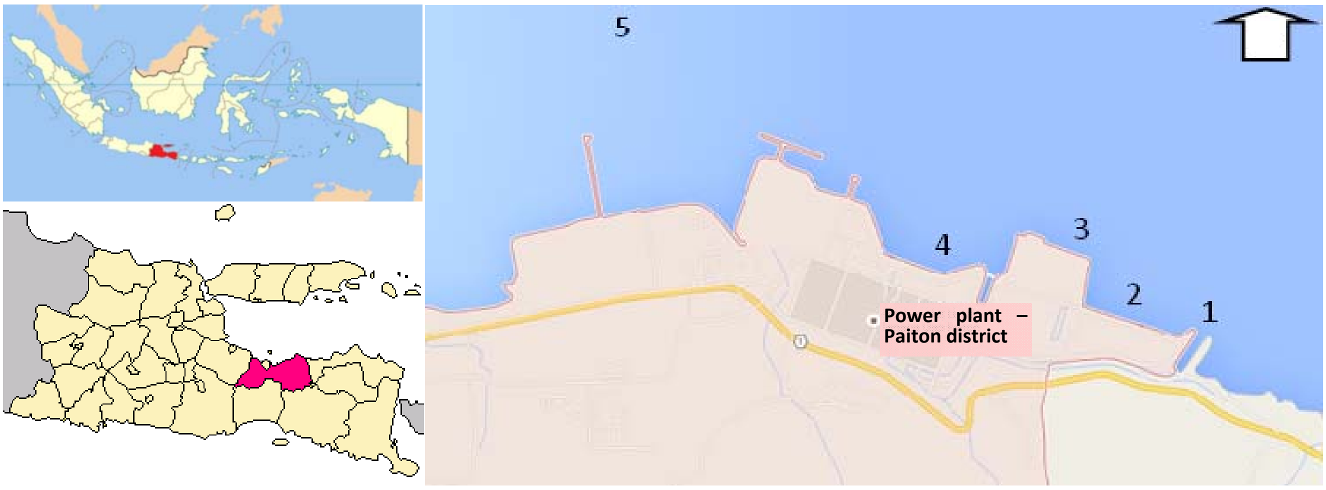

Figure 1. The research located at Paiton coastal of Probolinggo, East Java, Indonesia. Coral reef observation and physic-chemical parameter measured in five location

Statistic analysis

The influence of environment factor analysis (water temperature) to coral lifeform variations examined by *one-way* ANOVA.

RESULTS AND DISCUSSION

Coastal temperature condition

Temperature was a parameter that gave significant different result among research stations, compared to another physic-chemical water parameter (TSS, Salinity, and brightness) toward coral presence and growth in Paiton (Mukhtasor et al. 2015). Surfaces temperature had higher than others at station 1, and the distribution of high-temperature cooling water tends to lead the east side outfall. Landsat 8 visual analysis using using split window algorithm (SWA) showed the similar result that sea surface temperature near water outfall was higher than surround (Table 2) (Saptarini et al. 2015). It kept higher than coral growth optimum temperature which was 25°C-30°C (Dahuri et al. 2001).

High temperature improved toxic compound production for zooxanthellae, respiration, photo-inhibitio rate, feed behavior, reproduction, and larvae stock (Nakano 2004). Supriharyono (2000) argued that temperature changing suddenly at 4°-6°C above ambient level might reduce or even kill them. Healthy coral reef had acted to form their community structure. Limited larvae stock due to growth and reproduction troubles replaced dominant coral types (Nakano, 2004). The effect of elevated temperature on recruitment of corals including effect of temperature on production of coral planulae, effect of temperature on the planulae themselves and effect of temperature on settling and on the newly settled corals. Elevated temperature stimulates planula, but these planulae may be immature and less capable of survival. Coral with aggressive growth such as *Acropora arborescent*, often had influenced by high temperature (Loya et al. 2001).

Coral coverage

Since 2010, 2013 and 2015, coral coverage area tended to increase (Figure 2.A). The lowest coverage area occurred at 2010 with less than 50% percentage found in station 2 (37.70%) and station 4 (48.20%). Drought made warmer temperature and longer in time. Coastal temperature in Paiton from May, August, and December at 2010 reach 38°C near outfall area and normal coastal at ±32°C (Anon. 2010). Zooxanthellae released from coral due to bleaching process stimulating coral death, the rising of temperature above optimum rate moreover in longer time usually became the reason. Coral bleaching reported at 2010 by Saptarini and Muzaki 2010, it conducted because the algae losing in any or even all symbion algae population. Physiologically, bleaching phenomenon is due to the breakdown of the phototrophic mutualistic symbiosis between scleractinian corals and dinoflagellates endosymbionts (*Symbiodinium* spp.) commonly referred to as zooxanthelae. At the cellular level, coral bleaching refers to a substantial or partial loss of the endosymbiotic algae from the coral tissues, and the loss of photosynthetic pigment concentrations within zooxanthellae (Dupiol et al. 2009). During bleaching gate, coral had gone 60-90% of symbion, unfortunately algae was also lose 50-80% of their photosynthesis pigment (Glynn 1996). Lifelong or endless troubles made coral get passed away.

Table 2. The temperature of Paiton coastal, Probolinggo, East Java, Indonesia surfaces taken in 2010, 2013 and 2015

Year	Surfaces average temperature (°C)				
	sta-1	sta-2	sta-3	sta-4	sta-5
2010*	35	34	32.1	32	31
2013**	34.3	34	31.3	31.7	31
2015	33.5±0.85	32.3±0.75	31.4±0.41	32±0.57	31±0.5

Note: *Saptarini and Muzaki (2010); **Anon (2013)

Bleaching coral reefs normally recovered themselves when environment stressing decline, conducive, and recruiting again symbion algae. Those conditions had allegedly played at coral recovery in Paiton coastal area. According to hard coral coverage as main component of coral reef ecosystem there was increment coverage percentage that happened. Hard coral coverage percentage in averages for 2013 was 73.38% and 75.48% for 2015 at Paiton (Figure 2b). That informed what good coral condition over there. It was involve in recovery point after coral got stressed (Berumen and Prachet 2006).

Various composition of coral lifeform

There were three coral lifeform found for *Acropora* (branching-ACB, dgitate-ACD, tabulate-ACT) and amount six non *Acropora* (branching-CB, encrusting-CE, foliose-CF, massive-CM, mushroom-CMR, and submassive coral-CS) (Figure 3). Either *Acropora* or non-*Acropora* distinguished from axial coralite presence. Non-*Acropora* hadn't axial coralite but *Acropora* had both axial and radial coralite (Suharsono 2010).

There was various composition of coral lifeform in five locations. Hard coral (non *Acropora*) were more abundant in the coverage percentage rather than massive and encrusting coral. *Acropora* groups dominated at station 5 (Figure 3) with branching lifeform. The composition with more lifeform variation found at station 2, 3 and 4 compared to station 1 and 5. The high variations of coral life form found on stations 3 and 4, each with eight types of coral life form. Coral life form types on station 3 and station 4 is a massive coral, encrusting coral, *Acropora* tabulate, branching coral, coral and coral branching sub massive. In both these stations are the dominant life form types of coral massive coral. This indicates that the water quality of support for the growth of juvenile coral and massive coral growth. As for the three other stations, kind of life form in each station varies. Station 1 is dominated by the massive coral life form. Some types of coral life form in station 2 found in the percent cover on average 13-17%, i.e. life form coral massive, *Acropora* tabulate and coral foliose. This indicates if environment condition supported various types of coral growth of a type of non-*Acropora* and *Acropora*. This is consistent with Nakano (2004) that healthy coral reef had acted to form their community structure. Station 5 has a high coral cover but has a low variation lifeform. Type dominant lifeform on station 5 is the type of branching *Acropora*. There are differences in the composition of coral life form on the location affected with heat water produced by cooling water. ANOVA analysis performed significant differ (α<0.05) from lifeform in each location sampling with different temperature.

Coral that composed reef distinguished at sensitiveness level toward different environment stress. Temperature, water depth and current had allegedly influence that variation. Fluctuating condition affected growth level, lifeform, and coral multiplying (Kleypas et al. 1999), finally gave impact toward abundance, composition, and coral diversity (Baker et al. 2008). Station 1 had closed to heat water location produced higher temperature above in average than others.

Lifefrom composition at location 1 gained more massive coral (Figure 4). It had good endurance in temperature pressure than branching form. It, *Porites* spp, acknowledged able to recover over bleaching process although coral death still found (Rani 2001). Branching coral had more sensitive upon temperature challenge within environment so that above normal current changing of temperature might capture as soon as possible (Gleason and Wellington 1993; Nakano 2004). According to Hughes (1985), the genus *Acropora*, *Pocillopora* which usually recruit in larger numbers and are more sensitive to disturbances and so they are better indicators of whole coral community state than corals that are more sustainable, like most of the massive corals such as *Favia*, *Favites*, *Goniastrea*, and *Diploastrea*. Whereas at station 5, ± 2 km in distance from heat water entry location, branching *Acropora* performed domination (temperature stable at 29°C) (Figure 3). According to Sadhukhan (2012) higher diversity means longer food chains and more cases of symbiosis (mutualism, parasitism, and commensalism) and greater possibilities for negative feedback control which reduces oscillations and hence increases stability and species diversity.

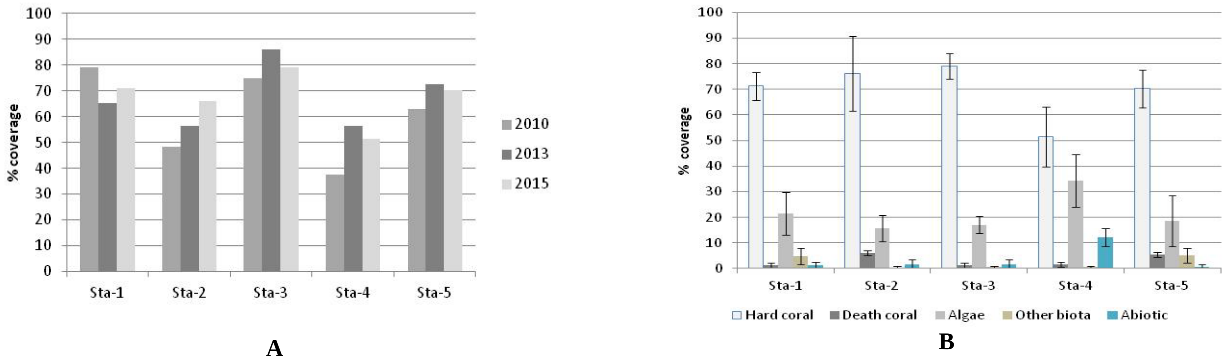

Figure 2. Coreal coverage in Paiton coastal of Probolinggo, East Java, Indonesia. A. Hard coral coverage of, B. Organism coverage

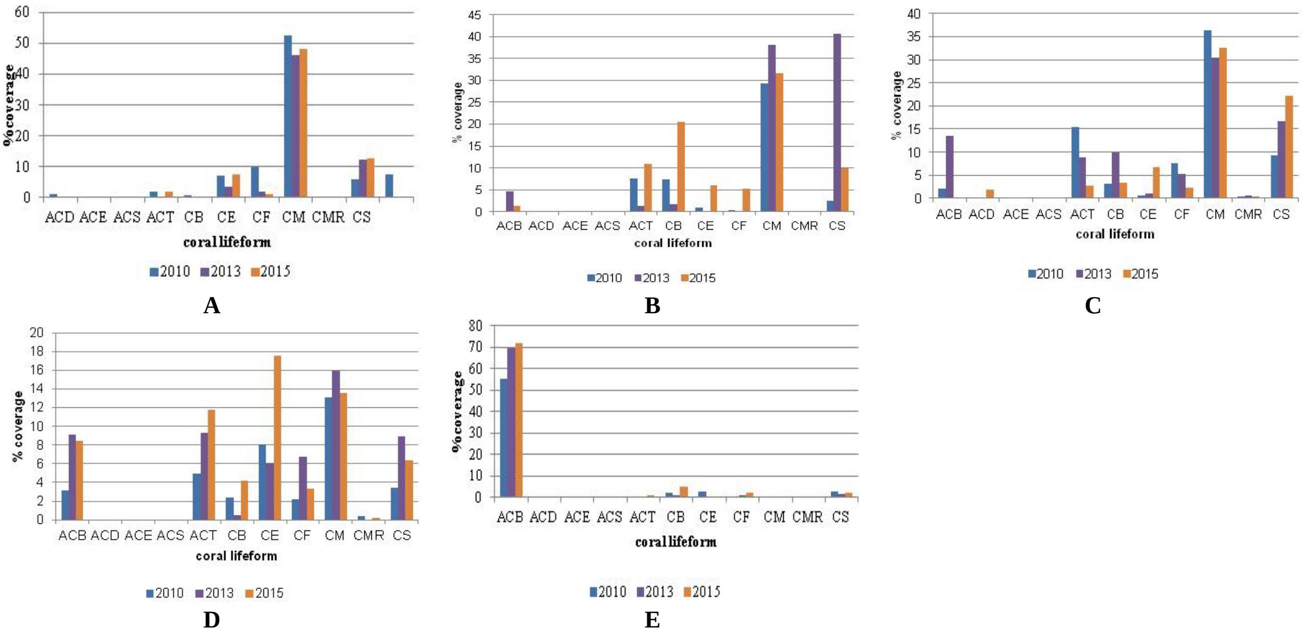

Figure 3. Lifeform composition at Paiton coastal of Probolinggo, East Java, Indonesia. A. Station 1, B. Station 2, C. Station 3, D. Station 4, E. Station 5.

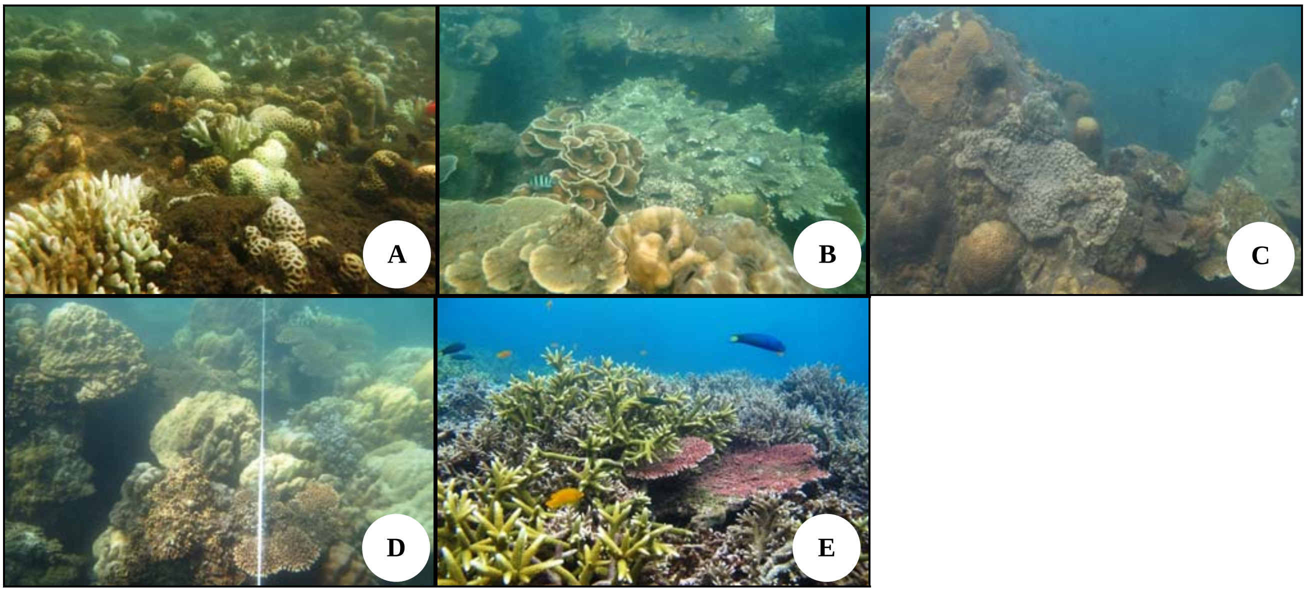

Figure 4. Coral diversity and lifeform variation at Paiton coastal of Probolinggo, East Java, Indonesia. A. Station 1, B. Station 2, C. Station 3, D. Station 4, E. Station 5.

Heat water temperature that produced by steam power plant of Paiton activity influenced significantly toward variation and composition of coral lifeform. Costal water which impacted by heat water had dominated by massive coral lifeform, while branching coral had abundant in heat water absence.

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