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THE MEASUREMENT OF CHLOROPHYLL A CONCENTRATION IN THE COASTAL WATERS ADJACENT TO KARANGANYAR SHRIMP PONDS, TUGU SEMARANG

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ABSTRACT

In order to determine the extent of eutrophication due to pollution of organic matter from brackishwater shrimp ponds, on the North coast of Central Java, chlorophyll a and nutrient concentration were measured in nearshore waters. It was revealed that ***chlorophyll*** *a contents in the study area were considerably high, ranging between 83 and 332 µg/l. The evidence of eutrophication was also supported by the relatively high level of nutrient, in which nitrate levels ranged between 1.295 and 2.060 mg/l and phosphate ranged between 0.093 and 0.270 mg/l. The relationship of chlorophyll a and nitrate indicated negative of chlorophyll a and phosphate also indicated negative correlation with regression : P = -0.2587 Chl a + 0.1945. This suggests that the increase in chlorophyll a is accompanied by a reduction of both nitrate and phosphate, which may be caused by luxurious consumption of nutrient by phytoplankton in the surface water.*

Keywords: shrimp aquaculture ponds, eutrophication, coastal pollution, Central Java

I. INTRODUCTION

The production of shrimp ponds in Central Java has decreased by 18.09% , from 36,291.90 in 1995 to 29,726.40 in 1996. It is suspected that the decline is due to the degradation of environment around shrimp ponds, which is caused by water pollution and disease outbreaks (Kartono and Sartono, 1997). The pollution is considered derived from the discharge of water from shrimp ponds, which is very rich in phosphorus and nitrogenous compounds and organic matters. In addition, the high concentration of organic matter could be a supporting factor for the development of particular bacteria such as *Vibrio sp.*

It is suspected that the vast area of shrimp ponds has produced considerable amount of pollutant of organic matters and phosphorus and nitrogenous compounds to the adjacent water body. It seems that the capacity of the water to purify the water has been surpassed. The phenomenon in which the water is very rich in nutrient such as phosphorus and nitrogenous compounds, as well as organic matters is commonly called eutrophication. This problem is sometimes reflected in increased aquatic plant, but usually in increased phytoplankton growth.

Increased phytoplankton crops may cause tastes and odors in the water through secretion of various organic compounds. They may produce substances toxic to fish and shrimps. Organic matter settling from the increased phytoplankton crops may increase the rate of deoxygenating in the river/sea bed. If the water become anaerobic and rich in sulfides it may be unusable for water supply for shrimp pond.

Chlorophyll a concentration in water could be used to determine phytoplankton standing stock that is an important indicator of primary productivity. The measurement of chlorophyll a concentration is an alternative approach to consider that the phytoplankton basically is primary producers and the estimation of the concentration of photosynthetic pigment in the algae is a measure of their abundance. The expression of chlorophyll per unit area is a particularly useful indicator of the total abundance of photosynthetic organisms in the water as the concentration per unit volume varies with depth since the phytoplankton are rarely homogeneously distributed. Moss (1993) suggested that the concentration of phosphorus in water body could be related readily to either mean or maximum chlorophyll a concentration. Knowledge of chlorophyll in water body could be used to determine the primary productivity and also as an indicator of aquatic productivity.

II. OBJECTIVES

The goal of this research is to (1) determine chlorophyll a levels in the coastal water adjacent to Karang Anyar Shrimp Ponds, as a proxy measure of primary productivity and the occurrence of eutrophication; (2) Collect information on physical and chemical properties of the water such as transparency, salinity, current, pH, temperature, phosphate, ammonia and dissolved oxygen, that can then be used to determine whether the water is suitable as water sources for shrimp culture; (3) Investigate the relationship between phosphate and nitrate levels and algae crop as indicated by chlorophyll a level.

III. METHODOLOGY

The concentration of chlorophyll a was measured along with some hydrological parameters such as: salinity, temperature, pH, alkalinity, current, transparency, phosphate, nitrate and dissolved oxygen. Salinity, DO, temperature, pH, current and transparency were determined at the field station using standard methods. The samples for nitrate and phosphate were preserved with sulfuric acid and chilled and then analyzed within 24 hrs following Spotte (1979). Alkalinity was measured following Spotte (1979). The location of the research was coastal waters adjacent to Karanganyar, Tugu Semarang. There stations were chosen: station I, located at the mouth inlet channel of shrimp ponds (tambak); station II, located at coastal waters close to the tambak; and station III, located at the outlet channel of the Tambak. Water samples were collected just below the surface (to a depth of ±0.5 m). Samples were collected four times daily (at 06.00, 12.00, 18.00, and 24.00 o'clock), Which was repeated three times with an interval of three weeks.

The determination of chlorophyll a concentration was conducted following Parsons et all (1992). The analysis of chlorophyll a content and water quality were conducted in the Laboratory of Pure Science Faculty, UNDIP Semarang.

The data collected from the three stations were then compared and presented descriptively using chart and tables, along with other hydrological parameters mentioned above. The relationship between chlorophyll a concentration and phosphate as well as nitrate level is determined using standard statistical regression analysis.

IV. RESULTS

4.1. Chlorophyll a (Chl a) Concentration & transparency

Chl a concentration in the study area, in general, was relatively high, ranging between 83 and 332 μg/l. The value varied diurnally, with the maximum at 12 am (286 μg/l in average) and the minimum at 12 p.m. (92.3 μg/l in average) (Fig. 1a)

Secchi transparencies were relatively poor (39 - 57.5 cm). During mid-day the water slightly cleared in station I, but remained relatively constant in station II and III. This coincides with the rise in Chl a concentration in the three stations (Fig. 1b)

4.2. Water temperature and Dissolved Oxygen (DO)

The coastal waters, because of its shallowness, responded rapidly to diurnal air temperatures (Fig. 2a). Surface water temperature reached at least 31.5° C during midday and dropped to 28°C in the morning.

The surface water was well oxygenated at the times sampled. DO concentrations were quite high (7,8 ppm) during mid-day. AT night, DO concentration slightly dropped to 6,4 ppm during the period of between mid-night until morning. Supersaturation occurred in mid-day and afternoon (Fig. 2b).

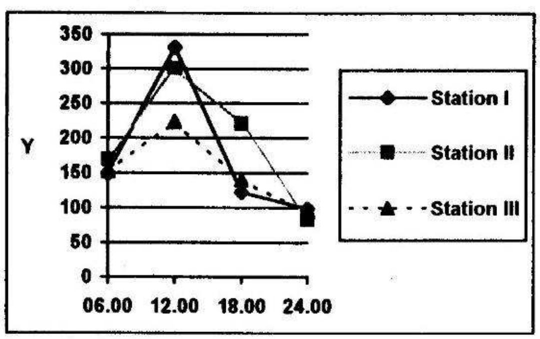
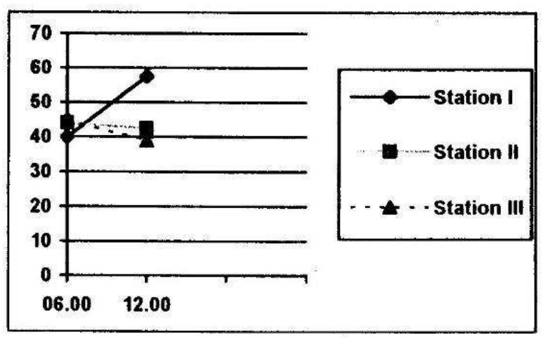
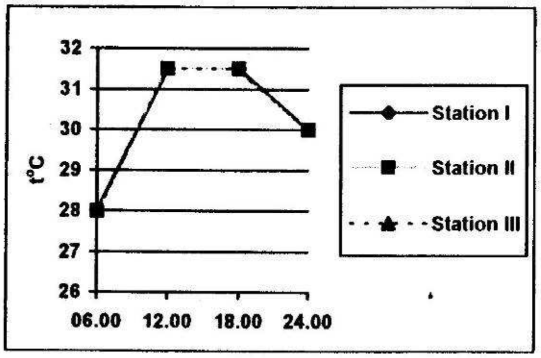


Fig 1.a. Chlorophyll a concentration



b. Transparency



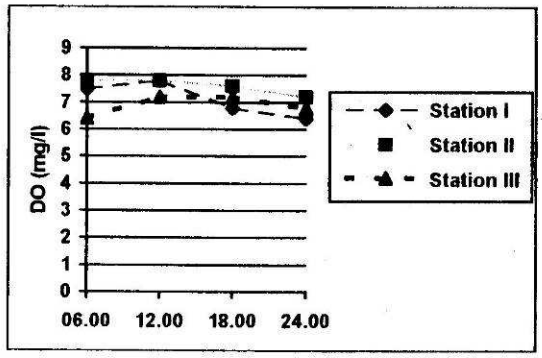


Fig. 2a. Surface water temperature b. DO content

4.3. Nitrate and Phosphate

Nitrate was generally high (1.295 - 2.060 mg/l). The greatest value was found in station II at 06.00 pm (2.060 mg/l), whereas the lowest was observed in station III at midday.

Phosphate was relatively high in the morning (0.187 - 0.270 mg/l) and dropped during midday (0.093 - 0.166 mg/l) and afternoon (0.110 - 0.131 mg/l). It rose again at night in station III, but relatively constant in the two other stations (Fig. 3b)

4.4. Alkalinity and pH

Alkalinity varied between 43.60 - 135.66 mg/l $CaCO_3$. Alkalinity was lowest in the morning (43.60 - 101.74 mg/l $CaCO_3$) and was highest during mid-day (62.98 - 116.28) and mid-night (77.52 - 135.66)

The value of pH was relatively stable (7-*) during the period of study. The highest pH was found at 12 am and 18.00 (Afternoon). This may be related to photosynthesis that tends to increase pH.

4.5. Current Velocity and Depth

The current velocities in the study area were generally slow. In station I current velocities ranged between 0.208 - 0.277 m/sec, in station II between 0.116 - 0.266 m/sec, and in station III between 0.228 - 0.288 m/sec. In this case, water current is closely connected to tidal movement (Fig. 5a).

In coastal waters, depth varies according to tidal movement. Depth measurement in the study area showed that in station I the depth ranged between 87.5 - 97.5 cm, in station II between 65 - 92.5 cm, and in station III between 89 -97.5 cm. (fig. 5b)

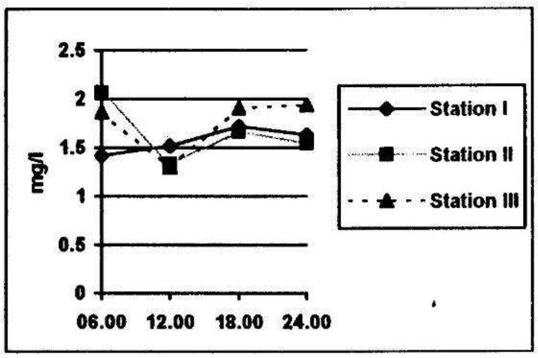


Fig. 3a. Nitrate

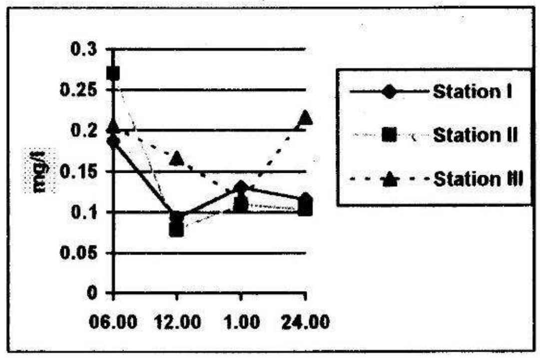


Fig. b. Phosphate

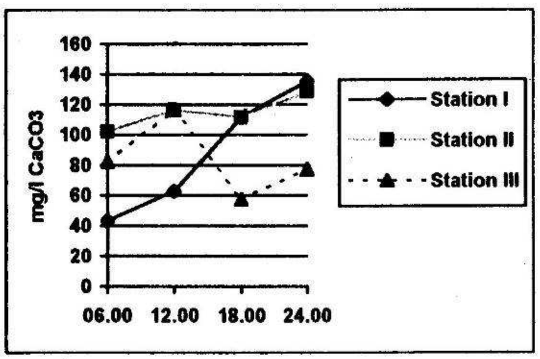
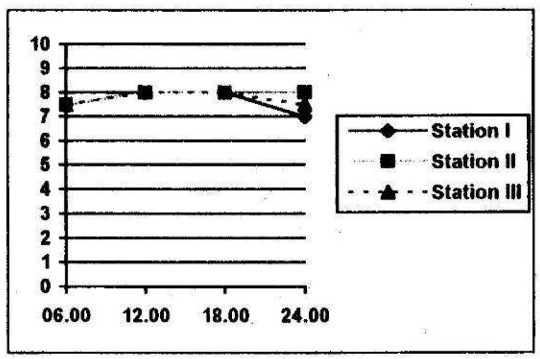


Fig. 4a. Alkalinity



b. pH level

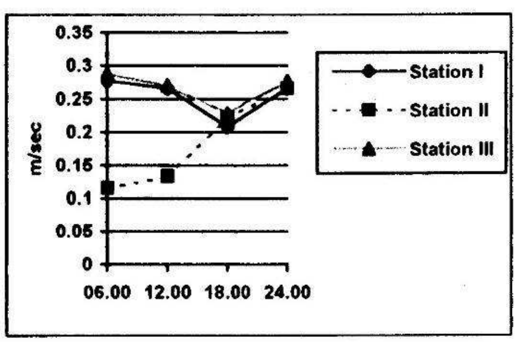
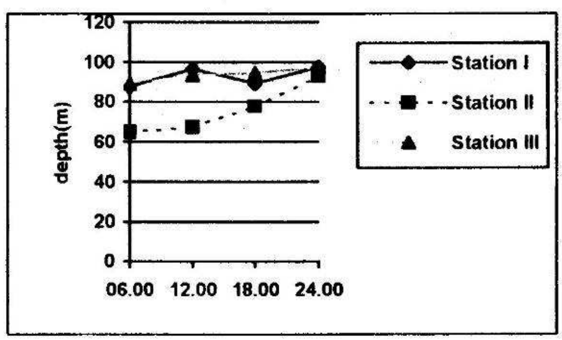


Fig. 5a. Current velocity



b. Depth

V. DISCUSSION

The coastal waters of Karang Anyar are very close to a vast area of shrimp ponds. Every year, it receives large quantities of waste from the adjacent shrimp farms. Recently, the effect of waste discharge is suspected to reach a dangerous level that adversely affects the coastal environment. This has lead to the decrease in shrimp production in the past several years. In order to determine the extent of eutrophication due to pollution of organic matter from the shrimp ponds and its impact on the receiving water body chlorophyll a and nutrient concentration were measured.

From the above results, it was concluded that in the three station the Chl a concentration was quite high in general, with the minimum at 12 pm and maximum at 12 am. From this, Chl a content appears to be closely related to photosynthesis processes in water, which is performed mainly by phytoplankton. Strickland and Parsons (1968) suggested that phytoplankton is the only source of Chl a in the water. Therefore, the role of light intensity is very significant in determining the Chl a content despite some other limiting factors, such as nutrient and suspended matter.

Based on the average value of Chl a concentration during the observation, it was found that the value is largest in station II (adjacent waters), followed by station I (inlet), and station III (Outlet).

The Chl a content in station III was, actually, expected to be highest than that of elsewhere due to excessive amount of organic matter from the tambak (brackish water fish pond) which in due course will be converted into nutrient and further utilized by phytoplankton. However, after examining some physical characteristic of the water in the study area, it was revealed that there were some factors that might contribute to the existing condition. For example visual observations indicate that the current in station III was more significant than elsewhere. Water current might play an important role in distributing phytoplankton and nutrient to the surrounding waters (Wickstead, 1965). Dugdale et al (1972) found that the pattern of nutrient distribution varied widely at different times, which is probably primarily in response to the wind induced current. As a result, the abundance of phytoplankton is also affected. Current may also affect water turbidity, which in turn affect the amount of light penetrating into water column (Russel and Hunter, 1970 *in* Haribowo, 1980). According to Raymont (1963) current could have significant effect on the water clearance, and this might reduce the rate of phytoplankton growth.

Another factor that might affect the existing condition is water transparency. Poor transparency of the water might significantly hinder photosynthesis process. This is suspended due to excessive amount of suspended solids of organic and inorganic matters from the wastes of tambaks. As a result, the photosynthesis process was hampered, which in turn affects the chlorophyll formation in the phytoplankton. According to Pillay (1992) turbidity and availability of light, as well as current and flushing time may affect the utilization of nutrients by phytoplankton. High turbidity of the water may adversely affect the photosynthesis process. The Turbidity may be attributed to:

1. Effluent discharge from tambak.

According to Pillay (1992) effluent discharge from aquaculture operation usually consists of solid and soluble wastes. Solid wastes may be in suspended form or may accumulate on the sediment, and consist mainly of organic carbon and nitrogen compounds. The main source of solids is the fecal matter of fish/shrimp cultures and the wastage of feed provided. Soluble wastes are mainly the metabolic products of the cultured stock.

2. *The considerable amount of suspended matter in the water*

The study area is adjacent to an estuary. The typical feature of an estuary is the large amount of suspended matter in the water. Much sediment from the catchment area is transported to the estuary. Also there are strong erosional forces from the tidal movement, which change their direction 4 times a day, which promote an alternation of resuspension and sedimentation. This might cause a maximum amount of suspended matter to remain which make the water extremely turbid.

Nutrient concentration (phosphate and nitrate) in the study area was also thought to significantly affect the Chl a concentration and distribution in the study area. In general the nutrient levels were moderate to high. The nutrient content usually has a close relationship phytoplankton production that affects the Chl a concentration. The nitrate level was found highest in station III (Outlet), which is suspected to be caused by metabolic wastes and feed residue from tambaks. At mid-day the level slightly decreased, which might be caused by its luxury utilization in photosynthesis process. The nitrate concentration in the study area was considered optimum for the growth of phytoplankton. According to Chu *in* Wardoyo (1982) nitrate concentration of 0.9 - 3.5 ppm is best for the growth of phytoplankton, and a concentration under 0.01 and above 4.5 ppm might become limiting for the growth there of.

In average, phosphate concentration was highest in station III. This was also deemed to be caused by effluent discharge from tambaks. It was also noticeble that the lowest concentration in the three stations was found at 12 am, during which the phosphate utilization for photosynthesis is at the maximum. Phosphate level in the study area indicates that aquatic productivity is good, as suggested by Joshimura *in* Wardoyo (1992). It was suggested that phosphate concentration of 0.10 - 0.20 mg/l indicated that the productivity of the water is very good.

Relationship between Chl a and Phosphate and Nitrate

Fig. 6 shows Phosphate plotted against Chl a. Phosphate concentration was greater when Chl a was low. Regression analysis indicated a poor linear for the above relationship. Phosphate and Chl a levels were related by poor regression (R2 = 0.1242); the equation was P = -0.2587 Chl a + 0.1945.

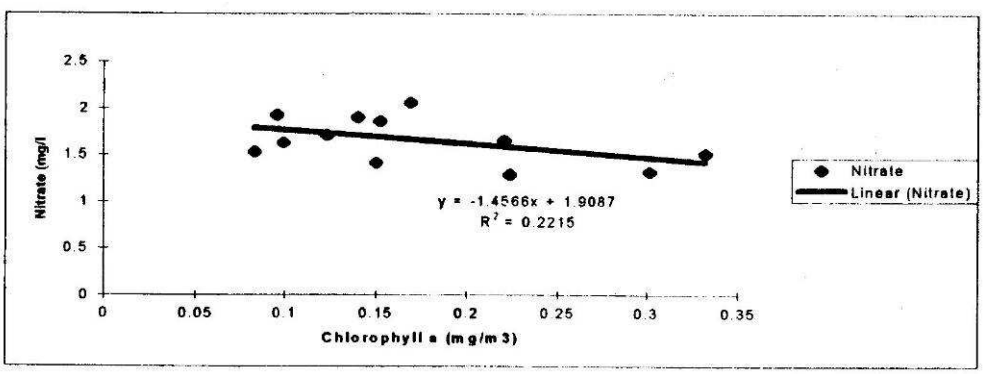
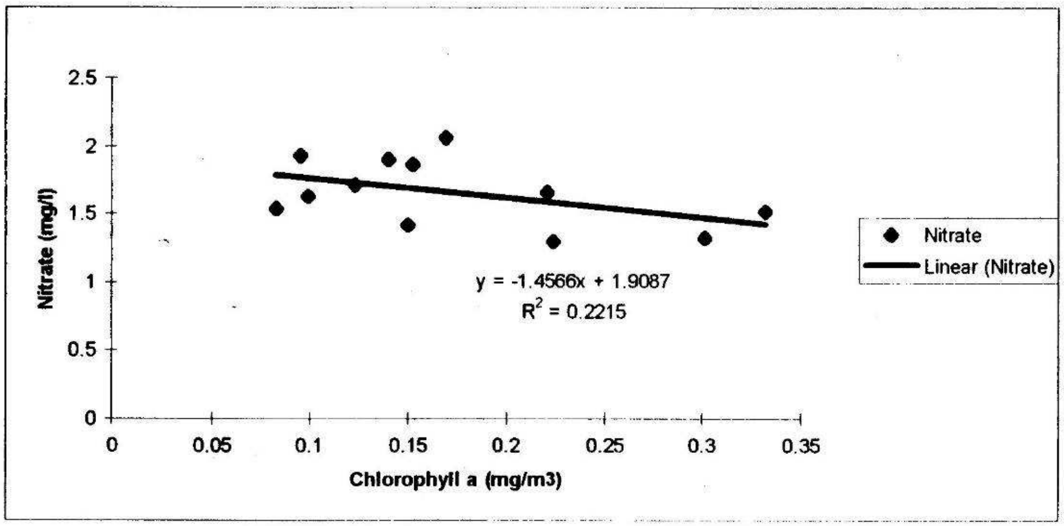


Fig. 7 indicates Nitrate plotted against Chl a. Regression analysis also suggests a poor linear relationship (R2 =0.2215) with the following equation N = -1.4566 Chl a + 1.9087. This suggests that nitrate concentration were lower when Chl a level was high.

The above evidence is not surprising since the phosphate and nitrate were analyzed from surface water, in which the rapid utilization of nutrients by phytoplankton is maximum. James and Head (1972) found that during spring bloom the increase in Chl a was accompanied by a rapid reduction of phosphate & nitrate from the surface waters.



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