La mer 37 : 91-101, 1999
Société franco-japonaise d'océanographie, Tokyo

# Seasonal variation in water quality at the northern coast of Karawang-West Java, Indonesia

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**Abstract :** Observation of seasonal variation in water quality at the northern coast of Karawang-West Java was conducted during the wet and dry seasons. The observation was focused on the monitoring of physical, chemical and biological characteristics through the season. Water quality was found to be mainly associated with seasonal change of precipitation and wind-driven current. An indication of water quality degradation toward to the eutrophication is obviously visible in the wet season by indicating high concentration of chlorophyll-*a*(>4.0 $\mu g/\ell$)at the area adjacent the coastal line. High precipitation in the wet season has affected on the excessive discharge of the organic waste with high level of DIN and $PO_4$ and it caused the enrichment of the coastal water. The residual agriculture and aquaculture organic waste were suspected to be main source of water quality deterioration in the observation area.

**Key words** : *seasonal variation, water quality, northern coast of Karawang.*

## 1. Introduction

The northern coast of Karawang, West Java is situated at 60 km of east Jakarta in the northern part of West Java (Fig.1). The land area mostly comprised of the rice field. Due to the potentiality, since 1985 land area along the shoreline has been gradually converted into shrimp pond with an intensification system. On the early stage, this system had provided a great contribution on shrimp production for the region with the average production rate of 4 ton/ha. However, after one decade, the production dramatically decreased less than 1.5 ton/ha. Rapid development of shrimp culture within this region and uncontrolled utilization of foodstuff as well as agriculture medicines and chemicals supplied an appreciable pollution and caused the degradation of water quality in the coastal water. This water quality deterioration ultimately generated a various diseases (PHILLIPS *et al*, 1993) threatening a shrimp live since the early stage of the cultivation to the pre-harvest stage.

To overcome such environmental deterioration in this region and to preserve the area for sustainable development, an integrated coastal management by introducing an innovative advanced science and technology is necessary to be established. The occurrences of water quality degradation due to the expansion of an intensive shrimp culture in the several areas have been reported (PILLAY, 1992; FLAHERTY and KARJANAKESORN, 1995; CHUA, 1993; GOWEN and ROSENTHAL, 1993), but for the northern coast of Karawang it is still very limited. Since the performance of shrimp culture yield is considered to be a problem within this region, a systematic understanding of water quality status in different seasons is important to be clarified in order to provide a better and proper management of shrimp culture in the future. As a part of this object, our paper describes a seasonal variation of water quality based on a physical, chemical and biological characte-

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ristics in the wet and dry seasons as a basic information to improve shrimp culture management within the northern coast of Karawang.

## 2. Observation

Observations to obtain a series of water quality data in the wet and dry seasons were conducted by using a small boat. The surface water sampling using a plastic bucket and direct measurement of some physical parameters (water temperature, transparency and salinity) in the wet season were carried out at 07 am –03 pm (flood tide) on 5 April and 07 am–03 pm (ebb tide) on 8 April 1993. Tidal range on 5 April was 70 cm and that on 8 April 80 cm. While in the dry season, the similar activities were also conducted at 07 am–03 pm (ebb tide) on 5 August and 07 am–03 pm (flood tide) on 9 August 1993. Tidal range on 5 August was 60 cm and that on 9 August 80 cm. The study area is located at the Northern Coast of Karawang-West Java with the geographical position 6° 03′ 00″–6° 11′ 00″ south and 107° 22′ 00″–107° 22′ 30″ east. The sampling stations consist of 13 stations in the coastal water and 9 stations at the river and shrimp pond in the land area (Fig. 1).

Water temperature was directly measured in the field by thermometer, salinity by salinometer and transparency by Secchi disk. Chemi-

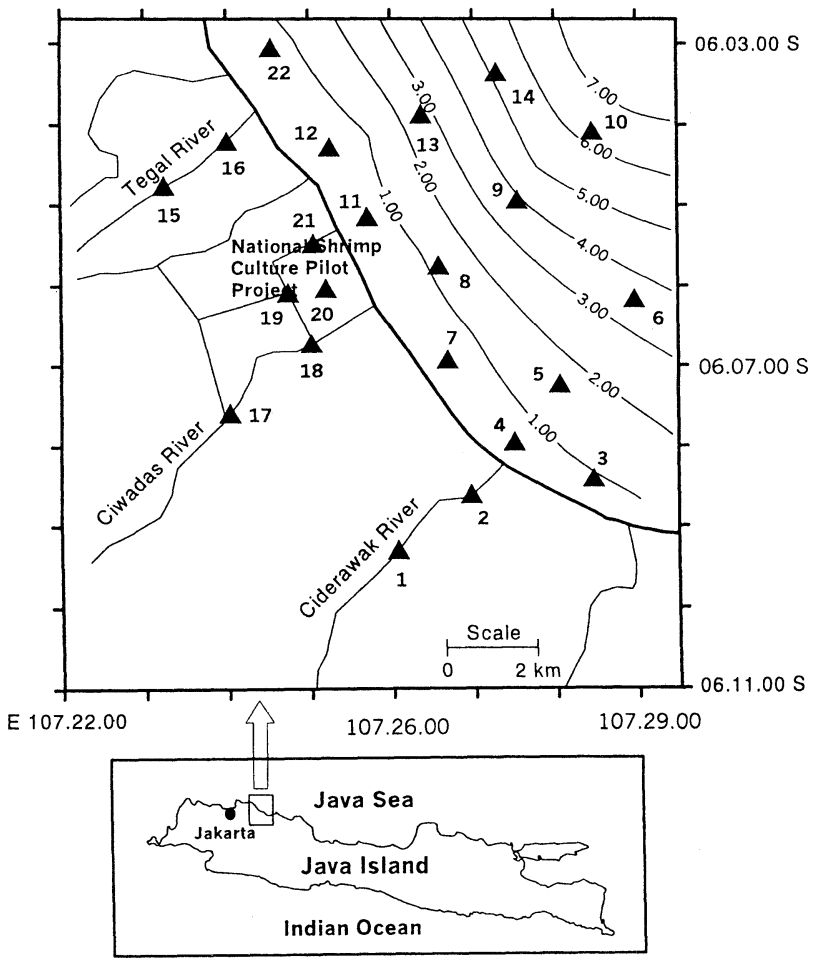


Fig. 1. Observation area, sampling stations and depth contour (in meters) of the northern coast of Karawang-West Java.

cal and biological parameters were measured in the laboratory. Total suspended solid (TSS) was measured by gravimetric method, dissolve oxygen (DO) by winkler method, dissolve inorganic nitrogen (DIN) composed of nitrate, nitrite and ammonium were measured by spectrophotometric method as well as phosphate ($PO_4$) and chlorophyll-*a* (PARSONS *at al*, 1984). The averaged date derived from flood and ebb tide measurements of each season were then analyzed to obtain an information of seasonal variation of water quality. The simple cluster analysis was also employed to clarify the effect of seasonal change of weather on the water quality (MAGURRAN, 1988).

## 3. Results

### 3. 1. Physical parameters

As shown in Fig. 2, the surface water temperature in the wet season, which is averaged from flood and ebb tide observation, is relatively higher than that in the dry season.

The surface water temperature in the wet season and that in the dry season are within a range of 30.5 to 32℃ and 29.5 to 31℃, respectively. Water temperature in the northwestern part is higher than that in other parts in the wet season, while water temperature in the northeastern part is higher than that in other parts in the dry season. In the contrary, salinity in the wet season is lower than that in the dry season. Salinity in the wet season is within a range of 13.00 to 23.00 psu and that in the dry season is within a range of 23.00 to 27.00 psu. Surface water density governed by temperature and salinity in the wet season is also lower than that in the dry season with the value within a range of 3.0 to 13.0. While that in the dry season is within a range of 11.0 to 15.0.

Water transparency in the wet season is lower than that in the dry season as shown in Fig. 3. Water transparency in the wet season is within a range of 10 to 60 cm for coastal water and 5 to 34 cm for land area. In the dry season, water transparency is within a range of 20 to 110cm for coastal water and 9 to 68 cm for land area. On the other hand, total suspended solid (TSS) concentration in the wet season is higher than that in the dry season. TSS concentration of coastal water and land area in the wet season is within a range of 2.60 to 3.40 g/ℓ and 1.72 to 2.96 g/ℓ, respectively. In the dry season, TSS concentration is within a range of 0.40 to 2.40 g/ℓ for coastal water and 0.50 to 1.43 g/ℓ for land area.

### 3. 2. Chemical parameters

As shown in Fig. 3, dissolved oxygen (DO) concentration indicated the characteristic pattern in both seasons, e.g. it is high at the front of shrimp pond. In the wet season, DO concentration is relatively higher than that in the dry season. DO concentration is within a range of 5.70 to 6.30 mg/ℓ for coastal water and 3.82 to 7.85 mg/ℓ for land area in the wet season. In the dry season, DO concentration is within a range of 5.60 to 6.20 mg/ℓ and 3.42 to 8.04 mg /ℓ for coastal water and land area, respectively.

Dissolved inorganic nitrogen (DIN) derived from nitrate plus nitrite and ammonium, and phosphate ($PO_4$) distributions are shown in Fig. 4. DIN concentration of coastal water is within a range of 0.80 to 0.95 mg/ℓ in the wet season and 0.75 to 0.95 mg/ℓ in the dry season. DIN concentration of land area in the wet season is within a range of 1.33 to 2.07 mg/ℓ and 0.75 to 1.40 mg/ℓ in the dry season. Higher concentration of DIN in the wet season is distributed more widely than that in the dry season with the highest concentration to be appeared in the area along the coastal line. $PO_4$ concentration of coastal water is within a range of 0.36 to 0.41 mg/ℓ in the wet season and 0.35 to 0.40 mg/ℓ in the dry season. While in land area, $PO_4$ concentration is within a range of 0.41 to 0.59 mg/ℓ in the wet season and 0.38 to 0.51 mg/ℓ in the dry season.

### 3. 3. Biological parameters

Chlorophyll-*a* as one of the marine algal's pigments is important in order to understand the marine algal's status in relation to the environment condition in the certain area. Seasonal variation of this pigment will also provide an information of the water quality status. As shown in Fig. 4, chlorophyll-*a* distributions are drastically different in seasons. In the wet season, chlorophyll-*a* concentration is within a range of 3.50 to 6.00 μg/ℓ for coastal water and

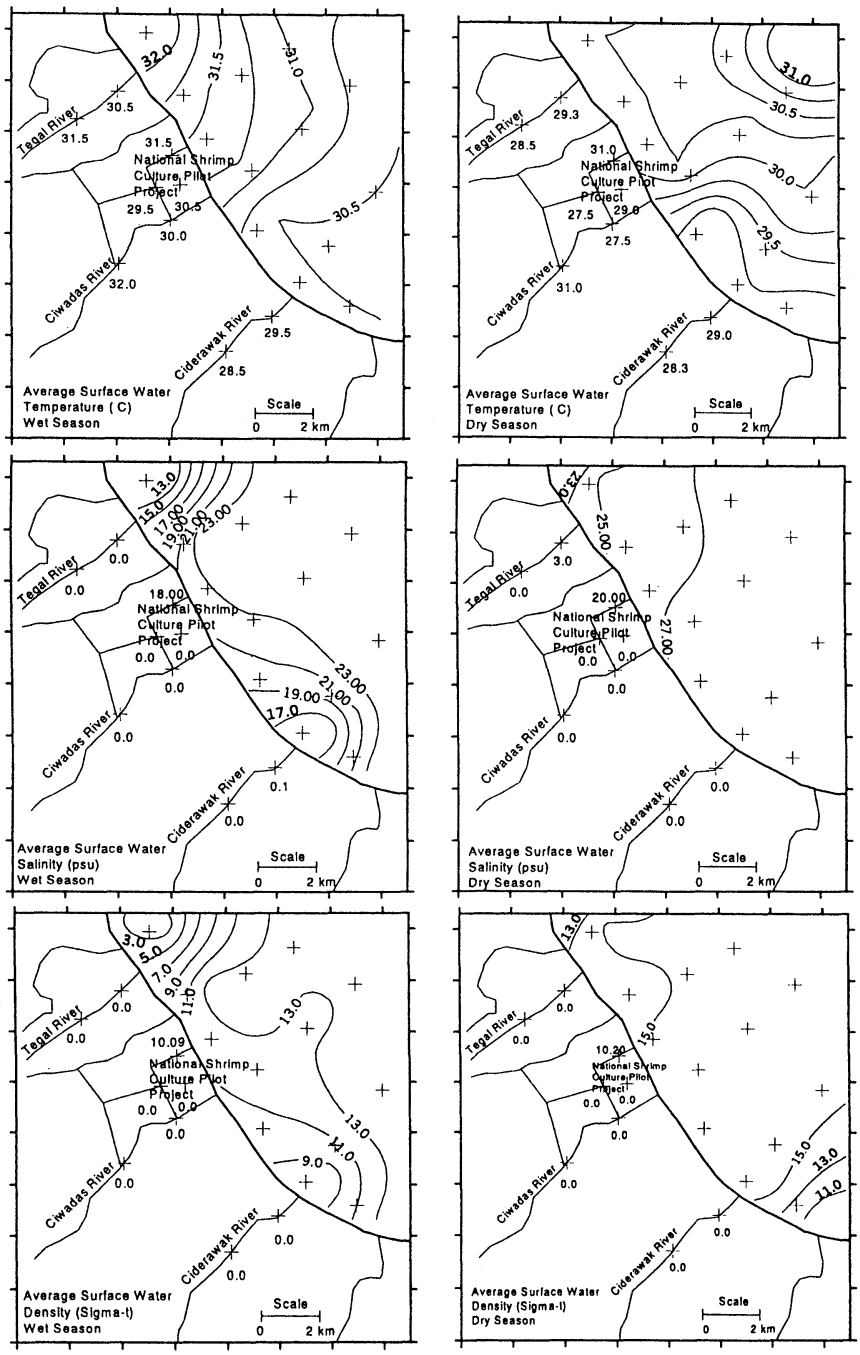


Fig. 2. Surface water temperature (℃), salinity (psu) and density (sigma-t) in the wet (April 1993) and dry (August 1993) seasons.

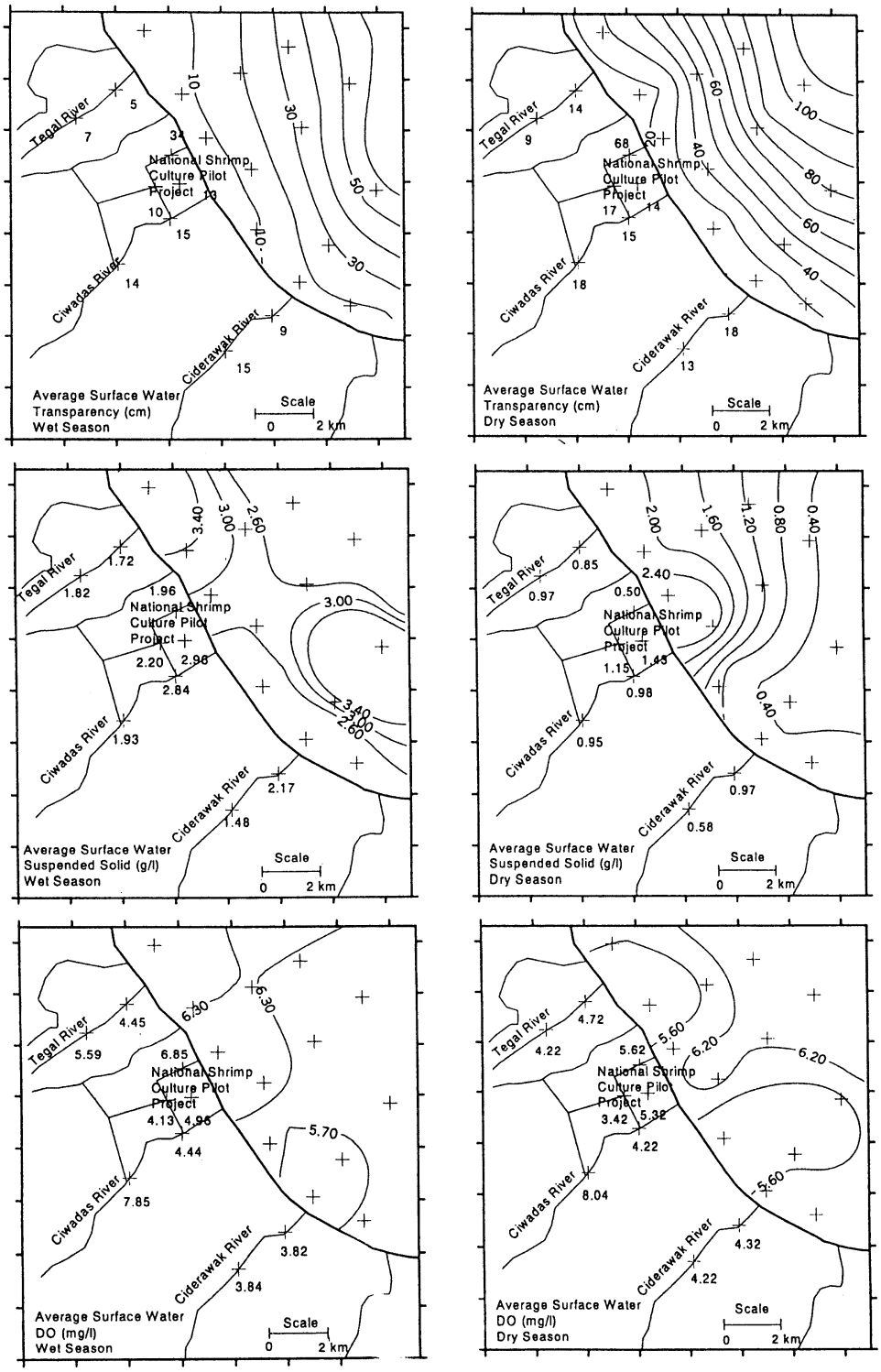


Fig. 3. Surface water transparency (cm), total suspended solid (g/ℓ) and dissolved oxygen (mg/ℓ) in the wet (April 1993) and dry (August 1993) seasons.

0.60 to 2.90 $\mu g/\ell$ for land area. However, in the dry season, chlorophyll-*a* concentration is extremely low within a range of 0.30 to 0.55 $\mu g/\ell$ for coastal water and 0.10 to 0.90 $\mu g/\ell$ for land area. A high discharge in the wet season has increased the DIN and $PO_4$ load into the river body and generated an algal bloom. It is obviously visible in the vicinity area of the Ciderawak, Ciwadas and Tegal rivers where chlorophyll-*a* concentrations are higher than those in other areas.

## 4. Discussion

The northern coast of Karawang as a coastal zone area is one of common areas in the world, where the environmental conditions are affected by the terrestrial and marine environmental conditions. As a tropical area where the seasonal change between the wet and dry seasons strongly influences the environmental situation, terrestrial and marine conditions are also responsible on the environmental status. Their influences indicated the different situation of the water quality between those seasons. In the wet season, surface water temperature was relatively higher than that in the dry season. It may be due to stronger solar radiation and higher air temperature in the wet season. Though there is no data of solar radiation and air temperature in 1993, we have an average data of 1931–1960 for Jakarta area obtained from Indonesian Meteorological Agency as shown in Fig. 5. We suppose that the solar radiation and air temperature in April 1993 was stronger than that in August 1993 and this is the primary reason why the sea surface water temperature in April 1993 was a little higher than that in August 1993. The similar situation was also reported by SETIAPERMANA *et al* (1992) where the sea surface water temperature in the wet season is relatively higher than that in the dry season. Nevertheless, more detailed investigation to confirm such situation has to be continued by measuring supported parameters such as heat flux.

Surface water salinity in the wet season (April 1993) as well as its density is relatively lower than that in the dry season (August 1993). As shown in Fig. 2, the salinity and density level in the area near the mouth of Ciderawak, Tegal and Ciwadas rivers are lower than those in other areas of the coastal water. The influence of river discharge caused the dilution of salinity and density level. This situation occurred due to the high precipitation level in the wet season as shown in Fig. 5.

The effect of seasonal variation of precipitation on the water turbidity and transparency was clearly visible in Fig. 3. The total suspended solid (TSS) concentrations in both coastal water and land area in the wet season are higher than those in the dry season. It is occurred due to a presence of high discharge in the wet season. Higher concentration is found at the area along the shoreline as well as the mouth of rivers and front of the National Shrimp Culture Pilot Project. Near the mouth of Tegal's river TSS concentration reaches 3.40 $g/\ell$. In the dry season, the effect of land water on TSS concentration was also obviously visible at the front area of the National Shrimp Culture Pilot Project which is reach 2.40 $g/\ell$. In this case, the alteration of the turbidity level was particularly due to the obstruction of wind-driven current which carried the particulate matter by seawater drainage in front of the National Shrimp Culture Pilot Project. This facility was constructed to intake clear seawater from the area up to 1.5 km in the coastal water. The wind-driven current in this area flows southeastward in the wet season and northwestward in the dry season as shown in Fig. 5.

In addition, a high load of TSS due to high discharge in the wet season affected on water transparency and dissolve oxygen (DO) concentration. As shown in Fig. 3, water transparency is lower in the wet season than that in the dry season. The increasing of turbidity level has caused the reduction of water transparency, but it seems to undisturbed the photosynthetic activity. This situation was obviously visible on DO concentration, that is, DO concentration in the wet season is higher than that in the dry season. The increasing of total suspended solid (TSS) in the wet season followed by increasing dissolved inorganic nitrogen (DIN) and $PO_4$ concentration has caused the enrichment of coastal water and it generated an algal's bllom. As shown in Fig. 4, chlorophyll-*a* concentration extremely increased in

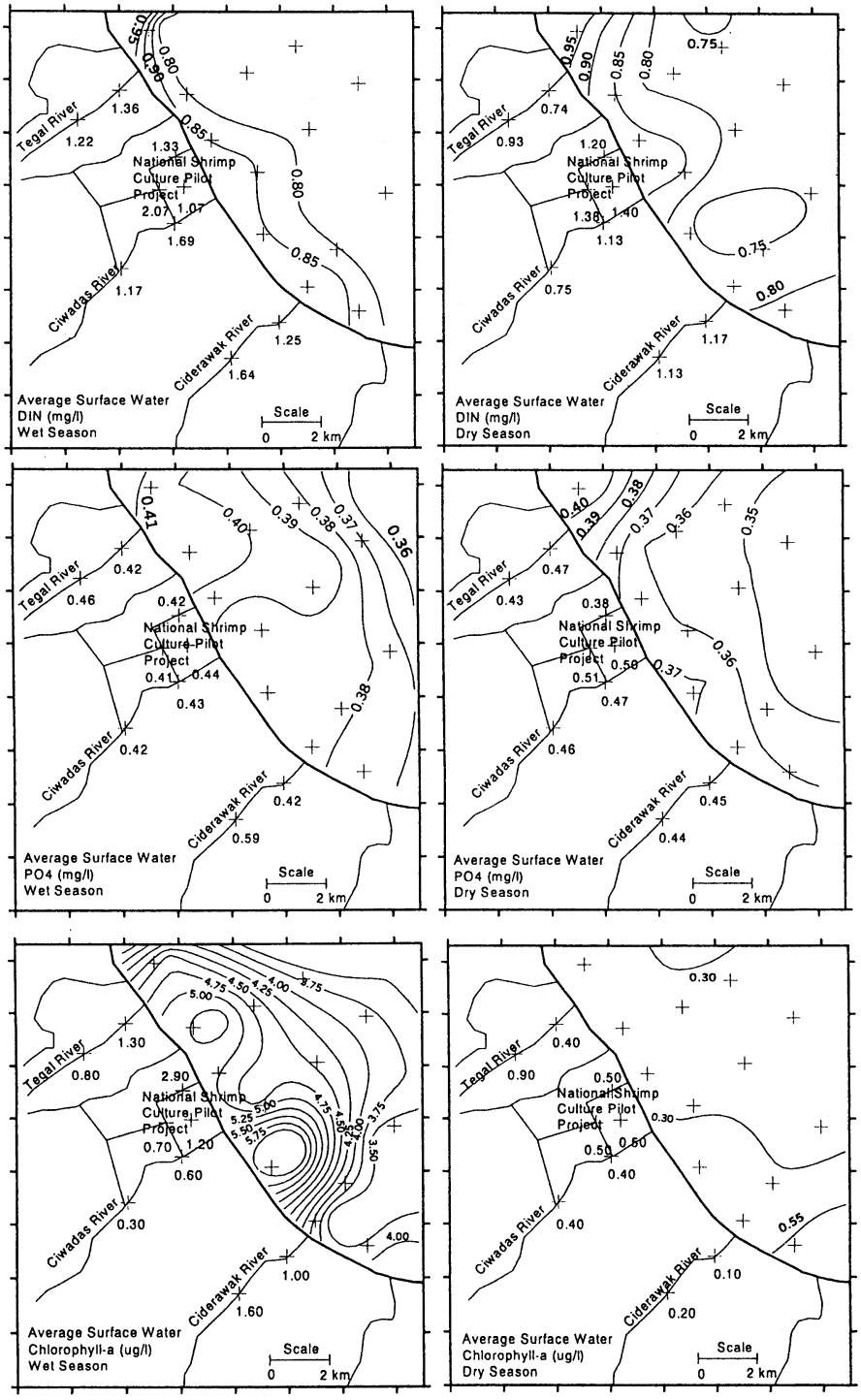


Fig. 4. Surface water DIN (mg/l), $PO_4$ (mg/$\ell$) and chlorophyll-*a* ($\mu$g/$\ell$) in the wet (April 1993) and dry (August 1993) seasons.

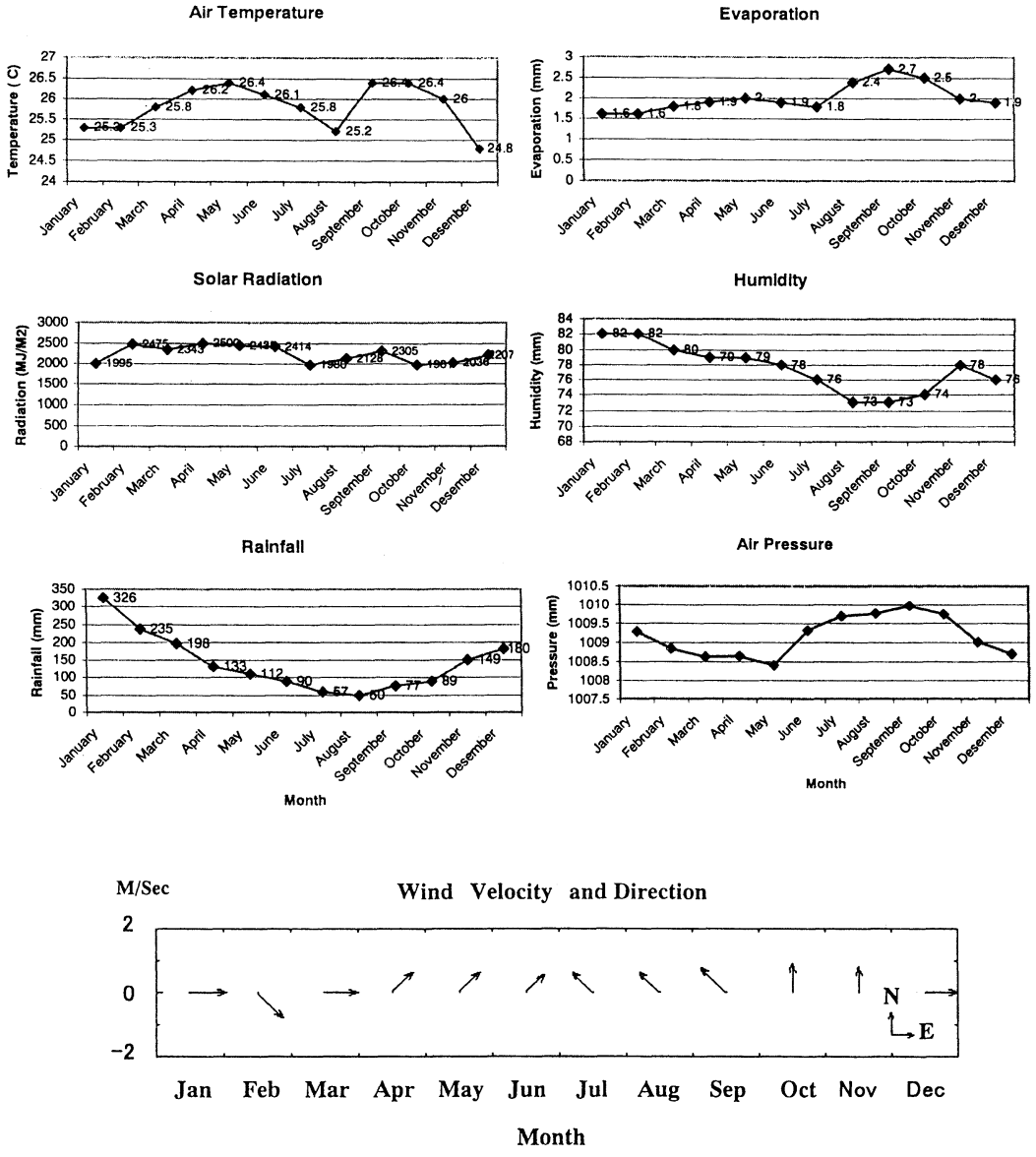


Fig. 5. Profile of meteorological condition (Air Temperature, Solar Radiation, Evaporation, Humidity, Rainfall, Air Pressure, Wind Direction and Wind Velocity) for Jakarta area derived from the data in 1931–1960 (Data Source : Indonesian Meteorological Agency).

the wet season. For the coastal water, the alteration even reached more than 10 times compared to the dry season, but slightly for the land area. In this situation, the photosynthetic activity was excessively strengthened and the DO concentration in the surface water became high. These results have indicated that there is a strong correlation among the river discharge, TSS, $PO_4$, DIN and chlorophyll-*a* concentrations with seasonal variation and the effluents of residual organic waste from the rice field and shrimp pond are suspected to be main sources of water quality deterioration.

Meanwhile, to ascertain a seasonal change of

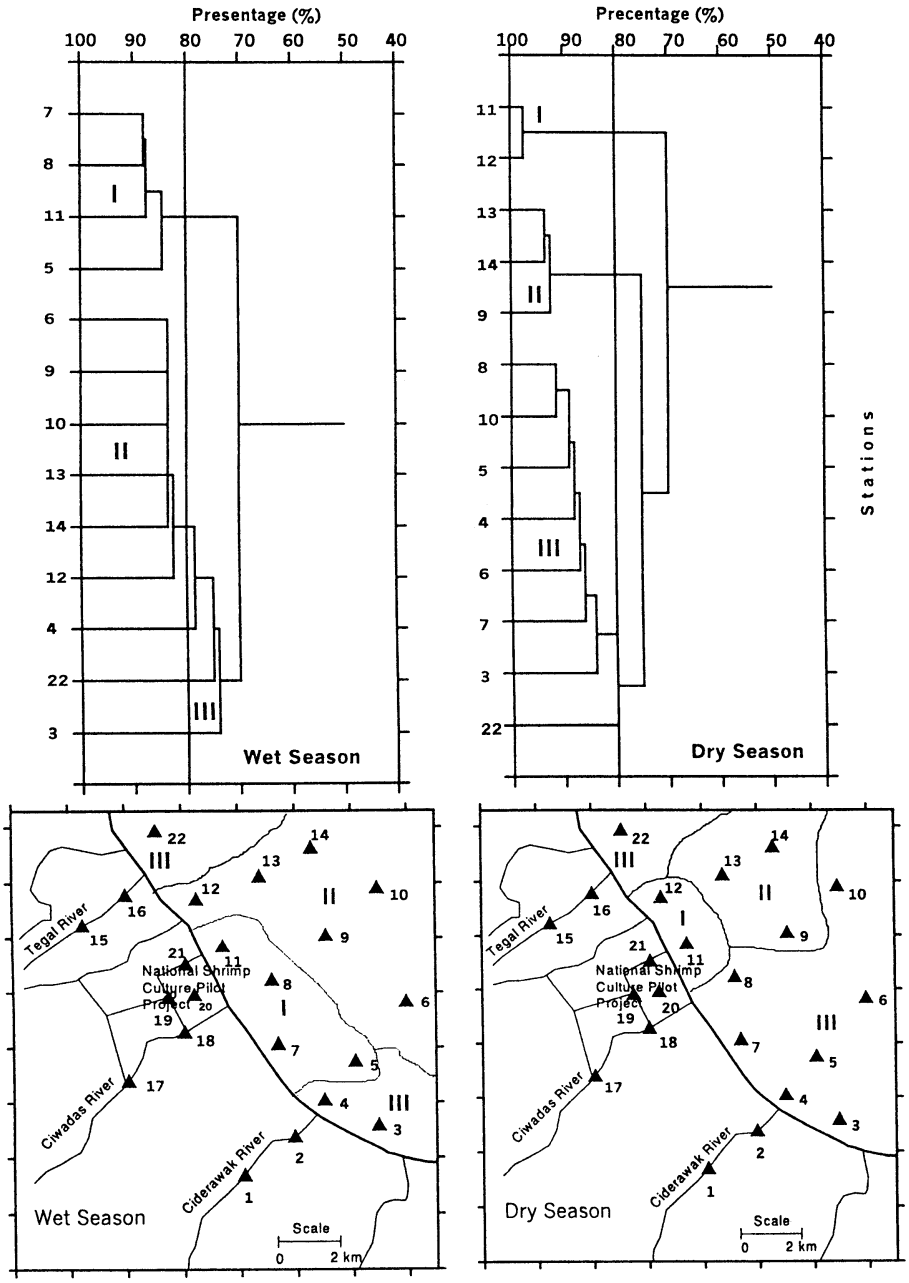


Fig. 6. Cluster diagram (above) and plot (below) of the sampling stations similarities in the wet (left, April 1993) and dry (right, August 1993) seasons based on physical, chemical and biological characteristics.

the water quality in the observation area, a simple cluster analysis was employed based on physical, chemical and biological characteristics. The result is shown in Fig. 6. The coastal water within this region can be grouped into three according to the index similarity at level 80%. There is a strong effect of the seasonal variation on the coastal water environment. In the wet season, the great effects of freshwater discharge are seen at the mouth of Ciderawak, Ciwadas and Tegal rivers as well as the flows of shrimp pond effluent. Those magnitudes are varied to the location. The combined effect of both Ciwadas discharge and shrimp pond are shown in Group I, which reaches 3 km away from the shoreline. Its influence extends to the eastern part covering four stations (Stations 5, 7, 8 and 11). The eastward movement of Group I occurred due to the wind-driven current affected by the Northwest Monsoon in the wet season as shown in Fig. 5. Meanwhile, Group II covering the six remaining stations are the intermediate water mass mixed of both the terrestrial and marine environment.

The inverse situation was clearly presented in the dry season where the rivers outflow was not visible, except the outflow of shrimp pond (Stations 11 and 12). The absence of rivers outflow is due to the low precipitation in the dry season. In this season the effect of marine environment is more dominant. The westward wind-driven current due to the Southwest Monsoon was obviously visible by extending of Group III covering 8 stations. On the other hand, the coverage of Group I was also moved to westward in the dry season. Because the activity of shrimp cultivation does not depend on the season, the effect of the organic waste effluent from the shrimp pond to the coastal water was clearly visible from the movement of Group I.

## 5. Conclusion

Water quality in the northern coast of Karawang is strongly affected by seasonal variations of precipitation and wind-driven current.

1. High precipitation and river discharge in the wet season caused salinity and density levels lower than those in the dry season. They also caused TSS, DO, DIN, $PO_4$ and chlorophyll-*a* concentration higher, and the opposite for water transparency.
2. The occurrence of the excessive enrichment at the coastal water due to the high load of residual agriculture and aquaculture organic waste, which is indicated by an algal's bloom in the wet season, caused the water quality toward deterioration. A limitation of the utilization of the organic matter, fish food and chemicals as well as aquaculture management is recommended to recover the water quality and the coastal environment for sustainable development.
3. The cluster analysis shows the effect of shrimp pond by the eastward spreading of Group I in the wet season due to the Northwest Monsoon wind-driven current.

Because of the high potentiality of the observation area for the advanced agriculture and aquaculture in the future, long term investigation covering physical, chemical and biological parameters is necessary to be established. Detailed information regarding material transport and its mechanism within the season will be valuable to advice a better management and utilization of this coastal area.

**Acknowledgements**

The authors wish to express thanks to Dr. S.M. VARLAMOV of RIAM-Kyushu University for his contribution in providing a base map data of Java Island.

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*Received May 28, 1999*
*Accepted July 30, 1999*