UDC 639

EVALUATION OF POND LANDS UTILIZATION AND STUDY OF ORGANIC MATTER SPATIAL DISTRIBUTION OF VANNAME SHRIMP (LITOPENAEUS VANNAMEI) AQUACULTURE IN THE COASTAL AREA OF LAMONGAN REGENCY

Insani Liga, **Fadjar Muhammad**, **Maftuch**
Faculty of Fisheries and Marine Science, University of Brawijaya, Indonesia
*E-mail: liga.insani@gmail.com

ABSTRACT

Coastal areas have a wide range of resources that can be utilized in multiple ways. Land utilization of coastal areas has been done for various interests, one of which is for shrimp aquaculture (farming). Continuous shrimp farming activities will lead to environmental degradation, characterized by decreased water quality. Besides, the area or spatial arrangement of shrimp aquaculture development that does not pay attention to the environmental carrying capacity due to improper management can cause environmental problems with all aspects of its complications in a long period of time, one of which is the problem emerging from shrimp farming with the use of intensive technology. Intensive shrimp farming can produce organic wastes, primarily from the residual feed, feces, and dissolved matters discharged into waters that significantly affect the quality of the coastal environment. This study aimed to determine the distribution pattern of organic matters resulted from Vanname shrimp *(Litopenaeus vannamei)* aquaculture in the coastal area of Lamongan Regency. This study was conducted from January to March 2018. The study used a descriptive method with *Geographical Information System* (GIS) approach. The spatial distribution analysis of organic materials was carried out using geostatistical analysis, by interpolating point data into areas (polygons) using IDW method. The interpolation results of each water quality of the ponds, river, and coastal waters were arranged in the form of thematic maps. The value pollution load index (PLI) value of the shrimp farming activities was determined based on six main indicators, namely dissolved oxygen, BOD_5, TOM, Ammonia, Nitrate, and Phosphate. Based on the results obtained, the highest spatial distribution value of organic matters was showed by the BOD parameter of 3.12 mg/l – 3.25 mg/l, included in the medium-polluted category. Meanwhile, the measurement result of the phosphate content as an indicator of water fertility ranged from 0.005 -0.006 mg/l. It suggests that the waters on the coastal area of Lamongan Regency are included in *oligotrophic* waters, indicating a low fertility rate. From the results above, it can be concluded that the largest pollution load index (PLI) value is contributed by the Biochemical Oxygen Demand (BOD) parameter while the smallest value is contributed by the phosphate parameter, signifying a low fertility rate in the coastal area.

KEY WORDS

Vanname shrimp, aquaculture, litopenaeus vannamei, organic matters, coastal area.

Coastal areas have a wide range of resources that can be utilized in multiple ways. Land uses of coastal areas have been done for various interests, one of which is for shrimp aquaculture (Bengen, 2004). Vannamei shrimp (*Litopenaeus vannamei*) is a shrimp commodity that has come to Indonesia as the solution to the problem of *Penaeus monodon* shrimp farming. Vanname shrimp commodity firstly entered Indonesia through the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 41 of 2001 (BMP WWF, 2014).

Utilization of coastal areas requires the improvement of fishery resource management, such as technology development and appropriate shrimp farming management so that coastal area development can proceed efficiently, properly, and sustainably (Dahuri, 2000). Coastal areas can be developed with Geographical Information System (GIS) technology approach. Geographical Information System (GIS) has been widely used as a primary data source of land use worldwide (Campbell, 2002). However, it rarely applies in Indonesia where land use maps at the regional level are still largely built based on terrestrial surveys (Danoedoro, 2004).

Shrimp farming activities are one example of land uses in coastal areas. Continuous shrimp farming activities will lead to environmental degradation, characterized by decreased water quality. Besides, the area or spatial arrangement of shrimp aquaculture development that does not pay attention to the environmental carrying capacity due to improper management can cause environmental problems with all aspects of its complications in a long period of time, one of which is the problem emerging from shrimp farming with the use of intensive technology. Shrimp farming with intensive technology is a highly productive economic activity in improving the welfare of the people and the country's foreign exchange, but the legitimacy of its sustainability is determined by the impacts of the environmental damage it causes (Supraptono *et al,* 2008). Furthermore, intensive shrimp farming activities can produce organic wastes, especially from the residual feed, feces, and dissolved materials discharged into waters that significantly affect the coastal area quality (Johnsen *et al,* 1993). Therefore, sustainable shrimp farming development should consider two important aspects, namely (1) quantification of pond wastes and (2) the ability of coastal waters to receive the burden of pond wastes (Soewardi, 2002).

Shrimp farming activities at any time will cause damage to the aquatic environment. If there is no responsible management undertaken, shrimp farming activities will ultimately threaten the sustainability of fishery resources of shrimp aquaculture. To preserve the sustainability of shrimp aquaculture and to minimize the deterioration of environmental quality due to the burden of wastes generated, the number or size of shrimp ponds in coastal areas must be adjusted to the environmental carrying capacity of the coastal areas. Harvest failure that is often experienced by shrimp farmers becomes one proof of the degradation of water quality and the supporting land of aquaculture, as well as the carrying capacity or ability of ponds that is often neglected as a medium of farming activities. The sustainability of pond farming (aquaculture) activities is largely determined by the dynamics aspects of coastal environmental quality due to the interaction among users in coastal areas, in addition to shrimp farming activities itself (Tiro, 2002).

Research Objectives:

- To determine the distribution pattern of organic matters resulted from Vanname shrimp *(Litopenaeus vannamei)* farming activities through analyzing the spatial distribution of the organic matters.
- To analyze the biogeophysical characteristics as well as the water and soil quality in the coastal area of Lamongan Regency used for Vanname shrimp *(Litopenaeus vannamei)* aquaculture.
- To estimate the use of pond lands based on the coastal waters carrying capability reviewed from the ecological, area and social activity aspects for the sustainability of shrimp farming activities using Geographic Information System (GIS) technology approach.

Research Location and Time. This research was conducted around the land use zone of shrimp aquaculture in the coastal area of Lamongan Regency during January – March 2018. The soil and water quality was tested at Oceanography Laboratory, Land Resource and Soil Laboratory of Trunojoyo University, Madura, and at the Laboratory of Agricultural Technology Faculty, Brawijaya University, Malang.

METHODS OF RESEARCH

This research used a descriptive method through Geographic Information System (GIS) approach. Determination of the observation points was done by analyzing the basic map before the field observation was implemented. There were three stages carried out in this research. The first stage was determining the sampling points, each of which was marked by using GPS (Global Positioning System) based on the land use zone of shrimp aquaculture in the coastal area of Lamongan Regency consisting of two districts, namely

Paciran district and Brondong district. The sampling points of both districts were determined using *Point-Quarter Method* technique, a method for determining sampling points randomly along a transect line in which the inter-points distance was set randomly or systematically. Meanwhile, the research location selection was determined using purposive sampling method, which is a technique of selecting samples deliberately to represent the whole research location.

The second stage was sampling water quality. The water quality sampling was done at the ponds located in Paciran district, consisting of 2 pond water stations, 2 pond water inlets and outlets (or drainage) stations, river (1 station) and coastal waters (2 stations). The position of each station of the water quality sampling was determined using Global Positioning System (GPS) while the parameters used in the physical-chemical observation of water quality included Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Ammonia, Phosphate, Nitrate and Total Organic Matter (TOM). In addition to the measurement in the field, the water quality was also analyzed in the laboratory.

In the third stage, the obtained results of the water quality measurement were then analyzed with geostatistical analysis, which is by interpolating point data into area data (polygon) using IDW method. The interpolation results of each water quality of the ponds, river, and coastal waters were arranged in the form of thematic maps. The spatial distribution analysis was conducted to determine the pattern of organic material distribution from Vanname shrimp farming in the coastal area of Lamongan Regency. The data were then divided into several classes to obtain pollution indicators of shrimp ponds, covering low, medium to high class.

RESULTS AND DISCUSSION

Results of Physical-Chemical Measurement of Water Quality. The results obtained from the measurement of water quality in the stations of intensive shrimp ponds, outlets and inlets, river, and coastal waters in the coastal area of Lamongan Regency are presented in Table 1 below.

Table 1 – Results of Physical-Chemical Measurement of Water Quality Parameters

Parameter	Measurement Station				
	Pond	Inlet	Outlet	Coastal Waters	River
Temperature	30.2	29.8	30	31.5	31.2
BOD_5 (mg/l)	2.52	0.90	3.12	0.94	3.25
BOT (mg/l)	28.49	16.26	30.17	19.27	31.99
NH3 (mg/l)	0.021	0.013	0.025	0.013	0.031
NO3 (mg/l)	0.025	0.014	0.027	0.002	0.032
PO_4-P (mg/l)	0.023	0.007	0.054	0.006	0.174

Dissolved Oxygen. Oxygen dissolved in water comes from the process of photosynthesis by phytoplankton and aquatic plants and derives from air diffusion (APHA, 1998). Oxygen diffusion from the atmosphere to waters takes place relatively slowly despite the occurrence of water mass upheaval so that the source of dissolved oxygen derived from oxygen diffusion is only 35% (Effendi, 2003). The content of dissolved oxygen in waters can be used as an indicator to know whether the waters are polluted or not. There are four categories of dissolved oxygen contents: 1) If the dissolved oxygen content is > 6 mg/L, the waters are categorized uncontaminated/unpolluted to very low-polluted; 2) If the dissolved oxygen content is between 4.5 – 6.4 mg/l, the waters are categorized low-polluted; 3) If the dissolved oxygen content is 2.0 – 4.4 mg/l, the waters are categorized medium-polluted; and 4) If the dissolved oxygen content is < 2.0 mg/L, the waters are categorized high-polluted (Lee *et al.,*1978). From the results of the measurement conducted in this research, the river station in the coastal area of Lamongan Regency showed the category of low-polluted. The spatial distribution pattern of dissolved oxygen can be seen in Figure 1.

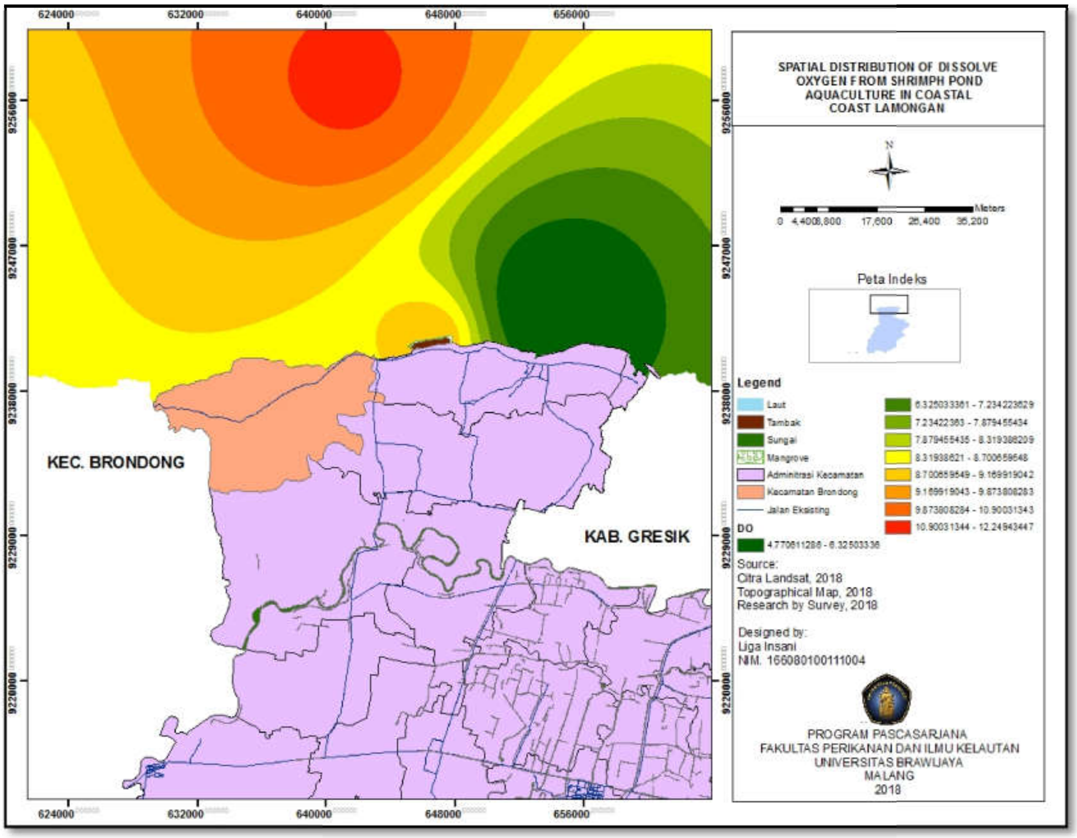

Figure 1 – Spatial distribution of Dissolved Oxygen from Shrimp Pond Aquaculture in the Coastal Area of Lamongan Regency

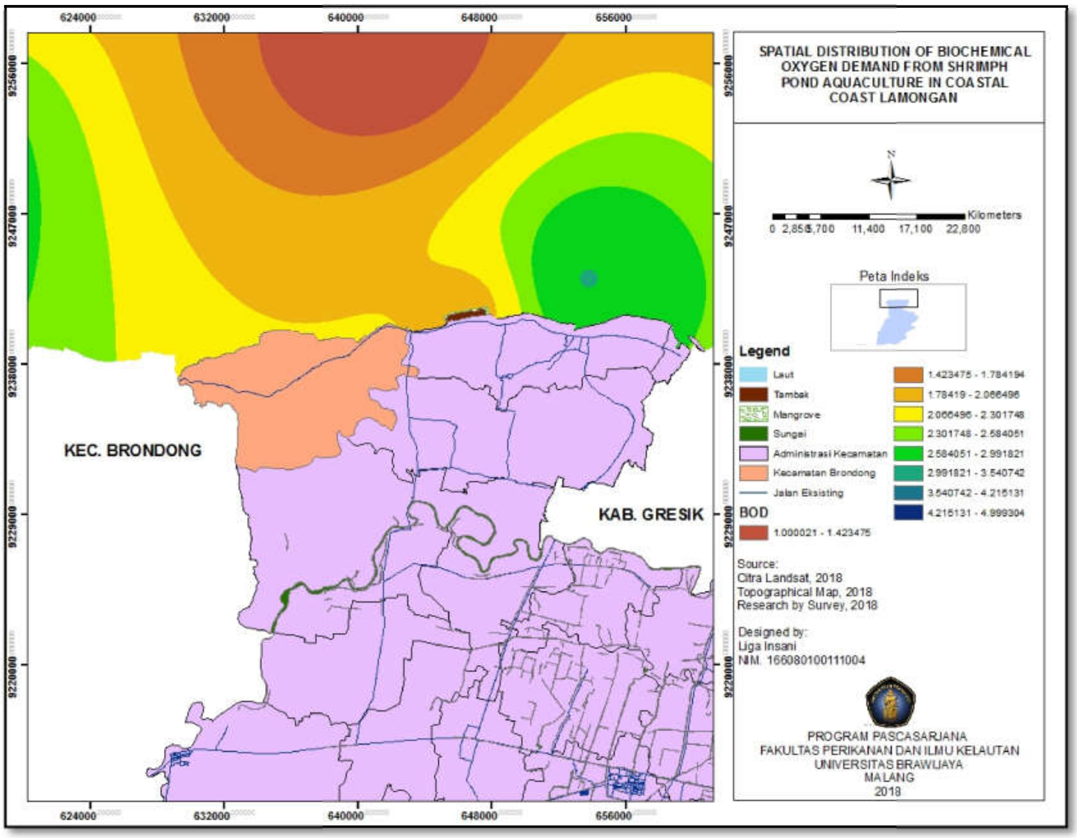

Figure 2 – Spatial distribution of *Biochemical Oxygen Demand* from Shrimp Pond Aquaculture in the Coastal Area of Lamongan Regency

BOD_5 (Biochemical Oxygen Demand). BOD_5 is one of the main indicators of organic pollution in waters. Waters with a high value of BOD_5 indicates that the waters have been contaminated by organic matters. Although its existence (BOD) is easily decomposed biologically, the process of its decomposing still involves bacteria through aerobic and anaerobic oxidation systems. This aerobic oxidation process will cause the decrease of dissolved oxygen in the waters to the lowest level, thus causing the waters become anaerobic and have a direct impact on the death of the organism.

The level of waters pollution can be determined based on the value of BOD_5 divided into four categories as follows: (1) if the value of BOD_5 is < 2.9 mg/l, the waters are categorized unpolluted; (2) if the value of BOD_5 is between 3.0 – 5.0 mg/l, the waters are categorized low-polluted; (3) if the value of BOD_5 is between 5.1 – 14.9 mg/l, the waters is categorized medium-polluted; and (4) if the value of BOD_5 is > 15 mg/l, the waters is categorized high-polluted. Based on the measurement results, it was obtained that the stations of the intensive shrimp ponds, outlets, and coastal waters fell within the category of low-polluted. The spatial distribution pattern of BOD_5 is presented in the following Figure 3.

Total Organic Matter (TOM). Organic matters contained in waters usually come from the remnants of dead organisms which then become accumulated waste. Meanwhile, the existing organic materials in shrimp ponds derive from the production process of the aquaculture system. The organic materials mix with the soil through percolation and tillage (Boyd, 1990).

Some negative impacts of high organic matters at the bottom of waters are due to increased consumption of oxygen at the bottom of the waters, relatively high ammonia levels and bacteria living at the bottom of the waters. According to the results of the measurement, the Total Organic Matter (TOM) in the intensive shrimp ponds was relatively high, reaching 28.49 mg/l. This condition is potential as a disturbance for the living of farmed shrimps. The spatial distribution pattern of the Total Organic Matter (TOM) is presented in Figure 4.

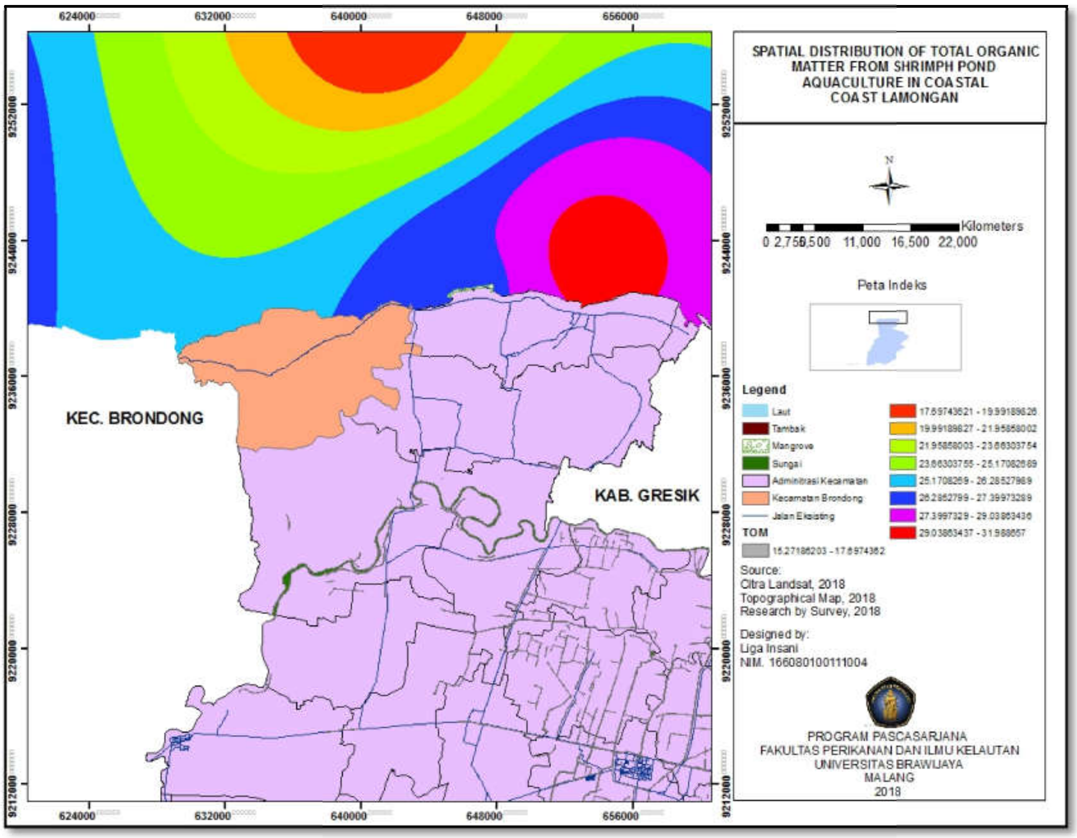

Figure 3 – Spatial distribution of Total Organic Matter from Shrimp Pond Aquaculture in the Coastal Area of Lamongan Regency

Ammonia (NH_3). Ammonia contained in waters is the result of the decomposition process of organic matters. Ammonia contained in waters is also caused by the accumulation of shrimp feces or derives from the result of microorganism activities in the decay of nitrogen-rich organic materials (protein). Too high ammonia levels in coastal waters are an indication of the contamination of organic matters derived from external loadings such as domestic waste, runoff, agricultural waste, livestock waste, and household waste. The measurement results of this research suggested that the ammonia content obtained from the stations of the ponds, river, and coastal waters was still considered in a good condition. If the NH_3 ammonia content in the waters exceeds 0.2 mg/L, the waters will have a little effect on the biota type that is too sensitive (Sawyer and McCarty, 1978 referring to Effendi, 2003). The spatial distribution pattern of Ammonia (NH_3) can be seen in Figure 4.

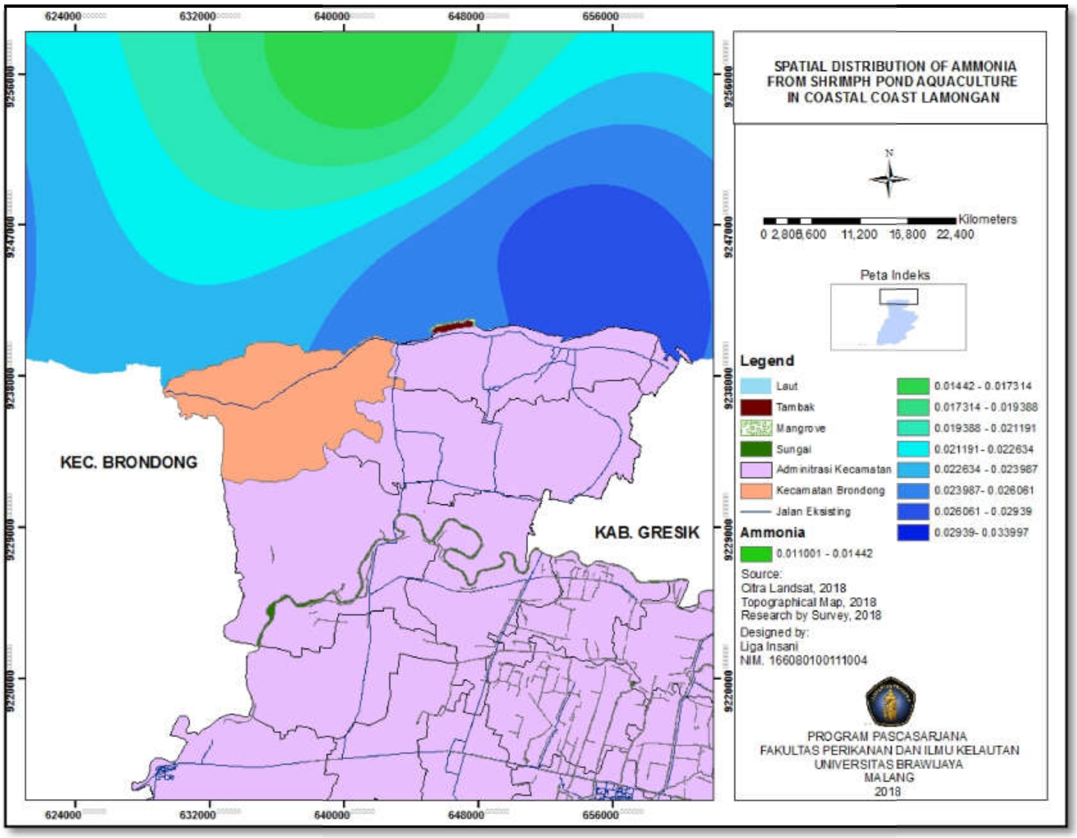

Figure 4 – Spatial distribution of Ammonia from Shrimp Aquaculture in the Coastal Area of Lamongan Regency

Nitrate. Nitric compounds (NO_3-N) are produced from the perfect oxidation process of nitrogen compounds in waters. The amount of nitrate content in waters depends on the speed of the nitrification process (which plays a role in it) such as nitrifying bacteria, pH value, dissolved oxygen content, and temperature. The content of nitrate in natural waters is almost never more than 0.1 mg/l. Based on the results of the measurement conducted, the nitrate content obtained from the stations of the intensive shrimp ponds, river, and coastal waters ranged from 0.025 – 0.064 mg/l. Nitrates are not toxic to aquatic organisms, and the nitrate content of more than 0.2 mg/l in waters may result in eutrophication (Effendi, 2003).

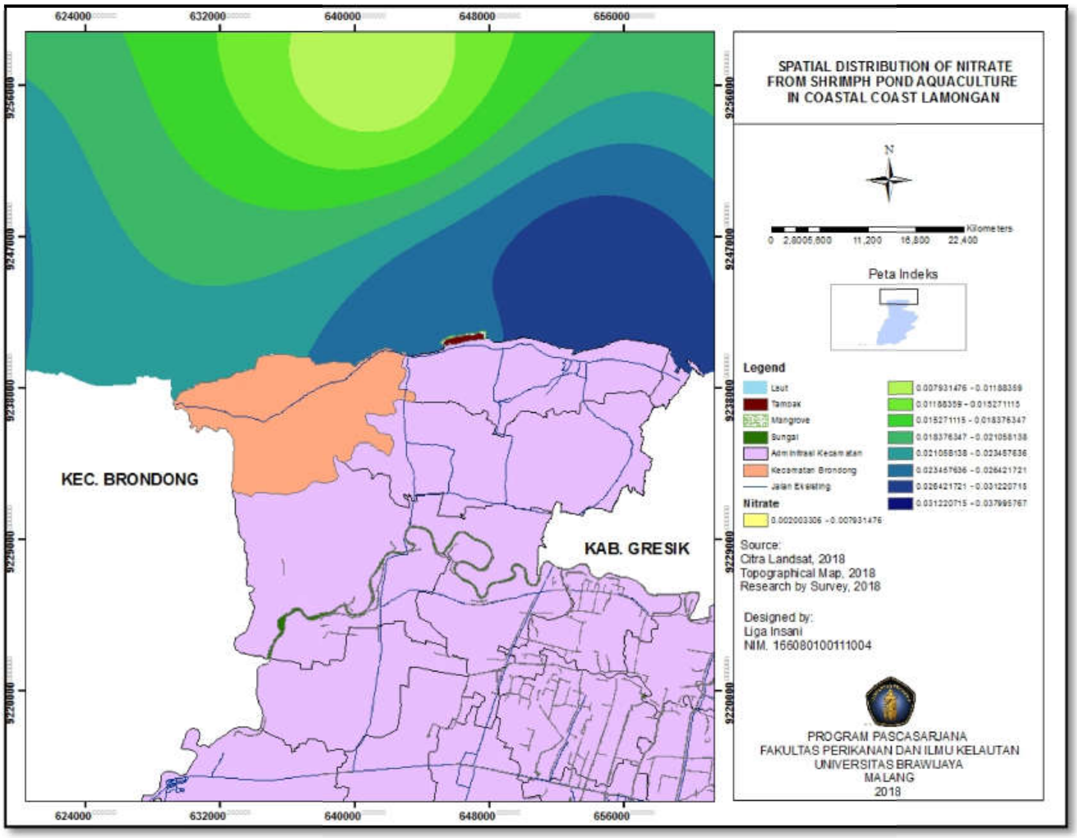

Figure 5 – Spatial distribution of Nitrate from Shrimp Pond Aquaculture in the Coastal Area of Lamongan Regency

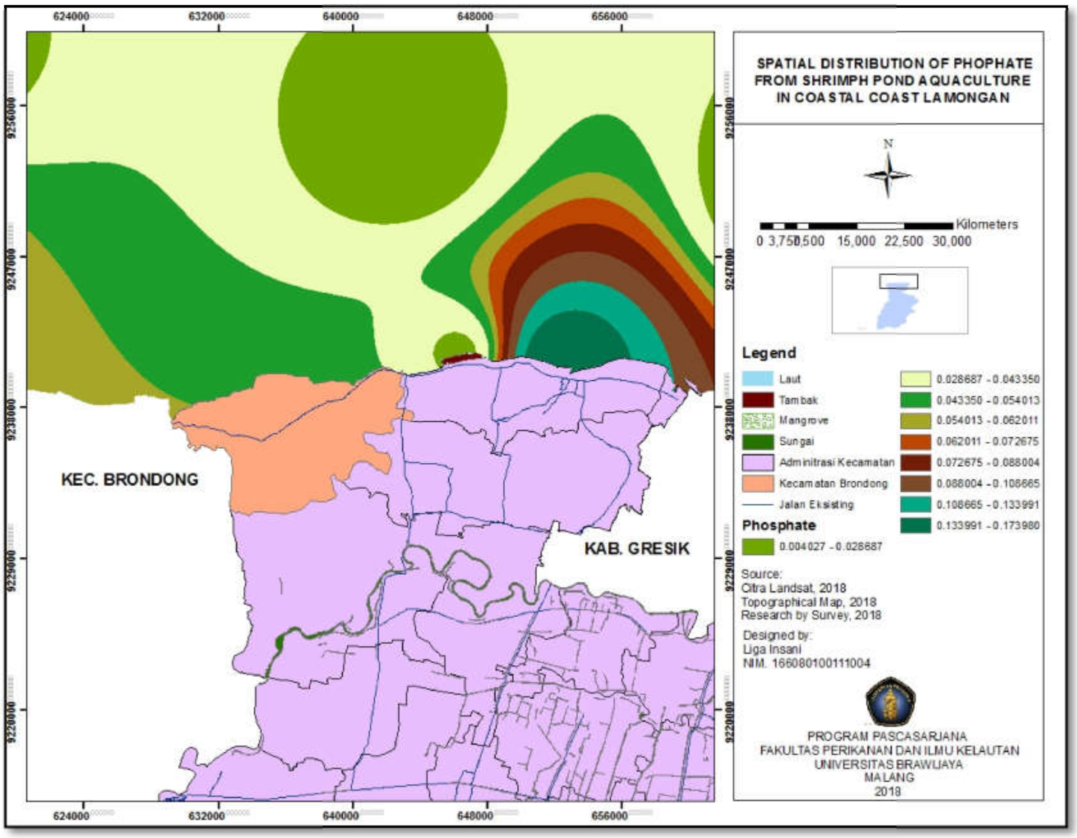

Figure 6 – Spatial distribution of Phosphate from Shrimp Pond Aquaculture in the Coastal Area of Lamongan Regency

Phosphate. Phosphate compounds are elements of nutrients that can be used as a guide for water fertility needed by organisms to grow and develop, one of which is phytoplankton. Phosphate (PO_4-P) is a primary productivity limiting factor and represents dissolved phosphate (P) nutrients. Phosphate content (PO_4-P) in natural waters rarely exceeds 1 mg/l (Boyd, 1995). According to Effendi (2003), there are 3 levels of water fertility, covering: (1) low fertility level with a total phosphate content of 0-0.02 mg/l; (2) medium fertility level with a total phosphate content of 0.21 – 0.05 mg/L; and (3) high fertility level with a total phosphate content of 0.051 – 0.1 mg/L. Based on the criteria, it was indicated that the Vanname shrimp ponds in the coastal area of Lamongan Regency were categorized having a low to high fertility level.

Based on the levels of phosphate content in waters, there are three classifications of waters, namely *oligotrophic waters* with the phosphate content level of 0.003-0.01 mg/l, *mesotrophic waters* with the phosphate content level of 0.11-0.031 mg/l, and *eutrophic waters* with the phosphate content level of 0.031 – 0.1 mg/l (Wetzel, 1975 referring to Effendi, 2003). The measurement results showed that the phosphate content in the coastal waters of Lamongan Regency ranged from 0.005 – 0.006, meaning that the coastal waters of Lamongan Regency fell within the category of *oligotrophic waters* with a low fertility level. The spatial distribution pattern of phosphate can be seen in Figure 6.

CONCLUSION AND SUGGESTIONS

The results of the research conducted in Vanname shrimp ponds in the coastal area of Lamongan Regency have led us to conclude that the pollution load index (PLI) value obtained from Vanname shrimp farming activities is observed from six parameters, namely DO, BOD, TOM, Ammonia, Nitrate, and Phosphate. Based on the value of each parameter, the highest spatial distribution of organic matters is obtained from the BOD parameter, amounted to 5 – 10 mg/l and included in the category of low-polluted.

Regarding the use of coastal areas for Vanname shrimp farming activities, the findings of this research suggest that the fishery resource management needs further improvement, such as technology development and appropriate shrimp farming management to run coastal development efficiently and sustainably so that farming activities will not pollute coastal waters in the coastal area of Lamongan Regency.

REFERENCES

1. Bengen DG. 2004. Ragam pemikiran menuju pembangunan pesisir dan laut berkelanjutan berbasis eko-sosiosistem. Pusat Pembelajaran dan Pengembangan Pesisir dan Laut (P4L). Bogor.
2. Boyd CE. 1990. Water quality in ponds for aquaculture. Alabama Agricultural Experiment Station. Auburn University, Alabama, 482p.
3. Better Management Practises WWF, 2014. Better Management Practices Budidaya Udang Vannamei, Tambak Semi Intensif dengan Instalasi Pengolahan Air Limbah (IPAL). Version 1. WWF-Indonesia.
4. Campbell, J. B. 2002. Introduction to Remote Sensing. Third edition. Guilford Press, New York.
5. Dahuri, R., 2000. Analisa Kebijakan dan Program Pengelolaan Wilayah Pesisr dan Pulau-Pulau Kecil. Makalah disampaikan Pada Pelatihan Manajemen Wilayah Pesisir. Fakultas Perikanan-IPB. Bogor.
6. Danoedoro. P. 2004a. Klasifikasi Penutup Lahan Secara Rinci:Pengalaman Dengan Citra Landsat ETM' dan QuickBird. Dalam: Danoedoro, P. (ed.), Sains Informasi Geografis:Dari Perolehan dan Analisis Citra hingga Pemetaan dan Permodelan Spasial. Jurusan Kartografi dan Penginderaan Jauh. Fakultas Geografi, Universitas Gadjah Mada, Yogyakarta.

7. Danoedoro. P. 2004b. Informasi Penggunaan Lahan Multidimensional: Menuju Sistem Klasifikasi Penggunaan Lahan Multiguna Untuk Perencanaan Wilayah dan Permodelan Lingkungan. Dalam: Danoedoro, P. (ed.), Sains Informasi Geografis:Dari Perolehan dan Analisis Citra hingga Pemetaan dan Permodelan Spasial. Jurusan Kartografi dan Penginderaan Jauh. Fakultas Geografi, Universitas Gadjah Mada, Yogyakarta.
8. Effendi H. 2003. Telaah kualitas air bagi pengelolaan sumberdaya dan lingkungan perairan. MSP-IPB Bogor.
9. Johnsen RI, Grahl-Nielson O, Lunestad BT. 1993. Environmental distribution on organic waste from marine fish farm. Aquaculture, 118 : 229 – 224.
10. Sawyer CN, McCarty PL. 1978. Chemistry for environmental engineering. Third edition. McGraw-Hill Book Company, Tokyo.
11. Soewardi, K 2002. Pengelolaan Kualitas Air Tambak, Makalah Dalam Seminar Penetapan Standar Kualitas Air Buangan Limbah, Ditjen Perikanan Budidaya, Puncak, 7-9 August 2002.
12. Sugiyono dan Alfabeta, 2008. Metode Penelitian Kuantitatif, Kualitatif. Bandung.
13. Supraptono TKP, Puspito DCL, Siswanto, Poniran, Suyoto. 2008. Optimalisasi produktivitas tambak idle melalui budidaya multispesies dengan sistem pemeliharaan paralel dan resirkulasi. Laporan Kegiatan Balai Besar Pengembangan Budidaya Air Payau Jepara. Tahun 2008, pp. 209-219.
14. Tiro LB. 2002. White shrimp Lithopenaeus vannamei dan Lithopenaeus stylirostris, The global culture species for shrimp farmers. Aqua Seed Technologies 11.