

SPATIAL DISTRIBUTION OF BRACKISHWATER POND SOIL CHARACTERISTICS IN PEKALONGAN CITY CENTRAL JAVA PROVINCE

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ABSTRACT

Spatial distribution of brackishwater pond soil has a vital role in the system of bio-environment including brackishwater pond environment. This research was aimed to determine the spatial distribution of brackishwater pond soil characteristics in Pekalongan City, Central Java Province. A total of 59 sampling points each with two different soil depth samplings were determined by simple random method. A total of 21 soil characteristics were measured in the field and analyzed further in the laboratory. Geostatistic with Kriging Interpolation method in the ArcGIS 9.3 software were used to depict the distribution of the data across the landscape. Furthermore, the spatial distribution was presented by using ALOS AVNIR-2 image. Research result indicates that in general, pond soil in Pekalongan City can be classified as soil with high variability or relatively heterogenic with the value of variation coefficient more than 36%. Soil characteristics which have similar pattern of spatial distribution are acid sulfate soil and soil nutrient content. High value of pH, organic matter, and total-N of soil, and on the other hand, low value of PO₄ were generally found in the pond area of Krapyak Lor Village, while in Pekalongan City, it was found high clayish soil content but relatively homogenous. It is recommended that pond management must be based on soil characteristics which are different from one area to another. The soil characteristics itself can be drawn and assessed through spatial distribution.

KEYWORDS: spatial distribution, soil characteristic, brackishwater pond, Pekalongan City

INTRODUCTION

Ministry of Marine Affairs and Fisheries (MMAF) of the Republic of Indonesia has been focusing most of its resources to boost aquaculture production and to control capture fisheries. MMAF has targeted that the total aquaculture production at the end of 2014 should reach 16.8 million tonnes meaning the increase of aquaculture production up to 353%. As being one of the main backbones of MMAF, aquaculture system consists of several subsector

which are mariculture, brackishwater and freshwater aquaculture. For brackishwater system, it is estimated that 1.22 million hectares of land are suitable for brackishwater pond with the current utilization rate only 40% (DKP, 2005). Based on the Decree of the Minister of Marine Affairs and Fisheries Number Kep.32/Men/2010 on Specification Minapolitan Area, Pekalongan City (Central Java Province) has been appointed as one of the Minapolitan regions with shrimp as the core commodity.

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Pekalongan City has a total area of 45.25 km² located on the lowlands north coast of Java Island with approximately one meter above sea level and geographic position between 6°50'42"-6°55'44" South latitude, and 109°37'55"-109°42'19" East longitude. The administrative boundaries is as follows: on the North: Java Sea; on the South: Regency of Pekalongan and Batang; on the West: Pekalongan Regency; on the East: Batang Regency. Pekalongan City is administratively divided into 46 self-sufficient village. These villages are located into 4 sub-districts namely West Pekalongan, East Pekalongan, South Pekalongan and North Pekalongan. Brackishwater ponds in Pekalongan City are only found on North Pekalongan Sub-district with the total area approximately 332.29 ha (Rachmansyah *et al.*, 2010). In addition, other types of land use besides brackishwater ponds in coastal areas of North Pekalongan Sub-district are paddy field, intrusion paddy field and residential with total area of 372.53; 183.83; and 619.73 ha respectively.

One of the environmental factors that affect the productivity of brackishwater ponds is soil quality. Soil quality is a major production factor in aquaculture because it can affect water quality, biological and engineering processes of ponds (Boyd, 1995; Sammut, 1999). Therefore, soil quality has been generally considered in the evaluation of land suitability for aquaculture (Muir & Kapetsky, 1988; Boyd, 1995; Treece, 2000; Salam *et al.*, 2003; Karthik *et al.*, 2005; Mustafa *et al.*, 2007).

Spatial distribution of soil characteristics has an important role in bio-environmental system (Rossi *et al.*, 1992; Zuo *et al.*, 2008; Dong *et al.*, 2009; Akbarzadeh & Taghizadeh-Mehrjardi, 2010; Zare-Mehrjardi *et al.*, 2010). Knowledge of spatial variability of soil characteristics and its relationship are important for the evaluation of land management practices (Huang *et al.*, 2001) and increased sustainability of land use (Liu *et al.*, 2006). Variability is one of the core soil quality characteristics and in the same ecosystem soil quality may show significant spatial variations (Robinson & Metternicht, 2006). These variations have mainly arisen from the factors and the process of pedogenesis and land use type (Ersahin, 2003; Liu *et al.*, 2006) and soil management practices (Anuar *et al.*, 2008) as well as structure of topography (Liu *et al.*, 2006). However, by applying classical statistics which

consider the soil dataset as an independent, their implementations lead very often to unrealistic results (Hasany-Pak, 1998 in Zare-Mehrjardi *et al.*, 2010). Furthermore, on the contrary assumption when applying the classical statistics is that the soil characteristics in a landscape are not distributed randomly (variability has not only random but also has not correlated to the spatial location) (Essington, 2004).

Natural soil characteristics can vary continuously in a particular time and place. In this conditions, soil quality is very difficult to measure at any point in the field continuously (Madyaka, 2008). Geostatistics can be used to characterize and measure the spatial variability of soil characteristics as well as to interpolate rationally and estimate the difference of the interpolated values (Lin *et al.*, 2001; Essington, 2004). Therefore, geostatistical methods need to be applied in order to understand the spatial distribution of soil characteristics of the brackishwater pond in the Pekalongan City Central Java Province. This will finally reach to a conclusion that land management can be done in accordance with the characteristics of the brackishwater pond soil. Proper land management can increase the productivity of land, including ponds aquaculture with a minimum use of inputs and environmental degradation.

MATERIAL AND METHOD

Research Location

This experiment was conducted at the coastal region of North Pekalongan sub-district Pekalongan City Central Java Province, Indonesia (Figure 1) in October 2009. At the first stage, the research was initiated in the form of discussions with staff of the Department of Agriculture, Animal Husbandry and Marine Pekalongan City to obtain general information of aquaculture land use in Pekalongan City.

Data Collection

Primary data

The primary data were collected covering biophysical data which was soil data. Soil sampling stations were determined by simple random sampling on 59 stations (Figure 1). Variables of soil quality measured directly in the field were pH_f (soil pH measured in the field)

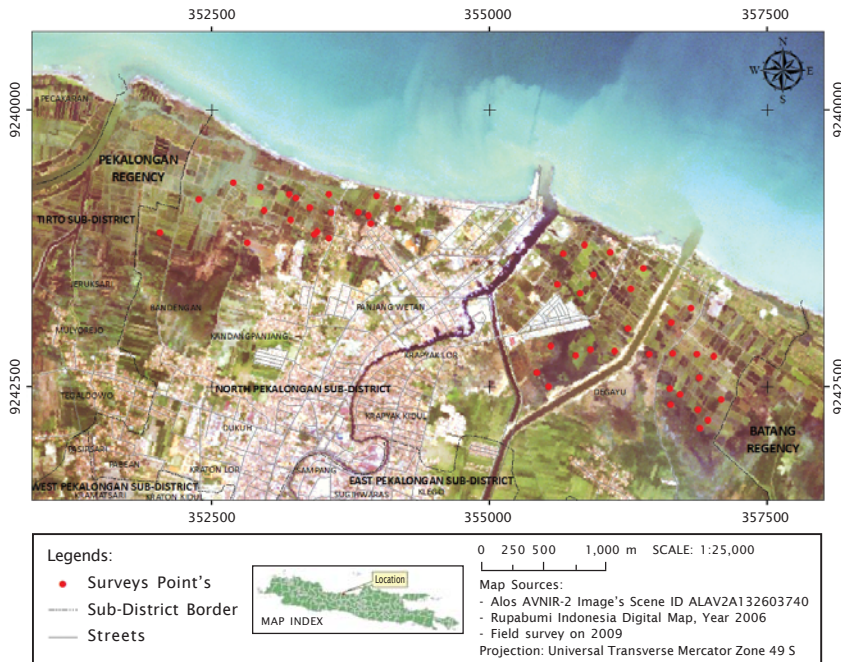


Figure 1. Soil sampling points in the coastal zone of North Pekalongan sub-district Pekalongan City Central Java Province

with a pH-meter (Ahern & Rayment, 1998), pH_{FOX} (soil pH measured in the field after oxidized with hydrogen peroxide (H_2O_2) 30%) with pH-meter (Ahern & Rayment, 1998) and redox potential with redox-meter.

Sampling Points

Soil samples were taken at two soil depths, which are 0 to 0.2 m and 0.5 to 0.7 m from ground level. For further analysis the soil samples were immediately placed in plastic bags and stored in a cool box. This had to be performed because some of the samples were classified as acid sulfate soil. Furthermore the soil samples were dried at 80°C-85°C for 48 hours (Ahern & Blunden, 1998) for acid sulfate soil and non-acid sulfate alluvial soil samples were dried naturally. After dried, soil samples were pounded on porcelain mortar and sieved with 2 mm size sieve then analyzed at the Soil Laboratory of Research Institute for Coastal Aquaculture (RICA) in Maros. The analyzed parameters were pH_{KCl} (pH of the KCl extract) (McElnea & Ahern, 2004a), pH_{OX} (McElnea & Ahern, 2004b), S_p (sulfur peroxide) (Melville, 1993; McElnea & Ahern, 2004c), S_{KCl} (sulfur was extracted with KCl) (Melville, 1993; McElnea &

Ahern, 2004d), S_{POS} ($S_p - S_{KCl}$) (Ahern & McElnea, 2004), TPA (Peroxide Titratable Acidity or formerly known as Total Potential Acidity) (McElnea & Ahern, 2004b), TAA (Actual Titratable Acidity or formerly known as Total Actual Acidity) (McElnea & Ahern, 2004a), TSA (Titratable Sulfidic Acidity or formerly known as Total Sulfidic Acidity) (TPA-TAA) (McElnea & Ahern, 2004b), FeS_2 (pyrite) (Ahern *et al.*, 1998a, 1998b), organic carbon by Walkley and Black method (Sulaiman *et al.*, 2005), total-N (total-nitrogen) by Kjeldhal method (Sulaiman *et al.*, 2005), PO_4 (phosphate) with Bray 1 or Olsen method (Sulaiman *et al.*, 2005), Fe (iron) which was measured by spectrophotometer (Menon, 1973), Al (aluminium) (measured by spectrophotometer) (Menon, 1973), and texture by hydrometer method (Agus *et al.*, 2006).

Secondary Data

Secondary data were collected through review of literature and research results from various relevant institutes. Maps were compiled include Indonesia topography map scaled of 1:50,000) with an index number 1409-112 (Pekalongan) and Administrative map of Pekalongan City.

Data Analysis

Land use/cover map was taken from image classification of ALOS (Advanced Land Observing Satellite) AVNIR-2 (The Advanced Visible and Near Infrared Radiometer type 2) acquisition of July 21, 2008. These were processed by ErMapper 1.7 software and integrated with basic map of Indonesia topography map. Other spatial information derived from primary and secondary data were also integrated with the land used map.

Soil characteristics data were analyzed using classical statistical methods to get the minimum, maximum, average, standard deviation, coefficient of variation, kurtosis and skewness based on the instructions Sokal & Rohlf (1981). In order to interpolate these data, particularly for soil at depth of 0 to 0.2 m, Kriging method in ArcGIS 9.3 was used. Kriging is a common method in geostatistical interpolation process of soil characteristic data (Yost *et al.*, 1982; DeBusk *et al.*, 1994; Lin, 2008).

RESULT AND DISCUSSION

Coefficient variation of brackishwater pond soil for pH_{KCl} varied from the lowest (5.34%) and highest for TPA, TSA and pyrite (146.72%) for soil depths of 0 to 0.2 m (Table 1). The lowest coefficient variation was in pH_F (9.26%) and highest in the TSA and pyrite (135.89%) for soil depth from 0.5 to 0.7 m (Table 2). It has been reported by Goh *et al.* (1998) that the coefficient variation of soil characteristics in Sabah (Malaysia) exceeded 100% on the same soil series.

Based on the classification established by Essington (2004), the variables, that were categorized as small or relatively homogeneous, were pH_F and pH_{KCl} . Middle variability was the content of clay fractions while other soil quality variables considered as high or relatively heterogeneous variability particularly for the depth of 0 to 0.2 m. At the depth of 0.5 to 0.7 m, the variables which were categorized as small variability were pH_F , pH_{KCl} and content of clay fractions, whereas the other soil quality variables were considered high variability. This indicates that the overall characteristic of the brackishwater pond soil in the Pekalongan City was relatively high or relatively heterogeneous variability. Essington (2004) stated that the characteristics of soils are highly variable relative to location on the landscape and depth within the profile. High variability of soil characteristics in the same soil

series have also been reported in Peninsular Malaysia by Law & Tan (1977).

The types of brackishwater soil in Pekalongan are non-acid sulfate alluvial soil and a few of acid sulfate soil with little gray color. Acid sulfate soil is mostly found at Krapyak Lor Village. Vertical spatial distribution of brackishwater ponds soil in Pekalongan City is shown in Tables 1 and 2 and horizontal distribution is presented in Figure 1, 2, 3, and 4.

Redox potential describes the condition of oxidized soil. Redox potential is the result of quantitative measurements to inform a diagnostic index of anaerobic or soil anoxia (Patrick & Delaune, 1977). Table 1 depicts the soil redox potential at depths of 0 to 0.2 m higher than the depth of 0.5 to 0.7 m. This is because of the drying of brackishwater pond bottom is usually done by farmers at the time of preparation where the surface of the brackishwater pond has become dry and increasing soil redox potential compared to the existing soil beneath. Figure 2 shows higher redox potential found in brackishwater pond soil of Degayu Village. Presumably, low organic matter in these locations had caused higher redox potential. Organic matter is a kind of material that has the ability to hold water, so the chance of lower redox potential may occur in particular areas that contain high organic matter. In general, brackishwater pond soil in the Pekalongan City is categorized as euded conditions. This was as a result of soil sampling conducted at the time where brackishwater pond in the process of cultivation of shrimp and milkfish either monoculture or polyculture, so the brackishwater ponds were full of water.

pH_F can be used as an indicator to measure the presence and severity of the actual acid sulfate soil. In general, relatively high pH_F soil can be found at the depth of 0 to 0.25 m than the soil depth of 0.5 to 0.7 m. It is assumed as the result of natural leaching process in a relatively long period of time that has caused the reduction of soil acidity compounds on the surface. In addition, land management practices such as the use of limestone by farmers cause high pH_F on surface soil. It has been reported by de Queiroz *et al.* (2004) that the application of lime in soil surface can significantly affect the soil to depth of 0.04 m. At 0 to 0.25 m soil depth, the spatial distribution of relative pH_F was the same as shown in Figure 2

Table 1. The quality of the brackishwater pond soil at the depth of 0 to 0.2 m in Pekalongan City Central Java Province

Variables	Minimum	Maximum	Average	Standard deviation	Coefficient variation	Kurtosis	Skewness
Redox potential (mV)	-313	-11	-137	45.1	32.78	3,982	-0.674
pH _F	3.14	7.45	6.69	0.630	9.41	19,098	-3,535
pH _{FOX}	1.16	7.09	3.38	1,638	48.52	-0.736	0.591
pH _F pH _{FOX}	0.61	5.74	3.31	1,814	54.74	-0.878	-0.487
pH _{KCl}	6.25	7.66	7.00	0.374	5.34	-0.748	0.070
pH _{OX}	1.82	7.66	4.62	2,024	43.82	-1,493	0.183
S _{KCl} (%)	0.21	1.39	0.70	0.290	41.05	-0.610	0.134
S _p (%)	0.14	27.30	7.49	9,594	128.14	-1,101	0.824
S _{POS} (%)	0.69	26.66	6.78	9,504	140.13	-1,075	0.836
TPA (mole H ⁺ /ton)	0.00	452.00	75.60	110,925	146.72	2,192	1,663
TSA (mole H ⁺ /ton)	0.00	452.00	75.60	110,925	146.72	2,192	1,663
Organic matter (%)	0.14	10.26	3.55	2,276	64.18	0.945	0.945
Pyrite (%)	0.00	2.02	0.34	0.495	146.72	2,192	1,663
Fe (mg/L)	9.50	4868.50	1422.47	1878.563	132.06	-0.906	0.933
Al (mg/L)	0.001	785.500	295,171	212,7609	72.08	-0.655	0.181
PO ₄ (mg/L)	0.001	148,486	42,585	342,871	80.52	1,916	1,389
Total-N (%)	0.005	0.054	0.026	0.0114	43.19	-0.249	0.524
C:N ratio	3.1	286.1	78.3	47.45	43.16	6,928	2,253
Clay (%)	32	86	69	11.5	16.69	4,350	-1,815
Sand (%)	6	28	15	5.4	37.13	-0.680	0.552
Silt (%)	0	46	16	9.2	56.69	4,757	1,912

Table 2. The quality of the brackishwater pond soil at the depth of 0.5 to 0.7 m in Pekalongan City Central Java Province

Variables	Minimum	Maximum	Average	Standard deviation	Coefficient variation	Kurtosis	Skewness
Redox potential (mV)	-3.11	-1.5	-1.23	58.7	47.70	1,527	-0.927
pH _F	4.92	8.49	6.43	0.596	9.26	1,706	0.544
pH _{POX}	1.04	7.53	3.10	2,059	66.42	-0.620	0.918
pH _F -pH _{POX}	1.11	7.45	3.33	2,275	68.29	-0.924	-0.554
pH _{KCl}	4.83	7.67	6.80	0.654	9.62	2,223	-1,410
pH _{OX}	1.18	7.63	4.17	2,338	56.07	-1,496	0.288
S _{KCl} (%)	0.14	2.03	0.66	0.366	55.47	2,638	1,273
S _p (%)	0.16	27.24	9.26	10,062	108.66	-1,478	0.515
S _{ROS} (%)	1.45	26.13	8.60	9,986	116.10	-1,463	0.521
TPA (mole H ⁺ /ton)	0.00	930.00	177.46	240,663	135.62	0.718	1,285
TSA (mole H ⁺ /ton)	6.50	930.00	177.16	240,752	135.89	0.719	1,285
Organic matter (%)	0.27	34.45	4.43	5,241	118.32	20,488	3,879
Pyrite (%)	0.03	4.15	0.79	1,075	135.89	0.719	1,285
Fe (mg/L)	9.50	4917.00	1977.96	2,138,623	108.12	-1,811	0.358
Al (mg/L)	0.001	1,334,000	466,175	3,167,975	67.96	0.208	0.613
PO ₄ (mg/L)	0.001	294,740	42,139	510,120	121.06	14,382	3,319
Total-N (%)	0.003	0.060	0.020	0.0132	64.22	0.743	1,066
C:N Ratio	8.7	480.9	120.3	86.45	71.86	4,207	1,874
Clay (%)	32	86	73	8.6	11.83	8,461	-2,103
Sand (%)	4	30	14	5.8	42.02	0.134	0.705
Silt (%)	0	46	14	6.2	45.10	14,353	2,857

and also indicated by the relatively low coefficient of variation as shown in Table 1 or relatively homogeneous in other words.

Characteristic of non-acid sulfate alluvial soil is clearly seen in Table 1 where $pH_F - pH_{FOX}$ is not too high. It was also found in the soil

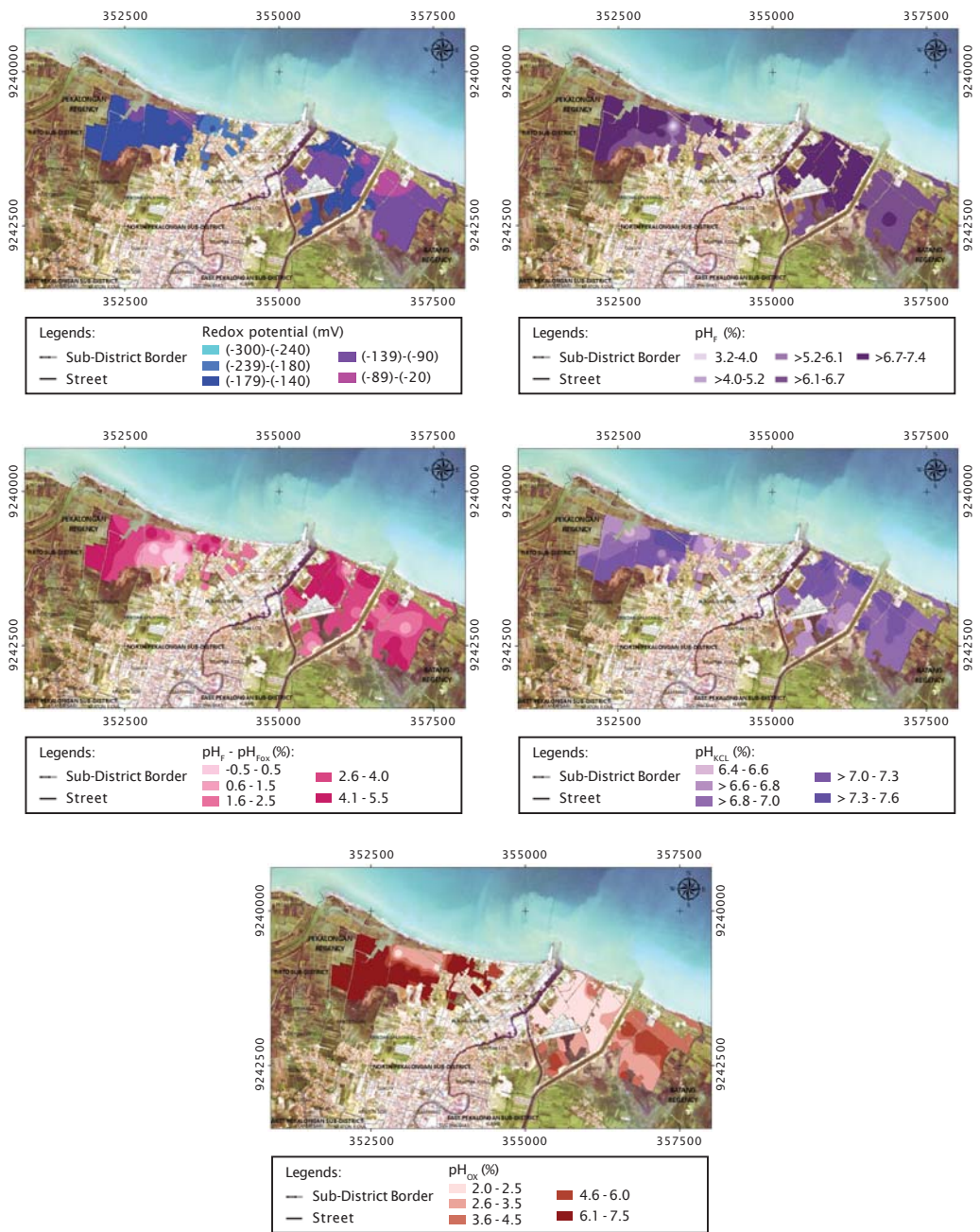


Figure 2. Spatial distribution map of redox potential (top left), pH_F (top right), pH_F-pH_{FOX} (left center), pH_{KCL} (right center), and pH_{OX} (bottom) of brackishwater pond soil at 0 to 0.2 m depth in Pekalongan City Central Java Province

depth of 0.5 to 0.7 m (Table 2). pH_F is soil pH which is measured in the field at the condition of soil saturated with water, while pH_{FOX} is soil pH which is measured in the field after being

oxidized perfectly with H_2O_2 30% (Ahern & Rayment, 1998). $pH_F - pH_{FOX}$ can be used to determine the potential of existing acidity in the soil. In the acid sulfate soil, $pH_F - pH_{FOX}$ may

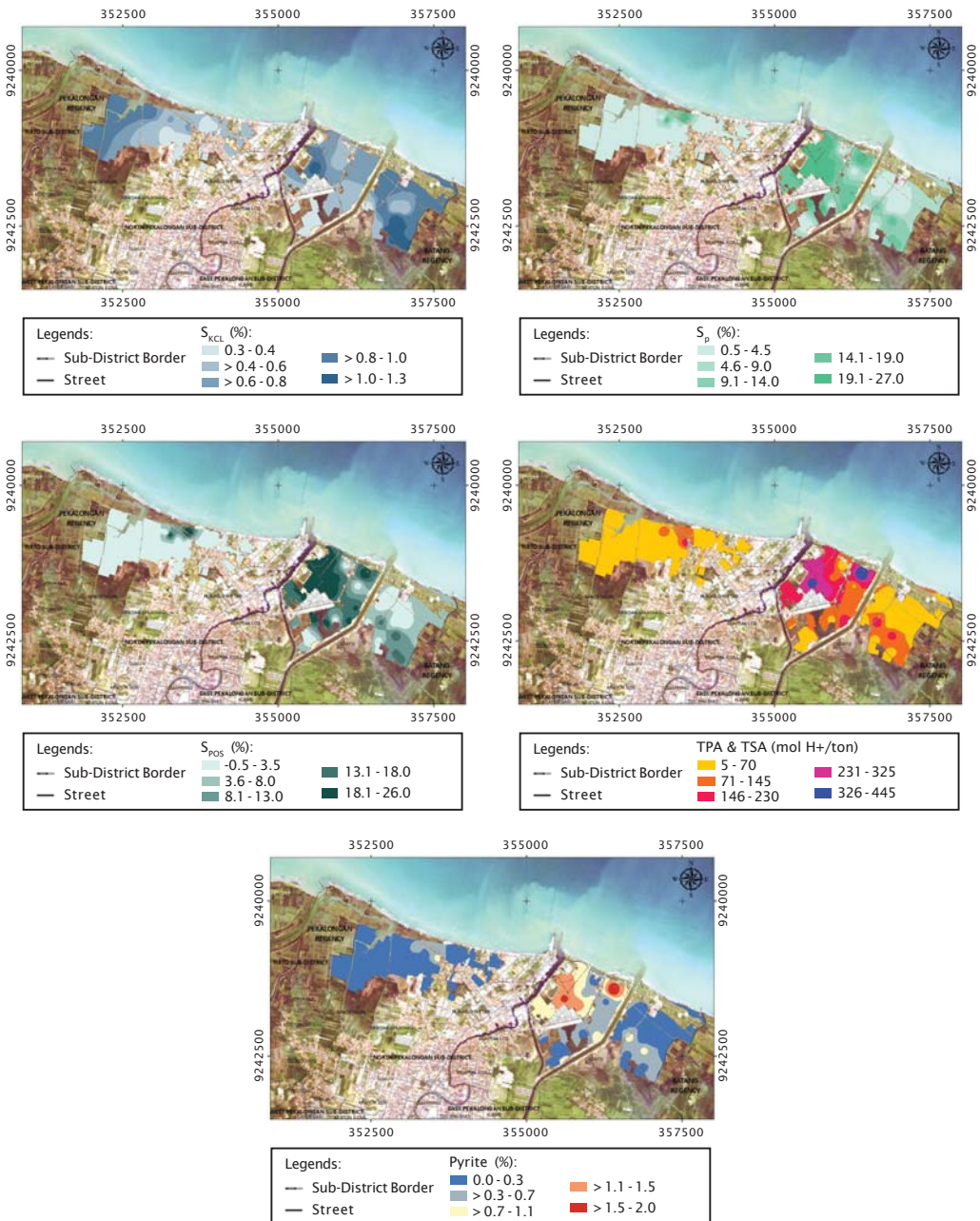


Figure 3. Spatial distribution map of S_{KCl} (top left), S_p (top right), S_{pos} (left center), TPA and TSA (right center) and pyrite (S_{bottom}) of brackishwater pond soil at 0 to 0.2 m depth in Pekalongan City Central Java Province

exceed the value 5 (Mustafa & Rachmansyah, 2008). Figure 2 shows that values of $pH_F - pH_{FOX}$ were high enough in the brackishwater pond areas of Pekalongan City. These areas were

distributed in Krapyak Lor Village. Similar spatial distribution pattern of $pH_F - pH_{FOX}$ was detected in the spatial distribution of the pH_{OX} . However, in areas where high $pH_F - pH_{FOX}$ was

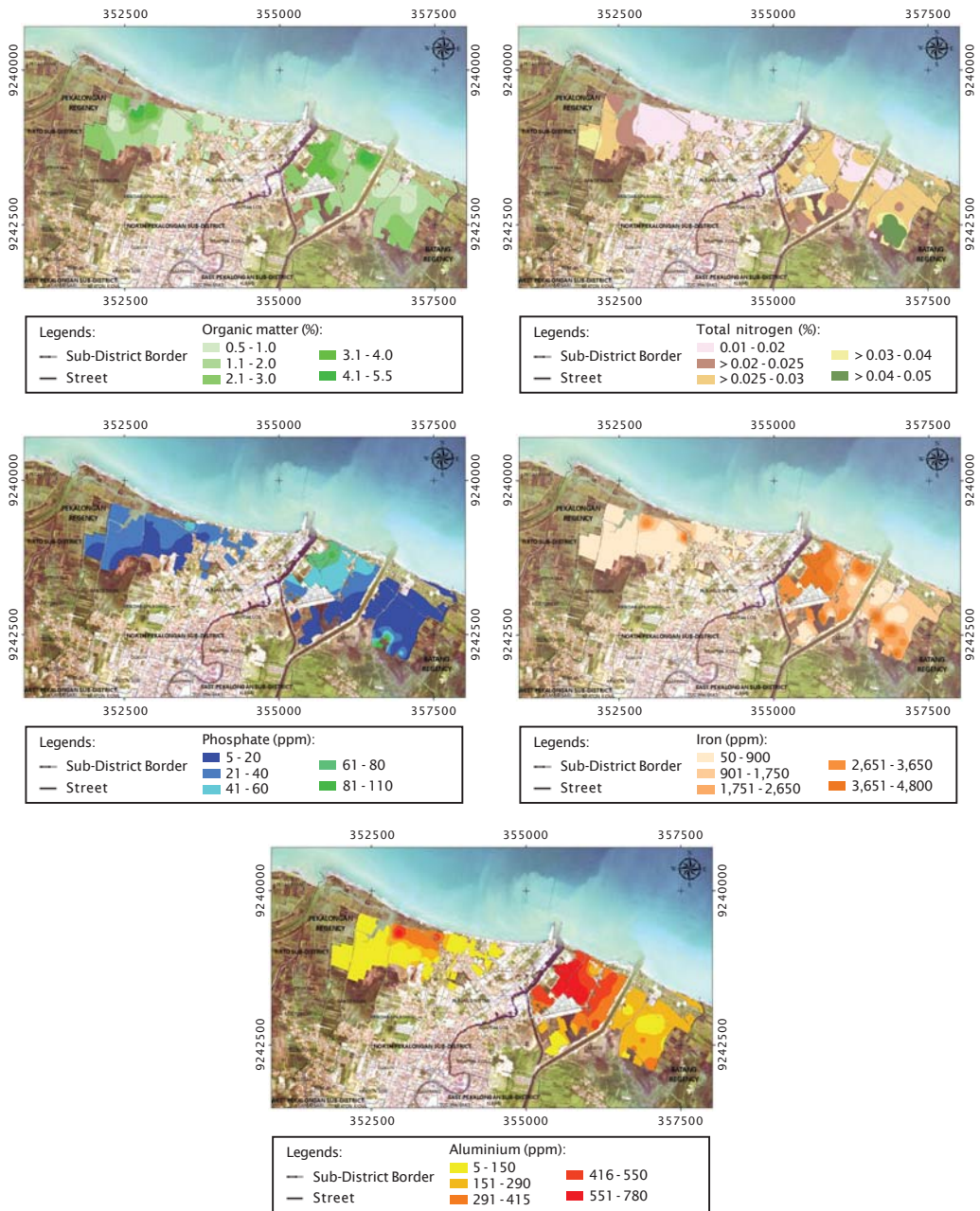


Figure 4. Spatial distribution map of organic matter (top left), total-N (top right), PO_4 (left center), iron (right center), and aluminum (bottom) of brackishwater pond soil at 0 to 0.2 m depth in Pekalongan City Central Java Province

detected the pH_{OX} was low. pH_{OX} is the pH of soil which has been dried and then oxidized with H_2O_2 30% (McElnea & Ahern, 2004b), thus describing the full potential of existing acidity in the soil.

Spatial distribution of organic matter also has the same pattern with pH_F - pH_{FOX} . This explains that the potential of soil acidity in the pond of Pekalongan City was generally derived from organic matter. Presumably, high organic matter is derived from mangrove vegetation which has been converted to brackishwater pond or growing mangrove vegetation in the pond. It was reported by Rachmansyah *et al.* (2010) that mangrove vegetations found around Krpyak Lor Village were dominated by mangrove species of *Rhizophora mucronata* and Nipah (*Nypa fruticans*). Falling leaves is the largest contributor to organic matter in sediments of mangrove forests (Koch, 2005). Decomposition of organic matter produces humus acids that cause the soil pH to become lower. Another possibility of high potential soil acidity in mangrove vegetation is because of the high content of tannin from *Rhizophora sp.*, *Bruguiera sp.*, *Ceriops tagal*, *Xylocarpus granatum*, and *Nypa fruticans* causing the soil to become more acidic (Sunarto, 2008). Thus, it was assumed that the utilization of the particular areas such as mangrove areas can cause the variation of soil organic matter. Land use type is one of the factors that cause the variation of soil organic matter (Liu *et al.*, 2006).

Results of other variables that describe the soil acidity are S_{KCI} , S_p , S_{POS} , TPA, and TSA. They showed the same relative spatial distribution with other soil acidity variables such as pH_F - pH_{FOX} . Figure 3 shows that the highest value of S_{KCI} , S_p , S_{POS} , TPA, and TSA were found in the soil located in the Krpyak Lor Village. It has been mentioned previously that acid sulfate soil in the brackishwater pond of Pekalongan City found at Krpyak Lor Village. McElnea *et al.* (2002a, 2002b) stated that in the acid sulfate soil, especially containing a low organic matter, the TSA correlates significantly with the S_{POS} . TSA also has a linear relationship with the content of pyrite (Sutrisno, 1990 in Noor, 2004) in acid sulfate soil. Variables that describe soil acidity were generally lower at 0 to 0.25 m soil depth than the depth of 0.5 to 0.7 m. Soil properties differ according to depth due to the process of horizonation (Essington, 2004). As also previously described that natural leaching in the long term can cause the

reduction of compounds or elements causing the acidity. It has been reported by Mustafa (2007) that the S_{POS} of pond bottom soil decreased from 2.1300% to 1.8587% or declined 0.2713% after the brackishwater pond bottom soil was remediated three times in the period of 72 days.

Pyrite is the main characteristic of acid sulfate soil. Relatively high amount of pyrite was only found at Krpyak Lor Village (Figure 3). Factors that influence the formation of pyrite are the amount of organic matter, sediment temperature, the supply of SO_4 and bicarbonate as well as anaerobic condition and amount of Fe (Dent, 1986). The high amount of pyrite in this village was the result of high organic matter content (Figure 4), a carbon source for bacteria for pyrite formation. In addition, Noor (2004) stated that clay deposits were derived from the fibers of remaining mangrove root. These deposits contain high pyrite. This is supported by Ersahin (2003) that variations in soil characteristics are not only as the result of land use type, but also the process of pedogenesis (soil formation).

As mentioned earlier, the soil organic matter was found relatively high in Krpyak Lor Village. It was also found in Bandengan Village, particularly in a specific area. However, the areas in both villages were not yet classified as peat soils because organic matters were lower than 20%. Peat soil is type of soil containing organic matter more than 20% (if the soil does not contain clay) or more than 30% (if the soil contains clay equal or greater than 60%) (Soil Survey Staff, 2001).

Spatial distribution of soil nutrient in the brackishwater ponds of Pekalongan City is shown in Figure 4. This shows that organic matter, total-N, Fe and Al have the similar relative distribution pattern. Organic matter does not only serve as the source of carbon, but also as a source of nitrogen (Boyd, 2008). Thus, the high content of total-N in the area of high soil organic matter can be explained as the result of the decomposition process of organic matter which produces nitrogen. Higher content of Fe and Al in the area of high organic matter is an impact of low pH that causes a higher solubility of those toxic elements. The content of Al in acid sulfate soil increased at lower pH, i.e. pH 4.0 to 4.5 (Dent, 1986).

In addition, the content of Al in acid sulfate soil is associated with pyrite oxidation. The

acid environment has accelerated weathering of aluminosilicate minerals due to the destruction of the lattice of the 2:2 type minerals (such as montmorillonite) to become 1:1 type minerals (kaolinite) to liberate and dissolve more Al (Pons, 1973). The content of Fe and Al were high in Krapyak Lor Village causing lower PO_4 (phosphate). This is as the result of Fe and Al which affects PO_4 to be unavailable. At low soil pH, PO_4 is bounded strongly by Fe and Al in the form of insoluble $FePO_4$ or $AlPO_4$ (Kselik *et al.*, 1992, Tu *et al.*, 1993; Mustafa & Sammut, 2007). Figure 4 shows that low PO_4 that was found in areas contained high Fe and Al.

Soil texture is the ratio between the fraction of clay, silt and sand within the soil. Pond soil texture affects the porosity and growth of *klekap* where the latter is the source of food for fish and shrimp. Fine textured

brackishwater pond soils are often found in areas where clay content ranges from 20% to 30% which can resist water infiltration into the pond (Boyd, 1995). Boyd (1995) also states that a soil material consisting of a mixture of particles of different sizes and containing a minimum of 30% clay is ideal for brackishwater pond construction.

In general, soil clay distribution in the brackishwater pond of Pekalongan City can be classified as heavy clay texture or have a very high clay content. Particularly, high content of clay and therefore lower content of silt and sand fractions were found in areas of Kandang Panjang, Krapyak Lor, and Degayu Villages (Figure 5). However, the content of clay fractions was relatively homogeneous which indicated by a relatively small coefficient variation ranging from 0.5 to 0.7 m soil depth (Table 2).

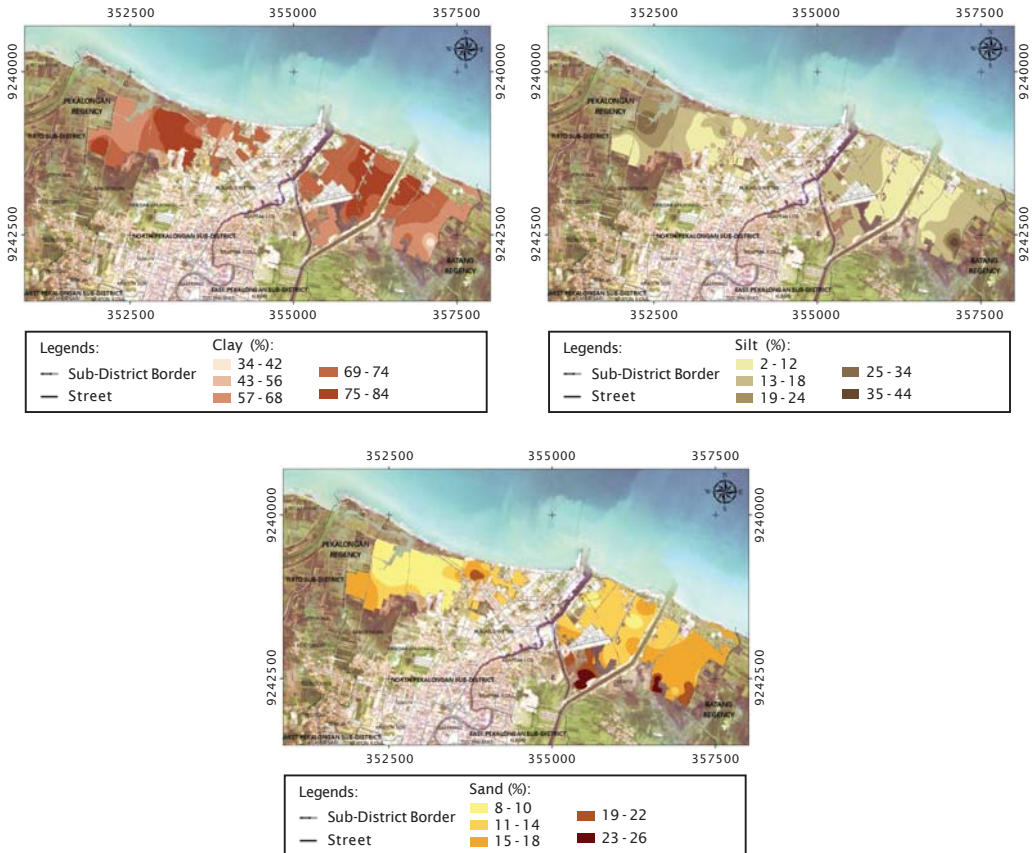


Figure 5. Spatial distribution map of clay fractions (top left), silt (top right) and sand (bottom) of brackishwater pond soil depth from 0 to 0.2 m in Pekalongan City Central Java Province

CONCLUSIONS AND SUGGESTIONS

Brackishwater pond soil in Pekalongan City is classified into non-sulfate alluvial soil without potential high soil acidity. Acid sulfate soil fraction mostly was found in Kropyak Lor Village. In general, brackishwater pond soil characteristics are considered to have high or relatively heterogeneous variability with coefficient variation more than 36%. Soil characteristics that describe the pattern of soil acidity relatively have the same spatial distribution. In addition, soil characteristics that describe the nutrient content of soil also have a similar spatial distribution pattern.

The high content of soil pH, organic matter, and total-N and conversely low PO_4 content was generally found in ponds of Krapyak Lor Village. The clay fractions were relatively homogeneous in pond soil of Pekalongan City. The typical pattern of spatial distribution of the brackishwater pond soil characteristics in Pekalongan City can be caused by the process of pedogenesis, land use type and land management practices. It is recommended that pond management should be tailored to the characteristics of the soil which is reflected by the pattern of spatial distribution of each soil characteristics.

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