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# Sustainable Land Management Supports Organic Farming in Tidal Swamp Area of South Kalimantan : Water Quality

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## ABSTRACT

Development of organic farming in tidal land should be wise and considers all aspects supporting the development of sustainable agriculture. The aim of this research was to quantify concentration of metals contained in tidal swamp water both at the single and double tides of various tidal typologies, including Pb, Cd, Cr, and Fe ions. The research was conducted in four villages in Barito Kuala regency (South Kalimantan) to represent tidal land types A, B, C and D, respectively. Sampling was carried out at spring and neap tides in each villages and the Barito river nearest to the villages. The water samples were collected in plastic bottles in the irrigation canals and brought to the laboratory for analysis of Pb, Cd, Cr and Fe concentrations. The results showed that the Pb, Cd, Cr and Fe concentrations in studied area were <0.002 - 0.0122 ppm, 0.0067 - 0.0122 ppm, <0.002 - 0.0064 ppm and 0.0358 ppm - 9.0807 ppm for Pb, Cd, Cr and Fe, respectively. Based on he limiting factor in heavy metals of water quality for agricultural crops in land C and D type are cadmium (Cd) and iron (Fe) elements. Acidity of water on the land types C (pH 2.72 - 2.95) and D (pH 2.68 - 4.41) were lower than those in the land types A (pH 6.01 - 6.83) and B (pH 3.6 - 6.29).

**Key words: Heavy metal, organic farming, tidal land, water quality**

## INTRODUCTION

Development of organic farming in tidal land should be wise and considers all aspects supporting the development of sustainable agriculture. One of the aspects is the quality of irrigation water. In tidal area, agricultural lands are easily contaminated by heavy metals due to the waste stream inundation.

There are some important non-point sources of metal pollutants in common agricultural lands, namely: (1) Cd, Cr, Pb, Mo, U, V, Zn from impure fertilizers (e.g. Cd and U in phosphatic fertilizer), (2) Cu, As, Hg, Pb, Mn, Zn from pesticides (e.g. Cu, Zn and Mn-contained fungicides, (3) As and Cu from wood preservatives, (4) Cd, Cu, Ni, Pb, Zn, As released from composts and manures, (5) Cd, Ni, Cu, Pb, Zn in sewage sludge, and (6) Zn and Cd released during the corrosion of metal objects (e.g. galvanized metal roofs and wired fences) (Alloway and Ayres, 1993).

The presence of heavy metals in tidal water should receive serious attention due to three things, namely: (1) the nature of metal toxicity and potential carsinogen, (2) the mobility of metals in soil can be quickly changed from immobile forms to mobile forms, (3) the metal has a conservative nature and tend to be cumulated in the human body. Due to these properties, the presence of metals in soil and water has a very high potential as a source of pollutants (Notodarmojo, 2005). The intertidal zone in south Kalimantan is at the down stream region of the Barito river basin as lowland where all pollutants can enter into the area. To create an organic farming in tidal land is not easy if we hope the main goal of good agricultural products and the clean and healthy environment (espesially soil and water) in supporting eco-labeling attributes, giving priority to the nutritional attributes and health.

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Based on the above explanation, the water quality research is certainly required if the tidal land to be developed for organic farming. The aim of this research was to quantify metals contained in tidal swamp water both at the single and double tides of various tidal typologies include, especially Pb, Cd, Cr, and Fe ions.

## METHODS

Periodic surveys were conducted by means of taking water samples. The water samples were taken at four villages in the Barito Kuala Regency, South Kalimantan (Figure 1).

Jelapat Baru village was selected to represent tidal zone A--the area is inundated when at spring and neap tides and always have drainage everyday. Jelapat II village was selected to represent tidal zone B--the area is inundated at only spring tide but always had drainage every day. Handil Turak village was selected to represent tidal zone C--the area is not inundated when at spring and neap tides and not get the overflow plug and suffered permanent drainage, rather the effect of tidal swing is obtained only through seepage and have a water table at a depth of <50 cm from the ground. Antar Jaya villages was selected to represent tide zone D--tidal areas that are not influenced by tidal swing at all, experiencing limited drainage and have a water table at a depth of > 50 cm from the ground.

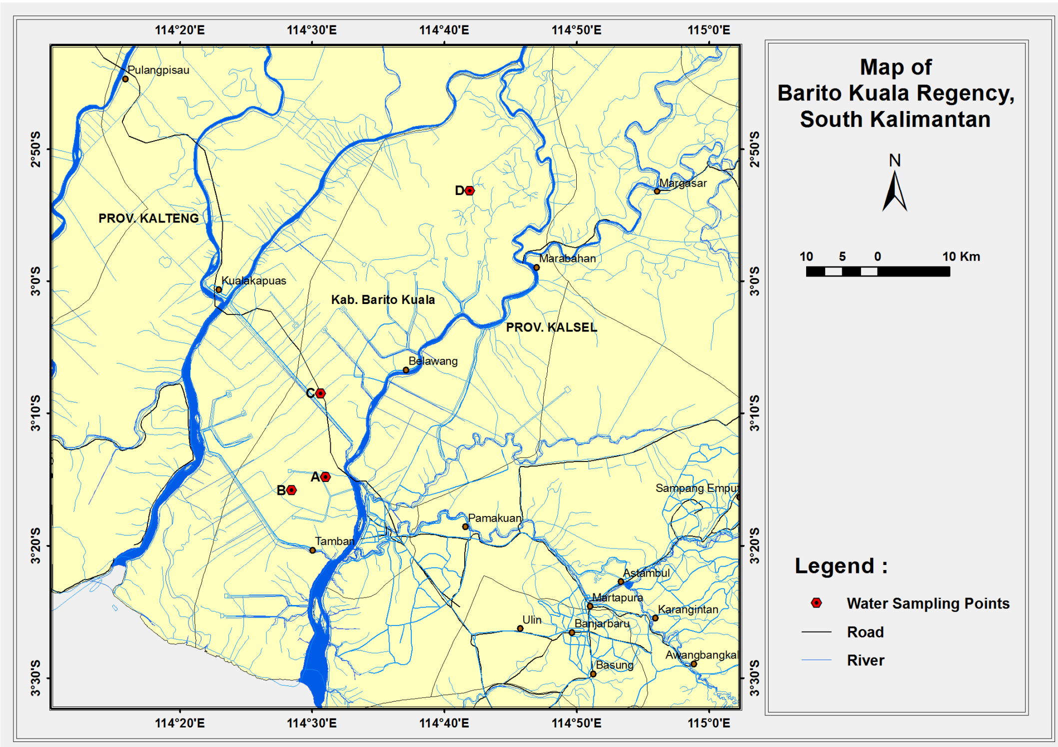


Figure 1. Map of study site (1:50.000; BAKOSURTANAL, 2007)

Sampling was carried out at spring and neap tides in each villages and the Barito river near by Barito bridge. The water samples were collected in plastic bottles in the irrigation canals and brought to the laboratory for analysis of Pb, Cd, Cr and Fe concentrations using atomic absorption spectrophotometer (AAS).

## RESULTS AND DISCUSSION

Tables 1 and 2 showed that the concentrations of Pb and Cr in the Barito river and canals at each villages both at the spring and neap tide. The Pb concentration of Pb ranged from <0,002 ppm to 0.0122 ppm, while concentrations of Cr ranged from <0,002 ppm to 0.0064 ppm. The ranges have

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still meet the irrigation water standards. Based on PP RI No. 82/2001 (about of water quality management and water pollution control), the irrigation water standards for Pb and Cr metal concentration of 0.03 ppm and 0.05 ppm, respectevely. The lead (Pb) is not an essential element for living beings, even it can toxic to animals and humans due to accumulated in bones. Toxicity of Pb in plants is relatively lower compared with other microscopic elements. Chromium is rarely found in natural waters. Chromium found in waters presents in trivalent chromium ($Cr^{3+}$) and hexavalent chromium ($Cr^{+6}$), but in water pH > 5, trivalent chromium was not found. Base on research Mariana *et al* (2014) showed that on B, C and D typologies, the water pH of canals at low tide is less 5 and is suspected of dominantly hexavalent chromium ($Cr^{+6}$).

Table 1. Concentration of Pb in the Barito river and irrigation canal of different tidal land types in the Barito Kuala Regency, South Kalimantan.

| Time | Water level | Barito river | A Type | B Type | C Type | D Type |
|---|---|---|---|---|---|---|
| Neap tide | Highest water level | <0.002 | <0.002 | <0.002 | <0.002 | 0.0122 |
| | Lowest water level | <0.002 | <0.002 | <0.002 | <0.002 | 0.0095 |
| Spring tide | Highest water level | <0.002 | <0.002 | <0.002 | <0.002 | 0.0122 |
| | Lowest water level | <0.002 | 0.0041 | <0.002 | <0.002 | 0.0095 |
| Neap tide | Highest water level | <0.002 | <0.002 | <0.002 | <0.002 | 0.0068 |
| | Lowest water level | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| Spring tide | Highest water level | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| | Lowest water level | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |

Table 2. Concentration of Cr in the Barito river and irrigation canal in different tidal land types in the Barito Kuala Regency, South Kalimantan

| Time | Water level | Barito river | A Type | B Type | C Type | D Type |
|---|---|---|---|---|---|---|
| Neap tide | Highest water level | 0,0015 | <0,002 | <0,002 | 0,0031 | 0,0048 |
| | Lowest water level | <0,002 | <0,002 | <0,002 | 0,0048 | 0,0040 |
| Spring tide | Highest water level | <0,002 | 0,0015 | 0,0031 | 0,0064 | <0,002 |
| | Lowest water level | <0,002 | <0,002 | 0,0023 | 0,0031 | 0,0040 |
| Neap tide | Highest water level | <0,002 | <0,002 | 0,0031 | 0,0048 | 0,0031 |
| | Lowest water level | <0,002 | <0,002 | 0,0031 | 0,0064 | <0,002 |
| Spring tide | Highest water level | <0,002 | 0,0031 | 0,0048 | 0,0040 | <0,002 |
| | Lowest water level | <0,002 | <0,002 | 0,0048 | 0,0023 | 0,0040 |

The Cd in water should be an insoluble form and very small amounts, generally around 0.0001 to 0.001 ppm in natural water or about 0.0001 ppm in marine waters (Effendi, 2003). The concentrations of Cd in the Barito River and drains at A, B, C and D typologies both at the spring and neap tides ranged from 0.0067 ppm to 0.0122 ppm

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(Figure 2). Based on PP RI No. 82/2001 (which stated that standard irrigation water for Cd concentration is 0.01 ppm), concentration of Cd in the Barito river and drains on D typology sometimes exceeded the standard threshold of water quality for irrigation.

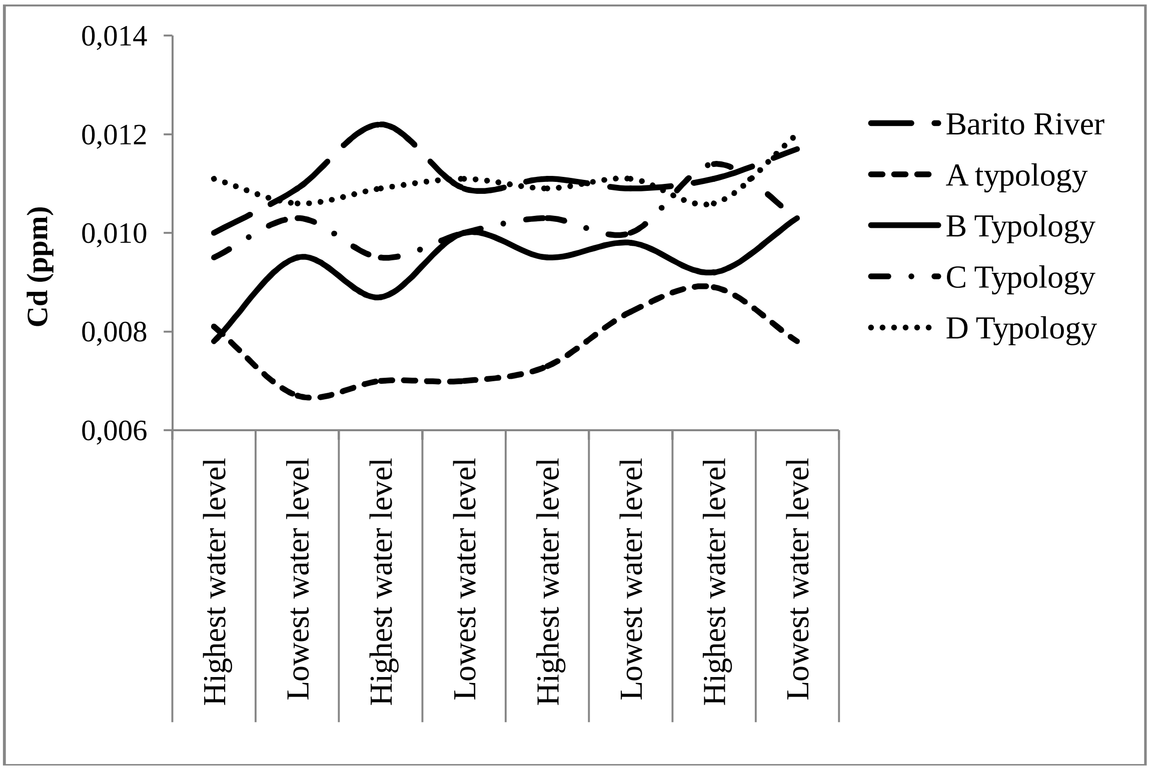


Figure 2. Concentration of Cd in the Barito river and irrigation canal in different tidal land types in the Barito Kuala Regency, South Kalimantan

The contents of Fe (iron) in the Barito river and drain canals in A, B, C and D tidal land typologies were very fluctuative and ranged between 0.0358 ppm - 9.0807 ppm, both at the high and low water level of tidal on spring and neap tides (Figure 2). The Fe concentrations in studied area were much higher than that is in natural water reported by Effendi (2013) which were below 0.2 ppm. The contents of Fe in low level tide of on A, B, C and D typology are higher than that at the high level tide. The water Fe concentration of D typology was higher than those in C, B and A land tipologies. The Fe levels exceed 1 ppm will be harmful to aquatic organisms. High levels of Fe in the channel might indicate the presence of pyrite oxidation. The pyrite ($FeS_2$) oxidation will produce Fe $(OH)_3$. In water submerged soil, the $Fe(OH)_3$ will be reduced to form soluble $Fe^{2+}$ and may flow to the irrigation channels (Konsten and Sarwani, 1992; Hicks *et al.*, 1999). The oxidation (eq. 1) and reduction (eq. 2) reaction of Fe can be described as follow:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \longrightarrow Fe(OH)_3 + 2SO_4^- + 4H^+ \quad \ldots\ldots. [eq.1]$$

$$Fe(OH)_3 + 1/4\ CH_2O + 2H^+ \longrightarrow Fe^{2+} + 1/4\ CO_2 + 1\ 1/4\ H_2O \quad \ldots\ldots. [eq.2]$$

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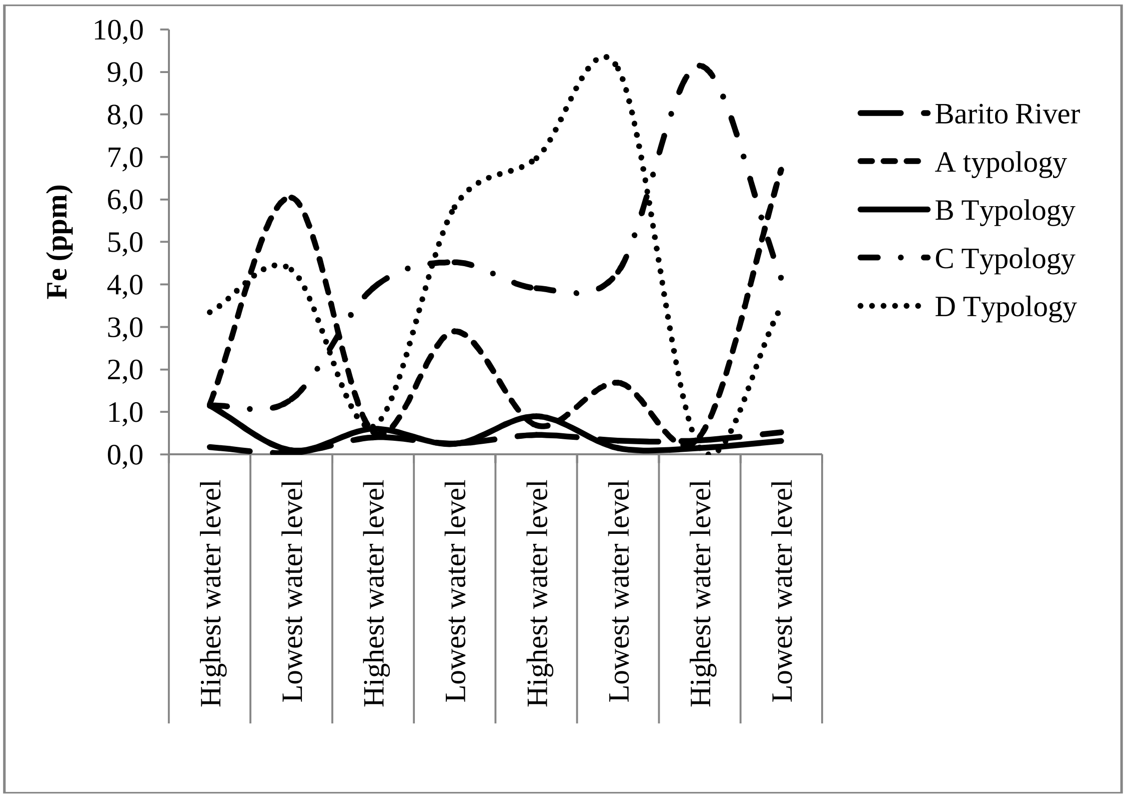


Figure 3. Concentrations of Fe in the Barito river and irrigation canal in different tidal land types in the Barito Kuala Regency, South Kalimantan

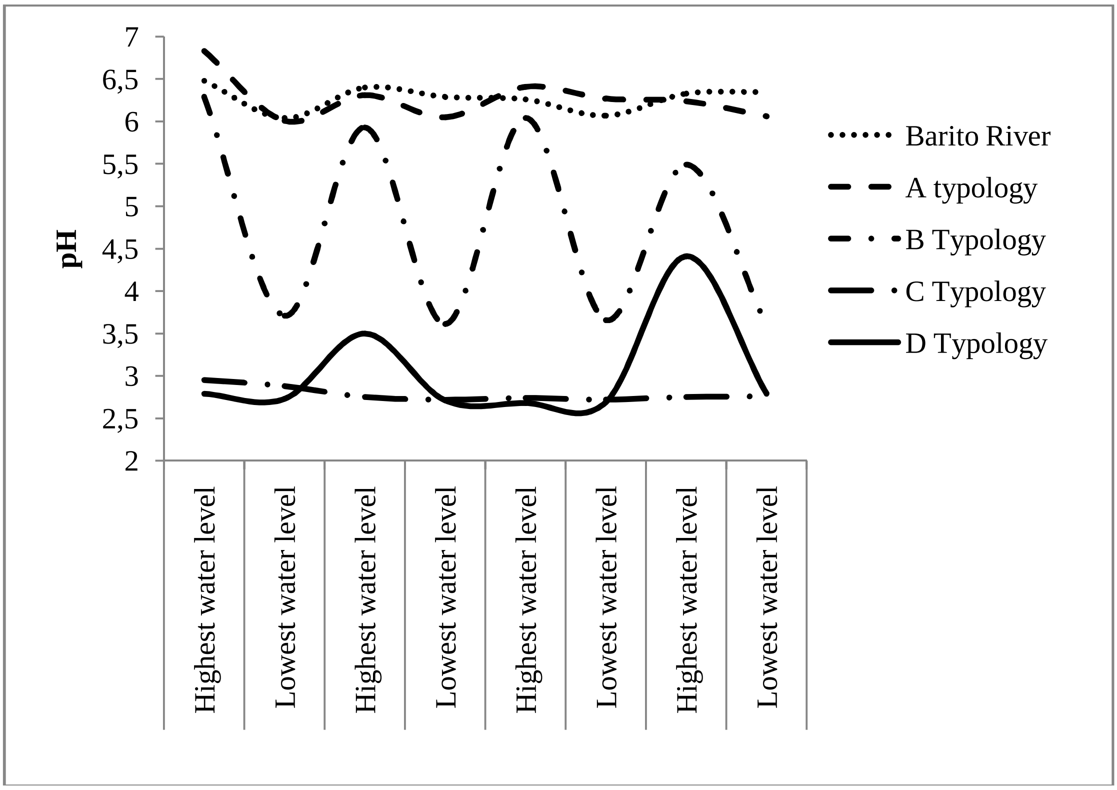


Figure 4. Acidity of water in the Barito river and irrigation canal in different tidal land types in the Barito Kuala Regency, South Kalimantan.

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Oxidation of pyrite produces sulfuric acid which then increased the water acidity in drains canals. Acidity of water in C and D types (pH 2.72 - 2.95 and pH 2.68 - 4.41, respectively) were lower than in A and B types (pH 6.01 - 6.83 and pH 3.6 - 6.29, respectively). The variation of the pH of water at various typologies of land may also caused by the movement of the tide. At A typology, surface water is dominated by river water, hence can overflow at spring and neap tides occasion lead to similar water pH in Barito river and water channels in the A land type. Water acidity of the Barito River and water channels typology A were around neutral. In the typology B, pH of the water ranged from 5.49 - 6.29 at high tide, but became more sour at low level water condition (i.e., 3.60 - 3.71). This probably because the spring and neap tides does not enter the areas (Figure 3).

## CONCLUSIONS

It could be concluded that:

1. The Pb, Cd, Cr and Fe concentrations in studied area were <0.002 - 0.0122 ppm, 0.0067 - 0.0122 ppm, <0.002 - 0.0064 ppm and 0.0358 ppm - 9.0807 ppm for Pb, Cd, Cr and Fe, respectively.
2. Based on he limiting factor in heavy metals of water quality for agricultural crops in land C and D typologies are cadmium (Cd) and iron (Fe) elements.
3. Acidity of water in land types C (pH 2.72 - 2.95) and D (pH 2.68 - 4.41) were lower than those in the land type A (pH 6.01 - 6.83) and B (pH 3.6 - 6.29).

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