INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 11, No. 3, p. 69-75, 2017

RESEARCH PAPER OPEN ACCESS

Iron (Fe) bio-concentration in purun tikus (*Eleocharis dulcis*) planted on the constructed wetland treating the coal acid mine drainage

Nopi Stiyati Prihatini[1*], Soemarno[2]

[1]*Department of Environmental Engineering, University of Lambung Mangkurat, South Kalimantan, Indonesia*

[2]*Department of Soil Sciences, University of Brawijaya, Malang, Indonesia*

Key words: Acid mine drainage, Purun tikus, vertical flow Constructed wetland, Iron (Fe), Bio concentration.

http://dx.doi.org/10.12692/ijb/11.3.69-75 Article published on September 14, 2017

Abstract

Acid mine drainage (AMD) is a wastewater from coal mining activities. The constructed wetland (CW) is one of the passive treatment technologies used in treating the AMD. This study used Vertical Subsurface Constructed Wetland (VSSF-CW) with *Puruntikus (Eleocharis dulcis*). *E. dulcis* is one of the natural plants in the sulphate acid swamp in South Kalimantan. *E.dulcis*is the potential bio filter, because it can grow and adapt well to the acidic growth media. The VSSF-CW is the engineered system designed using subsurface flow and is made by utilizing the natural processes; include wetland plant, soil, and a population of wetland microbe in treating wastewater. This study is intended to determine the ability *Purun tikus* planted in the Constructed Wetland in concentrateIron (Fe) from the coal acid mine water in its tissues. This research was carried out with two (2) kinds of media, the first VSSF-CW using mixed media of acid sulfate soil and manure; the second VSSF -CW using mixed media of acid sulfate soil and compost. The results showed that VSSF-CW with two kinds of media is capable of lowering the concentration of Fe effluent, respectively amounted to 98.26% and 91.17%. Bio concentration factor values (BCF) of Fe in *Purun tikus* (*Eleocharis dulcis*) that planted on VSSF-CW showed that *E. dulcis* is a Fe accumulator plant.

* **Corresponding Author:** Nopi Stiyati Prihatini ✉ ns.prihatini@unlam.ac.id

Introduction

Coal mining activities could adversely affect the environment. Results of research on coal mining impact study on the socio-economic and environmental development in Kutai regency showed that coal mining activities left holes that potentially gave long-term impact (Raden *et al.*, 2010). These impacts include a decrease in the quantity and quality of water, in addition to the potential for acid mine drainage pollution of surface and ground water. Acid mine drainage is a byproduct of coal mining. AMD has the characteristics of low pH, contain high concentrations of dissolved Fe, can cause corrosion and toxic to aquatic organisms. The major the caused AMD is the accelerated oxidation of iron pyrite (FeS_2) and other sulphidic minerals the resulting from the exposure of these minerals to both oxygen and water, as a consequence of the mining and processing of metal ores and coals (Johnson and Hallberg, 2005).
The handling of the AMD treatment can be done with active and passive treatment. Active treatment can produce changes in the quality of AMD in a relatively short time but costly, while passive treatment takes a relatively longer with lower costs. Passive treatment is recommended to be applied as it is considered more environmentally friendly. Researchers continue to improve the efficiency and effectiveness of the passive treatment. One passive treatment technology that is undergoing research developments namely Constructed wetland system.

Constructed wetland system is a system that is modeled on the natural wetland processes. In this system performed the engineering of the components of the System are: design, media, and the plants were grown. Constructed wetland System build custom-made to their intended use. In general there are two types of wetland which is based on the differences in rule of water flow, to allow adaptation with the objectives, the availability of soil and climate, namely: (1) surface flow (SF) or surface flow and (2) subsurface flow (SSF) or subsurface flow (Farooqi *et al.*, 2008; Herniwanti *et al.*, 2014; Hoffmann *et al.*, 2011; Prihatini *et al.*, 2016a; Prihatini *et al.*, 2016b; USEPA, 1993). There are two types subsurface flow constructed wetland (SSFCW), namely vertical SSFCW (VSSF-CW) and horizontal SSFCW (HSSF-CW). SSFCW use certain plants that are tolerant and can absorb contaminants. Purun tikus (*Eleocharis dulcis*) is a water plant which is the natural vegetation in the swamp areas with acid sulphate soil. Because of this characteristics *E. dulcis* are used in SSFCW in this study.

Previous research shows the model of the Horizontal Subsurface Flow Constructed Wetlands (HSSF-CW) with the Purun tikus capable of removing iron and raising the pH of the acid mine drainage. That models can remove 103.61 mg $Fe.day^{-1}$ from AMD(Prihatini *et al.*, 2015). The HSSF-CW were planted with Purun tikus (*Eleocharis dulcis*). This study indicated Purun tikus can accumulate iron in its tissue. Therefore research on bio-concentration metal in Purun tikus is needed. The AMD contain iron is with a large concentration. Therefore it is necessary to know the ability of Purun tikus to concentrate Fe in its tissues.

Materials and methods

Materials

This research used a model of vertical flow constructed wetland. The constructed wetland model is made of wood with dimensions of 0.65 mx 0.35 mx 0.35 m.Acid mine drainage (AMD) derived from waste coal mining PT Arutmin Indonesia, South Kalimantan. Wetland vegetation used are Purun tikus (*Eleocharis dulcis*) with an average height of 15 cm with a spacing of 15 cm. Media use is an acid sulphate soils, according to the original habitat of plants Purun tikus with a height of 30 cm on each model. Purun tikus and acid sulphate soils originating from Central Puntik Village, District Mandastana, Barito Kuala, South Kalimantan.

Methods

This research was carried out with the system SSFCW vertical flow with the operating system in batches. The research was conducted for 5 days with a sampling interval in the 1st, 3rd day, and day-to-5. Media on this model varied by two kinds of media, using the media of acid sulfate soil mixed with

manure and media acid sulphate soils mixed with compost. Effluent water samples will be tested by testing the parameters of iron (Fe) in the laboratory using flame AAS (Atomic Absorption Spectrophotometer with flame) in accordance with the standards for Fe namely ISO 6989.4: 2009.Bio concentration is ratio between metal in the Plant and metal concentration inthe surrounding environment. Bio-concentration factor (BCF) was calculated as follow:

$$BCF = \frac{F_e \text{ in the plant}}{F_e \text{ in the media}}$$

Results and discussion

Effluent Iron (Fe) concentration

Results showed that the concentration of Fe in the effluent VSSFCW decreased quite significantly over time (Fig. 2). Fe concentration in the effluent decreased by 98.26% in VSSF-CW with mixed media Acid sulphate soil with manure and while in VSSF-CW with mixed media Acid sulphate soil with compost Fe concentration in the effluent decreased by 91.17% within 5 day. This suggests that differences in the design of the media and the CW will produce different efficiency and performance of CW. Fe removal due to the complex processes that occur in VSSFCW, interaction processes involving physical-chemical and biological. These processes involving plants, media and microorganisms that exist in VSSFCW (Munawar, 2007; Vymazal, 2010; Vymazal and Kropfelova, 2008; Younger *et al*., 2002).

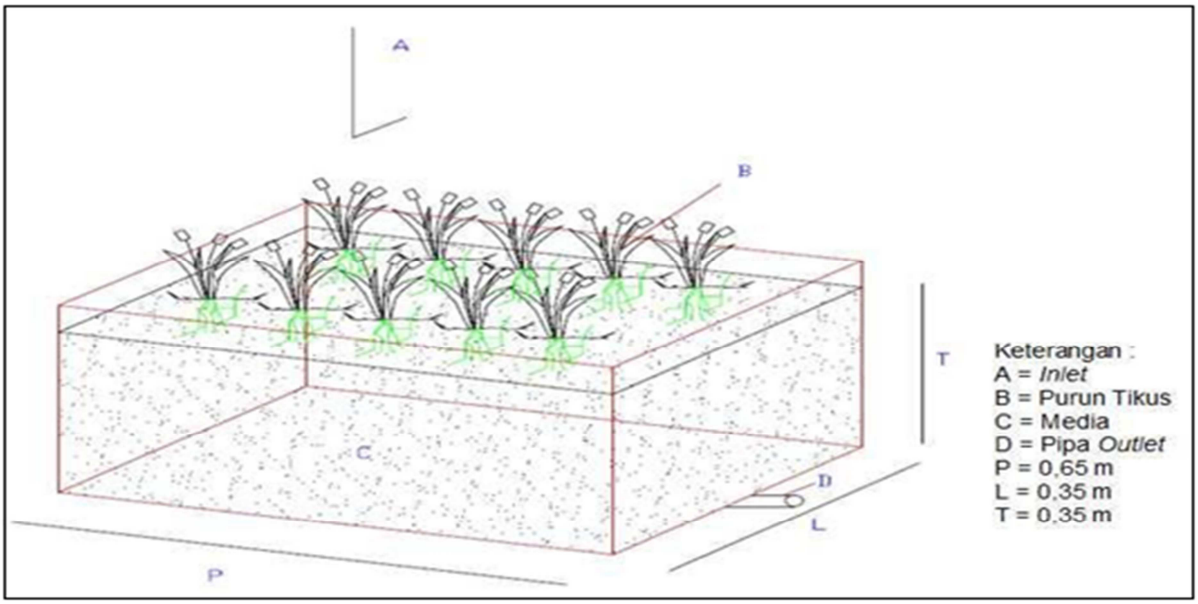

Fig. 1. Design Reaktor VSSF- Contructed Wetland.

Iron (Fe) concentration on the media of the Vertical Sub Surface Flow Constructed Wetland

In this study was used two different kinds of growth-media with a mixture of different combinations, the first VSSF-CW with mixed media Acid sulphate soil and manure, second VSSFCW with mixed media af sulphate-acid soil and compost. Fe concentration measurements at different VSSF-CW media showed that the VSSF-CW with sulphate acid soil + manure are higher than the VSSF-CW with sulphate acid soil + compost (Fig. 3). This shows that the manure can help Acid sulphate soil in adsorb Fe more than compost.

Iron (Fe) concentration of the E.dulcis

Fe concentration in *Puruntikus* grown in VSSF-CW with Acid sulphate soil + manure is lower than the concentration of Fe in *Puruntikus* grown in VSSF-CW with Acid sulphate soil + compost (Fig. 4). This shows that Purun tikus in model of VSSF-CW with acid sulphate soil + compost do more uptake Fe than Purun tikus in model VSSF Fe-CW with acid sulphate soil + manure. Plants provide a large surface area for the attachment and growth of microbes(Hua, 2003).

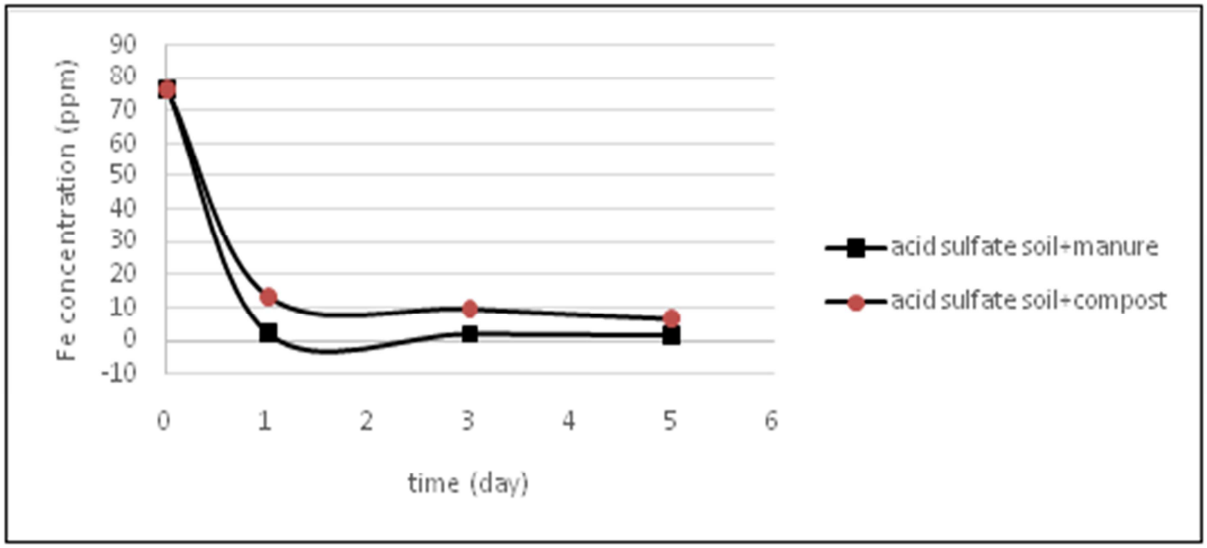

Fig. 2. Fe Concentration of AMD effluents in the VSSF-CW.

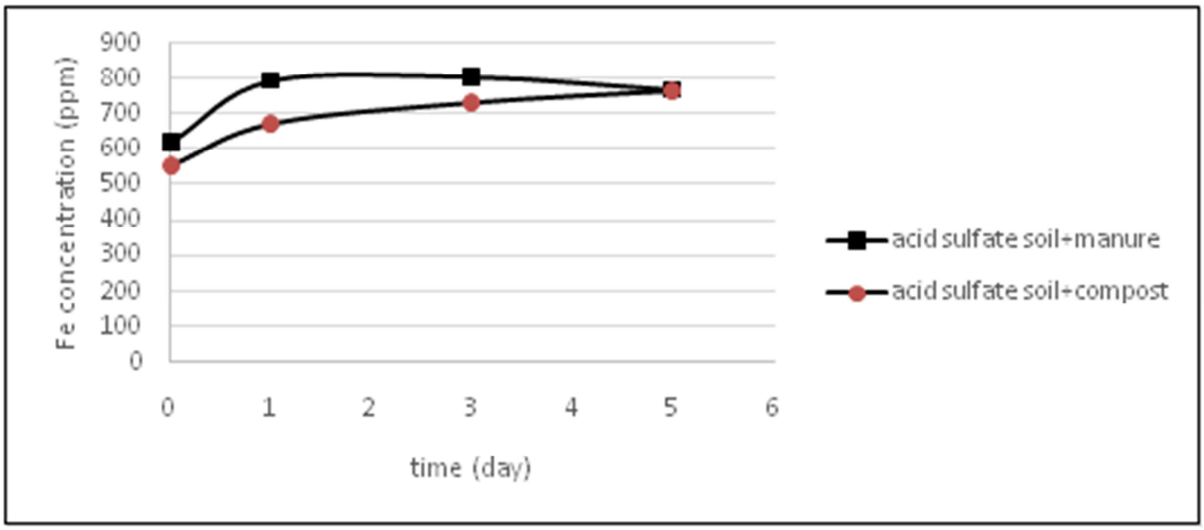

Fig. 4. Fe Concentration of media in the VSSF-CW.

The complex interaction of plants with microorganisms claimed to be the main process to eliminate metals from wastewater (Kosolapov *et al.*, 2004).

Purun tikus contain many phenolic compounds in the cell wall that makes the roots and stems of this plant has a high tolerance for Fe. Metal will accumulate in plants after forming complexes with other elements or compounds, one of which phytochelatin composed of several amino acids such as cysteine and glycine. Function of phytochelatin is to form complexes with heavy metals in plants and serves as detoxification of heavy metals to plants, if the plants cannot synthesize phytochelatin lead to impaired growth and lead to death. Phytochelatin highest levels found in plants that are tolerant to heavy metals (Anjum *et al.*, 2012; Cobbett, 2000; Hirata *et al.*, 2005; Hirata *et al.*, 2001; Liu *et al.*, 2006; Yadav, 2010; Yang *et al.*, 2005).

Bioconcentration Factor (BCF) of Fe in E. Dulcis

Iron as a micro nutrients it takes only less than 0.1% or ± 1000 ppm for plant growth. In general, the plant requires only Fe as much as 50-250 $mg.kg^{-1}$ of biomass in the network. If the Fe content in the network exceeds 300 mg.kg-1 plant is said to be poisoned. The high concentration of Fe in *Purun tikus* organs (Fig. 4) makes this plant's potential as a plant Fe hyper-accumulator, because it is able to absorb

and localize these elements more than 0.1% on the organ. Bio concentration Factor (BCF) is a parameter used to determine the potential of plants do accumulate metals (Rezvani and Zaefarian, 2011; Tommy, 2009).Results of BCF calculation in *Purun tikus* (Fig. 5) shows that *Purun tikus* is a plant which can accumulate Fe. From the point of view of phytoremediation, a good accumulator has been defined as having the ability to concentrate the heavy metal in its tissues. In general, a plant with a BCF of more than 1000 is considered a hyper-accumulator. A plant with a BCF of 1 to less than 1000 is considered an accumulator, and with a BCF of less than 1 as an excluder (Islam *et al*., 2013; Zayed *et al*., 1998).

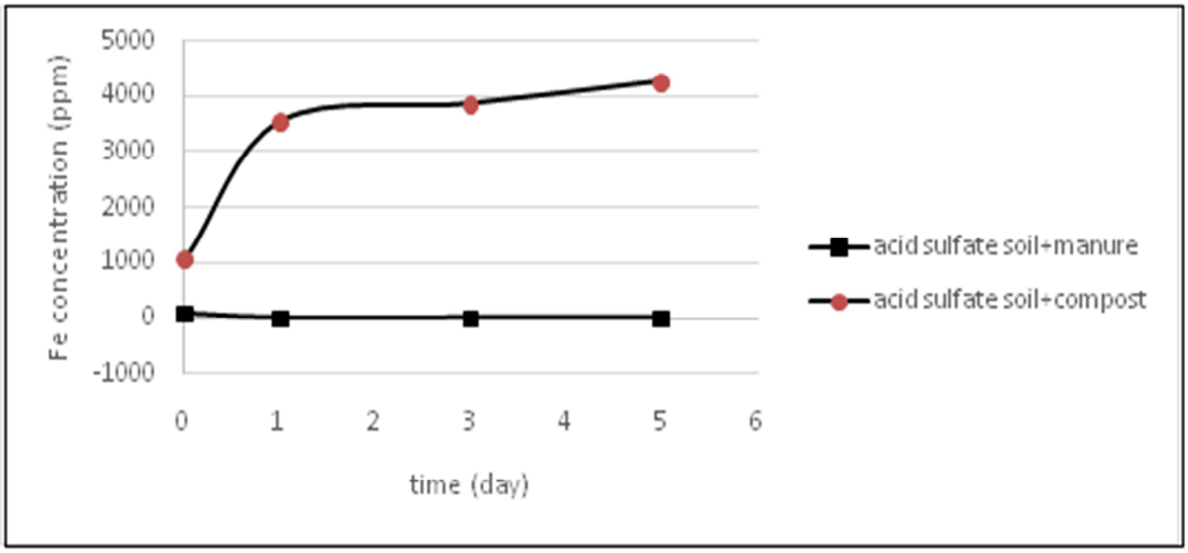

Fig. 4. Fe Concentration on *Purun tikus* in the VSSF-CW.

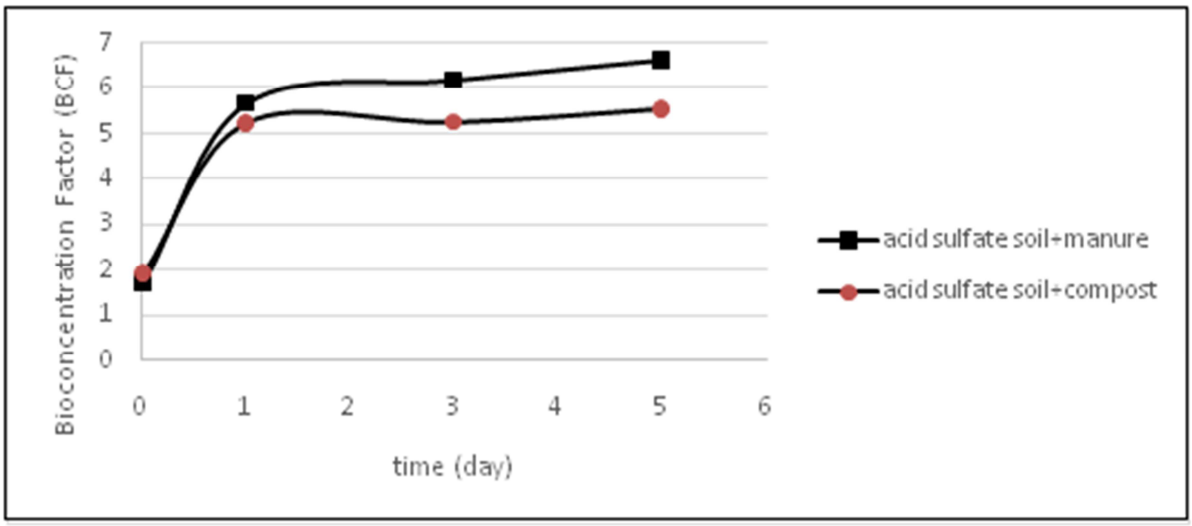

Fig. 5. Bioconcentration Factor of Fe in the *Purun-tikus*.

Conclusion

Model of the Vertical Subsurface Flow Constructed Wetlands (VSSF-CW) with the *Purun tikus* plant capable of removing iron from the acid mine drainage. The best performance is shown by the VSSF-CW with the mixture media of sulphate-acid soil and manure. The high BCF (Bio concentration factor) of Fe in *Puruntikus* (*Eleocharis dulcis*) planted on the VSSF-CW suggested that *Puruntikus* asthe accumulator plant.

Acknowledgement

The author thank to M. Rizky Setiawan, Tiara Wulansari, Johar Latifah, Nor Alpian for helping providing raw data.

References

Anjum NA, Ahmad I, Mohmood I, Pacheco M, Duarte AC, Pereira E, Umar S, Ahmad A, Khan NA, Iqbal M, Prasad MNV. 2012. Modulation of glutathione and its related enzymes in plants' responses to toxic metals and metalloids-A review. Environmental and Experimental Botany **75(1),** 307-324.

Cobbett CS. 2000. Phytochelatin biosynthesis and function in heavy-metal detoxification. Current Opinion in Plant Biology **3 (3),** 211-216.

Farooqi IH, Basheer F, Chaudhari RJ. 2008. Constructed Wetland System (CWS) for Wastewater Treatment. The 12th World Lake Conference.

Herniwanti, Yanuwiadi B, Priatmadi BJ, Soemarno. 2014. Comparison of Characteristic Aquatic Local Plants for Phytoremediation with Different Media of Acid Mine Drainage Passive Treatment. J. Appl. Environ. Biol. Sci. **4(3),** 167-176.

Hirata K, Tsuji N, Miyamoto K. 2005. Bio-synthetic regulation of phytochelatins, heavy metal-binding peptides. Journal of Bioscience and Bioengineering **100 (6),** 593-599.

Hirata K, Tsujimoto Y, Namba T, Ohta TT, Hirayanagi N, Miyasaka H, Zenk MH, Miyamoto K. 2001. Strong induction of phytochelatin synthesis by zinc in marine green alga, *Dunaliella tertiolecta*. J. Bioscience and Bioscience **92 (1),** 24-29.

Hoffmann H, Platzer C, Winker M, Muench Ev. 2011. Technology review of constructed wetlands. Subsurface flow constructed wetlands for greywater and domestic wastewater treatment. Germany, Federal Ministry for Economic Cooperation and Development; Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Sustainable sanitation - ecosan program.

Hua SC. 2003. The use of constructed wetlands for wastewater treatment. Malaysia, Wetlands International.

Islam MS, Ueno Y, Sikder MT, Kurasaki M. 2013. Phytofiltration of Arsenic and Cadmium from The Water Environment Using *Micranthemum umbrosum* (J.F. Gmel) S.F. Blake as a Hyperaccumulator. International Journal of Phytoremediation **15,** 1010-1021.

Johnson DB, Hallberg KB. 2005. Acid mine drainage remediation options: a review. Science of the Total Environment **338,** 3- 14.

Kosolapov DB, Kuschk P, Vainshtein MB, Vatsourina AV, Wießner A, Kästner M, Müller RA. 2004. Microbial Processes of Heavy Metal Removal from Carbon-Deficient Effluents in Constructed Wetlands. Eng. Life Sci **4,** 403-411. https://doi.org/10.1002/elsc.200420048

Liu YG, Zhang HZ, Zeng GM, Huang BR, Li X. 2006. Heavy Metal Accumulation in Plants on Mn Mine Tailings. Pedosphere **16 (1),** 131-136.

Munawar A. 2007. Pemanfaatan Sumberdaya Biologis Lokal Untuk Pengendalian Pasif Air Asam Tambang: Lahan Basah Buatan (Utilization of local biological resources in the passive tretment method of acid mine drainage: Constructed Wetlands). Jurnal Ilmu Tanah dan Lingkungan (Jour. of Soil and Environment Sciences) **7(1),** 31-42.

Prihatini NS, Nirtha I, Iman MS. 2016a. Role of Purun Tikus in Vertical Subsurface Flow Constructed Wetland in Treating Manganese (Mn) From Coal Mine Drainage. Tropical Wetland Journal **2(1),** 1 - 7.

Prihatini NS, Priatmadi BJ, Masrevaniah A, Soemarno. 2015. Performance of The Horizontal Subsurface-flow Constructed Wetland With Different Operational Procedures. International Journal of Advances in Engineering & Technology **7(6),** 1620-1629.

Prihatini NS, Priatmadi BJ, Masrevaniah A, Soemarno. 2016b. Effects of the Purun Tikus (Eleocharis dulcis (Burm. F.) Trin. ex Hensch) Planted in the Horizontal Subsurface Flow-Constructed Wetlands (HSSF-CW) on Iron (Fe) Concentration of the Acid Mine Drainage. J. Appl. Environ. Biol. Sci. **6(1),** 258-264.

Raden I, Pulungan S, Dahlan M, Thamrin. 2010. Kajian Dampak Penambangan Batubara Terhadap Pengembangan Sosial Ekonomi dan Lingkungan di Kabupaten Kutai Kartanegara. Jakarta, Badan Penelitian dan Pengembangan Kementrian Dalam Negeri.

Rezvani M, Zaefarian F. 2011. Bioaccumulation and translocation factors of cadmium and lead in *Aeluropus littoralis*. Australian Journal of Agricultural Engineering **2(4),** 114-119.

Tommy MP. 2009. Bioremediasi Merkuri (Hg) Dengan Tumbuhan Air Sebagai Salah Satu Alternatif Penanggulangan Limbah Tambang Emas Rakyat. Agritek **17(5),** 918-931.

USEPA. 1993. Constructed Wetland for Wastewater Treatment and Wildlife Habitat, 17 Case Studies. Washington DC, USEPA.

Vymazal J. 2010. Constructed Wetlands for Wastewater Treatment. Water Air Soil Pollut **2,** 530-549. https://doi.org/10.3390/w2030530

Vymazal J, Kropfelova L. 2008. Wastewater Treatment in Constructed Wetlands with Horizontal Sub-Surface Flow. Czech Republic, Springer Science

Yadav SK. 2010. Heavy metals toxicity in plants: An overview on the role of glutathione and phytochelatins in heavy metal stress tolerance of plants. South African Journal of Botany **76(2),** 167-179.

Yang X, Feng Y, He Z, Stoffella PJ. 2005. Molecular mechanisms of heavy metal hyperaccumulation and phytoremediation. Journal of Trace Elements in Medicine and Biology **18(4),** 339-353.

Younger PL, Banwart SA, Hedin RS. 2002. Passive Treatment of Polluted Mine Waters. Environmental Pollution **5,** 311-396.

Zayed A, Gowthaman S, Terry N. 1998. Phytoaccumulation of trace elements by wetland plants: 1. Duckweed. Environ Qual **27(3),** 715-721.