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Biomonitoring Agent for Heavy Metals Run off from Acid Sulfate Soil of Aquaculture Industries in Selangor, Malaysia

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Abstract: The disturbance of acid sulfate soils due to poor wastewater management of aquaculture activities caused a major environmental issue such as metal pollution in coastal regions of many countries over the world. Peninsular Malaysia also challenged the same problem where it lost 18700 ha of coastal lowlands from 1980-1990. This activity caused the oxidation of pyrite which produces high concentrations of ferrous ions and sulfuric acid in turn attacks clay minerals and produces high concentrations of monomeric Aluminum (Al) and other acid-soluble metals. Subsequent leaching of these toxic products into adjacent water bodies is rapidly increasing the stress on ecosystems. Therefore, the research was aimed to monitor heavy metal runoff from acid sulfate soil at shrimp aquaculture areas through phytotechnology approach. The study was conducted at fourteen different sites in Selangor which contains large amount of acid sulfate soil. The result showed that *Pistia stratiotes* was substantially the best phytoindicator for Al, Iron (Fe) and Manganese (Mn) toxicity followed by *Lemna minor*, *Nymphaea stellata* and *Urticulata aurea*. On the other hand, *N. stellata* was observed to be best phytoindicatorfor Nickel (Ni) whereas for Arsenic (As) was *Ludwigia palustris*. Among these six species, the most potential biomonitoring agent to indicate acid-soluble metals are *P. stratiotes* and *N. stellata*as they are presence in low D.O level, high pH, high concentration of ammonium and tolerance to Al, Fe, Mn and Ni.

Key words: Acid sulfate soil, phytotechnology, heavy metals, aquatic plant species, aquaculture

INTRODUCTION

Shrimp aquaculture has recognized among the important marine industries which produces large amount of waste comprising of shrimp's head, shell and tail (Quan and Turner, 2009). Wastes are produced from uneaten feeds, fecal and other excretory wastes (Ali *et al*., 2011) that consist of nutrients like nitrogen and phosphorus which are discharged into drains without any or minimal treatment. The destruction of mangrove ecosystem has led to several problems such as may degrade existing natural populations and habitats, expose the coastlines to storm and tidal surges (Azad *et al*., 2009) cause soil acidification (Mitra and Bhattacharyya, 2003) and water pollution (Martin, 2011).

Globally, the report shown that 1-1.5 million ha of coastal lowlands of the ASEAN countries have been converted for shrimp aquaculture pond and it is estimated that more than one third mangrove forests have been degraded (Azad *et al*., 2009). Peninsular Malaysia also challenged the same problem where it lost 18700 ha from 1980-1990 (Chan *et al*., 1993). The loss is estimated to be increased as the large scale of shrimp aquaculture has boomed, since last two decades (Ronnback *et al*., 2002). The disturbance of acid sulfate soils due to poor wastewater management of aquaculture activities caused a major environmental issue such as heavymetals toxicity as well others inorganic pollutants. This activity caused the oxidation of pyrite which produces high concentrations of ferrous ions and sulfuric acid in turn attacks clay minerals and produceshigh concentrations of monomeric Aluminum (Al) and other acid-soluble metals. Subsequent leaching of these toxic products into adjacent water bodies is rapidly increasing the stress on ecosystems (Cook *et al*., 2000). In Peninsular Malaysia, acid sulfate soils probably cover an area of about 141 700 ha, found mainly in the coastal region of Melaka, Kedah, Perlis, Kelantan, Selangor, Terengganu,

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Johor and Pahang (Law and Selvadurai, 1968). Previous research has demonstrated that plants are effective in cleaning up contaminated soil (Wenzel *et al*., 1999). Phytotechnologies employ plants to remediate, stabilize or control toxic contaminants from the environment (Vanek and Schwitzguebel, 2003). These techniques use plants to extract, degrade, contain or immobilize pollutants in soil, groundwater, surface water and other contaminated media (USEPA, 2000).

Therefore, this research aimed to monitor heavy metal runoff from acid sulfate soil using aquatic plant species, as biomonitoring agent.

MATERIALS AND METHODS

Site sampling: This study was conducted in Selangor situated in SabakBernam, SgBesar, TanjongKarang, Kuala Selangor, Kapar, Pulau Indah and Sepang in which the acid sulfate soil most likely formed. Fourteen potential areas of acid sulfate soil were identified as detailed in (Fig. 1) and data was collected to identify best phytoindicator for monitoring heavy metals run off from acid sulfate soil. The site criteria were based on the availability and co-relation between acid sulfate soil, water and aquatic plant species (Fig. 2).

Water sampling: Five replicates of water samples were collected in 2 L water capacity polyethylene containers at identified station using standard methods of APHA or standard methods for the examination of water and waste water for analyzing polluted freshwater bodies (APHA, 1995). All samples were brought to the laboratory and stored at 4°C. Preservation of samples was done by the addition of 2.5 mL chloroform in 500 mL of water for further analysis.

Heavy metal analysis: Each replicates were sequentially divided into ten samples for heavy metal analysis in order to evaluate the variations (Iamchaturapatr *et al*., 2007). The analysis of heavy metals which are Al, Fe, Mn, Ni and as were determined using ICPMS (Inductively Coupled Plasma Mass Spectrometry). Samples were acidified with 1 mL of concentrated nitric acid. Samples were then aspirated for 30 sec prior to the collection of data. Samples having concentrations higher than the established linear dynamic range should be diluted into range and reanalyzed. The sample was analyzed for the trace elements, protecting the detector from the high concentration elements. Statistical analyses were performed for analysis of variance and data significance.

Fig. 1: Location of study area and sampling station

Fig. 2: Unhealthy freshwater bodies dominated by 6 type of aquatic plant species at fourteen different sites in Selangor; a) *Pistia stratiotes*; b) *Ludwigia palustris*; c) *Ipomea aquatica*; e) *Nymphaea stellata*; f) *Lemna minor*

Table 1: Mean (±SD, n = 10) value (mg L^{-1}) of Al, Mn, Fe, Ni and as water samples dominated by *P. stratiotes*, *L. minor*, *L. palustris*, *N. stellata*, *I. aquatica*, *U. aurea* and *L. minor* at fourteen different sites in Selangor with analysis

Stations	Species	Al (mg L^{-1})	Fe (mg L^{-1})	Mn (mg L^{-1})	Ni (mg L^{-1})	As (mg L^{-1})
(BaganNakhoda Omar)	*P. stratiotes*	1.10-1.45	0.87±0.63	0.30±0.30	NA	NA
(Sg. Air Tawar)	*L. minor*	0.44-0.92	0.17±0.16	0.07-0.10	NA	NA
(Batu 9)	*L. palustris*	NA	0.01±0.01	0.01-0.02	NA	0.01-0.02
(Batu 10)	*I. aquatica*	NA	0.03-0.04	NA	NA	NA
(Parit 9)	*N. stellata*	0.09-0.10	0.16±0.12	0.05-0.08	0.08-0.27	NA
(Parit 13)	*N. stellata*	0.09-0.12	0.17±0.15	NA	NA	NA
(Batu 6)	*L. minor*	0.09±0.12	0.12±0.11	NA	NA	NA
(Kg Dungun)	*I. aquatica*	0.08-0.10	0.14-0.22	NA	NA	NA
(SgTengi)	*L. minor*	0.05-0.10	0.12-0.15	0.05-0.10	NA	NA
(Kg Sepakat)	*L. palustris*	0.12±0.09	0.16±0.13	0.03-0.06	NA	NA
(Parit 1)	*P. stratiotes*	0.17±0.09	0.16±0.12	0.05-0.08	NA	NA
(Kg UluTris)	*L. palustris*	0.09±0.11	0.09±0.12	NA	NA	NA
(Kg Perigi)	*U. aurea*	0.06-0.08	0.13±0.08	0.03-0.07	NA	NA
(Kg Batu 39)	*N. stellata*	0.06-0.08	0.09±0.08	0.06-0.08	NA	NA

RESULTS AND DISCUSSION

Heavy metal concentration: Results established that the presence of Al, Mn and Fe are highly significant to indicate type of heavy metals contaminant at 14 selected types. As shown in Table 1, the accumulation of Al, Mn and Fe were found higher in Station 1 with the presence and abundance of *P. stratiotes*. Al might be naturally mobile within the unhealthy environment, however anthropogenic activities and acid sulfate soil disturbance might also contribute considerable quantities of Al toxicity. The concentration of Al in the drainage water samples was ranging from 0.09-1.10 mg L^{-1} which exceeded the acceptable limits of 0.2 mg L^{-1} for raw water. Thus, high concentration of Al showed a great potential for *P. stratiotes* as phytoindicator for Al toxicity. As for Mn, the concentration range for all samplings were also exceeded the standard required for raw water supply (0.2 mg L^{-1}). In short, the result indicated that *P. stratiotes* was substantially the best phytoindicator for Al, Fe and Mn toxicity followed by *L. minor*, *N. stellata* and *U. aurea*. On the other hand, *N. stellata* was observed to be best phyto indicator for Ni whereas for as was *L. palustris*. Among these six species, the most potential biomonitoring agent to indicate acid-soluble metals are *P. stratiotes* and *N. stellata* as they are capable growing in low D.O level, high pH, high concentration of ammonium and tolerance to Al, Fe, Mn and Ni. Results of these studies clearly showed that acid sulfate soil is a main source of contamination of Al, Fe, Mn, Ni and As as well as main contributor to heavy metals pollutant in shrimp aquaculture.

CONCLUSION

High concentrations of metals are usually associated with acidic drainage as the solubility of metals increases with decreasing of pH. The potential and positive relation created between soil properties and the criteria of plants is importance to ensure the phytoremediation technology is effective. Macrophytes were recognized as integrators of environmental conditions and can be used as long-term indicators with high spatial resolution and thus can be effectively used as biological indicators. Continuous monitoring of chemical parameters of water as well as distribution and abundance of aquatic plant species are important parameters in planning and defining of different cleaning and maintenance programmes to ensure thesustainable development of healthy aquatic ecosystems. In conclusion, all six species which are *P. stratiotes*, *L. minor*, *N. stellata*, *U. aurea*. *L. minor* and *L. palustris* were observed as potential phytoindicator for monitoring heavy metals (Al, Fe, Mn, Ni and As) runoff from acid sulfate soil.

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