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Preliminary Study of Phytoremediation for Sulphide Treatment using *Scirpus grossus*

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Abstract

Objectives: Phytoremediation is known as one of the green solutions to remove toxic contaminants from waste using plants. In this phytoremediation study, the synthetic Spent Sulfidic Caustic (SSC) was introduced to *Scirpus grossus plant*. The survival of the plant was observed physically and the percentage of sulphide removal from SSC was analyzed. **Methods/Statistical Analysis:** Methodology were comprised of initial growth of *Scirpus grossus*, the growth of *Scirpus grossus* after induced with synthetic SSC and preparation of synthetic SSC including analysis of pH, Chemical Oxygen Demand (COD) and sulphide content. **Findings:** The physical observation on the plants showed that after five weeks of exposure, the withered leaves were detected in all sulphide concentration with the highest percentage recorded as 44.00% corresponded to the sulphide concentration of 4.24 mg/L. The analysis for sulphide concentration revealed the concentration of the sulphide reduced and meets the minimun concentration (<0.5 mg/L) as required in Standard A and B of Environmental Quality Act (Industrial Effluents) 2009. **Application/Improvements:** Phytoremediation process is possible for sulphide removal using *Scirpus grossus* plant.

Keywords: Phytoremediation, *Scirpus grossus*, sulphide

1. Introduction

The effluent generated by refineries usually contains either organic or inorganic materials such as heavy metals, hydrocarbons, sulphur compounds and etc. The sulphur compounds will be known as Spent Sulfidic Caustic (SSC) once reacted with sodium hydroxide (NaOH). NaOH solutions always are used in many chemical industries i.e., in liquefied petroleum gas, natural gas, and refining industries to wash out different gases such as hydrogen sulphide and carbon dioxide[1]. The toxicity and malodorous characteristics of the SSC may deteriorate finished products, and need to be treated for environmental protection and mankind[2] and reach the allowable standard i.e., the sulphide content must be lower than 0.5 mg/L (Standard A and B of Environmental Quality Act (Industrial Effluents) 2009).

Phytoremediation, in which plant is used to remediate the contaminants, is one of the possible methods to remediate or reduce the sulphide content. It has been reported that a number of plant species have been used for the remediation of arsenic, zink, cadmium, aluminium and plumbum[3–5].

It is believed that the process of phytoremediation will be one of the methods which can be applied to remediate the contaminated environment. Soil texture, pH, salinity, pollutant concentrations and the presence of other toxins must be within the limits of plant tolerance. It has been reported

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that several species of plant have their ability to uptake contaminant from their growth medium, such as *Lepironia articulate*, *Eleocharis ochrostachys* and *Scirpus grossus*[6]. The use of plants and the microbes associated with their growth to clean up contaminated soils and water is an innovative technique approved by state and federal regulators for use in full-scale restoration of hazardous waste sites[7].

Phytoremediation involves several mechanism or processes such as rhizofiltration, phytostabilization, phytoextraction and phytovolatilization[4]. Recent study on the growth of *Eleocharis ochrostachys* using different diesel concentrations in phytoremediation process showed that whenever the concentration increased, the number of withered plants also increased[8]. A study has been reported by[4] where the observation on the growth of *Lepironia articulate* using mixture of ferric and aluminium, has shown that as the concentration increased, the symptoms of dried plants also increased[4].

In this study, the *Scirpus grossus*, is chosen as the plant for sulphide removal in SSC. Several concentrations of synthetic SSC were prepared and the physical observation of the plant was observed.

2. Materials and Methods

2.1 Propagation of *Scirpus grossus*

The *Scirpus grossus* plants were grown in a container with sand as the substrate for approximately 4 weeks. Five healthy *Scirpus grossus* plants were transferred and planted to each of five containers for physical observation. The earlier prepared synthetic SSC was poured into the plants in each container with different concentration including one container as a control which contains only wastewater without any addition of sodium sulphide.

The plant growth was observed physically for six weeks to access the ability of the plant to survive. At the end of the exposure period, the percentage of the withered plants was determined using the following equation (1)[4]. W_L and T_L represent the withered leaves and the total leaves respectively.

$$\% \text{ of withered plants} = \frac{W_L}{T_L} \times 100\% \tag{1}$$

After 12 days, some water was added to the plants to ensure the plants having sufficient water during the observation period[9]. The water level was kept at the upper layer of the sand. The pH, COD and sulphide content were analyzed before the water being added into the plant.

2.2 Preparation and characterization of synthetic SSC

Four different concentrations of synthetic SSC were prepared by adding predetermined amount of sodium sulphide ($Na_2S.xH_2O$) (R&M Chemicals) into 2 L of wastewater. The raw prepared synthetic SSC was analysed for pH, COD and sulphide content.

The pH of the synthetic SSC was measured using the Mettler Toledo Seven Easy S20 pH meter. The calibration procedure was applied before the pHs of the synthetic SSC sample were analyzed. The COD and sulphide were analyzed using USEPA Reactor Digestion and USEPA Methylene Blue Methods respectively.

3. Results and Discussion

3.1 *Scirpus grossus* growth and physical observation

The growth of *Scirpus grossus* from week 0 to week 4 is shown in Figure 1. From the observation, it was found that about four weeks is needed to obtain a healthy *Scirpus grossus*. The time required to grow a healthy plant will vary depending on the type of plant[4].

Figure 2 summarizes the observation for the physical appearance of *Scirpus grossus* during the exposure to the synthetic SSC. On the other hand, the percentage of the withered leaves obtained from physical observation of *Scirpus grossus* after exposed to the synthetic SSC is shown in Table 1.

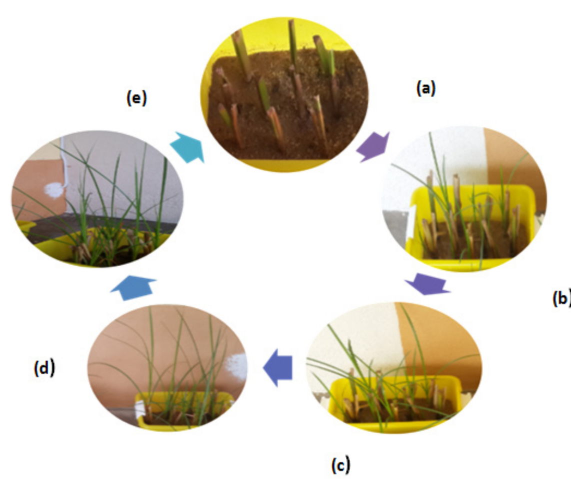


Figure 1. The growth of the *Scirpus grossus*. (a) 0 week. (b) 1 week. (c) 2 weeks. (d) 3 weeks. (e) 4 weeks.

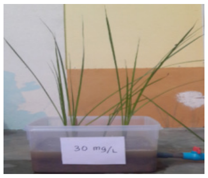
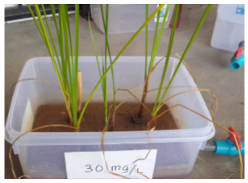
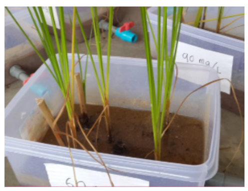
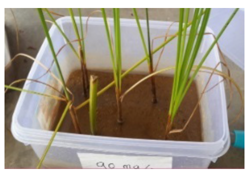
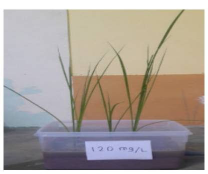
Sulphide content	Exposure time	
	Week 0	Week 6
0.20 mg/L		
2.54 mg/L		
3.00 mg/L		
3.54 mg/L		
4.24 mg/L		

Figure 2. Physical observation of *Scirpus grossus* plants.

It was found that for control (0.2 mg/L), 24.00% of the leaves were withered while 37.32% of the leaves were withered for both 2.54 mg/L and 3.00 mg/L of sulphide. The response increased with the increasing concentration of contaminant until it became 44.00% on the sulphide concentration of 4.24 mg/L. The percentage of the withered leaves increases proportionally to the concentrations. The withered plant started to be detected in the second week for the sulphide concentrations with 4.24 mg/L followed by sulphide concentrations of 3.00 and 3.54 mg/L in the fourth week and finally, in the fifth week for the concentrations of 0.20 and 2.54 mg/L. The percentages of withered leaves after 6 weeks sulphide exposure was calculated using Equation (1) as tabulated in Table 1.

Table 1. Response of withered leaves. (%) obtained from calculation using Equation (1).

Sample	Concentration (mg/L)	Response of withered leaves (%)
1	0.20	24.00
2	2.54	37.32
3	3.00	37.32
4	3.54	42.68
5	4.24	44.00

The findings revealed that the plant resistance to sulphide contaminant at the exposed concentration was notable, in which the plant can grow and survive in all sulphide concentrations exposed. Previous study reported that the half of the maximum effect can be obtained if the 100% of withered leaves were observed[5].

3.2 Synthetic SSC characterization

Table 2 shows the analysis obtained for initial sample of pH, COD and sulphide concentration (S^{2-}). The pH for all the synthetic SSC samples were more than 10, with high in COD and sulphide concentration. The analysis of pH and sulphide concentration for control sample shows the content meets the allowable environment standard which is the pH lower than 9.0 and sulphide concentration lower than 0.5 mg/L (Standard A and B of Environmental Quality Act (Industrial Effluents) 2009).

Table 2. Initial pH, COD, and sulphide concentration

pH	COD value (mg/L)	Initial concentration of sulphide (mg/L)
8.85	460	0.2
11.06	876	2.54
10.69	737	3.00
11.26	1133	3.54
11.37	1284	4.24

As compared to the initial sample, Table 3 shows the pH, COD and sulphide concentration values were reduced after 12 days of exposed and meet the environmental standard (Standard A and B of Environmental Quality Act (Industrial Effluents) 2009).

This finding revealed that this preliminary phytoremediation study using *Scirpus grossus* has successfully reduced the pH, COD and sulphide concentration.

Table 3. Final pH, COD, and sulphide concentration

pH	COD value (mg/L)	Final concentration of sulphide(mg/L)
6.22	36	0.10
6.59	84	0.31
6.79	106	0.36
7.13	63	0.23
7.88	133	0.40

4. Conclusions

The findings revealed that as the concentrations of the synthetic SSC increased, the withering of *Scirpus grossus* leaves were increased up to 44.00%. In addition, the phytoremediation has successfully reduced the pH, COD and sulphide concentration. Thus, it is suggested that the *Scirpus grossus* plant can be one of the plant to treat the sulphide from SSC in phytoremidiation process.

5. Acknowledgement

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