



## 6.0 CONCLUSIONS

From this short term study on the treatment of landfill leachate using the High Rate Algal Pond (HRAP) System, we can conclude that:

1. Treated leachate (TL) obtained from the Air Hitam Sanitary Landfill is characterized by pH values ranging between 6.0 to 8.8. The COD,  $\text{NH}_3\text{-N}$ ,  $\text{PO}_4$  and TSS contents in TL ranged from 860 to 8066  $\text{mgL}^{-1}$ , 3.20 to 151.66  $\text{mgL}^{-1}$ , 2.40 to 8.20  $\text{mgL}^{-1}$  and 555.33 to 3651.10  $\text{mgL}^{-1}$  respectively.
2. Based on COD,  $\text{NH}_3\text{-N}$  and  $\text{PO}_4$  content in TL, C : N : P ratio value in the TL ranged from 81 : 26 : 1 to 4607 : 58 : 1.
3. TL has high content of potassium (1398  $\text{mgL}^{-1}$ ), magnesium (59  $\text{mgL}^{-1}$ ) and chloride (19  $\text{mgL}^{-1}$ ). Other metals include iron (Fe), manganese (Mn), cobalt (Co), nickel (Ni), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), cobalt (Co), chromium (Cr), lead (Pb) and copper (Cu) were low in content.
4. Studies on selection of microalgae species for growth shows, in the preliminary toxicity test, of eleven species of microalgae tested, *Chlorella vulgaris* (UMACC 001), *Chlorella* sp. (UMACC 078), *Scenedesmus* sp. (UMACC 039), *Mougeotia* sp. (UMACC 069), *Synechococcus* sp. (UMACC 075) and *Ankistrodesmus arcuatus* (UMACC 170) were most tolerance to manganese (Mn). *Chlorococcum oviforme* (UMACC 110), *Euglena* sp. (UMACC 058) and *Oocystis polymorpha* (UMACC 153) were tolerance to cadmium (Cd), while *Ulothrix* sp. (UMACC 071) and *Ankistrodesmus*

*convolutus* (UMACC 101) was tolerance to chromium (Cr) and copper (Cu) respectively.

5. Studies on 96h  $IC_{50}$  values for toxicity testing with  $CdCl_2$  on six microalgae shows *Oocystis polymorpha*, (UMACC 153) was very resistant to Cd with  $IC_{50}$  value at 59.05 ppm and *Chlorococcum oviforme* (UMCC 110) was less resistant to the Cd with  $IC_{50}$  values at 7.86 ppm. However, of the Malaysian isolates, *Ankistrodesmus convolutus* (UMACC 101) was found to be tolerant to heavy metals
  
6. Laboratory studies on screening of microalgae for growth in TL shows the growth rate of UMACC 058 *Euglena* sp. (50% TL medium) was highest compared to other species tested ( $\mu = 0.1294 d^{-1}$ ). The  $IC_{50}$  values also show that this *Euglena* sp. (UMACC 058) has the highest value with 51.27%. This shows this algae is very resistant to toxic compounds in the TL and it can be used to treat TL while *Chlorococcum oviforme* (UMACC 110) cannot grow well in the TL medium. The  $IC_{50}$  values also show that the UMACC 110 has the lowest tolerance with  $IC_{50} = 14.62\%$ .

7. Studies on HRAP system due to TL supplementation shows:

PARAMETER	HRAP CULTURES	
	T <sub>0</sub> POND	T <sub>1</sub> POND
<b>Physical parameter</b>		
• Temperature	27 – 33 °C	27 – 33 °C
• Irradiance	7.26 – 60.52 $\mu\text{mol}^{-1}\text{m}^{-2}$	7.26 – 60.52 $\mu\text{mol}^{-1}\text{m}^{-2}$
• pH	4.86 - 9.03	5.26 - 9.91
• Dissolved Oxygen (DO)	4.0-15.25 $\text{mgL}^{-1}$	7.0-17.0 $\text{mgL}^{-1}$
<b>Growth parameter</b>		
• OD <sub>620nm</sub>	0.15-1.86	0.08-2.48
• Chl a	1.85-13.07 $\text{mgL}^{-1}$	0.71-11.31 $\text{mgL}^{-1}$
• Cell count	2.37-27.37 X $10^6\text{cells.mL}^{-1}$	2.12-72.06 X $10^6\text{cells.mL}^{-1}$
• Dry weight	2000-4190 $\text{mgL}^{-1}$	3080-5290 $\text{mgL}^{-1}$
<b>Pollution parameter</b>		
• COD	40-1800 $\text{mgL}^{-1}$	40-2160 $\text{mgL}^{-1}$
• NH <sub>4</sub> -N	0.08-42.21 $\text{mgL}^{-1}$	0.02-16.65 $\text{mgL}^{-1}$
• PO <sub>4</sub>	0.01-14.26 $\text{mgL}^{-1}$	0.01-15.26 $\text{mgL}^{-1}$
<b>Treatment efficiency</b>		
• % reduction of COD	36.17-98.95 %	16.27-98.83 %
• % reduction of NH <sub>4</sub> -N	63.39-99.91 %	65.08-99.90 %
• % reduction of PO <sub>4</sub>	18.7-97.55 %	5.25-98.38 %

8. Species succession of microalgae in HRAP shows T<sub>0</sub> pond was dominated by *Spirulina* sp and *Chlorella vulgaris* while T<sub>1</sub> pond was dominated by *Chlorella vulgaris*. It must be noted here that *Spirulina* was abundant due to

the reason that the two ponds used have been regularly used for *Spirulina* culture and therefore were present in the ponds as natural inocula. This was in spite of the ponds having been cleaned at the start of the experiments.

9. This study shows that selected algal species can be used for treating landfill leachate and reduction of COD, NH<sub>4</sub>-N and PO<sub>4</sub>-P contents of the leachate. However, this study is a preliminary investigation.

Further detailed studies focusing on the following areas should be conducted:

- i. Effect of further increasing the loading rate with simultaneous supplementation with limiting nutrients (N, P).
- ii. Pretreatment of leachate with physical-chemical reduction of heavy metals.
- iii. Effect of mixing speed and pond culture depth.
- iv. Bacterial-algal relationship in the HRAP.
- v. Bioaccumulation of heavy metals in the algal biomass.
- vi. Methods for recovery of heavy metals from algal biomass.
- vii. Utilization of algal biomass, example fermentation for methane.