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## Comparative Phytotoxicity of *Azolla pinnata* and *Lemna minor* in Low Strength Palm Oil Mill Effluent

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### Abstract

Palm Oil Mill Effluent (POME) is rich of nutrients and therefore it is beneficial to extract its nutrients by cultivating duckweed that can later be used as animal feedstock. In this study, two native duckweeds (*Azolla pinnata* and *Lemna minor*) were cultivated in POME to meet the dual functions of phytoremediation and later be used as feedstock. Both duckweed was grown in four different dilutions (2.5%, 5%, 10%, 15%) of POME under greenhouse conditions. Five grams of *A. pinnata* and two grams of *L. minor* were transferred to 1 L POME (COD 198mg/L, nitrates 4.3mg/L; pH 9.53; phosphorus 4mg/L; ammonia 2.98mg/L) with different dilution in 3 L-plastic pots and samples of POME were taken every 2-day intervals up to 10 days. Growth content, phosphorus, ammonia, nitrates, pH, and COD content of POME were monitored within 10 days of incubation to select the most suitable plant growth medium for both duckweeds. Results shows that 2.5% POME dilution had the most positive effect on *L. minor* (wet weight increase to 8.7g) growth parameters compared to *A. pinnata* (9.8g) with all plants could survive until the end of exposure. In addition, ammonia activity reached its maximum removal in 5% POME dilution by *A. pinnata* (98%) compared to *L. minor* (95.5%). The maximum phosphorus removal was obtained in 10% POME dilution; 93.3% removal was obtained by *A. pinnata* compared with only 86.7% by *L. minor*. No significant effect was indicated by pH readings by both plants but significant reduction of COD content in 15% POME solution by *L. minor* (78%) compared to *A. pinnata* (66%). Both plants had responded positively to the phytoremediation process especially for *A. pinnata* causing a significant decrease in all parameters. The results give evidence that the two duckweed can be cultivated in POME to remediate POME and at the end become feedstock.

**Keywords** ---*Azolla pinnata*, *Lemna minor*, palm oil mill effluence (POME)

## Phytotreatment of Textile Wastewater using Aquatic Plant and Bioaugmentation Technique

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### Abstract

As one of the fastest growing industries in Indonesia, textile industry provides challenges on wastewater treatment, in particular dyes containing wastewater. In the natural water environment, these dyes may inhibit the natural photosynthesis process. This leads to anaerobic and unpleasant conditions, and an increase of BOD. One of the commonly used dyes is methylene blue. Methylene blue may cause irritation of gastrointestinal tract if swallowed, cause cyanosis if inhaled, and irritation of the skin if touched by the skin. Therefore, treatment of textile wastewater is required in order to remove organic contaminants, i.e., dyes degradation (decolorization). This study uses biological method which are considered to be more environmentally friendly, cost-effective, and do not produce residues after processing. Biological methods can be done using consortium which involves plants and bacteria in order to increase the treatment efficiency. In this study, a consortium was established between *Eichornia crassipes* (water hyacinth) and *Bacillus subtilis* to remove Methylene Blue. The dye concentration used was 23 mg / L. Research was done by testing the potential of bacteria, 30-days plant propagation, including 7-days acclimatization stage. Further experiment includes a 7-day decolorization step by analyzing color intensity or concentration as well as supporting parameters. i.e., temperature, pH, plant morphology, bacterial colonies, and plant cell analysis. There were three reactors used for decolorization step, i.e., consortium reactor, bacteria control reactor, and color control reactor. The results showed that color removal reached 64% of methylene blue on day 7 by consortium *E. crassipes* with *B. subtilis*, whereas the efficiency removal in bacteria reactor reached 35%, and the color control reactor reach 10%. Based on these results, the consortia is way more effective than using single bacteria or without any treatment.

**Keywords---** *Bacillus subtilis*, consortium, decolorization, *Eichornia crassipes*, textile wastewater

## Deconcentration of Chromium Containing in Wastewater Using Bacteria and Microalgae Consortia with High Rate Algal Reactor Systems

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### Abstract

Heavy metal pollution has recently gained serious attention by means of environmental issue. One of the heavy metal pollution cases in natural water environment is chromium, which is released by several industries. The polyvalent chromium 6 is one of the most difficult environmental pollutants to be removed due to its dissolved and unstable properties. Bioremediation using a consortium of bacteria and microalgae in the High Rate Algal Reactor (HRAR) system can be expected to decrease chromium concentration. The treatment includes biosorption process and mutualism symbiosis of both microorganisms. In this study a consortium between *Azotobacter S8* bacteria and *Chlorella vulgaris* microalgae were used to perform to remove the heavy metal. The objectives of this study was to determine minimum chromium concentration tolerant to *Azotobacter S8* and *Chlorella vulgaris*, chromium removal percentage by consortium, as well as the best composition between the two microorganisms in removing pollutants. Evaluation was done based on percentage ratio of *Azotobacter S8* and *Chlorella vulgaris* composition (50:50, 75:25, and 25:75) and ratio of consortium to the pollutant media tested (5:95 and 10:90). The concentration of chromium metal was adjusted according to the Minimum Inhibitory Concentration (MIC) and Range Finding Test (RFT) test results. The chromium metal concentrations used in the MIC and RFT tests (in mg / L) were 0, 17, 42, 85, 169, and 339. pH, temperature, salinity, total chromium concentration, microalgae cell count and bacterial colonies were monitored during the experiments. The results showed that the highest chromium removal was 18.68% that occurred in reactors of 50:50 ratio (bacterial composition:microalgae) and 5:95 (consortium : pollutant media) with 17 mg/L of chromium initial concentration. Both of variables did not give significant effect to the result of chromium removal (P-value > 0,05).

**Keywords---** *Azotobacter S8, Chlorella vulgaris, consortium, Cr, HRAR*

## Plant Growth-promoting Activities of Rhizosphere Bacteria Isolated from *Scirpus grossus*

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### Abstract

Plant growth promoting rhizobacteria (PGPR) have an important role in phytoremediation process to enhance plant health, growth, protect plant from pathogen infection and reduce the effects of toxic stresses to the plant when exposed to pollutants in contaminated medium. However, there is no information on PGPR activities of *Scirpus grossus* plant exposed to heavy metals. Therefore, the aim of this study was to characterize plant growth promoting (PGP) activities of rhizosphere bacteria isolated from *Scirpus grossus*. Three rhizobacteria, *Bacillus cereus*, *Bacillus aerius* and *Exiguobacterium profundum*, which showed high tolerance towards 60 mg/L of hexavalent chromium [Cr(VI)] in wastewater, were evaluated their PGP ability to solubilize phosphate, to fix nitrogen, to produce ammonia, Indole-3-acetic acid (IAA) and siderophore, and ACC deaminase activity. PGPR trait analysis showed that all of rhizobacteria have the ability to produce more than one trait, while *B. aerius* and *B. cereus* produced the most PGP trait with ammonia production,  $257.3 \pm 2.5$  mg/L and  $302.8 \pm 2.2$  mg/L respectively, and also showed positive result on nitrogen fixation, phosphate solubilization and IAA. The results indicated that all these PGPR possess a vital function to improve plant growth as well treating chromium contaminated wastewater.

**Keywords---** *Scirpus grossus*, *rhizobacteria*, **hexavalent chromium**, **plants growth promoting rhizobacteria (PGPR)**

## Effect of Hydraulic Retention Time (HRT) on COD Removal in a Pilot-Scale Multimedia-Sequencing Batch Biofilm Reactor (MM-SBBR) for Recycled Paper Mill Wastewater

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### Abstract

Improper discharges of treated effluent from pulp and paper mill industries are likely to cause tremendous harm to the environment. Fortunately, biofilm based treatment technology manages to provide promising performance in treating real wastewater. In this study, the effect of hydraulic retention time (HRT) was studied and monitored using a pilot-scale-multimedia-sequencing batch biofilm reactor for the removal of chemical oxygen demand (COD) from recycled paper wastewater. A 2000L-reactor made up of high-density polyethylene (HDPE) with a diameter of 1.2 m, and a maximum water depth of 1.8 m and packed with cylindrical plastic media filled with granular activated carbon (GAC; coconut shells) was used to continuously treat real recycled paper mill effluent with initial COD range between 980-1300 mg/L. Three different HRTs at 16, 24 and 48h were manipulated to evaluate the reactor's performance. Based on the results obtained, COD removal efficiencies increased from 65 to 86% when HRTs was increased from 16 to 48h. The COD shows stable removal throughout the study. As a conclusion, the overall performance results confirmed that combination of biofilm and GAC adsorption was able to be the best configuration for wastewater treatment as this combination shows good performance efficiency and stable treatment process under stern organic load fluctuations. Therefore, this hybrid system is recommended for the treatment of pulp and paper mill effluents.

**Keywords --- hydraulic retention time (HRT), multimedia, sequencing batch biofilm reactor (SBBR), recycled paper mill wastewater**

## Removal of COD, Colour and Suspended Solids in Recycled Pulp and Paper Mill Effluent in Horizontal Free Surface Flow Constructed Wetland

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### Abstract

Pulp and paper mill industry has already been known as heavy emitter of pollutant that cause this industry faced a stringent regulation to comply. This study was conducted to determine the effectiveness of horizontal free surface flow (FSF) constructed wetlands with and without *Scirpus grossus* in removing COD, colour and TSS under the 3-day HRT within a 80-day exposure. This exposure was conducted in a recycled paper mill treatment plant located at Temerloh, Pahang. Throughout the 80 days of experiment, the planted FFS system have achieved removals of 46.4% and 35.8% respectively for COD and colour. While, the control FSF showed lower removals for both parameters with 41.4% and 30.7% for COD and colour, respectively. However, for suspended solids (SS), the planted FSF system had lower removal with 74.4% compared to 75.4% removal from control FSF tank. On overall, the planted system has performed better and it shows that phytoremediation can be an alternative and attractive treatment to remove pollutants from pulp and paper effluent.

**Keywords---**phytoremediation, constructed wetland, free flow surface (FFS), pulp and paper mill wastewater treatment

## Use of Beneficial Bacteria as Bioremediators in Treating Shrimp Pond Wastewater Sludges

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### Abstract

Rapid development of shrimp farming has raised significant concerns on the ponds effluents and its management. Intensive culture of shrimp farming requires high feeding rates which will increase the production of sludge. Sludge in shrimp ponds contains mainly organic matter, nitrogen, phosphorus and pathogenic bacteria which can be hazardous if disposing it to the environment without proper treatment. Bioremediation is one of the method of waste treatment and have considerably gain attention due to its promising results and cost effective. This research focus on isolation and characterization of beneficial bacteria that are able to treat shrimp pond sludge by reducing or removing nitrate, phosphorus, heavy metals, pathogenic bacteria and degrading organic matters to ensure the safety of the sludge before disposing to the environment. In addition, microbial communities present in the sludge and its potential in recovering nutrients from the sludge; mainly ammonia that can be very useful in microalgae culture will be studied. There are various factors that need to be considered to ensure the effectiveness of the bacteria in treating the sludge and those factors will be further studied in order to obtain better results and understanding on sludge treatment process.

*Keyword---* **bioremediation, beneficial bacteria, shrimp sludge**



## Potential of *Scirpus grossus* and *Eichhornia crassipes* for Textile Industry Effluent Phytoremediation: A Preliminary Study

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### Abstract

This study was conducted to identify the ability of two native tropical plants (*Scirpus grossus* and *Eichhornia crassipes* or water hyacinth) to survive in textile industry effluent. Both plants were exposed to five different concentrations of textile effluent for 21 days and they were physically and visually observed for every seven days. The preliminary tests indicated that *Scirpus grossus* can survive in batik wastewater with COD concentration up to 565 mg/L while water hyacinth can only survive in COD concentration up to 249 mg/L. Based on these results, it is suggested that the COD concentrations selected for next study; phytotoxicity test using a more tolerant plant *Scirpus grossus* is up to 565 mg/L.

**Keywords---** phytoremediation, preliminary test, batik wastewater, *Scirpus grossus*, *Eichhornia crassipes*

## Hydrocarbon Removal in Oil Contaminated Soil using In-Vessel Composting with Yard Waste and Rumen Waste

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### Abstract

This study aimed to determine hydrocarbon removal in oil contaminated soil using composting with amendment of yard waste and rumen waste. Hydrocarbon contaminated soil samples from a public oil mining field in Wonocolo District, Bojonegoro, Indonesia, were composted with yard waste (Y), rumen waste (R) and mixed YR in varied compositions. Manual agitation was applied every 3 days for air supply and homogenization. The experiment was conducted in 2 replicates in reactors of 3.5 L capacity for 80 days. Moisture was kept 50-60%. Measurements of temperature, pH, and moisture contents were done every 3 days, whereas those of TKN, nitrite, nitrate, total bacterial count, organic carbon, and hydrocarbon concentrations were measured every 20 days. The results showed that the highest hydrocarbon removal efficiency (45.26%) was observed in the reactor containing 50% contaminated soil amended with mixed YR. The second and third highest hydrocarbon removal efficiencies of 42.11% and 38.33% occurred in contaminated soil reactors, which were added with 50% w/w R and Y, respectively. The hydrocarbon removal in these reactors followed first order kinetics with a rate constant range of 0.006-0.007 day<sup>-1</sup>. In order to meet the quality standard limit for oil contaminated soil, the estimated composting time was 135-181 days.

**Keywords---** oil, organic waste, pollution, public mine, removal kinetics

## Comparative Performance of Batch and Continuous Laboratory-Scale Moving Bed Biofilm Reactors (MBBR) for Palm Oil Mill Effluent (POME) Treatment

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### Abstract

The treatment performance of a batch and continuous laboratory-scale moving bed biofilm reactor (MBBR) for palm oil mill effluent (POME) was investigated. Black plastic media (BPM) was used as the biofilm carrier in this study with 50% filling fraction and was aided by aeration for movement and agitation inside reactor column. POME with three different initial COD concentrations (COD: 1000 mg L<sup>-1</sup>, 1500 mg L<sup>-1</sup> and 2500 mg L<sup>-1</sup>) and organic loading rate (OLR) of 0.33 kg m<sup>-3</sup>d<sup>-1</sup>, 0.50 kg m<sup>-3</sup>d<sup>-1</sup> and 0.83 kg m<sup>-3</sup>d<sup>-1</sup> respectively were used to be treated in batch and continuous operated MBBR at a constant air flow rate of 5 L min<sup>-1</sup> with similar RT and HRT at 72 hours for 3 day-exposure. The influent flow rate for MBBR operated in the continuous mode was 0.01 L min<sup>-1</sup>. Then, the performance of batch and continuous MBBR using each initial COD concentration were compared in term of COD and ammonia-nitrogen removal. Based on the results obtained, POME with 2500 mg L<sup>-1</sup> initial COD concentration (OLR: 0.83 kg m<sup>-3</sup>d<sup>-1</sup>) in batch MBBR managed to reduce as much as 91.2% of COD and 93.43% of ammonia-nitrogen while in continuously operated MBBR manage to achieve comparable removals of 91.4% and 94.67% for COD and ammonia-nitrogen respectively. However, MBBR operated in continuous mode works slightly better at higher organic loading. Overall, it can be concluded that MBBR operated either in continuous mode or batch mode was able to withstand variation of organic load and able to give stable performance in the POME treatment.

**Keywords**--- biofilm; moving bed biofilm reactor, palm oil mill effluent; chemical oxygen demand, ammonia-nitrogen