Erosion and Soil Contamination Control Using Coconut Flakes And Plantation Of Centella Asiatica And Chrysopogon Zizanioides

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Abstract. Land degradation in Malaysia due to water erosion and water logging cause of loss of organic matter, biodiversity and slope instability but also land are contaminated with heavy metals. Various alternative such as physical remediation are use but it not showing the sustainability in term of environmental sustainable. Due to that, erosion and soil contamination control using coconut flakes and plantation of Centella asiatica and Chrysopogon zizanioides are use as alternative approach for aid of sophisticated green technology known as phytoremediation and mycoremediation. Soil from carbonaceous phyllite located near to Equine Park, Sri Kembangan are use for monitoring the effect of phytoremediation and mycoremediation in reducing soil contamination and biotechnology for erosion control. Five laboratory scale prototypes were designed to monitor the effect of different proportion of coconut flakes i.e. 10%, 25%, 50% & 100% and plantation of Centella asiatica and Chrysopogon zizanioides to reduce the top soil from eroding and reduce the soil contamination. Prototype have been observe started from first week and ends after 12 weeks. Centella asiatica planted on 10% coconut flakes with 90% soil and Chrysopogon zizanioides planted on 25% coconut flakes with 75% soil are selected proportion to be used as phytoremediation and mycoremediation in reducing soil contamination and biotechnology for erosion control.

Keywords: erosion, contamination, coconut, Centella asiatica and Chrysopogon zizanioides

1.0. Introduction
The impact of rain water washing away topsoil and surface runoff results in massive loss of soil fertility, causes erosion and soil contamination and it known as soil degradation. Soil degradation refers to a reduction in the capacity of soil to function as a living system. Soil degradation can take a number of forms, including soil erosion, soil salinisation, nutrient depletion, a loss of soil biodiversity, soil pollution and contamination, soil compaction, and the loss of organic matter [1]. Soil contamination implies, when the concentration of a substance (e.g. heavy metal, nutrient, pesticide, organic chemical, acidic or saline compound) in soil is higher than would naturally occur [1 & 2]. Approximately 33% of our world’s soils are facing moderate to severe degradation especially heavy metal contamination [1 & 2]. Heavy metals are of the hazardous environmental pollutants which cause dangers to humans, plants and other organisms through entering the food chain. These metals can be entered into the biosphere through human activities such as incomplete combustion of fossil fuels, mining, refining rocks containing metals, urban waste water, agricultural pesticides and natural erosion of rocks [3]. The amount of heavy metals in soils is affected by different factors such as parent rock, industrial pollution sources, chemical fertilizers used in agricultural and industrial and urban effluents which due to the physical and chemical properties of soil and environmental conditions, their aggregation and accumulation process is different in soil layers [4]. Erosion, soil type and age are example of factors affecting on the distribution of these heavy metal in the soil [5]. To conserve the soil from degradation and maintaining a diverse community of soil organisms as healthy soils, a concerted effort towards the sustainable management of soil are needed. Green technology technique using
biotechnology and bioremediation concepts are introduced in this paper for managing soil erosion and soil contamination. In this paper bioremediation technique are focus on phytoremediation and mycoremediation.

According to [6, 7 & 8], “phytoremediation involves the use of vascular plants, algae, and fungi either to remove and control wastes or to spur waste breakdown by microorganisms in the rhizosphere.” An integral part of phytoremediation is the use of plants to promote microbial degradation or biotransformation of contaminants through the process of rhizodegradation. Phytoremediation is also low-cost, especially when compared to many of the traditional or conventional approaches for hazardous waste management.

Mycoremediation is a process of using fungi to return an environment (usually soil) contaminated by pollutants to a less contaminated state by means using various strains of fungi to clean as radio nuclide [9]. One of the primary roles of fungi in the ecosystem is decomposition, which is performed by the mycelium. The mycelium secretes extracellular enzymes and acids that breakdown lignin and cellulose, the two main building blocks of plant fiber. The key to mycoremediation is determining the right fungi species to target a specific pollutant [9].

In this paper bioremediation technique are focus on mycoremediation using coconut flakes to induce fungus and phytoremediation by plantation of Chrysopogon zizanioides and Centella asiatica. Chrysopogon zizanioides (vetiver grass) is widely known for its effectiveness in erosion and sediment control, can tolerate extreme climatic variations and soil conditions, including as phytoremediation media for heavy metals decontamination [10, 11]. Centella asiatica is a tasteless, odourless plant that thrives in and around water and is used for medicinal purposes [12]. Centella asiatica (‘pegaga’) have the ability to take up metals [13, 14 & 15]. As literature Chrysopogon zizanioides (vetiver grass) are suitable to use as phytoremediation for controlling erosion and contamination, however Centella asiatica (‘pegaga’) and coconut flakes, the current understanding of the metal tolerance/resistance of these plants and their strategy to accumulate heavy metals and controlling erosion is still limited.

2.0. Methodology – Prototype Development

Residual soil from cabonaceous phyllite located near to ex-landfill area near to Equine Park, Sri Kembangan are used for monitoring the effect of phytoremediation and mycoremediation in reducing soil contamination and erosion. This clayey soil is alkaline soil with the average of ph of 7.42 and detail heavy metal concentration result using Atomic Absorption Spectrophotometry (AAS) show as Table 1.

| Heavy Metal concentration | Content (µg/g) |
|---------------------------|---------------|
| Zn                        | 10, 320       |
| Cu                        | 11, 812       |
| Pb                        | 6, 750        |

Table 1: Heavy metal amount in residual soil from cabonaceous phyllite

Five laboratory scale prototypes were designed to monitor the effect of different proportion of coconut flakes i.e. 10%, 25%, 50% & 100% and plantation of Centella asiatica and Chrysopogon zizanioides to reduce the top soil from eroding and reduce the soil contamination. Residual soil from carbonaceous without mixing with coconut flakes and 100% of coconut flakes are use as controller. Centella asiatica and Chrysopogon zizanioides are planted using bare root planting technique. Bare root planting involve placing single or bunches of rooted plants into excavated holes on the slope. These methods are use normally for non-woody plants that will eventually spread into uniform root coverage and the plant is transplant directly from nurseries. Centella asiatica and Chrysopogon zizanioides root are measure before it be planted and the root must not bent upwards in the holes during the plantation process. Slope prototypes are designed similar to original site with slope angle is 25°. The prototypes development shows as Figure 1.
3.0. Observation on Soil Decontamination using Phytoremediation and Mycoremediation

First week observation shows that coconut flakes are growth with fungi and most fungi can be found in 50% coconut flakes and 50% soil; and 100% of coconut flakes. *Centella asiatica* and *Chrysopogon zizanioides* start to growth in first week as show in Figure 2. Observation in weeks five shows, both plant are not survive at the prototype proportion of 50% coconut flakes with 50% soil and 100% coconut flakes. Only three prototype are survive until weeks twelve but *Centella asiatica* planted using 10% coconut flakes with 90% soil shows more healthy, while *Chrysopogon zizanioides* more healthy on slope with proportion of 25% coconut flakes with 75% soil as Figure 3.

Observation of decontamination after 12 weeks for *Centella asiatica* planted using 10% coconut flakes with 90% soil shows heavy metal content in the sample are reduced about 24.5% for Cu, 57.8% for Pb and 18.3% for Zn. However, *Chrysopogon zizanioides* planted on 25% coconut flakes with 75% soil shows the reduction as 48.2% for Cu, 39.8% for Pb and 62.4% for Zn. While 100% soil planted with *Centella asiatica* show reduction of 12.3% for Cu 22.68% for Pb and 4.6% for Zn and *Chrysopogon zizanioides* show reduction of 18.73% for Cu 28.9% for Pb and 3.2% for Zn.
Prototype which coconut flakes that have been mix with soil without both plant shows that after 12 weeks of observation, reducing of 4.5% for Cu, 8.3% for Pb and 7.8% for Zn occur. Results shows coconut flakes are medium for fermentation of fungus as mycoremediation and it suitable to be use together with *Centella asiatica* and *Chrysopogon zizanioides* for absorbing more heavy metal compared without the mixtures of coconut flakes. Table 2 shows the reduction of heavy metal after twelve weeks treatment using phytoremediation and mycoremediation. *Centella asiatica* is suitable to be use for phytoremediation of Pb in contamination soil, while *Chrysopogon zizanioides* suitable for Zn and Cu.

| Table 2. The reduction of heavy metal after 12 weeks treatment using phytoremediation and mycoremediation |
|-------------------------------------------------|
| **Heavy Metal concentration before treatment** | **Content (μg/g)** |
| **Zn** | **Cu** | **Pb** |
| 10, 320.00 | 11, 812.00 | 6, 750.00 |
| Heavy Metal concentration after treatment using *Centella asiatica* planted on 10% coconut flakes with 90% soil | 8, 431.44 | 8, 918.06 | 2,848.50 |
| | (18.3%) | (24.5%) | (57.8%) |
| Heavy Metal concentration after treatment using *Chrysopogon zizanioides* planted on 25% coconut flakes with 75% soil | 3,880.32 | 6, 118.62 | 4, 063.50 |
| | (62.4%) | (48.2%) | (39.8%) |
| Heavy Metal concentration after treatment using *Centella asiatica* planted on 100% soil | 7,979.42 | 10,359.12 | 6,439.50 |
| | (22.68%) | (12.3%) | (4.6%) |
| Heavy Metal concentration after treatment using *Chrysopogon zizanioides* planted on 100% soil | 9,989.76 | 9,599.61 | 4,799.25 |
| | (3.2%) | (18.73%) | (28.9%) |

4.0. Observation on Erosion Rate base on Soil Loss Estimation

Erosion rate are monitor for *Centella asiatica* on slope with proportion of 10% coconut flakes with 90% soil and *Chrysopogon zizanioides* on slope with proportion of 25% coconut flakes with 75% soil. Soil mixing with 10% coconut flakes and 25% coconut flakes without plantation of *Centella asiatica* and *Chrysopogon zizanioides* and with *Centella asiatica* and *Chrysopogon zizanioides* are use as control prototype for soil loss estimation. To accumulate the runoff for soil loss estimation, the prototypes are watering with 1000ml water, which is poured at height of 100 mm measure from the base of prototype. The water is poured constantly and the medium sizes of artificial raindrop are use. The prototypes are watering with total of 4000ml water and these soil losses are observe after 2 days. Eroded soils are collected at the toe of the slope and are weighted using electronic balance. Reducing of soil loss indicated by 71.34% for *Centella asiatica* planted on 10% coconut flakes with 90% soil, 93.57% for *Chrysopogon zizanioides* 25% coconut flakes with 75% soil, 53.22% for *Centella asiatica* planted on 100% soil and 76.61% for *Chrysopogon zizanioides* planted on 100% soil as shows in Table 3. Beside collected the soil at the prototype toe, erosion feature are observe. Less erosion feature occur in *Centella asiatica* on slope with proportion of 10% coconut flakes with 90% soil and *Chrysopogon zizanioides* on slope with proportion of 25% coconut flakes with 75% soil compared to the control prototype.

| Table 3. Soil loss estimation before and after treatment |
|-------------------------------------------------|
| **No** | **Distributed water (ml)** | **Centella asiatica** planted on 10% coconut flakes with 90% soil | **Chrysopogon zizanioides** planted on 25% coconut flakes with 75% soil | **Centella asiatica** planted on 100% soil | **Chrysopogon zizanioides** planted on 100% soil |
| **Before** | **After** | **Before** | **After** | **Before** | **After** | **Before** | **After** |
| 1 | 1000 | 1.25 | 0.52 | 1.25 | 0.10 | 1.25 | 0.86 | 1.25 | 0.42 |
| 2 | 1000 | 1.90 | 0.49 | 1.90 | 0.11 | 1.90 | 0.79 | 1.90 | 0.39 |
| 3 | 1000 | 2.00 | 0.48 | 2.00 | 0.09 | 2.00 | 0.80 | 2.00 | 0.38 |
| 4 | 1000 | 1.70 | 0.49 | 1.70 | 0.15 | 1.70 | 0.75 | 1.70 | 0.41 |
| Prorate | 1000 | 1.71 | 0.49 | 1.71 | 0.11 | 1.71 | 0.80 | 1.71 | 0.40 |
| **%** | 71.34% | 93.57% | 53.22% | 76.61% |

Observation of root growth for all prototype shows, *Centella asiatica* root growth 1.07mm a week with a total growth about 12.84mm for 12 week and *Chrysopogon zizanioides* are 5.41 mm a week and total growth
are 64.92mm. The height of *Centella asiatica* from 25cm height to average total height 68.87cm on weeks 12. While, *Chrysopogon zizanioides* are measure from 32cm in first week and growth up to the average total height after 12 weeks are 132.61cm. Control prototype shows, *Centella asiatica* planted on original soil growth less than 0.5mm per week and total growth for 12 weeks are 5.82mm and *Chrysopogon zizanioides* growth 2.85mm per week and total growth for 12 weeks are 32.24mm. Observation shows that the soil have be treated with coconut flakes give suitable environment for *Centella asiatica* and *Chrysopogon zizanioides* to growth as shows in Table 4. The modification of soil environment that have been treated with coconut flakes are confirm by the increase of permeability (k) from 1.02 x 10^{-4} for original soil to 1.14 x 10^{-4} for *Centella asiatica* and 1.51 x 10^{-4} for *Chrysopogon zizanioides*.

Table 4. The root growth and the height of *Centella asiatica* and *Chrysopogon zizanioides* before and after treatment

| Treatment | *Centella asiatica* planted on 10% coconut flakes with 90% soil | *Chrysopogon zizanioides* planted on 25% coconut flakes with 75% soil | *Centella asiatica* planted on 100% soil | *Chrysopogon zizanioides* planted on 100% soil |
|-----------|---------------------------------------------------------------|---------------------------------------------------------------|----------------------------------------|----------------------------------------|
| Duration (Week) | Root Growth (mm) | Plant Height (cm) | Root Growth (mm) | Plant Height (cm) | Root Growth (mm) | Plant Height (cm) | Root Growth (mm) | Plant Height (cm) |
| 1 | 0.96 | 5.65 | 4.98 | 10.65 | 0.48 | 3.10 | 2.78 | 6.35 |
| 2 | 0.96 | 5.72 | 5.03 | 10.97 | 0.46 | 3.12 | 2.84 | 6.24 |
| 3 | 0.98 | 5.68 | 4.98 | 10.86 | 0.52 | 3.13 | 2.82 | 6.26 |
| 4 | 1.00 | 5.72 | 5.05 | 10.92 | 0.49 | 3.11 | 2.77 | 6.32 |
| 5 | 1.20 | 5.73 | 5.15 | 10.87 | 0.50 | 3.15 | 2.85 | 6.23 |
| 6 | 1.10 | 5.69 | 5.28 | 11.21 | 0.46 | 3.12 | 2.79 | 6.25 |
| 7 | 1.20 | 5.73 | 5.55 | 11.15 | 0.49 | 3.15 | 2.92 | 6.31 |
| 8 | 0.98 | 5.71 | 5.63 | 11.18 | 0.51 | 3.13 | 2.89 | 6.32 |
| 9 | 0.96 | 5.82 | 5.62 | 11.13 | 0.47 | 3.16 | 2.91 | 6.32 |
| 10 | 1.00 | 5.81 | 5.76 | 11.18 | 0.45 | 3.14 | 2.88 | 6.35 |
| 11 | 1.30 | 5.79 | 5.93 | 11.22 | 0.48 | 3.12 | 2.87 | 6.35 |
| 12 | 1.20 | 5.82 | 5.96 | 11.27 | 0.51 | 3.13 | 2.92 | 6.37 |
| Total Root Growth | 12.84 | 68.87 | 64.92 | 132.61 | 5.82 | 37.56 | 34.24 | 75.67 |
| Prorate | 1.07 | 5.74 | 5.41 | 11.05 | 0.48 | 2.85 | 2.85 | 6.31 |

Results shows that the combination of phytoremediation and mycoremediation technique reduced more soil loss compared to using phytoremediation technique. *Centella asiatica* and *Chrysopogon zizanioides* shows both of the plant can growth well in environment that have been treated with coconut flakes. The growth of root modified the strength of soil about 38% from the original and these factor contribute for reducing of soil loss. While the height of plant are contribute to the growth of root.

5.0. Concluding Remarks

*Chrysopogon zizanioides* (vetiver grass) are suitable to use as phytoremediation for controlling erosion and contamination, however *Centella asiatica* (‘pegaga’) that previously use as medication herbs shows the avaibility to be used as as phytoremediation for controlling erosion and soil contamination. While, coconut flakes is suitable to be used as mycoremediation media for treated soil especially for fine grain soil because it shows that the soil capillary system are modified because of fungi producing from coconut flakes after it be fermented. *Centella asiatica* is suitable to be use for phytoremediation of Pb in contamination soil, while *Chrysopogon zizanioides* suitable for Zn and Cu.

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