

แบบฟอร์มแจ้งความประสงค์การใช้งบประมาณสำหรับการพัฒนาบุคลากรคณะวิทยาศาสตร์

ประจำปีงบประมาณ พ.ศ.2560

ข้าพเจ้า นางสาวอภิญญา พงษ์จันทร์ ตำแหน่ง อาจารย์สังกัด เทคโนโลยีสิ่งแวดล้อม

ได้ขออนุญาตเข้าร่วม งานประชุมวิชาการ TSB 2016 โรงเรียนอัสสัมชัญ

ตามหนังสือขออนุญาต ศบ.0523.4. 43 / 191 ลงวันที่ 30 พฤษภาคม 2559 โดยข้าพเจ้ามีความประสงค์จะขอ

ใช้งบประมาณพัฒนาบุคลากรของคณะวิทยาศาสตร์ ใน

- ☐ กรณีที่ 1 ไม่มีเอกสารใด ๆ เสนอคณะฯ (คนละไม่เกิน 6,000 บาท)
- ☐ กรณีที่ 2 มีเอกสารรายงานสรุปเนื้อหา (คนละไม่เกิน 8,000 บาท) โดยจัดส่งเอกสาร
รายงานสรุปเนื้อหาและการนำไปใช้ประโยชน์ อย่างน้อย 1 หน้ากระดาษ A4
- ☒ กรณีที่ 3 เข้าร่วมนำเสนอผลงานวิชาการ
- คนละไม่เกิน 15,000 บาท (สำหรับสายวิชาการ)
 - คนละไม่เกิน 10,000 บาท (สำหรับสายสนับสนุนวิชาการ)

โดยจะจัดส่งหนังสือตอบรับการเข้าร่วมนำเสนอผลงานฯ และเอกสารดังต่อไปนี้

1. บทคัดย่อ หรือสำเนาโปสเตอร์(ย่อขนาด A4) หรือบทความฯ ฉบับเต็ม
2. รายงานสรุปเนื้อหาและการนำไปใช้ประโยชน์ อย่างน้อย 1 หน้ากระดาษ A4
3. เอกสารอื่น ๆ (โปรดระบุ).....

- ☐ กรณีที่ 4 เข้าอบรมเชิงปฏิบัติการ
- คนละไม่เกิน 15,000 บาท (สำหรับสายวิชาการ)
 - คนละไม่เกิน 10,000 บาท (สำหรับสายสนับสนุนวิชาการ)

โดยจะจัดส่งหนังสือตอบรับการเข้าร่วมอบรมเชิงปฏิบัติการฯ และเอกสารดังต่อไปนี้

1. สำเนาใบรับรอง หรือหนังสือรับรอง หรือใบประกาศนียบัตร หรือวุฒิบัตร จากการเข้าอบรมฯ
2. รายงานสรุปเนื้อหาและการนำไปใช้ประโยชน์ อย่างน้อย 1 หน้ากระดาษ A4
3. เอกสารอื่น ๆ (โปรดระบุ).....

ในปีงบประมาณ พ.ศ.2560 (1 ต.ค.59 -30 ก.ย.60) ข้าพเจ้าได้ใช้งบประมาณบุคลากรฯ ไปแล้ว จำนวนทั้งสิ้น...1. ครั้ง ดังต่อไปนี้

-ครั้งที่ 1	เลือกใช้กรณีที่.....3.....	ใช้งบประมาณไปแล้วเป็นจำนวนเงินทั้งสิ้น.....10000.....บาท
-ครั้งที่	เลือกใช้กรณีที่.....	ใช้งบประมาณไปแล้วเป็นจำนวนเงินทั้งสิ้น.....บาท
-ครั้งที่	เลือกใช้กรณีที่.....	ใช้งบประมาณไปแล้วเป็นจำนวนเงินทั้งสิ้น.....บาท

(หากมีจำนวนครั้งเกินกว่านี้ ให้ทำรายละเอียดแนบท้ายเพิ่มเติม)

นางสาวอภิญญา พงษ์จันทร์
(นางสาวอภิญญา พงษ์จันทร์)
30 / 05 / 59

ผู้ขออนุญาต

นางสาวอภิญญา พงษ์จันทร์
(นางสาวอภิญญา พงษ์จันทร์)
ประธานหลักสูตร/เลขานุการคณะ/หัวหน้างาน

ประธานอาจารย์ประจำหลักสูตรวิทยาศาสตร์มหาวิทยาลัย
สาขาวิชาเทคโนโลยีสิ่งแวดล้อม

หมายเหตุ : 1. งบประมาณที่ใช้สำหรับการพัฒนาบุคลากร หมายถึงค่าใช้จ่ายทุกประเภทที่ใช้ในการเข้าร่วมการอบรม/สัมมนา/ประชุม เช่น ค่าลงทะเบียน ค่าใช้จ่ายในการเดินทาง และอื่น ๆ ที่เกี่ยวข้อง

2. การใช้งบประมาณพัฒนาบุคลากรในคณะวิทยาศาสตร์จัดสรร ให้ถือปฏิบัติตามเงื่อนไขที่กำหนดไว้ในแต่ละกรณี

(ฉบับปรับปรุงใหม่ตามมติที่ประชุมคณะกรรมการประจำคณะฯ ครั้งที่ 5/2556 เมื่อวันที่ 10 พฤษภาคม 2556)

รายงานสรุปเนื้อหาและการนำไปใช้ประโยชน์จากการเข้าอบรม สัมมนาหรือประชุมวิชาการ

ข้าพเจ้า นางมุลินทร์ ผลจันทร์ ได้เข้าร่วมการประชุมและนำเสนองานวิจัยแบบposterและมี full paper เรื่อง Challenges and opportunities of landscape grass species in cadmium removal for sustainable stormwater management ในการประชุมวิชาการระดับนานาชาติ The 28th annual meeting of the Thai society for biotechnology and international conference ซึ่งจัดโดย Chiang Mai University ในวันที่ 28-30 พฤศจิกายน 2559 ณ จังหวัดเชียงใหม่ ตามหนังสือขออนุญาตเดินทางไปราชการเลขที่ ศธ 0523.4.4.3/171 ลงวันที่ 20 ตุลาคม 2559 นั้น ข้าพเจ้าของรายงานการเข้าประชุมวิชาการดังนี้

1. ได้นำเสนองานวิจัยแบบบรรยายในหัวข้อ Challenges and opportunities of landscape grass species in cadmium removal for sustainable stormwater management

2. ได้เข้าร่วมการประชุมวิชาการ

การนำไปใช้ประโยชน์

1. ได้มีการแลกเปลี่ยนข้อมูลและประสบการณ์ในวิจัยกับคณาจารย์และนักวิจัยจากมหาวิทยาลัยในประเทศและต่างประเทศ
2. ได้ความรู้ที่ทันสมัยสำหรับการเรียนการสอนทั้งในหลักสูตรระดับปริญญาตรีสาขาเทคโนโลยีชีวภาพและหลักสูตรระดับบัณฑิตศึกษาสาขาเทคโนโลยีสิ่งแวดล้อม

ผู้ทำรายงาน

(อ.ดร.มุลินทร์ ผลจันทร์)

หลักสูตรเทคโนโลยีสิ่งแวดล้อม

6 / ธันวาคม /2559

ความคิดเห็นของผู้บังคับบัญชาชั้นต้น (ประธานหลักสูตร)

รับทราบ

(อ.ดร.มุลินทร์ ผลจันทร์)

ประธานหลักสูตรเทคโนโลยีสิ่งแวดล้อม

6 / ธันวาคม /2559

ความคิดเห็นของคณบดีคณะวิทยาศาสตร์หรือผู้แทน

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(รองศาสตราจารย์ ศิริรินทร์ญา ภักดี)

...../...../.....

Challenges and Opportunities of Landscape Grass Species in Cadmium Removal for Sustainable Stormwater Management

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ABSTRACT

*Growing urbanization and daily human activities led to significant changes in both quantity and quality of urban runoff. Heavy metals in urban runoff have been of concern to the environmental pollution due to their direct adverse effects on aquatic ecosystem. The development of green areas is one of the important strategies for the urban sustainable development. Biofiltration system, a new concept of low impact urban sustainable development, has been used to improve the quality of urban stormwater runoff. This could be done and success by applying the plant species that have the phytoremediation potential. However, the knowledge of the ability of landscape plants frequently used for Thailand greenspace development for heavy metal removal is still lacking. This study investigated the ability of three grass landscape species (*Axonopus compuuressus* P.Beauv, *Zoysia matrella* (L.) Merrill and *Zoysia japonica*) in treating the synthetic stormwater runoff contaminated with 1 and 3 ppm of cadmium. The highest concentration of Cd was found from the root of *Z. japonica* with the value 462.54 mg/kg dry wt. The average removal efficiencies by *Z. japonica* in the bioretention system for SS and COD were 88% and 78%,*

respectively. The system had high capabilities to remove TKN, NO₃, PO₄ and Cd from polluted stormwater up to 100%.

Keywords: Stormwater runoff treatment, Cadmium removal, *Axonopus compneuressus* P.Beauv, *Zoysia matrella* (L.) Merrill, *Zoysia japonica*

INTRODUCTION

A rapid rate of urban development over recent years has led to significant changes in both quantity and quality of urban runoff. Stormwater runoff is non point source pollution that carries different kinds of organic matters, nutrients, sediments, pathogens, along with several hazardous chemicals (Bratieres et al., 2008). This kind of non point source has been recognized to be the largest source of aquatic pollution (USEPA. 1983 ; BC-MoE. 1999 and Marsalek et al., 1999). Apart from the wash off process from the roof surface, atmospheric dust, agricultural area, runoff from road has been pointed out as the important contributor of water pollutants, especially heavy metals. Road traffic-related heavy metal emissions, especially from automobiles, are known to pose serious ecological and human health problems due to their high toxicity and persistency in the environment (Davis et al., 2001a; Khan et al., 2011). Consequently, this complex pollution and its treatment process have gained an increase scientific attention in the past few decades (Budai and Clement, 2011)

Biofiltration systems (also called bioretention systems, biofilter or rain garden), a relatively concept of low impact development, are increasingly being used to improve the quality of stormwater runoff and stormwater management (Davis et al., 2009). It is due to the flexibility of the process, this system can be broadly designed for the urban runoff quality improvement (Davis et al., 2001b) and in the same time as replacements for urban green spaces (Bratieres et al., 2008; Denman et al., 2006). The efficiency

of the biofiltration systems rely strongly on vegetations, symbiotic relationships between microorganisms and soil media (Kadlec and Knight, 1996, Hsieh and Davis, 2005). Plants are one of the main players in both direct and indirect pollutant eliminations such as organic pollutants degradation, macronutrients and micronutrients uptake, supporting the chemical and biological reaction for pollutants removal such as heavy metals (Read et al., 2008; Davis et al., 2003) and also an increase in hydraulic conductivity of the media (Hatt et al., 2008). Although microorganisms have been reported as the important part of the remediation potential, plants also have the great ability to accumulate and withstand high concentration of heavy metals from contaminated water and soils (Bert et al., 2002; Sun et al., 2009). The heavy metal removal efficiency varies among plant species and characteristics, metal stress and soil conditions (Sun and Davis, 2007). Thus, plant selection is one of the strategies for heavy metal removal in bioretention systems. It has been reported that two types of vegetation, including hyperaccumulator plants and non-accumulator plants, are commonly applied in phytoremediation process (Baker and Brooks, 1989; Pulford and Watson, 2003; Khan et al., 2011). The species that may accumulate heavy metals while producing high biomass and suitable for green urban development would be the key success for bioretention process and also urban stormwater management.

The population in Thailand, especially in capital cities, has been increasing rapidly leading to the speedy expansion of urban areas (less green areas), natural resource depletion and increase runoff rates and volumes. The solution for the current water scarcity in Thailand, however, seems to target on the water demand and the need for additional water resources. It is likely that urban runoff is still not a major concern regarding to the risks for soil, surface water and groundwater contamination. In order to develop the green areas which is one of the important strategies for the urban sustainable development, the biofiltration system for

urban stormwater management could be the promising process. This could be done and succeeded by applying the plant species that have the phytoremediation potential. However, the knowledge of landscape plants that have been frequently used for Thailand greenspace development for stormwater management and heavy metal removal is still lacking. Plant selections must be based not only on their treatment performances but also on their capabilities to survive in the local environment. Moreover, the feasibility of landscape plants for the bioretention system in Thailand has not yet been evaluated and the fundamental issue of these plants are significantly different from the plants that are conventionally used in the bioretention system. In this study, we investigated the ability of three landscape grass species on cadmium removal from the synthetic stormwater runoff. This study could allow us to have the lists of landscape grass having the phytoremediation potential that can be used for future bioretention processes.

MATERIAL AND METHODS

Materials

Landscape grass preparation

Three grass species; Saranna grass (*Axonopus compuuressus* P.Beauv), Manila grass (*Zoysia matrella* (L.) Merrill) and Japanese lawn grass (*Zoysia japonica*) that potentially used for urban landscape applications were chosen. All species with the same age were obtained from Kham Thieng flower market, Chiang Mai in June 2013. Each grass species was individually separated and selected before testing in the hydroponic system.

Experimental set up

The hydroponic system

The phytoremediation experiments were carried out using the hydroponic system located outdoors at Chulaporn building Faculty of Science, Maejo University, as shown in Fig.1. The

synthetic stormwater runoff containing of 0 (control), 1 and 3 ppm of cadmium used in this study was adapted from Davis *et al.* (2001) as shown in Table 1. Approximately 3 L of freshly prepared synthetic runoff was applied to each container (24×30×11 cm) over 15 days. Each experiment was conducted in an open air area with natural light, temperature, and humidity. The plastic cover was used to prevent the rain and to avoid the dilution of the synthetic stormwater runoff. The samples including synthetic stormwater runoff (approximately 50 ml) and plants (0.2 g dry wt.) were then collected for cadmium analysis at the end of the experiment (15 days). Plant morphology and growth were also physical investigated.

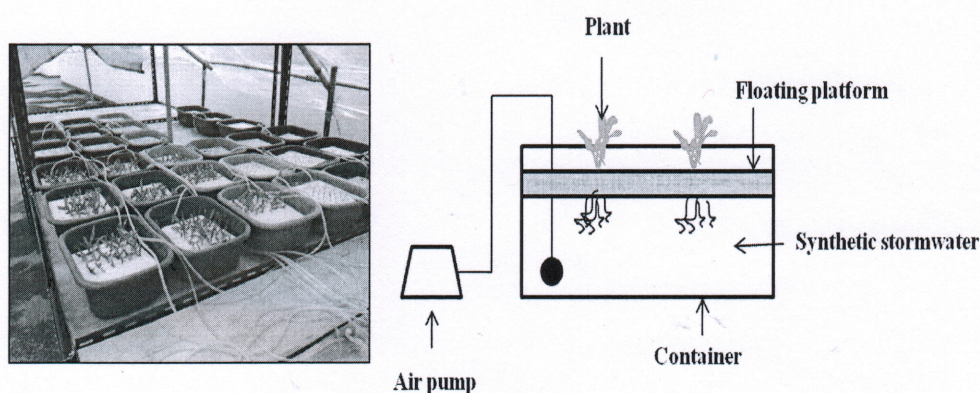


Figure 1. Hydroponic experimental set up

Table 1 Chemical characteristics of synthetic stormwater runoff

Parameters	Chemicals *	Concentration (mg/L)
Nutrients	Sodium nitrate (NaNO_3)	2
	Glycine ($\text{NH}_2\text{CH}_2\text{COOH}$)	4
	Dibasic sodium phosphate (Na_2HPO_4)	0.6
Cadmium	Cadmiumsulfate ($3\text{CdSO}_4 \cdot 8\text{H}_2\text{O}$)	3 (as Cd)
Turbidity**	Calcium chloride (CaCl_2)	120
Soil**	sieved 0.25 mm.	150

* Adapted from Davis *et al.* (2001)

** Sandy loam soil was used only for the bioretention experiments

Laboratory scale of bioretention system

The bioretention system (500 L) was installed in multiple layers (Fig. 2) at Chulaporn building, Faculty of Science, Maejo University. Approximately, 208 kg. of sandy loam soil were used for treatment 3 and 4. The system was fed every 6 hrs by spraying with 40 L of the synthetic stormwater runoff containing of 0 (control) and 3 ppm of cadmium adapted from Davis *et al.* (2001) (Table 1). *Z. japonica* was selected in this study and each experiment was conducted for 30 days according to the experimental design (Table 2). The samples including synthetic stormwater runoff (influent and effluent), plants and soil were then collected for cadmium analysis at the beginning and the end of the experiment. Water samples were also collected every 3 days for chemical analysis (ss, COD, TKN, pH, NO_3 and PO_3 , while soil samples were collected for pH, moisture, TKN, available phosphate, organic carbon and cation exchange capacity according to the standard method (APHA-AWWA-WPCF, 2005). Moreover, grass morphology and growth were also physical investigated.

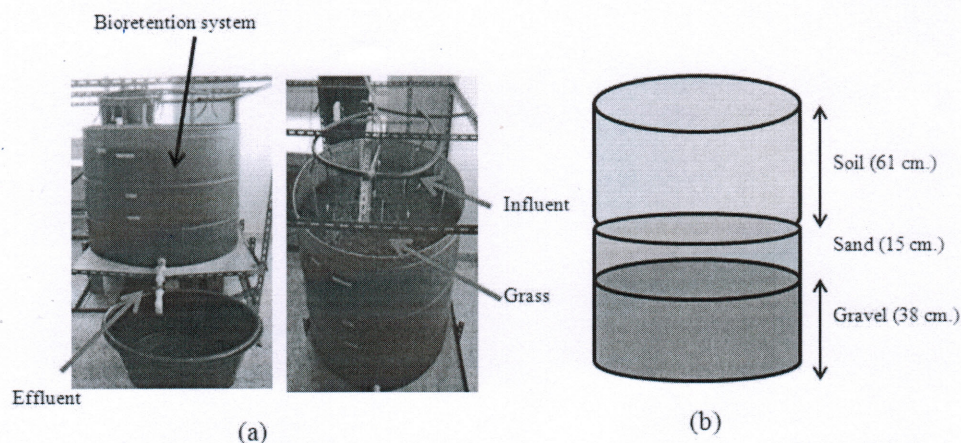


Figure 2 Bioretention system used in this experiment; a) Bioretention system and b) Schematic diagram of the bioretention system

Table 2 Experimental set up for bioretention system

Treatment	Grass		Synthetic wastewater		Abbreviation
	Yes	No	Cadmium addition		
			Yes	No	
Treatment 1		✓		✓	NGCd0
Treatment 2	✓			✓	GCd0
Treatment 3		✓	✓		NGCd3
Treatment 4	✓		✓		GCd3

Determination of cadmium in the plant tissue

Grass samples collected at the beginning and at the end of the experiment were washed with the tap water and distilled water, respectively. They were dried and its roots and shoots were separated. Each root and shoot part was oven dried at 100°C for 1 d. Before digestion, the dried plant tissues were grounded, and the dry weight of roots and shoots were determined. Only 0.2 g of plant

tissues were digested with mixed acid; HNO₃:HClO₄ (2:1) and digested at 80°C until a final volume of 1 ml was obtained. The samples were then diluted with 5% v/v HNO₃ to 50 ml. The Cd content was analyzed by flame atomic absorption spectrometry (FAAS) (Bert et al., 2002). The Cd content was analyzed by flame atomic absorption spectrometry (FAAS) (Bert et al., 2002). The bioconcentration factor (BCF, L kg⁻¹) (Sun et al., 2009) and translocation factor (TF) (Yang et al., 2004), were calculated using equation (1) and (2), respectively.

$$BCF = \frac{C_{Cd \text{ in plant}}}{C_{Cd \text{ in solution}}} \quad (1)$$

$$TF = \frac{C_{Cd \text{ in shoot}}}{C_{Cd \text{ in root}}} \quad (2)$$

When $C_{Cd \text{ in plant}}$ was the Cd concentration in the plant (mg kg⁻¹) and $C_{Cd \text{ in solution}}$ was the Cd concentration in the solution (mg L⁻¹); $C_{Cd \text{ in shoot}}$ was the Cd concentration in the shoot (mg kg⁻¹) and $C_{Cd \text{ in root}}$ was the Cd concentration in the root (mg kg⁻¹).

RESULTS

Effect of Cd contaminated stormwater runoff on the growth of grass species

The effect of cadmium concentration on the growth of three grass species is given in Figure 3. Results showed significant differences in shoot height and root length between grass species after contacted with Cd contaminated stormwater runoff (Anova and LSD; $p < 0.05$). It was found that both shoot height and root length of all grass species decreased after adding 1 ppm and 3 ppm of cadmium. However, *Z. japonica* had the highest shoot height than others, while *A. compuuressus* (Sw.) P. Beauv had the longest root length from both cadmium concentrations (Fig. 3). The average shoot height of *Z. japonica* obtained at day 15 after adding

1 ppm and 3 ppm of cadmium were 5.89 ± 0.43 cm. and 5.92 ± 0.78 cm., respectively. On the other hand, *A. compuuressus* (Sw.) P. Beauv had the maximum average value of root length of 3.59 ± 0.46 cm. and 3.06 ± 0.74 cm. at day 15 after adding 1 ppm and 3 ppm of cadmium respectively.

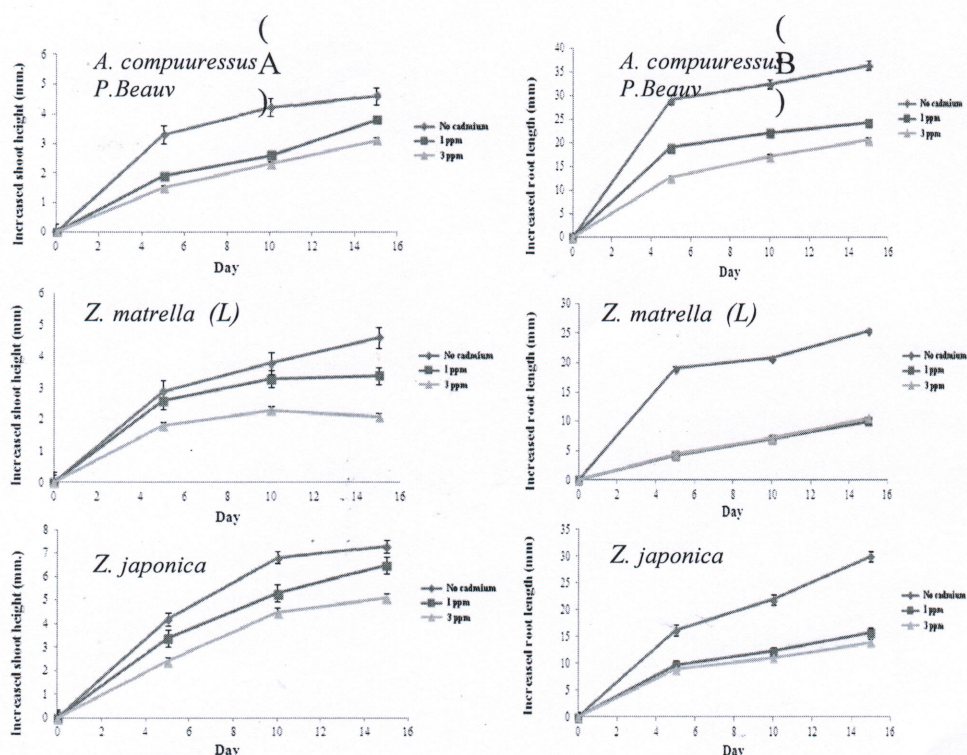


Figure 3 Effect of cadmium concentration on the plant growth (a) Increased shoot height and (b) Increased root length after adding 1 and 3 ppm of Cadmium.

In addition, the results showed that increasing in cadmium concentrations affected the plant morphology and also plant growth (data not shown). At the beginning (5 days), both aerial and root parts of all species had still developed well for all cadmium concentrations (still less than the control). After 10 days, however,

both parts (especially the roots length) appeared to decrease its extension. Moreover, the color of leaves had been changed from green to yellow and brown at higher level of cadmium.

Concentrations of Cadmium in grass species

The concentrations of cadmium among grass species detected from both shoot and root is shown in Table 3 and Figure 4. It has been observed that *A. compuuressus* (Sw.) P. Beauv, *Z. matrella* (L.) Merrill and *Z. japonica* had less Cd concentrations containing in both parts at the beginning of the experiment which is less than 0.02 ppm according to the detection limit of FAAS (Perkin Elmer Analyst 100). After applying the Cd contaminated stormwater runoff, it was found that all grass species had higher Cd concentration in roots more than shoots (Figure 4) or having higher BCF_{root} than the BCF_{shoot} (Table 3). However, it was found that every grass species had the Translocation factor (TF) lower than 1.0.

Significantly higher Cd concentrations were found from both parts of *Z. japonica* with the value of 211.56 mg/kg dry wt. and 462.54 mg/kg dry wt. for shoot and root, respectively (Anova and LSD; $p < 0.05$). Moreover, all grass species could be able to remove cadmium from the stormwater with the efficiency higher than 90% and *Z. japonica* showed significant highest cadmium removal efficiency that reached approximately 99% (Anova and LSD; $p < 0.05$).

Table 3 The bioconcentration factor (BCF) and translocation factor (TF) obtained from 3 landscape grasses

Plants	Cd* concentration (mg kg ⁻¹ dry weight)		BCF _{shoot} (L kg ⁻¹)	BCF _{root} (L kg ⁻¹)	TF	Cd removal (%)
	shoot	root				
<i>A. compuuressus</i> (Sw.) P. Beauv	106.57	225.10	18.5	75.0	0.2	96.1
<i>Z. matrella</i> (L.) Merrill	107.46	275.84	22.6	127.9	0.2	92.3
<i>Z. japonica</i>	211.56	462.54	57.8	127.1	0.5	98.6

* data from day 15

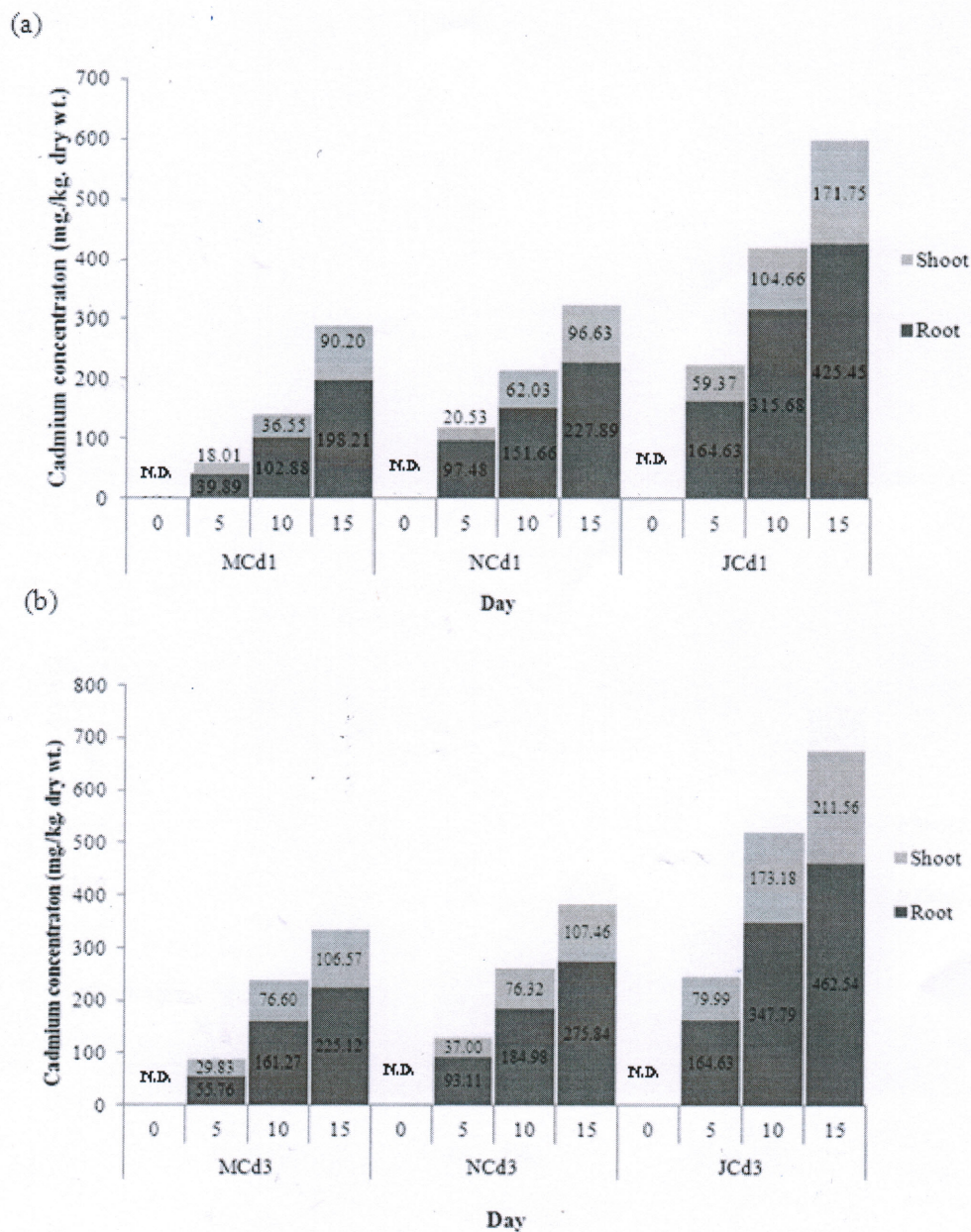


Figure 4 Cadmium concentration detected in shoot and root after adding (a) 1 and (b) 3 ppm of Cadmium.

* MCd = *A. compuressus* P.Beauv, NCd = *Z. matrella* (L.) Merrill, JCd = *Z. japonica*

The efficiency of the bioretention system

During the monitoring period of 30 days, the treatment performance of the bioretention system in terms of SS, COD is shown in Figure 4. In general, No significant differences in suspended solids (SS) (Figure 4), TKN, NO₃ and PO₄ removal (data not shown) among the treatments were observed. Every treatment could remove 100% of TKN, NO₃ and PO₄ (data not shown) and more than 80% of SS. However, it was found that the system that grass (Treatment 2 (no Cd) and Treatment 4 (3 ppm Cd) has been planted could significantly remove COD greater than those without grass (Anova and LSD; $p < 0.05$) with the value of $78.04 \pm 1.17 \%$ and $77.94 \pm 1.27 \%$ for treatment 2 and 4, respectively. Moreover, no cadmium had been found from the effluent coming from treatment 3 and treatment 4.

The effect of *Z. japonica* and soil on Cadmium removal

Total accumulated cadmium entering to the bioretention systems for 30 day was approximately 4020 ± 228 mg/L and 3708 ± 576 mg/L for treatment 3 and treatment 4, respectively. However, if there was no cadmium in the effluent from both treatments, the cadmium could be removed via plants or soil in the system. The results found that 4006 mg and 3615 mg of cadmium were absorbed in soil for treatment 3 and treatment 4, respectively. As *Z. japonica* was used for only in treatment 4, it was observed that 39.71 g dry wt. and 44.63 g dry wt. of cadmium was found from shoot and root respectively. After standardization to the surface area of the bioretention system, *Z. japonica* had the ability to remove cadmium from the stormwater approximately $54 \text{ g/m}^2/30 \text{ d}$.

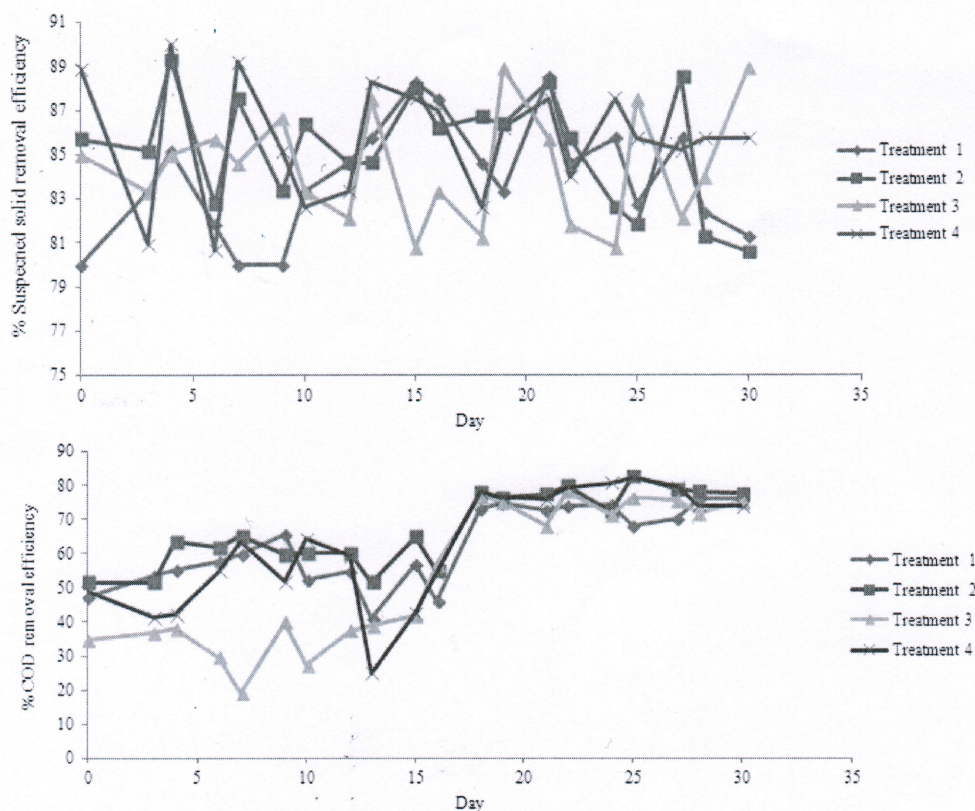


Figure 4 Suspended solids and COD removal efficiency

DISCUSSION

Most plant species naturally contained cadmium both in their roots and their shoots as it acts as trace element for plant. The vegetations that have higher cadmium concentration in roots more than shoots or having higher BCF_{root} than the BCF_{shoot} implies that they have the ability to translocate the heavy metal from root and stored in shoot. Moreover high BCF_{shoot}/BCF_{root} ratio found in plants could be linked to high TF values which indicated that those plants were the heavy metal hyperaccumulators (Bert et al., 2002; Sun et al., 2009). Our findings showed that all grass species achieved high cadmium removal efficiency more than 95% and had higher cadmium concentration in root than shoot. This means that

they could accumulate or remove cadmium from the environment. Even though, all grass species were found to have the Translocation factor (TF) lower than 1.0, which mean that landscape grasses were not defined as the cadmium hyperaccumulators. These landscape grasses may still be used to remedy Cd contaminated stormwater runoff by phytoextraction because they were fast growth, produced high biomass in short time, stored Cd in shoot more than 100 mg kg⁻¹ and also could translocation of Cd from root to shoot. *Z. japonica* appeared to have the highest cadmium accumulation in both tissue parts and less sensitive to the heavy metal due to their physical characteristics. This grass had then been chosen for testing in the bioretention system.

In the bioretention system we measured the performance of the *Z. japonica* as well as soil media in cadmium contaminated stormwater treatment. We found that the system with or without plants effectively removed suspended solids, organic carbon (COD, nutrients (TKN, NO₃, PO₄) and cadmium from the polluted stormwater. This is due to the mechanisms between vegetations as well as the symbiotic relationships between microorganisms and soil media (Kadlec and Knight, 1996, Hsieh and Davis, 2005; Read et al., 2008; Davis et al., 2003). Even though non vegetated soil has been reported to produce nitrogen (Hatt et al., 2008), planted soil might also have been expected to have more aerobic conditions supporting the growth of soil microorganisms leading to an increased biodegradation and nitrification resulting in nitrogen removal (Dernan et al., 2006). Moreover, our results showed that cadmium was detected greater in soil than the landscape grass tissues. It may be speculated that the cadmium reduction in soil was due to the absorption process between organic matters in soil particles (Read et al., 2008 Bratieres et al., 2008). There are different variations between landscape plant species, root system, physicochemistry of soil medium and the microbial community that could affect the performance of the bioretention

system. These issues still needed to be explored both in pilot and full scales, and over a longer duration.

CONCLUSION

Landscape grass species showed high concentrations of cadmium accumulation mainly in root more than shoot which could be used to remediate Cd contaminated stormwater runoff. The current study found that *Z. japonica* had the highest cadmium removal efficiency which was further applied in the bioretention process. The average SS and COD removal efficiencies by *Z. japonica* in the bioretention system were 88% and 78%, respectively. The system showed high capabilities to remove TKN, NO₃, PO₄ and Cd from polluted stormwater up to 100%.

ACKNOWLEDGEMENTS

This research was supported by grants funded by the Office of Higher Education Commission. The authors thank the Faculty of Science, Maejo University for providing instruments.

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บันทึกข้อความ

ส่วนราชการ คณะวิทยาศาสตร์ หลักสูตรวิทยาศาสตรมหาบัณฑิต สาขาวิชาเทคโนโลยีสิ่งแวดล้อม โทร.๓๘๗๐-๒
ที่ ศธ ๐๕๒๓.๔.๔.๓/๖๗๑ วันที่ ๒๐ ตุลาคม ๒๕๕๙

เรื่อง ขออนุญาตเข้าร่วมโครงการประชุมวิชาการระดับนานาชาติ และเสนอผลงานวิจัย

เรียน คณบดีคณะวิทยาศาสตร์

ตามหนังสือที่ ศธ ๖๕๙๒(๑๑)/๐๖๙ ลงวันที่ ๘ กรกฎาคม ๒๕๕๙ ศูนย์บริหารงานวิจัย และสาขาวิชาเทคโนโลยีชีวภาพ สหสาขาวิชา บัณฑิตวิทยาลัย ร่วมกับสมาคมเทคโนโลยีชีวภาพแห่งประเทศไทย จะได้จัดโครงการประชุมวิชาการระดับนานาชาติ The ๒๘th Annual Meeting of the Thai Society for Biotechnology and International Conference (TSB ๒๐๑๖) ในหัวข้อ “Natural Resources & Bio-based Innovation Products” ระหว่างวันที่ ๒๘ – ๓๐ พฤศจิกายน ๒๕๕๙ ณ โรงแรมดิเอ็มเพรส อำเภอเมือง จังหวัดเชียงใหม่ นั้น

ในการนี้ ข้าพเจ้าจึงขออนุญาตเข้าร่วมโครงการประชุมวิชาการระดับนานาชาติ The ๒๘th Annual Meeting of the Thai Society for Biotechnology and International Conference (TSB ๒๐๑๖) และเสนอผลงานวิจัยรูปแบบบรรยาย หัวข้อเรื่อง “Challenges and opportunities of landscape grass species in Cadmium Removal for Sustainable stormwater management” ตามวัน และสถานที่ดังกล่าว ทั้งนี้ เดินทางโดยรถยนต์ส่วนตัวและไม่เบิกค่าชดเชยน้ำมันเชื้อเพลิง

จึงเรียนมาเพื่อโปรดพิจารณาอนุญาต

(อาจารย์ ดร.มูจลินทร์ ผลจันทร์)

ประธานอาจารย์ประจำหลักสูตรวิทยาศาสตรมหาบัณฑิต
สาขาวิชาเทคโนโลยีสิ่งแวดล้อม