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# Applying diversity index and dominant species in research and selection of some indigenous plant species to absorb Pb, Zn

*Ứng dụng chỉ số đa dạng và ưu thế loài trong nghiên cứu và lựa chọn một số loài thực vật bản địa có khả năng hấp thụ Pb, Zn*

Research article

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The study was carried out at Dai Dong and Chi Dao communes, Van Lam District, Hung Yen Province. The biological diversity indexes and dominance index of species were used to identify native plant species which have the ability to absorb Pb and Zn. The results were verified by applying methods such as plant classification, quadrat cell counting, biological indicators and chemical analysis. Results showed that there are five species of plants with the highest dominant index calculated due to number of individuals in the study area including *Bidens pilosa L* (33.03%), *Acroceras munroanum* (8.14%), *Commelina coelestis* (7.83%), *Carex capillacea* (5.41%), *Ipomoea aquatic* (5.26%). Verified results showed that *Bidens pilosa L, Acroceras munroanum*, *Commelina coelestis*, *Ipomoea aquatic* can be used to treat Pb with the absorption concentration of 380 mg/kg, 288 mg/kg, 270 mg/kg, 223 mg/kg, respectively. Only *Commelina coelestis* can absorb Zn with the highest concentration of 73mg/kg. In summary, Pb absorption of dominant species in the study area is higher than the absorption of Zn.

*Nghiên cứu được thực hiện tại hai xã Đại Đồng và xã Chỉ Đạo, huyện Văn Lâm, tỉnh Hưng Yên nhằm xác định một số loài thực vật bản địa có khả năng hấp thụ Pb, Zn bằng cách sử dụng chỉ số đa dạng sinh học và chỉ số ưu thế loài. Kết quả được kiểm chứng bằng các phương pháp như phân loại thực vật, đếm ô quadrat, sử dụng chỉ số sinh học và phân tích hóa học. Kết quả cho thấy có có năm loài thực vật có chỉ số ưu thế cao nhất tính theo số lượng cá thể trong khu vực nghiên cứu là: Đơn buốt (33,03 %), Cỏ lá tre (8,14 %), Thài lài (7,83 %), Kiết tóc (5,41 %), Rau muống (5,26 %). Kết quả phân tích kiểm chứng thấy Đơn buốt, Cỏ lá tre, Thài lài, Rau muống có khả năng xử lý Pb với giá trị lần lượt là 380 mg/kg, 288 mg/kg, 270 mg/kg, 223 mg/kg. Trong khi đó chỉ có Thài lài là có khả năng hấp thu Zn với giá trị cao nhất là 73 mg/kg. Nhìn chung khả năng hấp thu Pb của các loài ưu thế tại khu vực nghiên cứu cao hơn so với khả năng hấp thu Zn.*

**Keywords:** heavy metals, spend some diversity, species dominance index

## 1. Introduction

Studies on the heavy metal absorption ability on soil of plant were done by many national and foreign authors and provided meaningful results. Identification of the native plants that have capable to treat heavy metals usually bases on the general principle that is to identify polluted areas. Currently, two approaches used in the selection of plant species are based on the heavy metal content accumulated in plants and tolerance to effects of pollutants. With the first method, the plants will be collected from the contaminated areas. Then the contents of heavy metal in all parts of the plants are analyzed and combined with selection criteria of plant species suitable for initial purpose. To verify the heavy metal treatment ability, we need to optimize growth conditions for plants. This method has high-precision but high cost for chemical analysis. With the second method, contaminated areas, information on the diversity and dominance of the study area must be determined by assessement of changes in diversity and dominance of plants before and after they are affected by the

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wastesource. In the polluted environmental conditions, if any plants are still living, adaptive and are the dominant species, their resistance to contaminants is very high. To verify the heavy metal absorption ability, accumulated levels in the plants will be analyzed. This method is high efficient because it requires low cost by less sample analysis experiments but could select plants with high heavy metal absorption ability.

# 2. Materials and methods

## 2.1. Study area

Dai Dong and Chi Dao communes were chosen for study because both of communes have many households working on metal recycling which discharged Pb and Zn for long time. The climatic and soil conditions are represented for Red river delta and suitable for the growth of crops as well as weeds. In this study, we take samples in canals, rice fields and disposal sites receiving waste sources.


**Figure 1: Map of study area (GoogleEarth)**

## 2.2. Soil and plant sampling method

Soil samples were taken by specialized tools and same locations with plant samples. Soil samples are taken at the surface (0-15 cm) at 7 different areas. Two kinds of soil samples include 3 dry samples at the landfill (KV1, KV6, KV7) and 4 semi-submerged samples collected at rice fields and canals (KV2, KV3, KV4, KV5). While, the vegetable cells were taken from the east - west - south - north - center. In the wetland areas (canals), the plants were taken at every 2 meters in the distance from upstream to downstream. Based on current conditions and the sampling location, we selected 38 plant samples at the study areas. The detail of sampling locations is shown in the Table 1.

## 2.3. Biodiversity survey method

* Botanical classification method
Collected plants at study sites were identified through the references combined with expert advice.

* Vegetation survey method
Vegetation survey was conducted based on standard cell counting methods (O quadrat) with dimensions of 120 × 80 cm of each cell.

* Biostatistics method
In this method, the biological indicators applied include:
Shannon & Weiner index:

$$H' = -\sum_{1=1}^{s} pi \ln pi$$

Simpson index:

$$Cd = \sum_{i=1}^{S} \left( \frac{ni}{N} \right)^2$$

Where pi: Percentage of individuals in the $i^{th}$ species
pi = ni/N
ni: Total individual of i species
N: Total individual of all species

## 2.4. Analysis method

* Soil samples: organic carbon was analyzed by Walkley - Black, pH by pH meter, total Pb and Zn by Asano – Kato method, 1997.

* Plant samples: heavy metal concentrations were analyzed by Asano Kato method.

# 3. Results and discussion

## 3.1. Diversity and dominance of plant

### 3.1.1 The list of plants appearing on the study area

The study results showed that 37 plant species belonging to 17 families appeared in the study area (Table 2).

**Table 1**. **Soil and plant sampling location**

| Location symbol | Soil sample | Sampling location |
|---|---|---|
| KV1 | Đ1 | Landfill - Chi Dao commune |
| KV2 | Đ2 | Rice filed and Landfill – Chi Dao commune |
| KV3 | Đ3, B3 | Canals - Chi Dao commune |
| KV4 | Đ4 | Rice field - Chi Dao commune |
| KV5 | Đ5, B5 | Canals - Chi Dao commune |
| KV6 | Đ6, B6 | Ma Chuc, Long Thuong, Dai Dong |
| KV7 | Đ7 | Dai Tu, Dai Dong |

*Note: KV- Location; Đ – Soil*

**Table 2. The list of plants appearing on the study area**

| No | Family | Latin name | Vietnamese name |
|---|---|---|---|
| 1 | Asteraceae | *Bidens pilosa L.* | Don buot |
| 2 | | *Artemisia vulgaris L..* | Ngai cuu |
| 3 | | *Sp1* | Cai dong |
| 4 | | *Eclipta prostrata (L.)* | Nho noi |
| 5 | | *Torenia asiatica L.* | Ngo dai |
| 6 | | *Grangea maderaspanata (L.)* | Cai dong |
| 7 | | *Gynura divaricata L.* | Bầu đất |
| 8 | Poaceae | *Acroceras munroanum* | Co la tre |
| 9 | | *Eleusine indica (L.)* | Co man trau |
| 10 | | *Cynodon dactylon* | Co ga |
| 11 | | *Panicum paludosum* | Ke nuoc |
| 12 | | *Echinochloa crus – galli (L.)* | Co long vuc nuoc |
| 13 | | *Sp1* | Co |
| 14 | | *Sp2* | Co |
| 15 | | *Sp3* | Co |
| 16 | Commelinaceae | *Commelina coelestis* | Thai lai |
| 17 | Cyperaceae | *Carex capillacea* | Kiet toc |
| 18 | | *Cyperus serotinus Rottb* | Co ba canh |
| 19 | | *Cyperus rotundus L..* | Co gau |
| 20 | Convolvulaceae | *Ipomoea aquatic* | Rau muong |
| 21 | Urticaceae | *Parietaria debilis* | Tuong anh |
| 22 | Solanaceae | *Physalis angulala* | Tam bop |
| 23 | | *Solanum americanum* | Lulu duc |
| 24 | Onagraceae | *Ludwidgia adscendens (L.)* | Dua nuoc |
| 25 | | *Ludwidgia octovalvis* | Rau muong |
| 26 | Amaranthceae | *Alternanthera sessilis* | Rau deu |
| 27 | Marsileaceae | *Marsilea quadrifolia L.* | Co bo |
| 28 | Polygonaceae | *Polygonum hydropiper L..* | Nghe nuoc |
| 29 | | *Polygonum hydropiper L.* | Nghe ram |
| 30 | | *Rumex chinensis Campd* | Chut chit |
| 31 | Verbenaceae | *Lantana camara L.* | Ngu sac |
| 32 | Araceae | *Coloscasia esculenta L.* | Khoai nuoc than trang |
| 33 | | *Coloscasia Black* | Khoai nuoc than tim |
| 34 | Pontederiaceae | *Eichhornia crassipes* | Beo tay |
| 35 | Mackinlayoideae | *Centello asiatica* | Rau ma |
| 36 | Gleicheniaceae | *Dicranopteris dichotoma* | Guot |
| 37 | Pteridaceae | *Pteris vittata L.* | Duong xi |

### 3.1.2 Diversity and dominance of plants

Table 3 and 4 showed that in 7 study areas, KV1 had the lowest diversity but dominant value was the highest, while KV3 was opposite.

Diversity and dominance of plant species were homologous at all study areas based on the number of individual, fresh and dry weight. If diversity value was calculated only based on the number of individuals at the dry land areas (KV1, KV6, KV7), KV6 had the highest diversity with the presence of 15 species. This is the agricultural area so that many species appear there than in other locations. At the low field locations, KV4 was more diverse than KV2 with three analysis methods, while semi-submerged area, the diversity at the KV3 was higher than KV5. If calculated on the entire 7 reaserch areas, KV3 had the highest diversity beacause there are many canals at this location.

If the diversity was calculated due to the fresh weight, the results were 3.03; 2.93; 3.54 at dry land KV6, low field KV4, canals KV3, respectively. These locations had the highest diversity value. The dry weight based diversity values were also same with the above results.

Dominant values calculated according to individual were 0.84; 0.18; 0.16 at dry land KV1, low field KV4, canals KV5, respectively. If due to the fresh weight, the dominant values at the dry land KV7, low field KV2, canals KV5 were, respectively, 0.45; 0.21; 0.18. These areas also had the greatest values. It was the same value in the case of the fresh weight.

**Table 3. Diversity value of the research areas**

| Kind of land | Location | Total of species | Diversity (H) | | |
|---|---|---|---|---|---|
| | | | Individual | Fresh weight | Dry weight |
| Dry land | KV1 | 6 | 0.38 | 1.73 | 1.83 |
| | KV6 | 15 | 2.13 | 3.03 | 2.98 |
| | KV7 | 7 | 1.31 | 1.53 | 1.49 |
| Low field | KV2 | 8 | 1.91 | 2.41 | 2.33 |
| | KV4 | 14 | 1.99 | 2.93 | 2.74 |
| Canal | KV3 | 21 | 2.42 | 3.54 | 3.57 |
| | KV5 | 14 | 2.05 | 2.74 | 2.68 |

**Table 4. Dominant values of the research areas**

| Kind of land | Location | Total of species | Dominance (Cd) | | |
|---|---|---|---|---|---|
| | | | Individual | Fresh weight | Dry weight |
| Dry land | KV1 | 6 | 0.84 | 0.36 | 0.33 |
| | KV6 | 15 | 0.16 | 0.17 | 0.17 |
| | KV7 | 7 | 0.34 | 0.45 | 0.46 |
| Low field | KV2 | 8 | 0.16 | 0.21 | 0.24 |
| | KV4 | 14 | 0.18 | 0.15 | 0.19 |
| Canal | KV3 | 21 | 0.10 | 0.10 | 0.10 |
| | KV5 | 14 | 0.16 | 0.18 | 0.19 |

## 3.2. The relationship between Pb and Zn concentrations in soil with diversity and dominance of plant at the study area

Analytical results showed that all soil at the study areas were polluted by Pb and Zn except KV5 and KV6 that had Zn concentration lower than QCVN 03: 2015/BTNMT. At dry land locations (KV1, KV7, KV6), Pb and Zn concentrations in soil were higher than in other locations. In particular, at KV1 the values of Pb and Zn in soil were highest that reached to 23426mg/kg and 237mg/kg, respectively. This may because there were many Pb recycling households operating in this area for a long time. At semi-submerged lands including low field (KV2, KV4) and canals (KV3, KV5), Pb and Zn concentrations in soil were high because of receiving polluted wastewater from landfills at the high terrain. In these locations, the KV2 and KV3 had high Pb and Zn concentrations in soil The Pb content was 131,778 mg/kg and Zn was 1559 mg/kg at KV2, while Pb was 102,762 mg/kg and Zn was 366 mg/kg at KV3 (Table 5).

**Table 5. Pb and Zn concentrations in soil and the diversity and dominance values**

| Kind of land | Location | Pb (mg/kg) | Zn (mg/kg) | Diversity (H) | Dominance (Cd) |
|---|---|---|---|---|---|
| | KV1 | 23426 | 237 | 0.38 | 0.84 |
| Dry land | KV7 | 134 | 213 | 1.31 | 0.34 |
| | KV6 | 164 | 117 | 2.13 | 0.16 |
| | KV2 | 131778 | 1559 | 1.91 | 0.16 |
| Low field | KV4 | 1822 | 260 | 1.99 | 0.18 |
| | KV3 | 102762 | 366 | 2.42 | 0.1 |
| | KV5 | 7321 | 142 | 2.05 | 0.16 |
| **QCVN 03:2015/BTNMT** | | **70** | **200** | | |

### 3.2.1 The relationship between the Pb and Zn concentrations in soil and the diversity

Each plant species has the resistance differently with different heavy metal contents in soil. Figure 2 and 3 shows that the trend of the diversity fluctuations at dry land, low field and cannels is different. At the dry land (KV1, KV7, KV6), when the Pb and Zn concentrations in soil increase from KV6 (164 mg/kg Pb; 117 mg/kg Zn) to KV1 (23,436 mg/kg Pb; 237 mg/kg Zn), the diversity decreases from KV6 (2.13) to KV1 (0.38). This pointed out that the Pb, Zn affected on the flora in these areas. The similar results were found at the low field areas. Concentrations of Pb and Zn in soil at KV4 were 1,822 mg/kg and 260 mg/kg Zn, repestively and increased to KV2 (131,778 mg/kg Pb; 1,559 mg/kg Zn), the diversity decreased from KV4 (1.99) to KV2 (1.91). At the canals, the trend was reverse when Pb concentration increased, the diversity also increased, KV5 (7,321 mg/kg Pb; 142 mg/kg Zn) increased to KV3 (102 762 mg/kg Pb; 366 mg/kg Zn), the diversity increased from KV5 (2.05) to KV3 (2.42). Both areas (KV3, KV5) were high plant diversity values, it showed that these plant species in these locations had good resistance with heavy metal infected conditions.

### 3.2.2. The relationship between the Pb and Zn concentration in soil and the dominance

Figure 4 and 5 show the relationship between the concentrations of Pb and Zn in soil in all study locations and the dominance at the study areas.

At the dry land areas (KV1, KV7, KV6), when the Pb, Zn concentrations in soil increased from KV6 (164 mg/kg Pb; 117 mg/kg Zn) to KV1 (23,426 mg/kg Pb; 237 mg/kg Zn), the dominant values increased from KV6 (0.16) to KV1 (0.84). It means that the potential appearance of the dominant species was highest at KV1 because of the high levels of heavy metal contamination in soil, only some species can withstand and then become the dominant species.

In the wetland areas (low fields and canals), the trend was opposite with the dry areas. At the low field location, when the Pb, Zn concentration in soil increased from KV4 (1822 mg/kg Pb; 260 mg/kg Zn) to KV2 (131,778 mg/kg Pb; 1,559 mg/kg Zn), the dominant values decreased from KV4 (0.18) to KV2 (0.16), and similar to the canal area. This may be that the flora at the submerged areas had high uniformity.

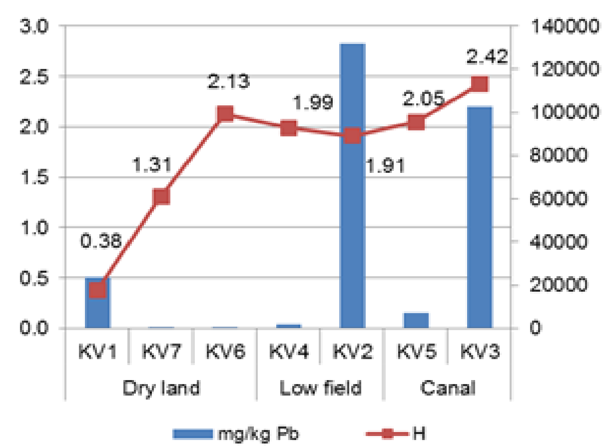


**Figure 2. The relationship between the Pb concentration in soil and the diversity**

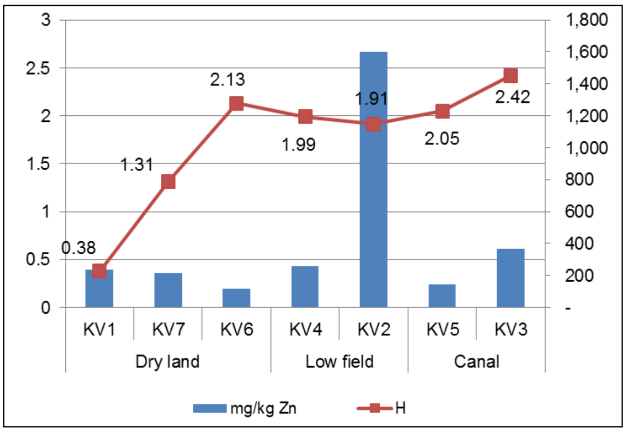


**Figure 3. The relationship between the Zn concentration in soil and the diversity**

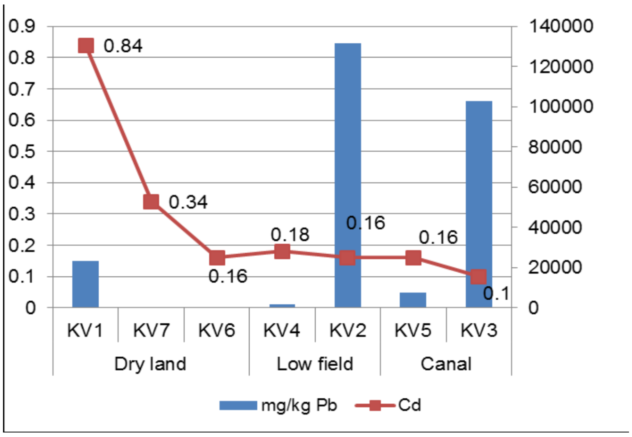


**Figure 4. The relationship between the Pb concentration in soil and the dominance**

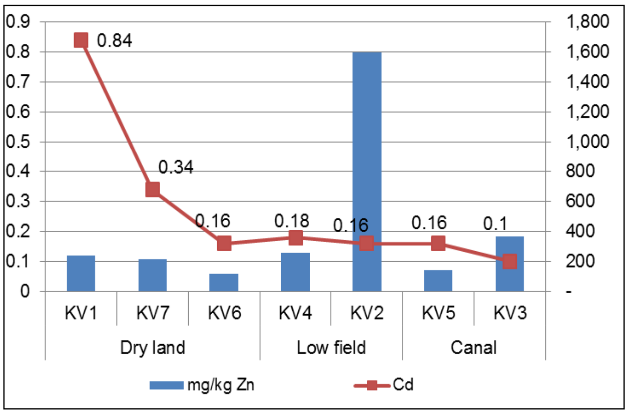


**Figure 5. The relationship between the Zn concentration in soil and the dominance**

## 3.3. Determination of the dominant species in the study area

Figure 5 and Table 6 showed that if the dominant values calculated by individual species, there were five dominant species including *Bidens pilosa L* (33.03%), *Acroceras munroanum* 8.14%), *Commelina coelestis* (7.83%), *Carex capillacea* (5.41%), *Ipomoea aquatic* (5.26%) (Table 6).

If taking into account of the fresh weight, the dominant species are Don buot (20,86 %), Tam bop (10,30 %), Thai lai (9,94 %), Rau muong (7,61 %), Co la tre (7,75 %). In which, Tam bop had the most dominant and followed by Don buot, these species had high biomass values and only appeared at the disposal areas (KV1). If based on the dry weight, there were five dominant species including *Bidens pilosa L.* (19.94 %), *Physanlis angulala* (9.81 %), *Acroceras munroanum* (7. 55 %), *Commelina coelestis* (7.41 %), *Carex capillacea* (7.23 %) (Figure 6).

**Table 6. The number and fresh, dry weight of plant species appearing in the study area**

| Vietnamese name | Latin name | Individual, % | Fresh weight, % | Dry weight, % |
|---|---|---|---|---|
| Don buot | *Bidens pilosa L.* | **33.03** | **23.86** | **19.94** |
| Co la tre | *Acroceras munroanum* | **10.26** | **7.75** | **7.55** |
| Thai lai | *Commelina coelestis* | **7.41** | **9.94** | **7.41** |
| Kiet toc | *Carex capillacea* | **5.12** | 4.24 | **7.23** |
| Rau muong | *Ipomoea aquatic* | **5.16** | **7.61** | 6.37 |
| Co long vuc nuoc | *Echinochloa crus - galli (L.)* | 4.91 | 1.18 | 2.58 |

| Vietnamese name | Latin name | Individual, % | Fresh weight, % | Dry weight, % |
|---|---|---|---|---|
| Ngai cuu | *Artemisia vulgaris L..* | 4.29 | 0.74 | 0.83 |
| Co man trau | *Eleusine indica (L.)* | 3.43 | 1.18 | 1.18 |
| Co ba canh | *Cyperus serotinus Rottb* | 2.65 | 2.29 | 3.36 |
| Tuong anh | *Parietaria debilis* | 2.39 | 1.10 | 0.96 |
| Cải | *Sp1* | 2.13 | 0.01 | 2.25 |
| Tam bop | *Physanlis angulala* | 2.04 | **10.30** | **9.81** |
| Co | *Sp3* | 1.97 | 1.61 | 2.06 |
| Dua nuoc | *Ludwidgia adscendens (L.)* | 1.91 | 2.76 | 2.66 |
| Rau deu | *Alternanthera sessilis* | 1.90 | 1.78 | 2.24 |
| Co bo | *Marsilea quadrifolia L.* | 1.60 | 0.29 | 0.33 |
| Nghe nuoc | *Polygonum hydropiper L..* | 1.06 | 4.42 | 6.49 |
| Ngu sac | *Lantana camara L.* | 1.03 | 0.23 | 0.32 |
| Co | *Sp2* | 0.91 | 1.01 | 1.32 |
| khoai nuoc | *Coloscasia esculenta L.* | 0.94 | 2.25 | 0.99 |
| Nho noi | *Eclipta prostrata (L.)* | 0.80 | 0.31 | 0.23 |
| Beo tay | *Eichhornia crassipes* | 0.70 | 2.50 | 1.77 |
| Nghe ram | *Polygonum hydropiper L.* | 0.61 | 0.23 | 0.21 |
| Ngo dai | *Torenia asiatica L.* | 0.52 | 1.10 | 0.95 |
| Rau muong | *Ludwidgia octovalvis* | 0.44 | 0.06 | 0.06 |
| Lulu duc | *Solanum americanum* | 0.37 | 3.12 | 3.39 |
| Co | *SP 1* | 0.65 | 0.19 | 0.11 |
| Co ga | *Cynodon dactylon* | 0.84 | 0.54 | 1.43 |
| Co gau | *Cyperus rotundus L..* | 0.28 | 0.03 | 0.03 |
| Rau ma | *Centello asiatica* | 0.22 | 0.04 | 0.03 |
| Guot | *Dicranopteris dichotoma* | 0.17 | 2.85 | 4.87 |
| Duong xi | *Pteris vittata L.* | 0.10 | 0.21 | 0.35 |
| Khoai nuoc than tim | *Colocasia Black* | 0.06 | 0.50 | 0.26 |
| Ke nuoc | *Panicum paludosum* | 0.04 | 0.54 | 0.36 |
| Cai dong | *Grangea maderaspanata L.* | 0.03 | 0.01 | 0.03 |
| Chut chit | *Rumex chinensis Campd..* | 0.03 | 0.04 | 0.03 |
| Bau dat | *Gynura divaricata L.* | 0.01 | 0.04 | 0.02 |

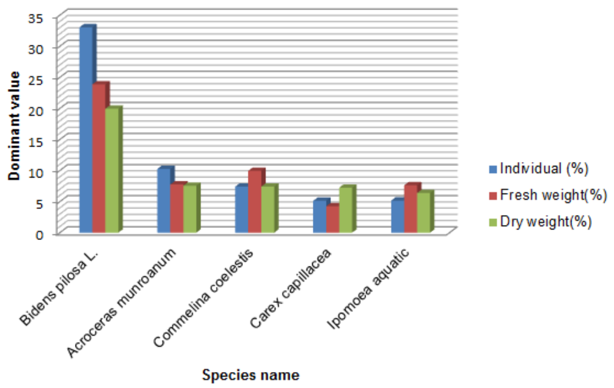


**Figure 6: The dominant values of five plant species**

## 3.4. Verification of Pb and Zn absorption ability of the selected plant species

Table 7 showed that *Bidens pilosa L* and *Acroceras munroanum* had ability to absorb Pb respectively 380 mg/kg and 288 mg/kg at the dry area, higher than other species within the same area. For Zn, *Acroceras munroanum* can absorb 69 mg/kg Zn and higher than the remaining *Bidens pilosa L and Physalis angulala*. At the wetland areas, *Commelina coelestis* and *Ipomoea aquatic* can absorb Pb at 270 mg/kg and 223 mg/kg, respectively. *Ipomoea aquatic* can absorb Zn at 59 mg/kg and better than *Cyperus serotinus Rottb* and *Carex capilacea.*

**Table 7. Pb and Zn absorption of the selected plants**

| Vietnamese name | Latin name | Location | Pb (mg/kg) in soil | Zn (mg/kg) in soil | Pb (mg/kg) in plant | Zn (mg/kg) in plant |
|---|---|---|---|---|---|---|
| Don buot | *Bidens pilosa L* | KV1 | 23426 | 237 | 380 | 58 |
| Tam bop | *Physalis angulala* | | | | 71 | 33 |
| Co la tre | *Acroceras munroanum* | | | | 288 | 69 |
| Thai lai | *Commelina coelestis* | KV3 | 102762 | 366 | 270 | 73 |

| Vietnamese name | Latin name | Location | Pb (mg/kg) in soil | Zn (mg/kg) in soil | Pb (mg/kg) in plant | Zn (mg/kg) in plant |
|---|---|---|---|---|---|---|
| Rau muong | *Ipomoea aquatic* | KV2 | 131778 | 1559 | 223 | 59 |
| Co ba canh | *Cyperus serotinus Rottb* | | | | 42 | 46 |
| Kiet toc | *Carex capillacea* | | | | 37 | 54 |

# 4. Conclusions

The results showed that the study area was contaminated lightly by Zn and seriously by Pb, especially at the KV1, KV2, KV3 with the corresponding concentrations of 23 426 mg/kg; 131,778 mg/kg; 102,762 mg/kg of Pb. There were 37 species belonging to 17 families identified. In which, there were 5 dominant species accounted due to individual number as *Bidens pilosa L.* (33,03 %), *Acroceras munroanum* (8,14 %), *Commelina coelestis* (7,83 %), *Carex capillacea* (5,41 %), *Ipomoea aquatic* (5,26 %).

At the dry land locations (KV1, KV7, KV6), when Pb and Zn concentrations in soil increased, diversity decreased. Pb and Zn concentrations in soil of KV6 were 164 mg/kg; 117 mg/kg and were 23,426 mg/kg; 237 mg/kg at KV1 respectively, the diversity decreased from KV6 (2.13) to KV1 (0.38). The same trend was found at the dry area. At the canal areas, the concentrations of Pb and Zn in soil were 7,321 mg/kg;, 142 mg/kg respectively at KV5 and increased at KV3 (102, 762 mg/kg Pb, 366 mg/kg Zn), the diversity also increased from 2.05 to 2.42. In contrast to the diversity, the dominant value changes in the same direction with the increase of the heavy metal concentrations. In seven researched plant species, *Bidens pilosa L.*, *Acroceras munroanum*, *Commelina coelestis* and *Ipomoea aquatic* had the highest Pb absorption ability. While Zn is absorbed the highest by *Commelina coelestis*. *Commelina coelestis* and *Bidens pilosa L.* can be used to treat both Pb and Zn in polluted soil.

# 5. References

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