Green vegetation to remove contaminants in surface runoff from an urban area, Xuzhou, China

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Abstract. Effects of different Greenbelt Plant configurations on pollutants from Urban Surface runoff varies. A study on the surface runoff samples of five different plant communities in the same green space between Fuchun Road and Shundihe River in Xuzhou City in 2017 due to 12 rainfall events. The results showed that: the content of Pb of *Osmanthus fragrans*+ *Crataegus pinnatifida* + *Nandina domestica* community was 0.263 mg.L-1 in summer(months of 4-6) ,and it was lower than that in autumn (months of 7-9) (0.333 mg.L-1), spring(months of 1-3) (0.444 mg.L-1) and winter (months of 10-12) (0.448 mg.L-1). Under the condition of less rainfall in winter and spring with longer rainfall interval, the pollutant content of surface runoff is higher in five plant communities studied than that in summer with shorter rainfall intervals. The order of average content of Zn in surface runoff in 1 year was as follows: *Koelreuteria integrifoliola* + *Forsythia suspensa* +*Cynodon dactylon* community (0.194 mg.L-1) > *Cedrus deodara*+ *F. suspensa* +*C. dactylon* community (0.178mg.L-1) > *O. fragrans*+ *C. pinnatifida* + *N. domestica* community (0.166 mg.L-1)> *Cinnamomum camphora* + *Photinia serrulata* community (0.149 mg.L-1) > *C. camphora* + *N. domestica* +*C. dactylon* community (0.128 mg.L-1). The average contents of COD, Cu, Pb, TSS, TP, TN and TOC were in the same order in the five communities studied. Therefore, in urban green space plant design, the plant community of evergreen tree and shrub such as *C. camphora* + *N. domestica* +*C. dactylon* community should be allocated as far as possible in order to purify the urban water resources environment.

1. Introduction

Urban green space plants are the basis for urban green space to play the role of micro-environment improvement, its dynamic changes in time and space, and the quantity and quality of plants also determine and affect the space-time dynamic characteristics of urban green space function. Different plants and their combinations have different ability to adapt or purify different kinds and concentrations of pollutants [1]. Some plants, such as Sedum southeastern China, can tolerate or superaccumulate pollutants by regulating their secretions [2]. The remediation of polluted environment by plants has been paid more and more attention by more and more scholars [3].

The surface runoff text process is an important link of regional ecological water circulation, which is related to the balanced development of ecological hydrology and ecological health in the area of the basin. Surface runoff is the result of multiple factors such as land use patterns and human activities on multiple scales. Studies by Walega *et al* [4] have shown that the total surface runoff in a catchment area can be estimated by using limited parameters and tested empirically. The effect of stand composition on surface runoff is very obvious, and the surface runoff of mixed forest is smaller than

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that of its corresponding pure forest. The interception rate of canopy and herbaceous layer also had a significant effect on the surface runoff [5]. Under the condition of existing vegetation, the surface runoff coefficient increases with the increase of rainfall, and the reduction rate of vegetation runoff is not a single increasing or decreasing relationship with rainfall [6].

The coefficient of urban surface runoff is not fixed. At the early stage of rainfall, the soil moisture content of permeable surface is relatively low, the soil infiltration capacity is larger, the runoff yield is less, and the actual runoff coefficient is smaller, but with rainfall, the soil moisture content increases. The actual runoff coefficient gradually increases and finally tends to be stable. For the impermeable surface, Rain Water consumes part of it in the initial stage of rainfall, which makes the actual runoff coefficient smaller. With the end of the filling, the actual runoff coefficient gradually increases and eventually tends to a fixed value. Under the background of accelerating urbanization, the change of land use mode has become the most important influence on surface runoff. The artificial change of land use type, especially the increase of construction land area, has a great influence on surface runoff. Studies by Fares *et al* [7] have shown that it is possible to establish an effective simulation model for the change of surface runoff in small catchment areas based on land use change. The high intensity of human activity changes the original landform of the city, increases the impervious area such as impermeable pavement, reduces the river network, and increases the urban surface runoff [8]. The research by Gill [9] shows that the increase of green land cover in residential areas can reduce the runoff by 4.9%, and increase by 10% similar to that of the greenbelt, and reduce the runoff by 5.7%.

In addition to suspended solids, aerobic substances and nutrients, urban rainfall surface runoff also contains pollutants such as heavy metals and hydrocarbons that are harmful to the environment. Most of the pollutants in the exhaust gas of the automobile will eventually be transported to the water environment under the action of natural sedimentation or leaching by Rain Water [10]. Some studies have shown that urban rainfall runoff pollution load is affected by two rainfall intervals and rainfall runoff. There is a significant positive correlation between the two rainfall intervals and the initial rainfall runoff pollution load [11]. In Beijing from May to June, the average concentrations of PAHs in the water penetrated by road dust and tree crown were significantly higher than those in July-August. [12]. However, for the concentration of TN, TP, COD, Cr, BOD, the surface runoff is higher than the roof runoff, but for SS concentration, the roof runoff is higher than the pavement runoff. At the same time, the concentration of pollutants in the initial runoff of Rain Water is very high, and with the prolongation of rainfall duration, the concentration of pollutants gradually decreases and tends to stabilize [13].

In the area with high vegetation cover, the surface runoff coefficient is relatively low [14]. In the Macao Peninsula, the urban small watershed with different green cover features has different pollution levels of the main surface runoff [15]. Vegetation cover reduces the impact of raindrops on the ground, increases the roughness of the ground, distributes the forces of air or water between mulches, and increases the content of organic matter in the soil after the vegetation decomposes, further improving the physical and chemical properties of the soil [16]. Vegetation can control soil loss by controlling surface runoff and weakening raindrop erosion, which usually decreases dramatically with the increase of vegetation coverage. Plant leaf area index is the main influencing factor for the difference of surface runoff and soil erosion under different vegetation types [17]. Grassland is generally considered to be effective in reducing runoff to water by reducing runoff, chemical oxygen demand and total suspended particles [18]. The plant green belt on both sides of the highway can reduce the suspended matter by 85%. The total phosphorus, total lead and total nitrogen can be reduced by 31-61% [19]. The reduction of surface runoff pollution caused by *Ophiopogon japonicus* occurred mainly in the deep 50-70cm soil layer [20].

After the rain passes through the canopy, the chemical characteristics of the rain have changed obviously [21]. The characteristics of canopy rainfall interception in different types of vegetation are significantly different [22]. The species of polycyclic aromatic hydrocarbons (PAHs) in surface runoff migration water of camphor forest are reduced by 50% and 87% compared with those in atmospheric precipitation [23]. *Pinus massoniana* and *Cinnamomum camphora* forest community had a strong

effect on the accumulation of pollutant ions in precipitation, while the total amount of pollutant ions in the penetrable rain and trunk runoff of *P. massoniana* forest was higher than that in the forest of *C. camphora* tree [24]. In wetland ecosystem, nitrogen, phosphorus and heavy metals are detoxified due to plant growth and absorption [25]. The study on the main greening trees in Harbin city shows that the enrichment characteristics of heavy metals in different plants are different and the enrichment coefficient is different [26].

Although many researches have been done on the characteristics of surface runoff pollution under different vegetation at home and abroad, it is rare to study the effects of plant communities on the characteristics of surface runoff pollution. Therefore, through the investigation of urban greening plants in Xuzhou, we select several common plant communities to monitor the surface runoff during rainfall in 2017, and provide basic data for the study of the effects of plant community structure on surface runoff pollution characteristics.

2. Materials and methods

2.1. Regional survey of research

The study site is located in Xincheng District of Xuzhou City, with Fuchun Road in the south of green space, Shundihe River in the north, Shendi River Bridge in the west and North Gate Station of Xuzhou University of Public bus in the east. The studied area is 2.5 hectares (500 m*50 m). The average slope was 8°on the north slopes, and the soil type was brown earth with weak alkalinity.

2.2. Research scheme and analysis method

Five representative plant communities were selected in the greenbelt to collect surface runoff formed by rainfall in their low-lying areas. The soil, slope and direction of five plant communities are consistent. The five plant communities were: A. *C. camphora* + *Nandina domestica* +*Cynodon dactylon* community (area of 40 m*20 m). B. *Koelreuteria integrifoliola* + *Forsythia suspensa* +*C. dactylon* community (area of 40 m*20 m). C. *Osmanthus fragrans*+ *Crataegus pinnatifida* + *N. domestica* community (area of 40 m*20 m); D. *C. camphora* + *Photinia serrulata* community (area of 40 m*20 m); E. *Cedrus deodara*+ *F. suspensa* +*C. dactylon* community (area of 40 m*20 m). Starting with surface runoff produced by rainfall, one surface runoff water sample was collected every 5 minutes. After the sixth water sample is collected, the next water sample was collected every 10 minutes. Three samples are collected at 10-minute intervals, and then the next water sample was collected at 30-minute intervals. After 30 minutes, the last water sample was collected. Each water sample was at 500 ml and it's divided into 100 ml and 400 ml parts. Those parts of 100 ml from all of water samples in a plant community were mixed. The pollutant contents of surface runoff were analyzed after the samples were collected from each community and mixed evenly. The analysis items include TSS, TN, TP, TOC, COD, Zn, Cu, Pb and the analytical methods are referred to the literature [27]. Each analysis was repeated 3 times.

2.3. Rainfall monitoring

A total of 12 rainfall events were monitored between January and December 2017, each characterized by table 1. The 5 groups collected surface runoff in 5 communities of each rainfall according to the uniform time.

Table 1. Basic information on 12 rainfalls from January to December 2017.

Rainfall time	Temperature (^{o}C)	2rainfall intervals (days)	Rainfall (mm)	Duration of rainfall (h)
2017-01-04	10/1	8	3.2	2
2017-02-21	3/-2	1	4.5	1.6
2017-03-19	14/7	18	18.1	4.2
2017-04-16	27/15	1	20.3	5.3

2017-05-14	28/18	5	12.4	3.7
2017-06-30	33/ 23	6	23.6	6.8
2017-07-12	34/27	2	28.4	8.1
2017-08-07	35/25	3	27.3	5.7
2017-09-03	25/20	3	24.2	4.3
2017-10-10	18/13	4	17.5	5.9
2017-11-17	14/1	36	22.7	7.5
2017-12-14	4/1	14	3.1	3.4

3. Results

3.1. Variation of average pollutant content in surface runoff during 12 rainfall periods in different communities in one year

The results showed that in the 12 field rainfall in 2017, the average content of Pb (0.006 $mg.L^{-1}$) (figure 1) of the community A was the lowest in 5 communities. The other index of community A such as TSS (18.6 $mg.L^{-1}$), TN (8.8 $mg.L^{-1}$), TP (0.12 $mg.L^{-1}$), COD (24 $mg.L^{-1}$), TOC (4.57 $mg.L^{-1}$), Zn (0.128 $mg.L^{-1}$), Cu (0.0089 $mg.L^{-1}$) also was the lowest in 5 communities respectively. The average content of Zn (0.194 $mg.L^{-1}$) of the community B was the highest in 5 communities. The other Pollutant index of community B such as TSS (51.3 $mg.L^{-1}$), TN (15.4 $mg.L^{-1}$), TP (2.87 $mg.L^{-1}$), COD (48 $mg.L^{-1}$), TOC (16.21 $mg.L^{-1}$), Pb (0.1430 $mg.L^{-1}$), Cu (0.0146 $mg.L^{-1}$) also was the highest in 5 communities respectively.

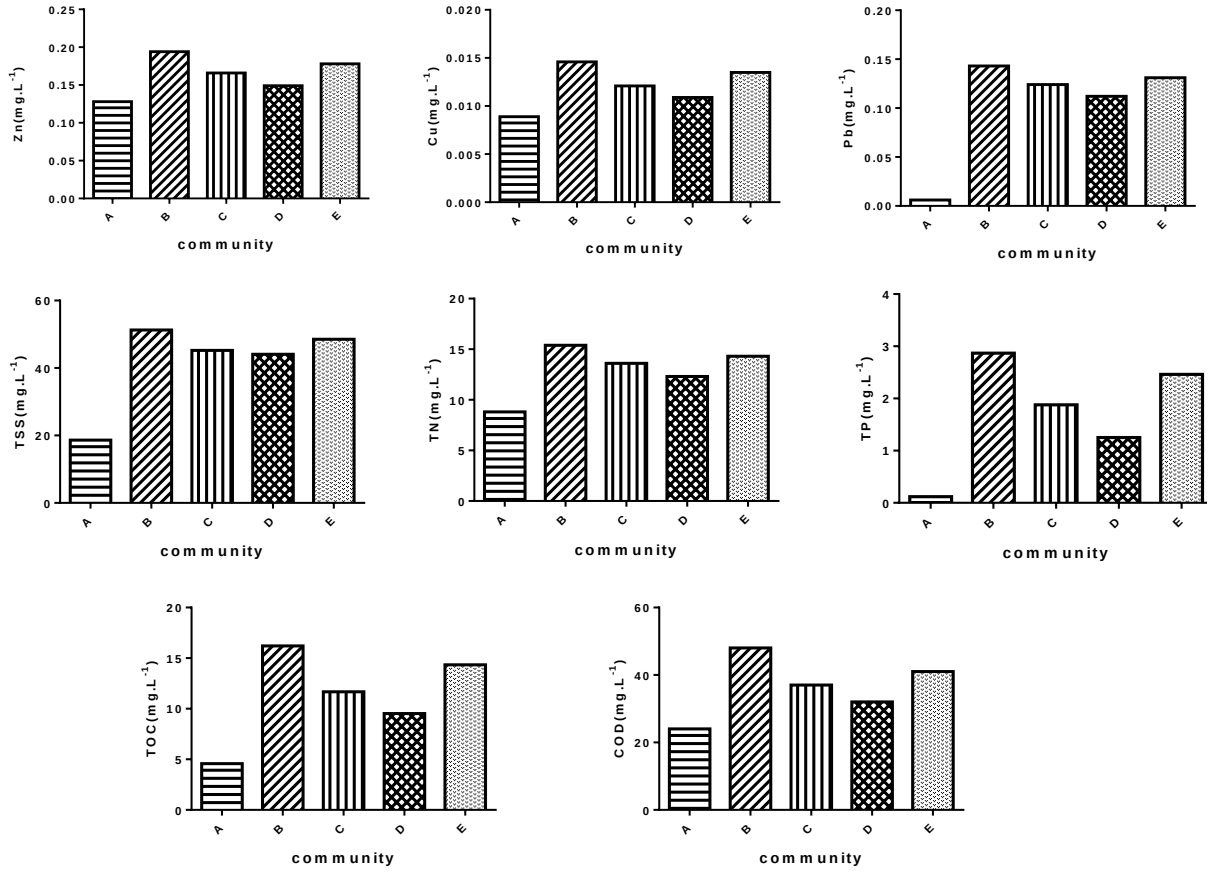


Figure 1. The change of the average content of each pollutant in 12 rainfalls in 1 years in 15 plant communities.

The order of average content of Cu in 5 communities was B (0.0146 mg.L^{-1}) > E (0.0135 mg.L^{-1}) > C (0.0121 mg.L^{-1}) > D (0.0109) mg.L^{-1} > A (0.0089 mg.L^{-1}). The order of average content of Zn in 5 communities was B (0.194 mg.L^{-1}) > E (0.178 mg.L^{-1}) >C (0.166 mg.L^{-1}) > D (0.149 mg.L^{-1}) > A (0.128 mg.L^{-1}). The order of average content of Pb in 5 communities was B (0.1430 mg.L^{-1}) > E (0.131 mg.L^{-1}) >C (0.124 mg.L^{-1}) > D (0.112 mg.L^{-1}) > A (0.006 mg.L^{-1}). The order of average content of TSS in 5 communities was B (51.3 mg.L^{-1}) > E (48.5 mg.L^{-1}) > C (45.2 mg.L^{-1}) > D (44.1 mg.L^{-1}) > A (18.6 mg.L^{-1}). The order of average content of TN in 5 communities was B (15.4 mg.L^{-1}) > E (14.3 mg.L^{-1}) > C (13.6 mg.L^{-1}) > D (12.3 mg.L^{-1}) > A (8.8 mg.L^{-1}). The order of average content of TP in 5 communities was B (2.87 mg.L^{-1}) > E (2.46 mg.L^{-1}) > C (1.88 mg.L^{-1}) > D (1.25 mg.L^{-1}) > A (0.12 mg.L^{-1}). The order of average content of TOC in 5 communities was B (16.21 mg.L^{-1}) > E (14.34 mg.L^{-1}) > C (11.67 mg.L^{-1}) > D (9.53 mg.L^{-1}) > A (4.57 mg.L^{-1}). The order of average content of COD in 5 communities was B (48 mg.L^{-1}) > E (41 mg.L^{-1}) > C (37 mg.L^{-1}) > D (32 mg.L^{-1}) > A (24 mg.L^{-1}).

3.2. Changes of pollutant content in surface runoff of 12 rainfall events in the same community in one year

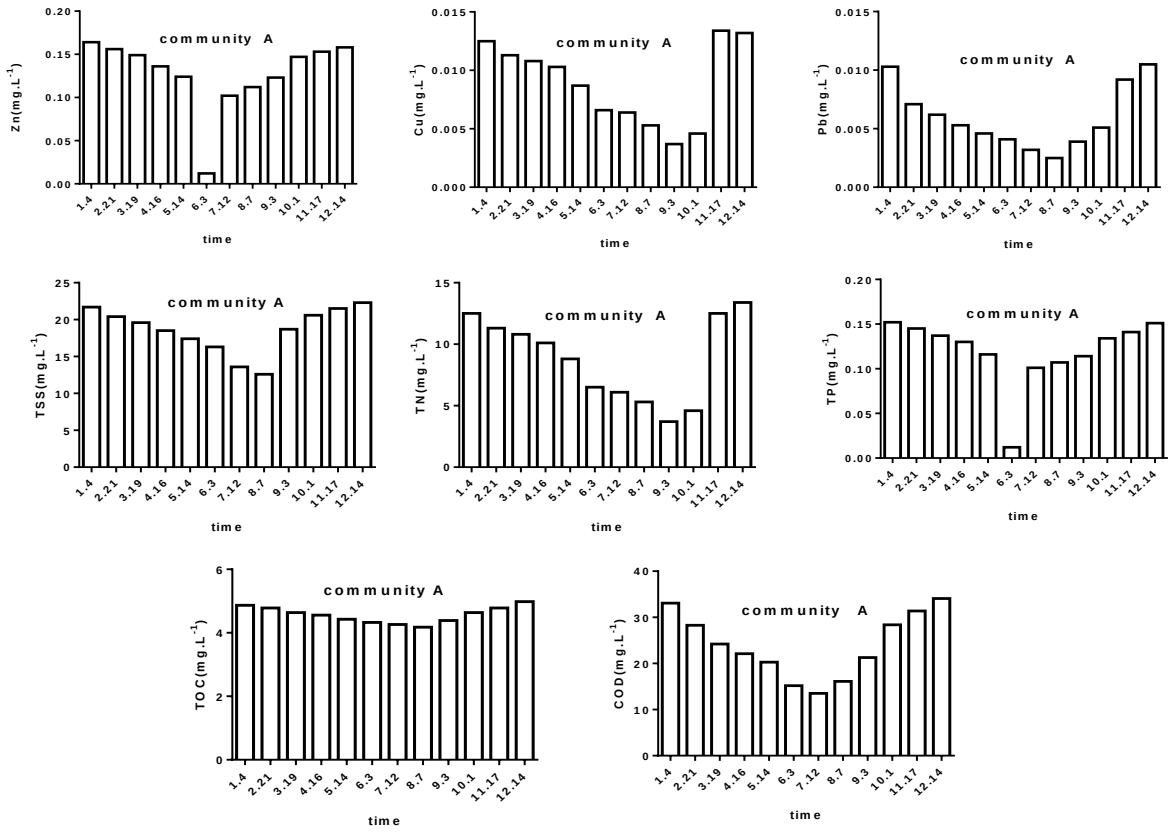


Figure 2. Changes of pollutants in community A during 12 rainfall periods in one year.

The season of lowest surface runoff different pollutants of the community A were varied in the 12 rainfall events during the 1 year (figure 2). The lowest value of Zn was 0.012 mg.L^{-1}in June, and the highest value was 0.164 mg.L^{-1}in January. The Zn content of surface runoff in four seasons was the lowest in summer (April-June) and it was 0.272 mg.L^{-1}. The highest was 0.469 mg.L^{-1}in spring (January-March). The second higher was 0.458 mg.L^{-1} in winter (October-December), and the second

lower was 0.337 mg.L^{-1} in autumn (July-September). The lowest value of Cu was 0.0037 mg.L^{-1}in September, and the highest value was 0.0134 mg.L^{-1} in January. The Cu content of surface runoff in four seasons was the lowest in autumn and it was 0.0154 mg.L^{-1}. The highest was 0.0346 mg.L^{-1} in spring. The second higher was 0.0312 mg.L^{-1} in winter, and the second lower was 0.0256 mg.L^{-1} in summer. The lowest value of Pb was 0.0025 mg.L^{-1}in August, and the highest value was 0.0105 mg.L^{-1}in December. The Pb content of surface runoff in four seasons was the lowest in autumn and it was 0.0096 mg.L^{-1}. The highest was 0.0248mg.L^{-1} in winter. The second higher was 0.0236 mg.L^{-1} in spring, and the second lower was 0.014 mg.L^{-1} in summer. The lowest value of TSS was 12.6 mg.L^{-1}in August, and the highest value was 22.3 mg.L^{-1} in December. The TSS content of surface runoff in four seasons was the lowest in autumn and it was 44.9 mg.L^{-1}. The highest was 64.4 mg.L^{-1} in winter. The second higher was 61.7 mg.L^{-1} in spring, and the second lower was 52.2 mg.L^{-1} in summer. The lowest value of TN was 3.7 mg.L^{-1}in September, and the highest value was 13.4 mg.L^{-1} in December. The TN content of surface runoff in four seasons was the lowest in autumn and it was 15.1 mg.L^{-1}. The highest was 34.6 mg.L^{-1} in spring. The second higher was 30.5mg.L^{-1} in winter, and the second lower was 25.4 mg.L^{-1} in summer. The lowest value of TP was 0.012mg.L^{-1}in June and the highest value was 0.152 mg.L^{-1} in January. The TP content of surface runoff in four seasons was the lowest in summer and it was 0.258 mg.L^{-1}. The highest was 0.434 mg.L^{-1} in spring. The second higher was 0.426 mg.L^{-1} in winter, and the second lower was 0.322 mg.L^{-1} in autumn. The lowest value of TOC was 4.18 mg.L^{-1}in august, and the highest value was 4.98 mg.L^{-1}in December. The TOC content of surface runoff in four seasons was the lowest in autumn and it was12.83 mg.L^{-1}. The highest was 14.4 mg.L^{-1} in winter. The second higher was 14.29 mg.L^{-1} in spring, and the second lower was 13.32 mg.L^{-1} in summer. The lowest value of COD was 13.5 mg.L^{-1} in July, and the highest value was 34.1 mg.L^{-1}in December. The COD content of surface runoff in four seasons was the lowest in autumn and it was 50.9 mg.L^{-1}. The highest was 93.9 mg.L^{-1} in winter. The second higher was 85.6mg.L^{-1} in spring, and the second lower was 57.6 mg.L^{-1} in summer.

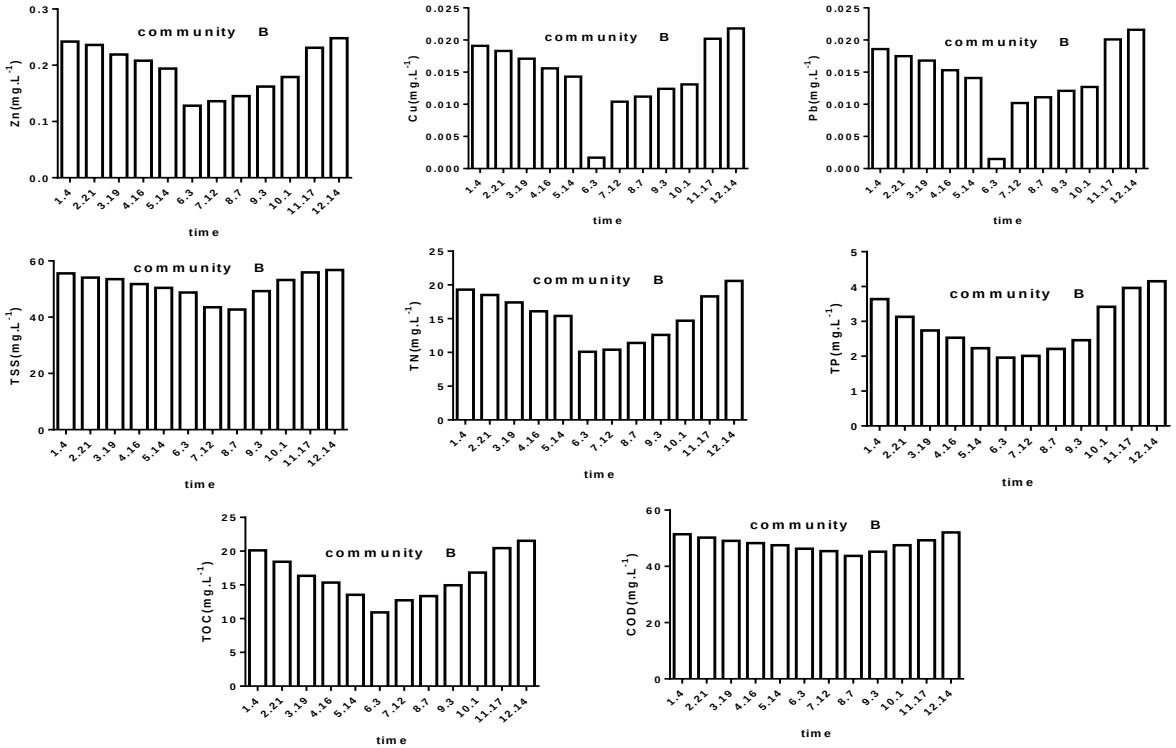


Figure 3. Variation of pollutant content in 12 rainfall events of community B.

The season of lowest surface runoff different pollutants of the community B were varied in the 12 rainfall events during the 1 year. The lowest value of Zn was 0.128 mg.L^{-1} in June, and the highest value was 0.248 mg.L^{-1}in December (figure 3). The Zn content of surface runoff in four seasons was the lowest in autumn and it was 0.443 mg.L^{-1}. The highest was 0.697 mg.L^{-1} in spring. The second higher was 0.658 mg.L^{-1} in winter, and the second lower was 0.53 mg.L^{-1} in summer. The lowest value of Cu was 0.0017 mg.L^{-1}in June, and the highest value was 0.0218 mg.L^{-1}in December. The Cu content of surface runoff in four seasons was the lowest in summer and it was 0.0316 mg.L^{-1}. The highest was 0.551 mg.L^{-1} in winter. The second higher was 0.0545 mg.L^{-1} in spring, and the second lower was 0.034 mg.L^{-1} in autumn. The lowest value of Pb was 0.0015 mg.L^{-1}in June, and the highest value was 0.0216 mg.L^{-1}in December. The Pb content of surface runoff in four seasons was the lowest in summer and it was 0.0309 mg.L^{-1}. The highest was 0.0544 mg.L^{-1} in winter. The second higher was 0.0529 mg.L^{-1} in spring, and the second lower was 0.0334 mg.L^{-1} in autumn. The lowest value of TSS was 42.7 mg.L^{-1}in August, and the highest value was 56.8 mg.L^{-1}in December. The TSS content of surface runoff in four seasons was the lowest in autumn and it was 135.5 mg.L^{-1}. The highest was 165.9 mg.L^{-1} in winter. The second higher was 163.2 mg.L^{-1} in spring, and the second lower was 151 mg.L^{-1} in summer. The lowest value of TN was 10.1 mg.L^{-1}in June, and the highest value was 20.6 mg.L^{-1}in December. The TN content of surface runoff in four seasons was the lowest in autumn and it was 34.4 mg.L^{-1}. The highest was 55.2 mg.L^{-1} in spring. The second higher was 53.6 mg.L^{-1} in winter, and the second lower was 41.6 mg.L^{-1} in summer. The lowest value of TP was 1.96 mg.L^{-1}in June, and the highest value was 4.15 mg.L^{-1}in December. The TP content of surface runoff in four seasons was the lowest in autumn and it was 6.68mg.L^{-1}. The highest was 11.53 mg.L^{-1} in winter. The second higher was 9.51 mg.L^{-1} in spring, and the second lower was 6.72 mg.L^{-1} in summer. The lowest value of TOC was 10.92 mg.L^{-1}in June, and the highest value was 21.53 mg.L^{-1}in December. The TOC content of surface runoff in four seasons was the lowest in summer and it was 39.8 mg.L^{-1}. The highest was 58.81 mg.L^{-1} in winter. The second higher was 54.9 mg.L^{-1} in spring, and the second lower was 41.01 mg.L^{-1} in autumn. The lowest value of COD was 43.7 mg.L^{-1}in August, and the highest value was 52.1 mg.L^{-1}in December. The COD content of surface runoff in four seasons was the lowest in autumn and it was 134.3 mg.L^{-1}. The highest was 150.7 mg.L^{-1} in spring. The second higher was 148.9 mg.L^{-1} in winter, and the second lower was 142.1 mg.L^{-1} in summer.

The lowest value of Zn in community D was 0.015 mg.L^{-1}in June, and the highest value was 0.213 mg.L^{-1} in December. The Zn content of surface runoff in four seasons was the lowest in summer and it was 0.33 mg.L^{-1}. The highest was 0.559 mg.L^{-1} in winter. The second higher was 0.55 mg.L^{-1} in spring, and the second lower was 0.349 mg.L^{-1} in autumn. The lowest value of Cu was 0.0067 mg.L^{-1} in July, and the highest value was 0.0137 mg.L^{-1} in December. The Cu content of surface runoff in four seasons was the lowest in summer and it was 0.0273 mg.L^{-1}. The highest was 0.0393 mg.L^{-1} in winter. The second higher was 0.0358 mg.L^{-1} in spring, and the second lower was 0.0284 mg.L^{-1} in autumn. The lowest value of Pb was 0.069 mg.L^{-1} in July, and the highest value was 0.0139 mg.L^{-1} in January. The Pb content of surface runoff in four seasons was the lowest in summer and it was 0.282 mg.L^{-1}. The highest was 0.397 mg.L^{-1} in winter. The second higher was 0.374 mg.L^{-1} in spring, and the second lower was 0.291 mg.L^{-1} in autumn. The lowest value of TSS was 39.3 mg.L^{-1} in august, and the highest value was 47.8 mg.L^{-1} in December. The TSS content of surface runoff in four seasons was the lowest in autumn and it was 121.4 mg.L^{-1}. The highest was 139.7 mg.L^{-1} in winter. The second higher was 138.8 mg.L^{-1} in spring, and the second lower was 129.3 mg.L^{-1} in summer. The lowest value of TN was 9.1 mg.L^{-1} in June, and the highest value was 16.1mg.L^{-1} in January. The TN content of surface runoff in four seasons was the lowest in autumn and it was 31.2 mg.L^{-1}. The highest was 43.6 mg.L^{-1} in spring. The second higher was 41.5 mg.L^{-1} in winter, and the second lower was 31.3 mg.L^{-1} in summer. The lowest value of TP was 0.81 mg.L^{-1} in June, and the highest value was 1.53 mg.L^{-1} in December. The TP content of surface runoff in four seasons was the lowest in summer and it was 3.12 mg.L^{-1}. The highest was 4.32 mg.L^{-1} in winter. The second higher was 4.26 mg.L^{-1} in spring, and the second lower was 3.3 mg.L^{-1} in autumn. The lowest value of TOC was 4.63 mg.L^{-1} in October, and the highest value was 13.52 mg.L^{-1} in January. The TOC content of surface runoff in four seasons was the

lowest in autumn and it was 18.43mg.L^{-1}. The highest was 37.76 mg.L^{-1} in spring. The second higher was 29.53 mg.L^{-1} in winter, and the second lower was 28.64 mg.L^{-1} in summer. The lowest value of COD was 24.4 mg.L^{-1} in august, and the highest value was 38.6 mg.L^{-1} in December. The COD content of surface runoff in four seasons was the lowest in autumn and it was 81.1 mg.L^{-1}. The highest was 106.1 mg.L^{-1} in winter. The second higher was 105.7 mg.L^{-1} in spring, and the second lower was 91.1 mg.L^{-1} in summer.

The lowest value of Zn in community E was 0.118mg.L^{-1}in June, and the highest value was 0.237 mg.L^{-1} in December. The Zn content of surface runoff in four seasons was the lowest in autumn and it was 0.399 mg.L^{-1}. The highest was 0.638 mg.L^{-1} in spring. The second higher was 0.626 mg.L^{-1} in winter, and the second lower was 0.473 mg.L^{-1} in summer. The lowest value of Cu was 0.0013mg.L^{-1}in June, and the highest value was 0.0202 mg.L^{-1}in December. The Cu content of surface runoff in four seasons was the lowest in summer and it was 0.0276 mg.L^{-1}. The highest was 0.0505mg.L^{-1} in winter. The second higher was 0.0504 mg.L^{-1} in spring, and the second lower was 0.0335 mg.L^{-1} in autumn. The lowest value of Pb was 0.015 mg.L^{-1}in June, and the highest value was 0.168 mg.L^{-1} in January. The Pb content of surface runoff in four seasons was the lowest in summer and it was 0.28 mg.L^{-1}. The highest was 0.476 mg.L^{-1} in spring. The second higher was 0.47 mg.L^{-1} in winter, and the second lower was 0.346 mg.L^{-1} in autumn. The lowest value of TSS was 42.7 mg.L^{-1}in august, and the highest value was 52.9 mg.L^{-1} in December. The TSS content of surface runoff in four seasons was the lowest in autumn and it was 133.9 mg.L^{-1}. The highest was 154.8 mg.L^{-1} in winter. The second higher was 152.2 mg.L^{-1} in spring, and the second lower was 141.1 mg.L^{-1} in summer. The lowest value of TN was 9.5 mg.L^{-1}in June, and the highest value was 20.6 mg.L^{-1}in December. The TN content of surface runoff in four seasons was the lowest in autumn and it was 33.4 mg.L^{-1}. The highest was 52.4 mg.L^{-1} in winter. The second higher was 49.5 mg.L^{-1} in spring, and the second lower was 36.3 mg.L^{-1} in summer. The lowest value of TP was 1.35 mg.L^{-1} in July, and the highest value was 3.51 mg.L^{-1} in December. The TP content of surface runoff in four seasons was the lowest in autumn and it was 5.22 mg.L^{-1}. The highest was 9.66 mg.L^{-1} in winter. The second higher was 8.64 mg.L^{-1} in spring, and the second lower was 6 mg.L^{-1} in summer. The lowest value of TOC was 9.98 mg.L^{-1} in June, and the highest value was 19.53 mg.L^{-1}in December. The TOC content of surface runoff in four seasons was the lowest in autumn and it was 34.1mg.L^{-1}. The highest was 50.84 mg.L^{-1} in winter. The second higher was 50.22 mg.L^{-1} in spring, and the second lower was 36.92 mg.L^{-1} in summer. The lowest value of COD was 30.8 mg.L^{-1}in august, and the highest value was 48.9 mg.L^{-1}in December. The COD content of surface runoff in four seasons was the lowest in autumn and it was 101.6 mg.L^{-1}. The highest was 137.6 mg.L^{-1} in winter. The second higher was 136.2 mg.L^{-1} in spring, and the second lower was 116.6 mg.L^{-1} in summer.

The lowest value of Zn in community C was 0.103mg.L^{-1}in June, and the highest value was 0.221 mg.L^{-1} in December. The Zn content of surface runoff in four seasons was the lowest in autumn and it was 0.37 mg.L^{-1}. The highest was 0.603 mg.L^{-1} in spring. The second higher was 0.578 mg.L^{-1} in winter, and the second lower was 0.441 mg.L^{-1} in summer. The lowest value of Cu was 0.0011 mg.L^{-1}in June, and the highest value was 0.0164 mg.L^{-1} in January. The Cu content of surface runoff in four seasons was the lowest in summer and it was 0.274 mg.L^{-1}. The highest was 0.0463 mg.L^{-1} in spring. The second higher was 0.04 mg.L^{-1} in winter, and the second lower was 0.0315 mg.L^{-1} in autumn. The lowest value of Pb was 0.011 mg.L^{-1}in June, and the highest value was 0.154 mg.L^{-1}in January. The Pb content of surface runoff in four seasons was the lowest in summer and it was 0.263 mg.L^{-1}. The highest was 0.448 mg.L^{-1} in winter. The second higher was 0.444 mg.L^{-1} in spring, and the second lower was 0.333 mg.L^{-1} in autumn. The lowest value of TSS was 40.4 mg.L^{-1} in August, and the highest value was 49.8 mg.L^{-1} in December. The TSS content of surface runoff in four seasons was the lowest in autumn and it was 123.7 mg.L^{-1}. The highest was 144 mg.L^{-1} in winter. The second higher was 141.9 mg.L^{-1} in spring, and the second lower was 135.9 mg.L^{-1} in summer. The lowest value of TN was 9.2 mg.L^{-1} in July, and the highest value was 18.2 mg.L^{-1} in December. The TN content of surface runoff in four seasons was the lowest in autumn and it was 32.6 mg.L^{-1}. The highest was 47.7 mg.L^{-1} in winter. The second higher was 46.5 mg.L^{-1} in spring, and the second lower was

36.4 mg.L^{-1} in summer. The lowest value of TP was 1.26 mg.L^{-1} in august, and the highest value was 2.25 mg.L^{-1} in December. The TP content of surface runoff in four seasons was the lowest in autumn and it was 4.61 mg.L^{-1}. The highest was 6.57 mg.L^{-1} in winter. The second higher was 6.14 mg.L^{-1} in spring, and the second lower was 5.24 mg.L^{-1} in summer. The lowest value of TOC was 6.96 mg.L^{-1} in July, and the highest value was 15.6 mg.L^{-1}in December. The TOC content of surface runoff in four seasons was the lowest in summer and it was 28.46 mg.L^{-1}. The highest was 41.78 mg.L^{-1} in winter. The second higher was 40.2 mg.L^{-1} in spring, and the second lower was 29.59 mg.L^{-1} in autumn. The lowest value of COD was 30.9 mg.L^{-1} in august, and the highest value was 43.6 mg.L^{-1} in December. The COD content of surface runoff in four seasons was the lowest in autumn and it was 98.2 mg.L^{-1}. The highest was 120.6 mg.L^{-1} in spring. The second higher was 119 mg.L^{-1} in winter, and the second lower was 105.4 mg.L^{-1} in summer.

4. Conclusion and discussion

The change of the average content of Zn, Cu, Pb, TSS, TN, TP, TOC, COD of 12 rainfalls in a year, which is related to the species composition of plant community. The community of evergreen Arbor and shrub plant *C. camphora* + *N. domestica* +*C. dactylon* can effectively reduce the content of pollutants in surface runoff. This is because evergreen trees can absorb or tolerate pollutants such as Zn through vigorous physiological in rainy season summer. For example, the community composed of *P. massoniana* and *C. camphora* have a strong effect on the polluted ions enrichment in precipitation [24]. At the same time, more branches and leaves have reduced the proportion of surface runoff in each rainfall due to the redistribution of precipitation. The increase of green land cover can reduce the runoff [9,14]. Therefore, it can greatly reduce the pollutant content in surface runoff in rainy season with more rainfall. Different evergreen plants with differences physiological and biochemical characteristics exhibit varies level of absorption and tolerance different pollutants. The community composed of evergreen Arbor, shrub and grass not only reduces the pollutant content of surface runoff greatly in the rainy season. The pollutant content in surface runoff is also reduced in the early spring and winter with not vigorous growth due to the existence of a large number of branches and leaves with small physiological and biochemical functions. Therefore, the average capacity of the evergreen community to reduce surface runoff pollutants in a year is higher than that in other deciduous communities. The effect of the plant community composed of evergreen tree *C. camphora* and evergreen shrub *P. serrulata* on the reduction of pollutants in surface runoff was better than that of evergreen shrub *O. fragrans*, *N. domestica* and deciduous shrub *C. pinnatifida*. The effect of deciduous Arbor and shrub community is lower than that of evergreen Arbor and shrub community on the reduction of pollutants in surface runoff. The effects of deciduous trees, deciduous shrubs and perennial flowers on the reduction of surface runoff pollutants were lower than those of other evergreen plant communities. This evergreen plant community is more obvious in winter and spring than the deciduous plant community in reducing the pollutant content in surface runoff. First of all, in addition to less physiological and biochemical effects on the absorption and tolerance pollutants, with the ability of redistribute rainfall greatly reduced and the proportion of surface runoff in rainfall increased due to fewer branches and leaves in winter and spring seasons, the pollutant content in surface runoff also increased accordingly. Secondly, the increase of pollutants in surface runoff in winter is also related to the increase of pollution sources such as more coal from heating supply and so on.

The effect of the same plant community on the reduction of surface runoff pollutant content in different seasons was significant different in one year. In the season of more rainfall, the interval between two rainfall intervals is relatively short. No matter evergreen plants or deciduous plants constitute the community, its surface runoff pollutants content is less than that of the same plants with less rainfall and longer rainfall intervals. The effect of the same plant community on the reduction of pollutants in different seasons is vary, and the more precipitation the better reduction effect. Because in the rainy season with more precipitation and more vigorous physiological and biochemical effects, pollutants such as Zn and Cu can be used as a trace component of plants will increased the absorption

as the consumption of nutrients with the vigorous plant growth, and thus reducing the content of pollutants in surface runoff.

In the plant design of urban green space, the plant community consisting of evergreen plants should be used as far as possible, and the plant community composed of evergreen trees and evergreen shrubs and evergreen herbs should be used as far as possible. Use evergreen plants as far as possible under the premise of diversity of landscape space.

This study was analyzing the changes of surface runoff pollutants in five existing plant communities. For a specific area, it is necessary to analyze the changes of surface runoff pollutants in a large number of plant communities. In order to find the most effective plant community structure to reduction local surface runoff pollutants.

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