The abundance and importance value of tree in “Sendang Kalimah Toyyibah” surrounding and its implication to the spring

Erry Wiryani*, Murningsih, Jumari

Biology Department, Faculty of Sciences and Mathematics, Diponegoro University Semarang, 50241, Indonesia

*Corresponding author Email: erry.wiryani@gmail.com

Abstract. One important factor affecting sustainability of spring is composition of vegetation around it. “Sendang Kalimah Toyyibah” is one of many springs in Semarang with intensive utilization. Vulnerability of spring can be monitored by dominant vegetation species indicated by vegetation importance value indices, especially for tree. This research aimed to study the variation of tree species around “Sendang Kalimah Toyyibah”, to analyze the importance value index of tree species and to analyze the implication of tree species which had dominant importance value index on “Sendang Kalimah Toyyibah” spring. Data collection was conducted via line transect with the length of 200 m on 4 directions which were defined based on the stream direction and the spring as the central point. Each transect has 4 observation plots occupying 20 x 20 m². Data collection was including tree species, abundance, presence frequency and basal area of tree. Data analysis was conducted for vegetation importance value index. The result showed that around “Sendang Kalimah Toyyibah” there were 28 tree species in which the abundance was dominated by Mahogany (33 individuals stands), Albizia (31 stands), Coffee (20 stands), Coconut (18 stands), Mangosteen (16 stands) and Banana (16 stands). Vegetation importance value index around “Sendang Kalimah Toyyibah” was dominated by the above 7 trees with important values (IV) respectively including species including Mahogany (28.97%), Albizia (26.70%), Mangosteen (23.47%), Java Black Bamboo (22.18%), Coffee (19.23%), Coconut (17.98%) and Durian (16.41%). Cumulatively, these 7 treespecies dominated the importance value of tree around “Sendang Kalimah Toyyibah” which was 154.95%. These dominant species had represented the ecosystem function in infiltration, filtration and absorption of water which were required for spring ecosystem sustainability.

Keywords: importance value index, abundance, spring, tree, “Sendang Kalimah Toyyibah”

1. Introduction

Spring is one of water resources which plays important roles for the availability of clean surface water [1]. The existence of springs in many regions is facing a serious threat. Drought and decreasing water quality had been occurred in most of the available springs [2]. Degradation of environmental quality of springs surrounding is considered as the main factor affecting the spring sustainability, especially its existing vegetation conditions [3].

One of the threatening factor for spring sustainability is destruction of the buffering ecosystem of the groundwater [4]. Land conversion from forest to farms, agriculture, settlements...
and industries in the catchment areas is one of the important factors which greatly affect the availability of groundwater [5]. The conversions lead to the decreasing plant abundance which has important role for the springs.

The diversity of plants is an important key to the maintenance of spring quality and quantity [6]. Among the plant species available in the springs surrounding, there are plants which have a particular role in the filtration, infiltration and absorption of groundwater [7], hence the groundwater and surface water balance could be maintained as well as its quality. But, limited availability of plant species in the spring surrounding, especially in the catchment areas definitely limits the expected functions [5].

The existing condition of spring is shown by its surrounding vegetation [8]. Each plant species plays a particular role for groundwater and spring [9]. Importance indices of vegetation are indicators for ecological role of vegetation structure in respective ecosystem [10,11]. If the importance indices of vegetation in the spring surrounding are well calculated, then the environment capacity in maintaining the sustainability of respective spring can be estimated as well.

Among the available vegetation structure, tree plays the most important role in the maintenance of water and soil stability. Root system of tree which are mostly deep and wide extent significantly affect the infiltration and absorption capacity of groundwater [12]. Some plant species also has dense root system which plays an important role in water filtration [13].

"Sendang Kalimah Toyyibah" is one of active spring which existed in Semarang Region which is highly utilized. Land conversion had been occurred in the spring surrounding. Unfortunately, the ecological condition of spring surrounding is not well studied. Hence, the environment capacity to maintain the sustainability of water resource is not well known.

Information concerning the ecological condition of spring is required to formulate the optimum management plan of related spring. The more information collected, the better management plan could be formulated and applied. The importance indices of vegetation in the spring surrounding could be utilized as the base of spring management. The vegetation structure indicated as importance indices define the existing potential condition of spring and water resources by its particular function of identified plant species.

The required information concerning the importance value of vegetation in the management of "Sendang Kalimah Toyyibah" triggered the study on the vegetation condition of the spring especially on the tree strata. This research aimed to study the existing tree species in "Sendang Kalimah Toyyibah" surrounding, to analyze the importance value of observed tree species and to analyze the potential impact of observed tree species on the water budget of "Sendang Kalimah Toyyibah" spring.

2. Methods
2.1. Time and Location
The research was conducted in "Sendang Kalimah Toyyibah" located in Nyatnyono Village, Western Ungaran District, Semarang Region in July 2014.

2.2. Research Procedure
The research was conducted within buffer area of the spring, covering 200 m downward from the spring center. The observation was conducted utilizing 4 line transects which were plotted based on the direction of river flow. The observation was conducted for tree community involving 4 quadrant transects at each line with quadrant size of 20 x 20 m. Thus, there was 16 transects as the observation plots. Total area of the quadrant transects utilized in this research was 5.09% of total spring buffer area. Data collection was conducted for tree abundance, frequency, and basal area.

2.3. Data Analysis
Data analysis was conducted to calculate the importance value of observed tree species involving the calculation of relative density, relative frequencies and relative dominances. Calculation of importance value of vegetation was conducted with Bower and Ende (1997) formula, including:

\[
\text{Frequency (F)} = \frac{\text{Number of plots where tree species existed}}{\text{Total number of plots}} \times 100\% \tag{1}
\]

Relative Frequency (RF) = \[
\frac{\text{Frequency of respective tree species}}{\text{Total frequency of all tree species}} \times 100\% \tag{2}
\]

Abundance (A) = \[
\frac{\text{Number of respective tree species}}{\text{Extent of sampling area}} \tag{3}
\]

Relative Abundance (RA) = \[
\frac{\text{Abundance of respective tree species}}{\text{Total abundance of all tree species}} \times 100\% \tag{4}
\]

Dominance (D) = \[
\text{Basal area of respective tree species} \tag{5}
\]

Relative Dominance (RD) = \[
\frac{\text{Basal area of respective tree species}}{\text{Total basal area of all tree species}} \times 100\% \tag{6}
\]

Importance Value Index (IV) = RF + RA + RD \tag{7}

3. Result and Discussion

The result showed there were 28 tree species found in "Sendang Kalimah Toyyibah" spring surrounding. Based on the observation result, it was known that the most abundant tree species in "Sendang Kalimah Toyyibah" surrounding was Mahogany (Swietenia macrophylla) with 33 stands. Some other tree species were also found in abundant numbers, including Albizia (Albizia falcataria) with 31 stands, Coffee (Coffea robusta) with 20 stands, Coconut (Cocosnucifera) with 18 stands, Mangosteen (Garcinia mangostana) with 16 stands and Banana (Musa sp.) with 16 stands. Detailed tree composition observed in "Sendang Kalimah Toyyibah" surrounding is presented in Table 1.

Table 1. Species, abundance, presence frequency, basal area and importance value indices of tree observed in "Sendang Kalimah Toyyibah" spring surrounding.

| No. | Scientific Name     | Local Name | Abundance (stand/ha) | BA (cm²) | Freq. | RA (%) | RD (%) | RF (%) | IV (%) |
|-----|---------------------|------------|----------------------|----------|-------|--------|--------|--------|--------|
| 1   | Arenga pinnata      | Aren       | 5                    | 4,271,93 | 5     | 1.95%  | 4.01%  | 3.60%  | 9.56%  |
| 2   | Syzygium aromaticum | Cengkeh    | 8                    | 1,340,43 | 4     | 3.13%  | 1.26%  | 2.88%  | 7.26%  |
| 3   | Durio zibethinus    | Durian     | 12                   | 7,878,83 | 6     | 4.69%  | 7.40%  | 4.32%  | 16.41% |
| 4   | Pitechelobium dulce | Jengkol    | 1                    | 95,07    | 1     | 0.39%  | 0.09%  | 0.72%  | 1.20%  |
| 5   | Cocos nucifera      | Kelapa     | 18                   | 6,292,32 | 7     | 7.03%  | 5.91%  | 5.04%  | 17.98% |
| 6   | Dimocarpus logan    | Klengkeng  | 4                    | 3,752,57 | 2     | 1.56%  | 3.53%  | 1.44%  | 6.53%  |
| 7   | Coffea robusta      | Kopi       | 20                   | 3,731,36 | 11    | 7.81%  | 3.51%  | 7.91%  | 19.23% |
| 8   | Leucaena glauca     | Lamtoro    | 10                   | 1,497,57 | 3     | 3.91%  | 1.41%  | 2.16%  | 7.47%  |
The tree distribution indicated the soil suitability and showed the potential role to the spring. The distribution was described by the presence frequency of particular tree species among the observation transects. The frequency of tree specieses observed in "Sendang Kalimah Toyyibah" surrounding were dominated by Albizia (A. falcataria) with 12 plots, Mahogany (S. macrophylla) with 11 plots, Coffee (C. robusta) with 11 plots, Mangosteen (G. mangostana) with 11 plots and Banana (Musa sp.) with 9 plots.

Basal area of tree indicated the coverage of particular species. The more tree extent potentially provides larger root coverage. Thus, it presented the potential role to the spring. The calculation on the basal area of tree trunks showed that Brown Bambbo (G. Atraviolacea) has the highest coverage with 17,563.269 cm², followed by Mangosteen (G. mangostana) with 9,907.856 cm², Mahogany (S. macrophylla) with 8,693.143 cm², Durian (D. zibethinus) with 7,878.829 cm², Pangi (P. edule) with 7,021.143 cm², Albizia (A. falcataria) with 6,343.071 cm² and Coconut (C. nucifera) with 5,729.014 cm².

Analysis of importance value index of trees in "Sendang Kalimah Toyyibah" surrounding showed that Mahogany (S. macrophylla) had the highest importance index with the importance value of 28.97%, followed by Albizia (A. falcataria) with 26.70%, Mangosteen (G. mangostana) with 23.47%, Brown Bambbo (G. Atraviolacea) with 22.18%, Coffee (C. robusta) with 19.23%, Mahogany (S. macrophylla) with 15.49%, Durian (D. zibethinus) with 12.11%, Pangi (P. edule) with 11.89%, Albizia (A. falcataria) with 11.72% and Coconut (C. nucifera) with 12.89%.

The mentioned tree specieses dominated more than 50% of all observed tree specieses. Total importance value of the mentioned tree specieses was 154.95%. Hence, the stability and sustainability of "Sendang Kalimah Toyyibah" spring is dominantly effected by the mentioned specieses.

Mahogany plays important role in surface water flow, sedimentation rate and soil erosion [14]. In an ecosystem with young mahogany stands, the surface water flow, sedimentation and

| No. | Scientific Name       | Local Name | Abundance (stand/ha) | BA (cm²) | Freq. | RA     | RD     | RF     | IV     |
|-----|-----------------------|------------|----------------------|----------|-------|--------|--------|--------|--------|
| 9   | Swietenia macrophylla | Mahoni     | 33                   | 8,693,14 | 11    | 12.89% | 8.17%  | 7.91%  | 28.97% |
| 10  | Garcinia mangostana   | Manggis    | 16                   | 9,907,86 | 11    | 6.25%  | 9.31%  | 7.91%  | 23.47% |
| 11  | Carica papaya         | Pepaya     | 6                    | 1,358,50 | 5     | 2.34%  | 1.28%  | 3.60%  | 7.22%  |
| 12  | Parkia speciosa       | Petai      | 3                    | 368,50   | 3     | 1.17%  | 0.35%  | 2.16%  | 3.68%  |
| 13  | Musa spp              | Pisang     | 16                   | 2,275,04 | 9     | 6.25%  | 2.14%  | 6.47%  | 14.86% |
| 14  | Ceiba pentandra       | Randu      | 6                    | 4,084,93 | 6     | 2.34%  | 3.84%  | 4.32%  | 10.50% |
| 15  | Albizia falcataria    | Sengon     | 31                   | 6,343,07 | 12    | 12.11% | 5.96%  | 8.63%  | 26.70% |
| 16  | Hibiscus tiliaceus     | Waru       | 11                   | 1,488,14 | 7     | 4.30%  | 1.40%  | 5.04%  | 10.73% |
| 17  | Persea americana Gigantochloa | Alpukat | 8                   | 2,733,50 | 4     | 3.13%  | 2.57%  | 2.88%  | 8.57%  |
| 18  | atraviolacea          | Bambu wulung | 6                  | 17,563,26 | 3     | 3.52%  | 16.50% | 2.16%  | 22.18% |
| 19  | Ficus benjamina       | Beringin    | 2                    | 4,331,64 | 2     | 0.78%  | 4.07%  | 1.44%  | 6.29%  |
| 20  | Pangium edule         | Kluwek      | 5                    | 7,021,14 | 4     | 1.95%  | 6.60%  | 2.88%  | 11.43% |
| 21  | Mangifera odorata     | Mangga kweni | 2                  | 460,43   | 2     | 0.78%  | 0.43%  | 1.44%  | 2.65%  |
| 22  | Melia azedarach       | Mindi       | 2                    | 279,71   | 2     | 0.78%  | 0.26%  | 1.44%  | 2.48%  |
| 23  | Gnetum gnemon         | Mlinjo      | 6                    | 3,862,57 | 5     | 2.34%  | 3.63%  | 3.60%  | 9.57%  |
| 24  | Artocarpus heterophylla | Nangka | 7                    | 2,000,43 | 5     | 2.73%  | 1.88%  | 3.60%  | 8.21%  |
| 25  | Lansium domesticum    | Duku        | 2                    | 330,79   | 2     | 0.78%  | 0.31%  | 1.44%  | 2.53%  |
| 26  | Pterocarpus indicus    | Angsana     | 1                    | 176,79   | 1     | 0.39%  | 0.17%  | 0.72%  | 1.28%  |
| 27  | Acantocepalus cadamba  | Jabon       | 2                    | 267,14   | 2     | 0.78%  | 0.25%  | 1.44%  | 2.47%  |
| 28  | Tectona grandis       | Jati        | 10                   | 4,014,21 | 4     | 3.91%  | 3.77%  | 2.88%  | 10.56% |

The table shows the scientific name, local name, abundance, basal area, frequency, relative abundance, relative density, relative frequency and importance value of each tree species in the "Sendang Kalimah Toyyibah" area. The importance value index is calculated based on the abundance, basal area, frequency and relative frequency of each species. The species with the highest importance index is Mahogany (S. macrophylla) with 28.97%, followed by Albizia (A. falcataria) with 26.70%, Mangosteen (G. mangostana) with 23.47%, Brown Bambbo (G. Atraviolacea) with 22.18%, Coffee (C. robusta) with 19.23%, Mahogany (S. macrophylla) with 15.49%, Durian (D. zibethinus) with 14.86%, Pangi (P. edule) with 12.11%, Albizia (A. falcataria) with 11.89% and Coconut (C. nucifera) with 12.89%.
erosion tend to be lower. While in the surrounding of old Mahogany stands, the soil porosity is higher increasing the potential of water infiltration into the ground. Water infiltration in an environment with Mahogany stands significantly defined by the level of macroporosity and the proportion of sand in the soil, otherwise inundation might be occurred since the infiltration rate would be inhibited [15]. Mahogany tree has active water absorption rate caused by its high stomatal evapotranspiration [16]. Hence, the existence of Mahogany tree in spring surrounding plays important role in the absorption of groundwater to the surface.

Albizia tree is commonly planted in the area with limited water resources as an effort of soil and water conservation [17]. The presence of Albizia tree can increase the soil fertility [18]. Nitrogen fixation processes was considered as the effecting factor which increased the concentration of N in the soil. Albizia is capable to increase th concentration of N in the water, decrease the concentration of organic nitrogen, organic carbon and increase the concentration of chlorophyll-a in the river stream under its stand as the effect of litter decomposition [19]. It showed that Albizia tree is capable to improve the water fertility of surface water. The presence plants with big and deep roots might lead to the change of soil structure and increase soil macroporosity, hence it lead to the increasing water infiltration [20]. It indicated that Albizia tree has main function on water filtration and infiltration into the ground in spring surrounding.

Mangosteen has good canopy and deep roots which play important role in protecting soil surface from erosion [21]. Mangosteen trees are mostly found in the areas with large amount of water such as river banks [22]. Abundant Mangosteen trees was found in river banks [23]. Mangosteen tree is often utilized as enrichment of vegetation in the catchment area, hence Mangosteen can be utilized as indicator for the availability and amount of groundwater in the spring surrounding [24].

Brown Bamboo plays important role to enhance the infiltration rate of water [20]. Various Bamboo specieses could be found in water catchment area. Bamboo dominated forest provide better infiltration rate compared to any other trees. It is proven that Bamboo has lower capability of water filtration than grasses, especially for sediment filtration [25]. Bamboo is a lot utilized in soil quality remediation, such as to stabilize sloped ground soil [26]. Bamboo is capable of infiltrating up to 90% of rainwater, hence it holds huge amount of soil water [27]. It can be concluded that Brown Bamboo in "Sendang Kalimah Toyyibah" surrounding has the function to maintain the stability of soil and infiltration surface water to the ground.

Generally, Coffee plantation is conducted for soil conservation. It is considered that Coffee trees can decrease the risk of soil erosion and increase the surface water flows [28]. Coffee tree could prevent soil erosion, hence there would be less sediment dissolved in the stream which resulting better water quality [29]. Unfortunately, the function of Coffee in soil and water conservation requires another plant species as compliment since its capability on preventing soil erosion is very weak [30]. Based on its function and its economic value, Coffee had been utilized in land rehabilitation activities, including rehabilitation of water catchment area as enrichment plants [24]. It showed that the existence of Coffee trees in "Sendang Kalimah Toyyibah" surrounding contribute to the sediment filtration of water catchment.

Conservative function of Coconut tree including its capability on water holding [31]. Coconut tree had been utilized in agroforestry application involving polyculture nor agro-mina combining Coconut and various agricultural plant specieses as well as fish culture [32]. The utilization of Coconut tree is as groundwater holder which is needed by another plants.

The last dominant important plant species among all plant specieses found in "Sendang Kalimah Toyyibah" surrounding was Durian (D. zibethinus). Durian has wide canopy cover and deep roots which indicate its water conservation functions [33]. Hence, Durian tree can break rain water into smaller drops and infiltrate it into the ground [34]. Durian tree is often found in catchment areas and watersheds [24]. It proved the relation between Durian trees and water availability. Durian is also often planted in agricultural areas to maintain water supply for the
farms. Instead of its function in water resources conservation, Durian also has high economic value, hence it can also provide economic advantages for the community [35,36].

According to the literature review, it is known that ecological function of spring ecosystem in "Sendang Kalimah Toyyibah" surrounding was determined by 7 tree specieses as mentioned above. Basically, the conservative role of "Sendang Kalimah Toyyibah" spring ecosystem including infiltration, filtration and absorption are fulfilled by 7 mentioned tree specieses. Based on the analysis result, spring ecosystem of "Sendang Kalimah Toyyibah" was dominated by only 7 specieses of total 28 specieses observed (25% of tree species). It indicated that the spring is quite vulnerable. Significant changes on the 7 tree specieses would greatly effect the whole ecosystem as the spring environment and the spring sustainability and stability as well. Prevention of extreme changes on the 7 tree specieses should be conducted to hinder spring degradation. The proposed management plans are including the enrichment of tree specieses and balancing the structural community of vegetation to decrease the risk of ecological degradation by structural community changes. It is aimed to maintain the quality and quantity of water resources and to improve the endurance of spring ecosystem over environment changes through resilience capacity improvement.

4. Conclusion

There were 28 tree specieses found in "Sendang Kalimah Toyyibah" spring surrounding. Based on its abundance, the most dominant tree specieses were including Mahogany (33 stands), Albizia (31 stands), Coffee (20 stands), Coconut (18 stands), Mangosten (16 stands) and Banana (16 stands). Analysis on the importance value of trees in "Sendang Kalimah Toyyibah" spring surrounding was dominated by Mahogany (28.97%), Albizia (26.70%), Mangosteen (23.47%), Brown Bamboo (22.18%), Coffee (19.23%), Coconut (17.98%) and Durian (16.41%). Based on the dominant tree composition, the spring water ecosystem functionality had been fulfilled by mentioned tree species including its function in water infiltration, filtration and absorption. However, the existing tree domination indicated its vulnerability of the sustainability. Further management is required to conserve the spring by maintaining the composition balance of tree specieses.

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Figure captions

Figure 1. Research Location
Figure 2. Transect Design