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Biodiversity in Urban Green Spaces in JABOTABEK area, Indonesia

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Abstract: - In this study, relative microbial diversity, as a biodiversity indicator in urban green areas, was determined using a molecular method. The terminal restriction fragment length polymorphism (TRFLP) analysis was used to characterize 15 green spaces in the JABOTABEK (Jakarta, Bogor, Tangerang, and Bekasi) area in Indonesia. Results showed that parks with smaller land areas and located at the most disturbed part of the city have lower microbial diversity. On the other hand, those that are well-managed, not frequently disturbed, and have big land areas which were established decades ago, have maintained a high biodiversity comparable and similar to a natural forest. Similarities and differences between and among the green spaces were also proven.

Key-Words: biodiversity, indicators, microbial diversity, sustainability, TRFLP, urban green spaces

1 Introduction

The 21st Century COE (Center of Excellence) Program for Social Capacity Development for Environmental Management and International Cooperation at the Graduate School for International Development and Cooperation, Hiroshima University, Japan, is concerned with social capacity development for environmental management, focusing in particular on the big cities of developing countries. This consists of three groups; the socio-economic assessment group, the transportation and urban air quality management group, and the urban ecosystem management group. The urban ecosystem management group desires to contribute to biodiversity assessment so as to complete the structural model of social capacity for environmental management (SCEM) (Fig. 1).

As the world faces ever-increasing urbanization, big cities are becoming the most common habitat for man [1]. Consequently, the urban landscape changes rapidly, and so maintaining biodiversity there requires the combination of protection, management, and recreation of urban

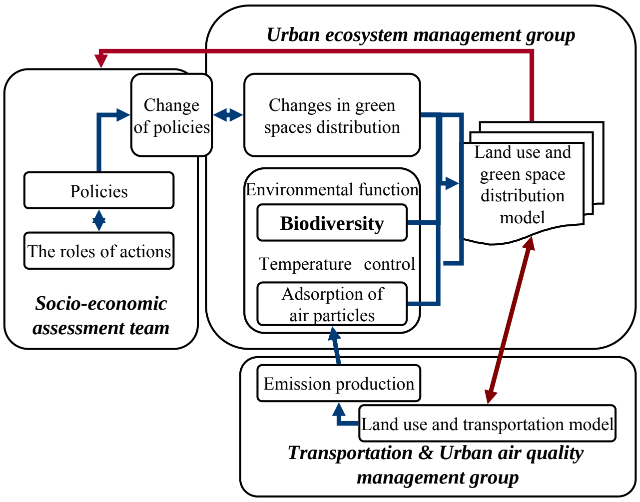

Fig. 1. SCEM model

green spaces. Urban green areas are universally valued as recreational venues, wildlife refuges and essential livable-city ingredients [2]. Urban green spaces have significant ecological, social and economic functions [3].

Unfortunately, most of these urban green spaces are not able to maintain their high biodiversity, and are not sustainable. They have become too dependent on physical and chemical amendments (e.g. organic or inorganic fertilizers) for survival. Natural cycling and turnover of nutrients have become less available because of continuing disturbances and lack of proper management. Soil productivity and nutrient cycling are influenced by the amount and activity of microorganisms, which are the key components in maintaining soil fertility [4]. Soil microorganisms are widely used as sensitive indicators of ecosystem productivity [5].

This study focused on the idea that functional networks of urban green space contribute to ecological sustainability, defined as the conservation of biodiversity and sustainable use of biological resources [6]. The objective of this study was to evaluate the relative soil microbial diversity in 15 green spaces in the JABOTABEK (Jakarta, Bogor, Tangerang, and Bekasi) area in Indonesia, as an ecological indicator of biodiversity.

2 Materials and Methods

2.1 Study site and sampling

This study was conducted in the JABOTABEK (Jakarta, Bogor, Tangerang, and Bekasi) area in Indonesia. The COE program of Hiroshima University, Japan, focuses on 5 developing countries, namely Indonesia, Vietnam, China, The Philippines and Thailand. The JABOTABEK area, Indonesia was chosen for this study because it was one of the two model cities (along with Beijing, China) of the COE projects on Social Capacity Development. At present, according to the Jakarta Planning Agency, the open green areas in Jakarta constitute 21.5 percent of the total city area [7]. Table 1 shows the location and characteristics of the 15 green spaces, which were chosen randomly. Sampling was done from July 13th to 16th, 2004. Soil samples were collected at A_0 layer (5cm depth). For each study area, 5 soil replicates were collected. Samples were transported to Japan and were stored at -30^{o}C until use.

2.2 TRFLP method

The TRFLP (terminal restriction fragment length polymorphism) analysis was used to provide a quick

Table 1 Characteristics of the study sites

Study areas	Location	Age	Litter thickness	Organic layer thickness	Altitude	Tree density	Soil color
Taman Monas	6^o 10'644" S 106^o 49'447" E	40yrs	1cm	≈2cm	41m	3/100m^2	5YR3/4
Taman Gunung Agung	6^o 10'831" S 106^o 50'390" E	<40yrs	2cm	2cm	26m	3/100m^2	10R3/2
Taman Surupati	6^o 11'942" S 106^o 49'965" E	60yrs	1cm	2cm	31m	2-3/100m^2	2.5YR2/4
Complex Senayan	6^o 12'955" S 106^o 48'103" E	>40yrs	<4cm	≈3cm	35m	2/100m^2	5YR2/4
Taman Langsat	6^o 14'539" S 106^o 47'530" E	≈40yrs	1-2cm	1-2cm	35m	4-5/100m^2	7.5YR2/3
Taman Cisanggiri	6^o 14'450" S 106^o 48'796" E	>30yrs	<1cm	≈2cm	53m	4/100 m^2	2.5YR3/4
Taman Seno	6^o 14'387" S 106^o 51'119" E	<25yrs	4cm	3cm	41m	3/100 m^2	7.5YR2/3
Taman Kodok	6^o 11'850" S 106^o 49'791" E	>30yrs	2cm	3cm	43m	3/100 m^2	7.5YR3/2
Taman Jelambar Hadiah	6^o 09'424" S 106^o 46'849" E	≈30yrs	<2cm	3cm	25m	1/100 m^2	5YR3/4
Srengseng	6^o 13'213" S 106^o 45'875" E	20yrs	1cm	1cm	35m	1/100 m^2	5YR2/4
Hutan Kotan	6^o 12'630" S 106^o 45'867" E	<25yrs	4cm	≈3cm	37m	8/100 m^2	5YR3/4
Cengkareng	6^o 07'426" S 106^o 40'149" E	60yrs	7cm	4cm	32m	10/100 m^2	7.5YR4/2
Cibodas Natural Forest	6^o 44'723" S 107^o 00'367" E	>140yrs	6cm	5cm	1421m	20/100 m^2	5YR2/1
Ciangur (Cibodas park)	6^o 44'723" S 107^o 00'400" E	>100yrs	3cm	3cm	1421m	10/100 m^2	5YR2/2
Bogor Botanical Garden	6^o 36'320" S 106^o 47'637" E	130 yrs	5cm	5cm	320	6/100 m^2	7.5YR2/3

comparison of the different communities in each area. The DNA extraction method used was based on the method described by Porteous et al. [8]. Polymerase chain reaction amplification was done following the procedure described by Furhman et al. [9] 16S rRNA 'universal primers' [10] with reverse primer (ACGGGCGGTGTGTRC) labeled with fluorochrome 5', 6-carboxylfluorescein (FAM) on the 5' end and the forward primer (CAGCMGCCGCGGTAATWC) unlabeled (Applied Biosystems Instruments – ABI), were used. This pair of primers yields PCR products between *E. coli* positions 519 and 1407 (positions include the primers), and is suitable for bacterial, archaeal, and eukaryotic target sequences. PCR products were cut with restriction enzymes *Hha1* and then run on Applied Biosystems model 3100 Genetic Analyzer and analyzed with Genescan software.

2.3 Statistical Analyses

For TRFLP analysis, replications were at the level of the samples, PCR and Genescan lane, resulting in 8 replicates per sample giving a total of 20 replicates per site.The Shannon-Weaver diversity index [11] was used to estimate soil microbial diversity based on the size and number of TRFs using Equation 1:

Shannon-Weaver diversity index ($\hat{H}$) =

$$C/N\,(N \log_{10} N - \sum n_i \log_{10} n_i) \qquad (1)$$

Where C = 2.3, N = sum of peak heights in a given TRFLP profile, n_i = height of TRF i and i = number of TRFs in each TRFLP profile.

ANOVA was used to assess the significant differences in biodiversity between study sites. Tukey's HSD test was used to separate means. To compare the biodiversity similarity between study sites, Ward's method of hierarchical cluster analysis and the Jaccard similarity matrix were used to show relationships between TRFLP profiles. An error was counted when two replicate profiles were clustered into different groups.

3 Results and Discussion

Fig. 2 shows the number of TRFs in each study site. It shows that the highest mean

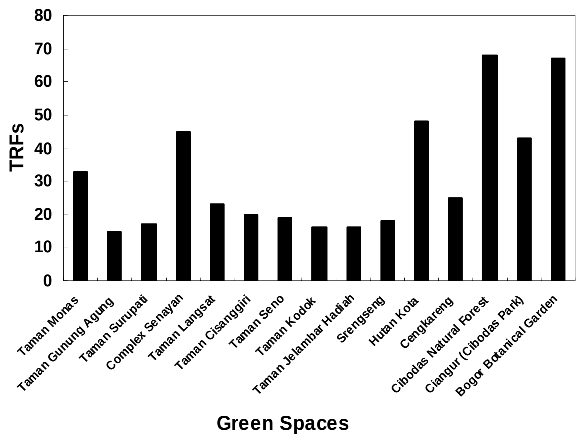

Fig. 2. TRF numbers at each site

numbers of TRFs were in the Cibodas natural forest and Bogor botanical garden, with 68 and 67 TRFs, respectively. On the other hand, the lowest TRF numbers were found in Taman Gunung Agung, Taman Kodok and Taman Jelambar Hadiah, with only 15, 16 and 16 TRFs respectively. ANOVA proved significant differences (P >0.05) in mean numbers of TRFs between the study sites (Table 3). In addition to this, Tukey's HSD test showed that Cibodas natural forest and Bogor botanical garden were not significantly different (P >0.05) from each other, but were significantly different from the rest of the study sites (P>0.01). Of the green spaces located at the center of Jakarta city, Taman Monas, Complex Senayan and Hutan Kota showed fairly high mean numbers of TRFs.

Looking at the TRF profiles of the 15 green

Table 3 Numbers of TRFs and diversity measurements based on TRFLP profiles

Study area	TRF numbers	Shannon-Weaver index of TRFLP patterns
Taman Monas	31.0 ± 4.5 a	2.67± 0.09 a
Taman Gunung Agung	15.0 ± 1.56 b	1.89± 0.12 bc
Taman Surupati	17.0 ± 1.78 b	1.66± 0.07 c
Complex Senayan	45.0 ± 5.51 c	2.69± 0.16 a
Taman Langsat	23.0 ± 1.93 bd	2.27± 0.13 abd
Taman Cisanggiri	20.0 ± 1.21 bd	2.21± 0.14 bd
Taman Seno	19.0 ± 1.37 bd	2.15± 0.11 bd
Taman Kodok	16.0 ± 1.71 b	1.98± 0.08 bc
Taman Jelambar Hadiah	16.0 ± 1.20 b	2.15± 0.19 bd
Srengseng	18.0 ± 1.49 bd	2.21± 0.15 bd
Hutan Kota	48.0 ± 3.43 c	2.92± 0.21 ae
Cengkareng	25.0 ± 2.36 d	2.06± 0.07 bcd
Cibodas Natural Forest	68.0 ± 6.28 e	3.22± 0.28 e
Ciangur (Cibodas Park)	44.0 ± 4.97 ac	2.45± 0.24 ad
Bogor Botanical Garden	67.0 ± 4.27 e	3.17± 0.17 e

Mean ± S.E.M of replicates are shown. Different letters denote significant Difference (ANOVA followed by Tukey's test, $P<0.05$)

spaces, it can be seen that the community composition vary from one site to another. On the other hand, the distance matrix analysis of the TRF profiles proved that significant similarities are present amongst the study sites. The dendrogram based on the Jaccard similarity index in Fig. 3 shows that among the study sites, Taman Jelambar Hadiah and Srengseng have the closest similarity in community composition with proximity distance equal to 0.031. This was followed by the Cibodas natural forest and Bogor botanical garden with proximity distance equal to 0.155. Using the Jaccard similarity distance, the 15 green spaces studied were divided into 5 groups. Group 1 was composed of Taman Monas, Taman Gunung Agung, Taman Surupati and Cengkareng. Group 2 was made up of Taman Langsat, Taman Cisanggiri and Taman Kodok. Group 3 was composed of Taman Jelamber Hadiah and Srengseng. Ciangur (Cibodas park), Cibodas natural forest and Bogor botanical garden comprised group 4, while Complex Senayan, Taman Seno and Hutan Kota made up group 5.

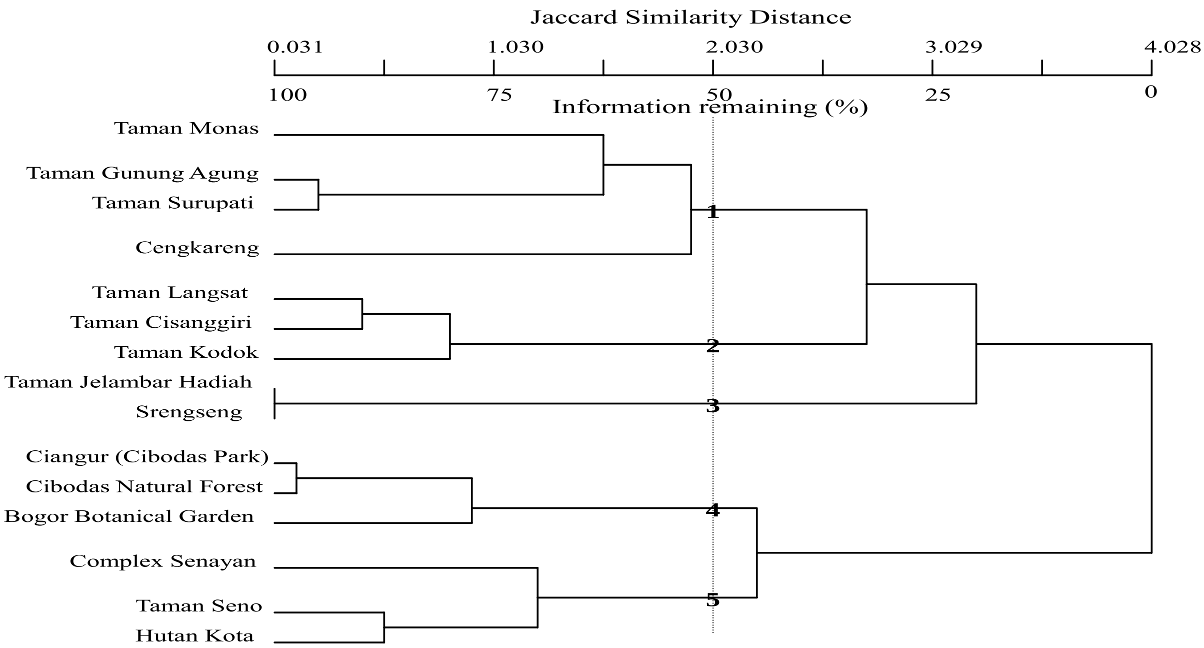

Fig. 3. Proximity matrix based on Jaccard measurements

The microbial community diversity (Shannon – Weaver index) as estimated from TRFLP profiles was significantly (P<0.05) higher in soil from Cibodas natural forest and Bogor botanical garden (Table 3). On the other hand, the lowest diversity was found in Taman Gunung Agung, Taman Surupati and Taman Kodok. Tukey's test revealed significant differences between study sites.

The greens spaces with lower community diversity are usually smaller in terms of land area, and are located in busy areas of Jakarta city. For example, the Taman Seno and Taman Gunung Agung serve as green belts or road breakers. With this kind of location, a high frequency of occurrence of disturbances can be expected. Also, in these green spaces, above-ground plant density is low. This fact affects soil microorganisms because of the interdependence of tree health and soil fertility [12]. Microbial diversity is often low, where low mature root zones and high degree of disturbance are present [13]. In most cases, these green spaces with low microbial diversity have no distinct or closed canopy, and so the under-story ecosystem is exposed to wider and extreme ranges of temperatures, which in turn affect the soil microbes. In addition, some of these green spaces with low diversity, such as Taman Seno and Srengseng, experience flooding during the rainy season. Their landscape location may not be suitable for a sustainable green space.

4 Conclusion

The many significant roles of the urban green spaces were mentioned above. There are important potential underlying principles for maintaining essential ecological processes, preserving biodiversity and ensuring sustainable ecosystems, which are very important considerations for landscape planners and designers. In addition, the planning and management of urban green spaces is of significance to overall urban sustainable development [14]. The implications of biodiversity in an ecosystem may not be totally understood by most common citizens, but awareness can be awakened. The most obvious role of biodiversity in the ecosystem is to ensure the multiplicity of functions ascribed to organisms, and to ensure that these functions are maintained in the face of perturbation. The greater degree of biodiversity between, or within, functional groups will increase the inherent variability in tolerance or resistance to stress or disturbance [15].

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