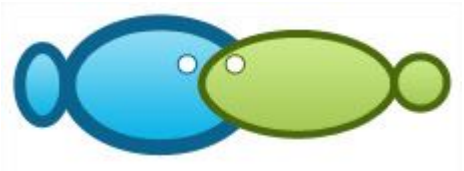

Floristic composition assessment of urban mangroves in Batasan River, Metro Manila, Philippines

[1]Patrick R. Relacion, [1]Anjeanette S. Sy, [1]Giannina Anais N. Rodas, [1]Aidam Luiz C. Cayanan, [1]Dustin Ryan C. Marcelino, [1]Khazbourn C. Sakamoto, [1,2]Loida R. Medina, [3]Haidee D. Pabalate, [4]Alma E. Nacua, [1,4]Ken Joseph E. Clemente

[1] Science Technology Engineering and Mathematics (STEM) Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines; [2] Natural Sciences Unit, College of Science, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines; [3] Manila Bay Site Coordinating and Management Office, Department of Environment and Natural Resources – NCR Regional Office, National Ecology Center, East Avenue, Diliman, Quezon City 1101, Philippines; [4] Urban Biodiversity Laboratory, Universidad de Manila, 659-A Cecila Muñoz Street, Ermita, Manila 1000, Philippines. Corresponding author: K. J. E. Clemente, keclemente@ust.edu.ph

Abstract. Mangrove forests have long been recognized for their enormous potential to provide valuable ecosystem services. Despite this, mangrove forests located in marine and estuarine peripheries of megacities are often victims of urbanization. This study attempts to describe for the first time the floristic composition, diversity, distribution, and abundance of mangrove species along Batasan River which is found in one of the top megacities in the world – Metro Manila, Philippines. Forty-two (42) plots, which run along the combined 4.2 kilometer stretch of river, were established during sampling done in December 2017 and January 2018. There is a total of nine (9) true species of mangroves belonging to six (6) families and seven (7) genera that were morphologically identified and verified. *Avicennia marina* (Forssk.) Vierh. is the most dominant species at 69.45% relative abundance while *Nypa fruticans* (Thunb.) Wurmb is the least occurring at 0.08% abundance. Interestingly, *Sonneratia ovata* Backer which is listed as near-threatened species under IUCN was found in the area. The community of mangroves in Batasan River have a mean diversity of 0.7001 (H') with a mean evenness of 0.6557 (J') indicating a generally moderate diversity and a mostly even species distribution of mangroves along the river. Forest distribution patterns may be attributed to the overall floristic features of mangroves, land and riverine topographies and influence of urban anthropogenic activities along the Batasan River. The baseline information that this floristic study provides also calls for immediate and rigorous conservation efforts amidst increasing urbanization.
Key Words: mangroves, *Sonneratia ovata,* floristic composition, Batasan river, Philippines.

Introduction. Mangroves are commonly found along the tropical and subtropical regions of the world (Alongi 2008). The Philippines, which is a tropical country, has been endowed with the optimum climatic conditions favorable for mangroves to thrive (Sinfuego & Buot 2014). The ideal geographical location of the country is immensely responsible for the relatively high amount of mangrove species present in the Philippines, which is the home for thirty-five (35) true mangrove species out of the world's sixty-five (65) species. Hence, the Philippines has approximately more than half of the total true mangrove species found around the world (Garcia et al 2013).

According to Garcia et al (2013), mangroves provide vast benefits to both humankind and other marine organisms. They are valuable source of plant products such as traditional and herbal medicine, as well as food, forest, and other wood products. Moreover, mangrove ecosystems serve as breeding grounds for various aquatic animals.

They serve as guardians of inland ecosystems and a sentinel of the marine waters, which are home to diverse flora and fauna (Buot 1994). A study by Primavera (2000) states that in the Philippines, a huge portion of the population depends on mangroves for food, shelter, and livelihood. Furthermore, mangrove ecosystems have the ability to attenuate strong waves, storm surges and protect the coastal areas from storm impacts thereby reducing coastal erosion (Barbier et al 2008; Barbier 2015). In synergy with adjacent ecosystems such as seagrass and coral reef communities, Garcia et al (2013) stated that mangroves also protect the coast against potential threats. During the Indian Ocean tsunami in 2004, mangroves seem to have attenuated its waves, reducing surge-related damage. Also, mangroves were able to reduce the effects of wind and swell waves in the coastal areas (Kathiresan & Rajendran 2005; Dahdouh-Guebas et al 2005; Alongi 2008). Studies by Das & Crépin (2013) have shown that at the same level of storm impact, villages without mangroves experienced more wind-related damage than those villages behind mangroves.

Despite their enormous potential, mangrove forests located in marine and estuarine peripheries of megacities are often victims of urbanization. In Metro Manila, one of the top megacities in the world, urban mangrove forests are existing and struggling to survive in various localities such as the Tanza Marine Tree Park in Navotas City, the Las Piñas-Parañaque Critical Habitat and Ecotourism Area, the Batasan River which is overlapping in the cities of Navotas and Malabon, and some small patches of mangroves scattered in the metro's western coast. Urbanization has long been identified as a challenge to mangrove conservation and little is understood of the ecology and function of urban mangroves at a global scale despite reports of mangrove loss around cities all over the world (Branoff 2017). Realizing the value of this ecosystem, some urban designers in other parts of the world such as Hong Kong and Shenzen are developing solutions to restore lost mangrove cover and develop ecotourism amenities around that would make mangroves survive amid urbanization (O'Malley 2014). The researchers believe that undertaking a baseline biodiversity assessment will be an essential primer for such development, restoration and conservation of mangrove forests in the urban setting.

With this, the researchers aim to identify and locate the species of mangroves found in Batasan River, Metro Manila. The study would mitigate the current lack of data regarding mangroves in Metro Manila and contribute to the limited knowledge regarding the biodiversity of mangroves in the Philippines.

Material and Method

Description of the study site. The study was conducted in Batasan River in the cities of Malabon and Navotas, Metro Manila at around 14°41'N to 14°42'N and 120°55'E to 120°56'E. The Batasan River with a combined length of approximately 4.2 km is a dichotomously branching river which diverged at around 2 km point upnorth of its major linear stretch. The sampling site was observed to be disturbed by human activities: several waste products and boat operations. Construction of lightweight houses either near the mangroves or within the mangroves was also found along the river. On the other hand, the water from the river is characterized by turbid dark green color.

Sampling techniques. This study was done on December 2017 and January 2018. Forty-two (42) plots were established along the Batasan river where each plot extends upto 100 m long and approximately thirty 30 m wide (Figure 1). Global Positioning System (GPS) was utilized to geographically tag the identified species. Mangroves species composition assessment and identification followed the protocol and nomenclature described by Primavera & Dianala (2009) and Calumpong & Meñez (1997). Samples were verified and kept by the University of Santo Tomas – Research Center for the Natural and Applied Sciences (UST-RCNAS) Herbarium.

Figure 1. Map of the sampling site and the established base line plots (in blue dots) per plots in Batasan River.

Species biodiversity index and analyses. In determining the species richness, species evenness, relative abundance, and species diversity of the mangroves in Batasan River, Shannon-Wiener Index and Simpson's Index were utilized. Direct observation of the site was also used to record the potential threats brought by the human interactions.

Results and Discussion

Species diversity. A total of nine (9) mangrove species were recorded from Batasan River, Metro Manila, Philippines. This represents nine (9) true species of mangroves from six (6) families and seven (7) genera (Table 1). Species and individual counts of mangroves differed across the established plots (Table 2) of which *Avicennia marina* (Forssk.) Vierh. had the highest number of individuals with a total number of one thousand six hundred sixty-six (1666) followed by *Rhizophora mucronate* Lamk. and *Excoecaria agallocha* L. with three hundred eighty-three (383) and two hundred twenty (220) respectively. *Nypa fruticans* (Thunb.) Wurmb had the lowest number of individuals with only two (2) emerging along the Batasan River. *Sonneratia ovata* Backer, which is listed as near-threatened species by International Union for Conservation of Nature (IUCN) according to Salmo III et al (2010), was also found in the area. In terms of relative abundance, *A. marina* had the highest percentage at 69.45% followed by *R. mucronata* and *E. agallocha* at 15.96% and 9.17% respectively and *N. fruticans* had the lowest at 0.08% (Table 2).

Table 1

Mangrove species identified along Batasan River

Family	*Species*	*Common name*
Acanthaceae	*Avicennia marina* (Forssk.) Vierh.	Api-Api (Tag.)
Arecaceae	*Nypa fruticans* (Thunb.) Wurmb	Nipa (Many Lgs.) / Mangrove palm (Eng.)
Combretaceae	*Lumnitzera racemosa* Willd.	Kulasi (Tag.)
Euphorbiaceae	*Excoecaria agallocha* L.	Buta-buta (Tag.)
Lythraceae	*Sonneratia alba* J. Smith	Pagatpat (BisC., Tag.)
	Sonneratia ovata Backer	Pedada (Mgd.)
Rhizophoraceae	*Bruguiera ylindrical* (L.) Blume	Pototan-lalaki (Tag.)
	Rhizophora apiculata Blume	Bakhaw-lalaki (Tag.) / Bakhaw (BisSL.)
	Rhizophora mucronata Lamk.	Bakhaw-babae (Tag.) / Bakhaw (BisSL.)

Note: Tag. = Tagalog; Eng. = English; BisC. = Bisaya Cebu (Cebuano); Mgd. = Maguindanao; BisSL. = Bisaya Southern Leyte (Waray).

Table 2

Species richness and abundance per mangrove species identified along Batasan River

Family	*Species*	*Species richness*	*Relative abundance*
Acanthaceae	*Avicennia marina* (Forssk.) Vierh.	1666	69.45%
Arecaceae	*Nypa fruticans* (Thunb.) Wurmb	2	0.08%
Combretaceae	*Lumnitzera racemosa* Willd.	22	0.92%
Euphorbiaceae	*Excoecaria agallocha* L.	220	9.17%
Lythraceae	*Sonneratia alba* J. Smith	4	0.17%
	Sonneratia ovata Backer	3	0.13%
Rhizophoraceae	*Bruguiera ylindrical* (L.) Blume	74	3.08%
	Rhizophora apiculata Blume	25	1.04%
	Rhizophora mucronata Lamk.	383	15.96%
	Total	2399	100%

Species geographical coordination and location. There were forty-two (42) established plots with each plot being assessed based on the individual species found within. Figure 2 shows the map of the geo-coordinates per individual species along the Batasan River, Metro Manila. Certainly, it is noticeable based on the figure that *A. marina* dominated the site having species emerged in every established plot along the Batasan river.

Species diversity indices. The Shannon-Wiener diversity index (H') at the established plots shows how evenly distributed each of the mangroves within the Batasan river (Table 3). Plots 26, 38, and 42 had a value of one (1) in which all were dominated by *A. marina*. On the other hand, plots 16, 27, and 40 had evenness value of (J') = 0.3749, 0.3243, and 0.3783 respectively. These values indicate that there is a dissimilarity on the distribution of number of species within the aforementioned plots. The domination of *A. marina* within the established plots was evident. The H' of plot 27 is 0.6650. This was not as high as the other plots such as plots 13, 18, 20, 21, 28, and 29 due to the even distribution of the number of individual species per type of species emerged at those aforementioned plots. In addition, there are some plots such as plot 26, 38, and 42 that have zero (0) value of H'. It is for the reason that there is only one (1) species that emerged in those plots and there is no chance for the researchers to interpret the evenness of the aforementioned plots. In general, plots with values close to or higher

than one (1) correlates to the total number and even distribution of the mangrove species within the established plots while plots with values close to or equal to zero (0) correlates to the slightly uneven to very dissimilar distribution and very least in the total number of mangrove species within the plots. Among the established plots, plot 27 had the most number of species with six (6) out of nine (9) mangrove species living in the area.

Table 3

Shannon diversity indices at mangrove established plots along Batasan River

Plot	*Number of species*	*Number of total individual species*	*Evenness (E)*	*Shannon-Wiener diversity index (H')*
1	4	103	0.5183	0.7292
2	2	74	0.9767	0.6696
3	3	52	0.4311	0.2573
4	3	80	0.6957	0.7358
5	4	90	0.5562	0.7997
6	3	72	0.8098	0.8877
7	3	64	0.8526	0.9392
8	3	48	0.4994	0.4042
9	4	22	0.602	0.8789
10	4	75	0.6032	0.8807
11	3	26	0.7867	0.8587
12	5	116	0.5265	0.968
13	3	21	0.9932	1.092
14	3	40	0.6921	0.7306
15	3	77	0.515	0.4351
16	5	82	0.3749	0.6282
17	5	66	0.4023	0.699
18	5	99	0.733	1.299
19	4	70	0.6047	0.8832
20	5	96	0.6054	1.108
21	5	58	0.6005	1.099
22	5	87	0.4596	0.832
23	3	118	0.5389	0.4803
24	3	28	0.7325	0.7873
25	3	42	0.5357	0.4745
26	1	45	1	0
27	6	70	0.3243	0.6656
28	4	54	0.7662	1.12
29	4	73	0.8685	1.245
30	3	43	0.6221	0.6239
31	4	66	0.5743	0.8317
32	3	57	0.5774	0.5493
33	3	43	0.7283	0.7816
34	2	11	0.6781	0.3046
35	4	23	0.4755	0.6429
36	5	47	0.5025	0.9212
37	3	29	0.8121	0.8905
38	1	28	1	0
39	2	36	0.9938	0.687
40	4	32	0.3783	0.4141
41	2	25	0.5914	0.1679
42	1	11	1	0

Figure 2. Map of the Plotted Coordinates of Identified Mangroves in Batasan River.

A study by Dangan-Galon et al (2016) claims that Puerto Princesa Bay located in Palawan Island, Philippines, is one of the most diverse mangrove forests in the country having 28 true mangrove species and with a highest diversity index at H' = 0.9120. In contrast, the Batasan River located in Metro Manila, Philippines, has a mean diversity index of H' = 0.7001 which indicates a moderately diverse and evenly distributed number of mangroves within the area. Considering the status of the river with some inhabiting locals, this diversity index would be a good indicator that the river is able to support such variety of mangrove species.

Generally, Batasan mangroves yielded a Simpson's index of 0.4827, indicating that the mangroves along the study area have a moderate distribution of species and diversity. Figure 3 shows the Simpsons index at each established plots along the Batasan River. The Simpson's indices per established plots were determined after assessing the evenness at the established plots. The higher the value of evenness, the lower the diversity of the area is. Hence, plots 26, 38, and 42 have a Simpson's index value of zero (0) since the respective evenness value was determined to be exactly one (1). On the other hand, plots 13, 18, and 29 had a Simpson's index values of 0.6621, 0.6785, and 0.6763 respectively. These results elucidate the characteristics of the said plots with respect to the even distribution of abundance per species compared to the rest. All the above-mentioned patterns may be attributed to the overall floristic features of mangroves, land and riverine topographies, influence of urbanization, and anthropogenic activities along the Batasan River.

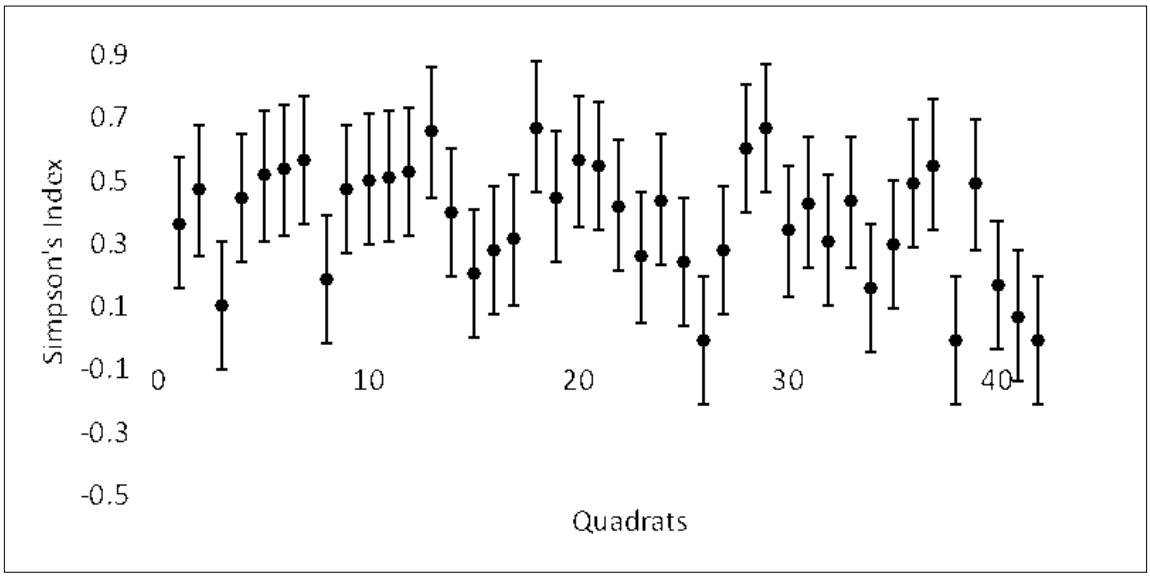

Figure 3. Simpson's indices per established plots along Batasan River.

Conclusions. There is a total of nine (9) true mangrove species belonging to six (6) families and seven (7) genera recorded for the first time from Batasan River, Metro Manila, Philippines. *Avicennia marina* (Forssk.) Vierh. was the most dominant species at 69.45% relative abundance while *Nypa fruticans* (Thunb.) Wurmb was the least occurring at 0.08% abundance. The community of mangroves in Batasan River have a mean diversity of 0.7001 (H') with a mean evenness of 0.6557 (J'). These numbers indicate a generally moderate diversity of mangroves and a mostly even species distribution along the river. It is also interesting to note that this study was able to report an IUCN-listed near-threatened species which is *Sonneratia ovata* Backer. This finding calls for rigorous conservation efforts amidst increasing urbanization. With such great diversity of mangroves being threatened, protection is necessary.

Acknowledgements. We are grateful for the close collaboration between the University of Santo Tomas and Department of Environment and Natural Resources for the successful fieldwork. We especially thank Mr. Jake Haldos and Mr. Bong Villanueva for their assistance and guidance during the field sampling, to the local government of Malabon City for granting us the permission to conduct this study, and to Mrs. Jennet Sy for her enthusiastic company during field works. We would also like to acknowledge the Commission on Higher Education (CHED) for supporting the publication of this project through the DARE-TO fund extended to the Urban Biodiversity Laboratory of Universidad de Manila.

References

Alongi D. M., 2008 Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. Estuarine, Coastal and Shelf Science 76:1-13.

Barbier E. B., 2015 Valuing the storm protection service of estuarine and coastal ecosystems. Ecosystem Services 11:32-38.

Barbier E. B., Koch E. W., Silliman B. R., Hacker S. D., Wolanski E., Primavera J., Granek E. F., Polasky S., Aswani S., Cramer L. A., Stoms D. M., Kennedy C. J., Bael D., Kappel C. V., Perillo G. M., Reed D. J., 2008 Coastal ecosystem-based management with nonlinear ecological functions and values. Science 319:321-323.

Branoff B. L., 2017 Quantifying the influence of urban land use on mangrove biology and ecology: a meta-analysis. Global Ecology and Biogeography 26:1339-1356.

Buot Jr. I. E., 1994 The true mangroves along San Remigio Bay, Cebu, Philippines. The Philippine Scientist 31:105-120.

Calumpong H. P., Meñez E. G., 1997 Field guide to the common mangroves, seagrasses and algae of the Philippines. Bookmark Inc., Makati City, Philippines, 197 pp.
Dahdouh-Guebas F., Jayatissa L. P., Di Nitto D., Bosire J. O., Lo Seen D., Koedam N., 2005 How effective were mangroves as a defence against the recent tsunami? Current Biology 15:443-447.
Dangan-Galon F., Dolorosa R. G., Sespeñe J. S., Mendoza N. I., 2016 Diversity and structural complexity of mangrove forest along Puerto Princesa Bay, Palawan Island, Philippines. Journal of Marine and Island Cultures 5(2):118-125.
Das S., Crépin A. S., 2013 Mangroves can provide protection against wind damage during storms. Estuarine, Coastal and Shelf Science 134:98-107.
Garcia K. B., Malabrigo P. L., Gevaña D. T., 2013 Philippines' mangrove ecosystem: status, threats and conservation. In: Mangrove ecosystems of Asia: status, challenges and management strategies. Faridah-Hanum I., Latiff A., Hakeem K. R., Ozturk M. (eds), Springer, New York, pp. 81-94.
Kathiresan K., Rajendran N., 2005 Coastal mangrove forests mitigated tsunami. Estuarine, Coastal and Shelf Science 65:601-606.
O'Malley S., 2014 Are mangroves the solution to urban sustainability in Asia? Available at: https://inhabitat.com/are-mangroves-the-solution-to-urban-sustainability-in-asia. Accessed: July, 2018.
Primavera J. H., 2000 Development and conservation of Philippine mangroves: institutional issues. Ecological Economics 35(1):91-106.
Primavera J. H., Dianala R. D. B., 2009 Field guide to Philippine mangroves. Philippine Tropical Forest Conservation Foundation Inc., 35 pp.
Salmo III S. G., Fernando E. S., Peras J. R., Sukardjo S., Miyagi T., Ellison J., Koedam N. E., Wang Y., Primavera J., Jin Eong O., Wan-Hong Yong J., Ngoc Nam V., 2010 *Sonneratia ovata*. The IUCN Red List of Threatened Species 2010: e.T178814A7615033.
Sinfuego K. S., Buot Jr. I. E., 2014 Mangrove zonation and utilization by the local people in Ajuy and Pedada Bays, Panay Island, Philippines. Journal of Marine and Island Cultures 3(1):1-8.

Received: 30 April 2018. Accepted: 31 May 2018. Published online: 28 July 2018.
Authors:
Patrick R. Relacion, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: patrickrelacion@gmail.com
Anjeanette S. Sy, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: anjeanettesy@gmail.com
Giannina Anais N. Rodas, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: giarodas@gmail.com
Aidam Luiz C. Cayanan, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: aidam.cayanan@yahoo.com
Dustin Ryan C. Marcelino, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: dustin_ryan14@yahoo.com
Khazbourn C. Sakamoto, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: khazbourn.sakamoto.shs@ust.edu.ph
Loida R. Medina, STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines; College of Science, University of Santo Tomas, Espana, Manila City, Philippines, e-mail: lrmedina@ust.edu.ph
Haidee D. Pabalate, Manila Bay Site Coordinating and Management Office, Department of Environment and Natural Resources – NCR Regional Office, National Ecology Center, East Avenue, Diliman, Quezon City 1101, Philippines, e-mail: haideediokno@yahoo.com
Alma E. Nacua, Urban Biodiversity Laboratory, Universidad de Manila, 659-A Cecila Muñoz Street, Ermita, Manila 1000, Philippines, e-mail: almanacua@yahoo.com
Ken Joseph E. Clemente, Urban Biodiversity Laboratory, Universidad de Manila, 659-A Cecila Muñoz Street, Ermita, Manila 1000; STEM Strand, Senior High School, University of Santo Tomas, España Blvd, Sampaloc, Manila 1015, Philippines, e-mail: keclemente@ust.edu.ph

How to cite this article:
Relacion P. R., Sy A. S., Rodas G. A. N., Cayanan A. L. C., Marcelino D. R. C., Sakamoto K. C., Pabalate H. D., Nacua A. E., Clemente K. J. E., 2018 Floristic composition assessment of urban mangroves in Batasan River, Metro Manila, Philippines. AACL Bioflux 11(4):1136-1143.