

THE ROLE OF PROTECTIVE PLANTS IN IMPLEMENTING LOW-CARBON BUILDING PRACTICES IN DEPOTS AND EDUCATIONAL MATERIALS IN SCHOOLS

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Abstract: *The research aims to find out the role of oil plants in the implementation of low-carbon development in Depok City as well as developing biology subjects teaching materials in upper secondary schools of the Xth grade from June to December 2023. This research uses a purposive sampling method by setting five location points. On the other hand, the development of teaching materials based on the ADDIE model is used. The parameters used include the number of stomata leaves, the large c/v ratio, and the ambient air quality index. The results of the research showed that on the road Margonda Raya City Depok has 21 types of protective plants with a total of 509 plants and with the most frequency is trembesi with the rate of the number of stomata 32,39 smaller than the control location on the street Boulevard GDC with the largest number of stoma, that is, an average of $50,33 \pm 7,09$ cells, so the stomatal density on the leaves of trembesi in this location is higher compared with other segments, which is $256,476 \pm 36,13$ cells/ mm². Data recorded the V/C ratio of Margonda Raya Street in 2022 at 0.91. Depok's air quality index on Monday, June 12, 2023, from 4.00 to 5.00 PM is PM10 of 33, PM2.5 of 60, SO₂ of 16, CO of 58, O₃ of 5, NO₂ of 19, and HC of 20. The results of the research are used as teaching materials. The results showed that the three-validator rating category was highly valid (86.57%), the one-on-one and small-group ratings also showed highly valid categories (85.57%), and the student's limited test result showed the category was very valid (90.75%). amounting to 80.95 on pre-test and post-test rates of 96.38. N-gain's effectiveness is 0.74, which means it's very effective.*

Keywords: *Protecting Plants, Teaching Materials, Stomata*

Abstrak: Penelitian bertujuan untuk mengetahui peran tanaman pelindung dalam penerapan pembangunan rendah karbon di Kota Depok serta mengembangkan bahan ajar mata pelajaran biologi di sekolah menengah atas kelas X dari Juni hingga Desember 2023. Penelitian ini menggunakan metode purposive sampling dengan menetapkan lima titik lokasi. Di sisi lain, pengembangan bahan ajar berbasis model ADDIE digunakan. Parameter yang digunakan meliputi jumlah stomata daun, besar cv rasio dan indeks kualitas udara ambien. Hasil penelitian menunjukkan bahwa pada jalan Margonda Raya Kota Depok memiliki 21 jenis tanaman pelindung dengan jumlah 509 tanaman dengan dengan frekuensi terbanyak yaitu trembesi dengan rerata jumlah stomata 32,39 lebih kecil dibanding lokasi kontrol di Jalan Boulevard GDC dengan jumlah stomata paling banyak, yaitu rata-rata $50,33 \pm 7,09$ sel, sehingga kerapatan stomata pada daun trembesi di lokasi ini lebih tinggi dibandingkan dengan segmen lainnya, yaitu $256,476 \pm 36,13$ sel/ mm². Data mencatat V/C ratio ruas Jalan Margonda



Raya tahun 2022 sebesar 0,91. Indeks kualitas udara Kota Depok pada Senin, 12 Juni 2023 pukul 16.00 – 17.00 WIB yang tercatat adalah PM₁₀ sebesar 33, PM_{2,5} sebesar 60, SO₂ sebesar 16, CO sebesar 58, O₃ sebesar 5, NO₂ sebesar 19 dan HC sebesar 20. Hasil penelitian digunakan sebagai bahan ajar. Hasil menunjukkan bahwa kategori penilaian tiga validator sangat valid (86,57 %), dan hasil penilaian satu-ke-satu dan kelompok kecil juga menunjukkan kategori sangat valid (85,57 %), dan hasil uji coba terbatas siswa menunjukkan kategori sangat valid (90,75 %). sebesar 80,95 pada *pre test* dan *post test* sebesar 96,38. Nilai keefektifan N-gain sebesar 0,74 yang berarti sangat efektif.

Kata kunci: Tanaman Pelindung, Bahan Ajar, Stomata

INTRODUCTION

Depok has an area of 200,29 km², Depok has a population density of 10,267 people/km², which makes it a density category, mainly due to its unequal population distribution. (BPS Kota Depok, 2021). According to Samsudin et al. (2015), Depok City is the least city park. Green spaces only exist in elite residential areas, which can sometimes be converted into commercial areas.

Pollution and environmental damage in the seas, forests, atmospheres, waters, or elsewhere is essentially caused by irresponsible attitudes and selfishness or selfish human behavior. Almost all countries, including Indonesia, are facing development and strategic issues related to climate change. The 2012 United Nations Conference on Sustainable Development placed climate change as a major international issue. The Indonesian Government acknowledges that initial measures for mitigation and adaptation will benefit Indonesia strategically and economically (Anderson et al., 2016).

According to Wahyudi (2016), an increase in the Earth's surface temperature caused by the infrared radiation of sunlight absorbed and re-emitted to the surface of the Earth by greenhouse gasses (GRKs) in the atmosphere is called a greenhouse-gas effect. The Intergovernmental Panel on Climate Change (IPCC) estimates an average Earth surface temperature rise of 1.8°C to 4.0°C by 2100.

"Low carbon development" is a macro policy in Indonesia that focuses on how to boost economic growth while reducing carbon emissions. Yuan (2011) states that it is a new type of economic and political development that achieves sustainable economic, environmental, and social development by suppressing carbon.

Protective plants are planted to protect people or objects underneath or around them from sunlight and rainwater. This definition is based on the function of plants in landscape architecture. The plants we choose to plant are categorized according to their physical classification, i.e. whether they will be used as fences (called fences), land-covering plants (called soil covers), or protective plants. (Dwiyani, 2013).

The stomata as one of the organs of plants serves as a place of gas exchange, like CO₂, which plants need for photosynthesis, and interacts with the environment. However, the stomata also serve as a place where pollutants enter, especially those coming from the air. Lead-like pollutants with particle sizes below 2 µm can pass through larger stomata, causing narrowing gaps and darkening colors. (Sulistiana dan Setijorini, 2016).

In the independent curriculum high school biology subject, the topic of environmental pollution is in class X material. However, according to Yanasin et al. (2023) specific discussion regarding student awareness regarding the role of protective plants against the impact of greenhouse gasses is still very minimal. Information regarding low carbon development studies and low carbon development plans in Indonesia, especially Depok City, is also still very lacking.

The reason the author chose this topic was because there was no research and scientific journals that observed the role of protective plants in the implementation of low-carbon development policies, especially in Depok City. Besides, no one has ever made it into a school lesson. The author chose SMAN 1 Depok as a research location due to the location that is very close to the main location of the research objects, namely Jalan Margonda Raya, and the status of SMAN 1, Depok, as the high school of Depok City. A writer can investigate the quality of environmental knowledge and literacy skills in students who have academic excellence.

METHOD

The location of the research is on Margonda Raya Street where the number of vehicles is crowded almost all the time. Sampling points include: in front of the town hall of Depok as a T1 point, outside the hotel of Earth Wiyata as T2, outside Margo City as T3, outside the Evencio apartment as T4, and on Boulevard Grand Depok City as a control point or T5. Stomata observations were conducted in the microbiology laboratory of the Faculty of Mathematics and Natural Sciences of the University of Sriwijaya, Indralaya, Ogan Ilir, South Sumatra. Meanwhile, the development of teaching materials is being carried out in SMAN 1 Depok City. As for the tools and materials used in the Mini Particle Counter, binocular microscopes, sharp knives or silets, glass objects, optic labs, drop pipettes, cameras, nail paint, tissue, and tree-cutting tools. The materials used are protective plant leaves.

Research uses direct observation methods, i.e. researchers collect data at the research site. Part of Margonda Raya Street, which stretches from the front of Depok Town Hall to the Evencio apartment, was sampled purposely for sampling. Each segment took five leaves as repetitions at the same height of 360 cm so it would total 25 leaf samples including the control location in the campus area of Boulevard Street Grand Depok City. The trembesi tree was chosen as a sample because this tree is the most protective tree found on

Margonda Raya Road with 275 trees. Leaf sampling on the Trembesi tree is chosen based on the leaf criteria determined.

Muntadhiroh (2015) stated that the criteria of the leaves taken were old green leaves, located on streets 3-5, close to the source of emission, and at the bottom of the tree because of the section near the source. However, according to Rahma et al. (2020), the leaves are fresh, green, not hollow, exposed to sunlight, and open leaves are perfect. The calculation of the stomata by observing directly the number of stomata of each leaf using a light microscope at zoom 40 x 0.65. The zoom was chosen because at the lower zoom the stoma was not visible. After all, the trachoma was covered. The length of the leaf is obtained by counting the length x width

$$\text{Leaf width} = \text{Length} \times \text{Sheet width}$$

However, the stomata density is calculated for each morphological condition using the formula (Lestari, 2006).

$$\text{Stomach density} * \text{stomach/mm}^2 = \frac{\text{Number of Stomata}}{\text{Width of the field of view}}$$

To determine the quantity and density of stomata between the stomata condition in Margonda Raya and the stoma condition in Grand Depok City Area (Control), the observation data was analyzed descriptively using numbers, pictures, and tables. The literacy of the student's environment in which the results of the pretest and posttest are analyzed using the statistical test Normalized gain (N-gain) with the following formula:

$$N - \text{gain} = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{maks}} - S_{\text{pre}}}$$

Description :

N-gain = normalized gain

S_{Pre} = Pretest score

S_{post} = PostTest score

S_{maks} = Maximum ideal score

According to Hake (1999), the score acquisition category is as follows: high: N-gain more than 0.7; medium: 0.3 to 0,7; and low: N-gain less than 0.3.

Furthermore, based on the results of field research, stomata observations, and literature research, the role of protective plants in the application of low-carbon development in the City of Depok is a lesson. The ADDIE model is used to develop this material and covers the process of analysis, design, development, application, and evaluation. Next, a limited trial and validation of the teaching material is carried out. Validation is carried out by one material expert, one media expert, and one linguist using a validation

sheet; a limited test is done using the limited test lift sheet, which is used both before and after the test.

RESULTS

From the data that the author obtained the number of protective plants found in the street Margonda Raya a total of 509 plants of which there are 275 trembesi plants. This number is very significant compared to other types of plants or about 54,02 % (data in table 1).

Table 1 List of names of protective plants found in Margonda Raya Depok. (DLHK Depok, 2023)

No	Nama Pohon	Nama Ilmiah	Jumlah	No	Nama Pohon	Nama Ilmiah	Jumlah
1	Trembesi	<i>Samanea saman</i>	275	12	Kersen	<i>Muntingia calabura</i>	4
2	Bungur Merah	<i>Lagerstroemia speciosa</i>	54	13	Sepatu Dea	<i>Spathodea campanulata</i>	2
3	Kamboja	<i>Plumeria</i>	48	14	Nangka	<i>Artocarpus Heterophyllus</i>	1
4	Beringin	<i>Ficus benjamina</i>	19	15	Pandan Bali	<i>Cordyline australis</i>	1
5	Mahoni	<i>Swietenia mahagoni</i>	24	16	Glodokan Tiang	<i>Polyalthia longifolia</i>	1
6	Tabebuia	<i>Tabebuia</i>	21	17	Mangga	<i>Mangifera Indica</i>	1
7	Palem Putri	<i>Veitchia merrillii</i>	14	18	Cemara Udang	<i>Casuarina equisetifolia</i>	1
8	Palem	<i>Arecaceae</i>	14	19	Teropongan	<i>Cecropia Peltata</i>	1
9	Batavia	<i>Jatropha Integerrima</i>	13	20	Tanjung	<i>Mimusops elengi</i>	1
10	Pucuk Merah	<i>Syzygium paniculatum</i>	9	21	Cemara	<i>Casuarinaceae</i>	1
11	Ketapang Kencana	<i>Terminalia mantaly</i>	4				

One indicator for road service is shown in the comparison of traffic volume with road capacity and speed ratio (V/C ratio). From the results obtained by the researchers through the report of the City of Depok Liaison Service, data on average capacity, volume, and speed as well as the ratio of V/C of Margonda Raya Street for the last three years (2020 – 2022) are available in table 2 below.

Table 2 Margonda Raya Depok 2020 – 2022 (Dephub Kota Depok 2023)

No	Nama Ruas Jalan	Tipe Jalan	Kapasitas			Volume			Kecepatan			V/C Rasio		
			2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
1	Jl. Margonda Raya	6/2D	3836.3	3836.3	9608.26	3102.49	2953.95	8775.54	22	33.83	30.07	0.88	0.77	0.91

From Table 2 you can see comparative data of capacity, volume, speed, and V/C ratio on Margonda Raya Road for three years 2020 to 2022. The value or index of the V/C ratio relates to the level of traffic congestion occurring indicated by the Volume per Capacity ratio, which indicates that traffic conditions are worse if the ratio is higher.

Table 3 Level of Road Capacity Service (Ministry of PU, 2022)

No	Service Level (LOS)	Current Level/Traffic Characteristics	V/C ratio value
1	A	Free current conditions at high speeds, the driver can choose the desired speed without obstacles	<0,6
2	B	The current is stable but operations are beginning to be restricted by traffic conditions. The driver has enough freedom to choose the speed	0,6 - 0,7
3	C	The current is stable but the speed of the vehicle's movement is controlled by the driver is restricted in selecting the speed	0,7 - 0,8
4	D	Currents start approaching unstable, low speeds still controlled sometimes stopped	0,8 - 0,9
5	E	Volume of traffic approaching or at unstable current capacity speed sometimes stopped	0,9 - 1
6	F	Current clogging, low speed, volume under capacity and triggering.	>1

From table 3 it is shown that the quality of the V/C of the 2022 Margonda Road includes the service level E which means traffic volumes are approaching or at unstable current capacity. On table 4, the data presented is the environmental air quality index data at the time the researchers took a leaf sample on Margonda Highway. The data suggests most of the parameter indicators are still below the standard limit set by the Ministry of Environment and Forestry.

Table 4.Indicator of air quality at the time of leaf sampling 12 June 2023

Waktu	PM10	PM2.5	SO2	CO	O3	NO2	HC	Critical Component
00:00:00	48	72	17	56	5	20	19	PM2.5
01:00:00	47	72	17	56	5	20	19	PM2.5
02:00:00	46	71	17	56	5	20	19	PM2.5
03:00:00	44	69	17	57	5	20	19	PM2.5
04:00:00	42	67	17	57	5	20	19	PM2.5
05:00:00	40	65	17	58	5	20	19	PM2.5
06:00:00	38	64	16	58	5	19	20	PM2.5
07:00:00	37	62	16	58	5	19	20	PM2.5
08:00:00	35	61	16	58	5	19	20	PM2.5
09:00:00	34	61	16	58	5	19	20	PM2.5
10:00:00	34	60	16	58	5	19	20	PM2.5
11:00:00	33	60	16	58	5	19	20	PM2.5
12:00:00	33	59	16	58	5	19	20	PM2.5
13:00:00	33	60	16	58	5	19	20	PM2.5
14:00:00	33	60	16	58	5	19	20	PM2.5
15:00:00	34	60	16	58	5	19	20	PM2.5
16:00:00	33	60	16	58	5	19	20	PM2.5
17:00:00	33	60	16	58	5	19	20	PM2.5
18:00:00	32	59	16	58	5	19	20	PM2.5
19:00:00	32	58	16	59	5	19	20	CO
20:00:00	31	58	16	59	5	19	20	CO
21:00:00	29	56	16	59	5	19	20	CO
22:00:00	27	55	16	59	5	20	20	CO
23:00:00	26	55	16	60	5	20	20	CO



The results also showed that of the seven indicators of the parameters, PM2.5 and CO indicators that exceed the standard threshold set by the Ministry of Environment and Forestry refer to the PP 22 of the year 2021. The standard number of threads set by the Ministry is 50.

In Table 5 of the observation data the researchers in the field presented observations of the size of the number and density of the stomata in the protective plant (*Samanea saman*) from five observation points.

Table 5 Observations of the size, quantity, and density of the stomata of the Trembesi plant (*Samanea saman*) in the street Margonda Raya Depok

Lokasi	Bagian	Ulangan	Panjang	Lebar	Luas	Jumlah Stomata	Rata-rata Jumlah Stomata	Kerapatan Stomata	Rata-rata kerapatan stomata
T1	Up	1	4,5	1,2	5,4	29	29,8±4,02	147,7707	152,017
		2	4,2	1,9	7,98	33		168,15287	
	Middle	1	4,3	2	8,6	31		157,96178	
		2	4	2,2	8,8	35		178,34395	
	Down	1	4	2,2	8,8	24		122,29299	
		2	4,7	2,3	10,81	27		137,57962	
T2	Up	1	4,6	2,8	12,88	23	18,5±4,64	117,19745	94,268±23,63
		2	4,9	2,8	13,72	25		127,38854	
	Middle	1	4,7	2,8	13,16	17		86,624204	
		2	4,7	3	14,1	15		76,433121	
	Down	1	4,2	2,6	10,92	18		91,719745	
		2	4,3	2,5	10,75	13		66,242038	
T3	Up	1	4,8	2,7	12,96	34	30,5±8,31	173,24841	155,414±42,36
		2	4,5	2,8	12,6	39		198,72611	
	Middle	1	4	1,8	7,2	31		157,96178	
		2	3,8	1,8	6,84	38		193,63057	
	Down	1	4,2	2	8,4	19		96,815287	
		2	4,5	1,9	8,55	22		112,10191	
T4	Up	1	3,5	2,2	7,7	34	32,83±4,62	173,24841	167,304±23,55
		2	4,8	1,9	9,12	39		198,72611	
	Middle	1	4,2	2,2	9,24	36		183,43949	
		2	3,9	2,3	8,97	33		168,15287	
	Down	1	3,8	2,2	8,36	28		142,67516	
		2	3,5	2	7	27		137,57962	
T5	Up	1	3	1,5	4,5	44	50,33±7,09	224,20382	256,476±36,13
		2	3,3	2	6,6	49		249,68153	
	Middle	3,5	2,2	2,6	5,72	41		208,9172	
		2	3,3	2	6,6	52		264,96815	
	Down	1	4,2	2,3	9,66	59		300,63694	
		2	4,2	2,2	9,24	57		290,44586	

Based on Table 5, the control location on Boulevard Street GDC has the most stomatitis, an average of $50,33 \pm 7,09$ cells, so the somatic density of the trembles leaf at this location is higher than in other segments, $256,476 \pm 36,13$ cells/mm².

The results of the research were converted into a unit of learning materials using the ADDIE development model. (Analysis, Design, Development, Implementation, and Evaluation). The teaching material is then validated. The material, language, proportion, suitability, and grading are the components used to evaluate the teaching material. Validation is carried out by three experts, a linguist, a materialist, and a media expert in succession. Highest and lowest validation results in a row. can be seen in Table 6.

Table 6 Summary of Expert Review Results

No	Aspek	Validator (Expert)	Skor	Kategori
1	Media	WS	86%	Very Valid
2	Matter	ZS	94%	Very Valid
3	language	DWP	80%	Very Valid
	Rerata		87%	Very Valid

Based on Table 6, the percentage of experts is 87% which means that the teaching material is highly qualified in the field trial. In Table 7, we can see the results of the one-to-one student test. In the test, the researchers test the advanced teaching materials after obtaining the results from the validator.

Table 7 Test Recapitulation One to one

No	Nama	Persentase	Kategori
1	AND	91,25%	Very worthy.
2	DAP	90%	Very worthy.
3	MRM	73,75%	Worth it.

The one-to-one test results showed a ratio of 73.75%, which indicates that advanced trials on small groups and field trials are a worthy option. The results of small group trials can be seen in Table 8 below.

Table 8 Small Group Stage Summary Results

Nama Siswa	Jumlah	Jumlah Skor Ideal	Presentase	Kategori
MDA	49	50	98	Very worthy
KOB	43	50	86	Very worthy
AFM	41	50	82	Very worthy
NA	47	50	94	Very worthy
KFZ	45	50	90	Very worthy
AIA	47	50	94	Very worthy
MT	44	50	88	Very worthy
TM	47	50	94	Very worthy
Rerata			90,75	Very worthy.

The results of a small group questionnaire with a ratio of 90.75 showed that respondents were highly eligible for the next stage test or field test, as shown in Table 8. To determine the effectiveness of the student's learning outcomes, the N-gain calculation is obtained from the initial and final test ratio values. The result is shown in the table below.

Table 9 Rekapitulasi Average Hasil Pretest, Posttest, N-gain

<i>Average Pretest</i>	<i>Average posttest</i>	<i>N-gain</i>
80,95	96,38	0,74
Kategori		Tinggi

Results with high N-Gain (category 0.74) show that the use of teaching materials for the role of protective plants in the application of low-carbon generators in Depok City has an excellent impact on student learning outcomes.

DISCUSSION

One of the plants that are often seen around the Protocol Road is the trembesi. Trembesi tree planting is not without reason: Trembesi belongs to the category of protective plants. Trembesi is a good plant to remove dust because of its abundant leaves and trichomes. According to Azzahro et al. (2019), a plant or tree that can absorb dust well should have a dense and tight head, leaves that graze and spread, and rough, sticky, hairy, and trichome surfaces.

The traffic jams in Depok City are due to the lack of optimal infrastructure to accommodate the population growth. Depok's main street, Margonda Raya, is often blocked. Depok's air pollution is becoming unstoppable, with more than 8,000 new vehicles added every month. Depok City air pollution is generally caused by the increasing number of vehicles owned by both Depok citizens and those passing through Depok. The population of Depok City has about 12,514 motor vehicles with a total of 10,451 motorcycles. It shows that already a lot of Depokers prefer motorcycles as a means to get to where they want to go. (Samsuedin et al., 2015).

V/C Ratio, which compares traffic volume to road capacity and speed, is one of the highway service indicators. According to Julianto, 2011, the relationship between volume and speed is an exponential function or growth where the higher the volume of the vehicle, the lower the speed. In Table 3, the researchers presented data on the capacity level of the Road service based on the V/C ratio values. The value or index of the V / C ratio is related to the level of traffic congestion occurring indicated by the Volume per Capacity ratio, which states that the higher the number of rations, the worse the existing traffic conditions. According to Tahir (2019), one of the traffic conditions is the degree of saturation of the road, also known as the V/C ratio. The volume ratio per capacity, also referred to as V / C, indicates that traffic conditions are worse if the ratio is higher.

According to Table 3, the characteristics of the service level of Margonda Raya Road are E; HC, NO₂, SO₂, O₃, and PM₁₀ emissions are still below the national environmental air quality standards; CO and PM_{2.5} have already exceeded the national ambient air quality standard, which is 50. On Monday, June 12, 2023, leaf samples were taken at five specified locations between 4:00 and 5:00 PM. City Depok air quality recorders owned by KLHK (Ministry of Environment and Forestry) showed the following air quality indices: PM₁₀ at 33, PM_{2.5} at 60, SO₂ at 16, CO at 58, O₃ at 5, NO₂ at 19 and HC at 20.

The results also showed that of the seven indicators of the parameters, PM_{2.5} and CO indicators that exceed the standard threshold set by the Ministry of Environment and Forestry refer to the PP 22 year 2021. The standard number of threads set by the Ministry is 50. Excess carbon dioxide will replace the position of oxygen associated with hemoglobin in the blood, making it very dangerous to humans, Rahmawati said. (2023). Carbon monoxide gas (CO), which is a metabolic toxin, can turn into carboxyhemoglobin (COHb) in the blood. This condition disrupts the vital function of the blood, which is to transport oxygen.

According to Jama'ani and Munawwaroh (2017) statements as a result of exposure to pollutant emissions, plants suffered damage to leaf morphology, low chlorophyll levels, stomata density, and a high percentage of stomata fissures. According to Waryanti et al. (2015), The dust that sticks to the leaves

can affect the opening of the stomata cracks. If the weight of dust increases, the opening will also be blocked and the crater will be smaller.

Of all the locations of the study, the number of stomata and the density of the stomata at point T2 (Cross Margo City) was the smallest. The number of stomata is 18.5 ± 4.64 cells and the stomatal density is 94.268 ± 23.63 cells/mm², which is the smaller number of stomates. The Trembesi plant leaf area on the T2 point sample proved to be small in all segments. affects the number and density of the stomata. According to Papuangan *et al.* (2014), the breadth of a plant leaf affects the rate of transpiration because there are many stomata on the large leaves, which causes more breathing.

The number of stomata affects the density of the stomata; a large stomata indicates high stomatal density. Marantika and Sahertian (2021) stated that Trembesi leaf stomata density was categorized as low altitude when low density ($<300/\text{mm}^2$), moderate ($300\text{-}500/\text{mm}^2$) and high ($>500/\text{mm}^2$). The results of the study showed that the Trembeci leaf at the study site had a low stomatal density, with an average stomatal density at the control site of 256,476 cells/mm², while the smallest stomatological density in the control location was about 208,9172/mm². Marantika and Sahertian (2021) stated that the density of the stomach can be influenced by environmental factors such as light and temperature, where the higher the temperature and intensity, the more it increases.

The ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) is used to develop teaching materials. The evaluation of the module was carried out by three experts: material experts, linguists, media experts, and media experts. The material aspects received the highest score, 94%, very valid; the media aspects, including grammatical and nutritious, received a score of 85.71%, highly valid, and the language aspects were rated 80%, extremely valid.

In general, of the three aspects of the assessment of the role of protective plants in the implementation of low-carbon construction in Depok City, thus, this material receives an average value of 86.57% and is in a very valid category. Validator suggests fixing concept maps, fixing typing errors, and using language in a way that is easy to understand by students.

This material needs to be modified or repaired to be used in air pollution learning because of the advice given by the validator. It is hoped that this material will make it easier for students to understand the role of protective plants in the implementation of low-carbon development in Depok City. In addition, with the availability of protection plants, this material can also enhance students' insight into the efforts made to reduce impacts, prevent air pollution, and increase awareness to preserve protective plants.

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In a one-on-one trial, the researchers involved three students, and they obtained a score of about 85 percent of the lift, which means very valid. In addition, the three students gave some suggestions for improving the teaching material. In a small group test, the researcher involved eight students and they got a rating of about 90,75 percent of a lift, meaning very valid for use. Test results in the field of teaching materials: two types of tests, pre-test, and post-test, showed an average of 80.95 and 96.38. The researchers presented lessons to students who took Pre and Post Tests. The pre and post-test results showed that students learned more about environmental change and air pollution chapters than after using lessons. This suggests that students can learn better with the right material.

The use of teaching materials for the role of protective plants in applications in low-carbon regeneration applications in Depok City has an excellent impact on student learning outcomes, according to N-Gain 0.74 high category results. The use of teaching materials has increased significantly. According to the questionnaire results, students' responses to the use of the material are excellent because the material is easy to understand, can be used as they wish, and has additional explanations through pictures and videos. This result research is relevance with previous research by those who develop teaching materials so that the results of the development are effective as seen from the results of cognitive ability tests obtained by students (Suarcita, 2020, Arif, 2017).

CONCLUSION

Based on the results of the inventory of researchers in Jalan Margonda Raya and from the data of KLHK Depok obtained 21 types of protective plants with a total of 509 plants. Of these there are 275 Trembesi (*Samanea saman*). At the time of leaf sampling, which is on Monday, June 12, 2023, at 4.00 – 5.00 pm, the Depok City air quality index was recorded on the Depok City air quality recording device from KLHK (Ministry of Environment and Forestry) as follows: PM₁₀ by 33, PM_{2,5} by 60, SO₂ by 16, CO by 58, O₃ by 5, NO₂ by 19 and HC by 20. The number of stomata and stomata density of Trembesi leaves at the control location (point T5) on Grand Boulevard Depok City Street is greater than the four points that are on Margonda Raya Street 55,33 cells and 256,476 cells/mm²). Based on research findings, it was found that the production of teaching materials is valid, practical, and effective. This is in line with the results that have been obtained, namely that the material was tested for its validity in terms of media, material, and language, with an average presentation of 86.57%. Similarly, the validity of the material at the one-to-one test stage, with

an average presentation of 85.00%, and the validation of the materials at the small test stage against the student, with an average presentation 90.75%, with a very qualifying category, and the development of the teaching material shows the fact that in both the initial and final tests, the student's average learning outcome was 80.95 good categories and 96.38 excellent categories, indicating an improvement before the materials were used in learning activities. Students' learning outcomes can also be categorized as high with a N-Gain score of 0.74.

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