

# The technique of green belt bamboo constructions for highway noise effect reductions

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**Abstract.** Noise affects human health and behavior. Significantly noise results in a decrease in quality of life. The World Health Organization states that noise pollution is the third most dangerous type of environmental pollution. Noise is seriously problematic in the health of the urban environment in the world. The city of Yogyakarta as a center of education in Indonesia has experienced a very large growth in urban numbers from various provinces in Indonesia. Noise testing is carried out in residential areas as well as being an education area in Yogyakarta. The tool used MU.04 / SLM / 04 (Sound Level Meter) shows a value of 62.1 dBA from the normal limit of 55 dBA. These results indicate that noise is disturbing. So it is necessary to do noise reduction along the crowded roads of vehicles with natural vegetation. Natural vegetation that is fast growing and capable of significantly reducing noise is bamboo. Bamboo vegetation can bind more carbon than tree plants. The green belt vegetation of bamboo plants will create a more comfortable, shady and beautiful environment in the city of Yogyakarta.

## 1. Background

Noise pollution significantly affects urban environmental problems. This problem continues to develop in densely populated cities in the world. Noise has become one of the pollutants that has become the concern of the international community. Sound pollution affects human health and behavior which has a significant impact on quality of life [1]. Road traffic plays a dominant role in causing environmental noise which has a negative impact on public health [2, 3].

In general, noise is an unwanted sound [4]. Noisy is defined as a sound level that exceeds an acceptable level so that noise causes interference [5]. The main sources of noise are motorized vehicles, aircraft and loud volume music [6]. The level of interference is affected by sound volume, time and frequency of noise. Noise is sound without meaning greater than ordinary volume. Noise in the form of unwanted sounds such as dogs barking, traffic sounds of vehicles or airplanes that have an effect on destroying peace [7].

The impact of noise on health is hearing loss. This is caused by exposure to loud sounds continuously for a long time. Symptoms of deafness will increase gradually if exposed to loud sounds over a long period of time [8]. The subjective response to noise is a disorder including fear and mild anger. Sleep disturbance is considered the most serious effect of environmental noise. In western countries, problems with sleep disorders increase due to lifestyle factors [9]. The increasing number of vehicles and industrial machinery resulted in noise pollution also increasing sharply. Urban noise, especially along arterial roads, has reached very disturbing levels [10]. The World Health Organization states that noise pollution is the third most dangerous type of environmental pollution. The world's urban population is 70% in developing countries [11]. Most urban populations are vulnerable to the effects of noise so that public health conditions are poor. Noise has a large negative impact on the quality of life in urban areas [12, 13].

[14] conducts research on the influence of plants on reducing road traffic noise. The types of plants used are *Juniperus horizontalis* L., *Spirea vanhouetti* Briot., *Cotoneaster dammerii* C.K., *Berberis thunbergii* D.C. and *Pyracantha coccinea* M. The results showed the maximum noise reduction values were 6.3 dB (A),



4.9 dB (A) and 6.2 dB (A). [15] states that green belts in a row of trees along the road play an important role in reducing temperatures and reducing heat intensity in cities. The decreasing temperature in urban areas can save electrical energy significantly [16]; [17]. The green belt of the tree functions as a noise filter, cleanses the air and binds the carbon [18].

Noise disorders affect people's physical and psychological health. So it needs a fast-growing green belt that is able to absorb carbon along urban roads. [19] states that bamboo is known as one of the fastest growing plants in the world, with developments ranging from 20 to 100 mm per day during growth. The height of bamboo can reach 36 m in diameter 1-30 cm. Bamboo is the fastest growing and most renewable natural resource of [20]. So that bamboo plants are expected to be able to reduce the impact of noise significantly in urban areas.

## 2. Literature review

Research to reduce noise levels has been carried out by many researchers from various countries around the world [21]; [22]; [23]; [24]; [25]; [26]; [27]. The green belt acoustic effect of trees along the highway has been a popular research topic for the past 40 years [28]; [29]; [30]; [31]; [32]; [33]; [34]; [35]; [36]; [37]; [38]; [39]. This is because the level of urban noise has become a disaster for the community. Plants are more economical to prevent traffic noise than concrete walls. Plants are preferred because they contribute to the beauty of the environment [40]. But in general, the green belt of vegetation with a spaced tree layout makes it impractical to dim noise [41]; [42]. [43] concludes that the distance between trees of 3 m to 25 m only has little effect on noise. Green belts of trees with a length of more than 30 m are better able to reduce noise compared to open grass [44]. The results of the study [45] showed that the noise spectrum was attenuated by the green belt of a pine tree with a length of 100 m.

Rows of green belts of trees and shrubs are very important to reduce noise effectively. Random arrangement of tree sequences the ability to reduce noise is smaller than a well-planned array of trees [46]. Rows of green belts of specially regulated trees can reduce the sound [47]. [48] conducts research by applying a different to 3D time method to predict sound propagation in a green belt of vegetation with a length of 15 m along the highway. The results showed that the green vegetation belt was able to reduce the traffic noise level by 3 dBA. The wider the diameter of the tree, the noise level decreases.

Bamboo is the fastest growing plant [49]. There are more than 70 bamboo genera and also more than 1000 bamboo species in botany literature literature[50]. Bamboo grows in the sub-tropical zone, especially in the sandy topsoil to the clay layer. This plant can adapt to a short life cycle. Bamboo stems grow fast, around 70 mm every day and can reach 350 mm up to 450 mm. [51 ] states that bamboo culms develop within 4-6 months and become adults, it takes 2-6 years depending on the species. Bamboo stems are generally cylindrical with smooth leather surfaces, diameters ranging from 29 to 300 mm, 60–70% bamboo consisting of fibers, and fiber substance more prominent at the edges than inside. The average height of bamboo is around 100 times its diameter of [52]. Bamboo plants are fast growing, do not require special treatment when planted and are able to grow in various land conditions [53]. Timber and fruit plants to reach adulthood take a long time while bamboo only takes about 4 years. Bamboo absorbs more carbon dioxide than wood or fruit plants. One hectare of bamboo plants can absorb more than 12 tons of carbon dioxide in free air [54].

Bamboo was chosen to reduce the impact of noise due to its rapid growth, frozen resistance, salt resistance and slight defoliation of [55]. Bamboo is more optimal in reducing the reswing effect of the effect of the wind on the object and the direction of the sound wave [56]. [57] research conducted on bamboo vegetation to block noise with the help of acoustic computer simulation models. [58] has carried out microscopic bamboo analysis.

## 3. Problem identification

[59] conducts noise pollution in traffic in the school area and examines the negative impact of noise on the performance of teachers and students. The research site is located in the Valencian Public School of Spain. The city of Yogyakarta Indonesia experienced a very high population increase, which caused the increase in motorized vehicles to increase rapidly. So that the traffic flow on the highway is getting denser [60].

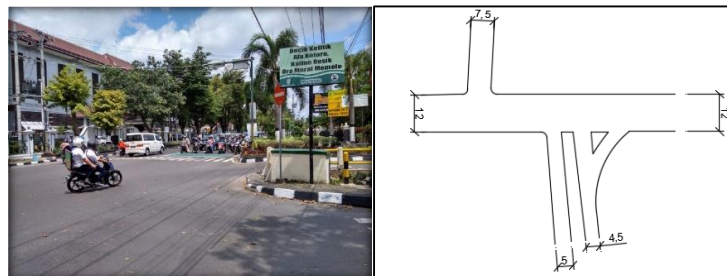
From the literature study it can be formulated the important problem of knowing the noise magnitude in the education area of Yogyakarta city of Indonesia. The advantages of the green belt of bamboo plants in reducing noise and its high ability to bind carbon dioxide, it needs to be studied to be planted along the education area highway.

#### 4. Objectives

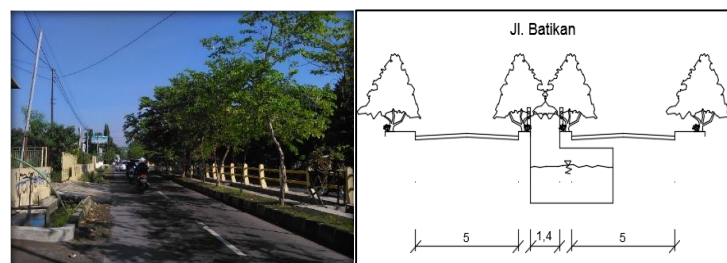
The impact of noise pollution results in a decrease in physical and psychological health. This study aims to determine the amount of noise in the education area and study bamboo plants as vegetation to reduce noise pollution in the city of Yogyakarta Indonesia.

#### 5. Methodology

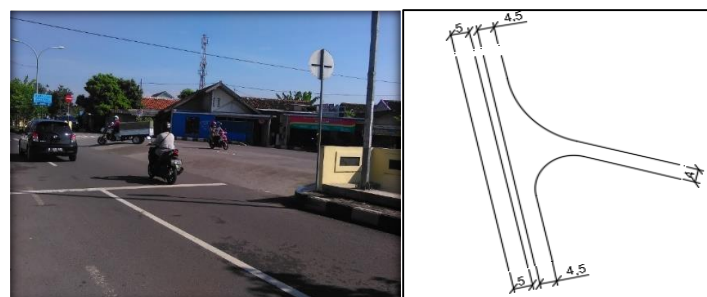
The research was conducted on a traffic lane along Jl. Candel the city of Yogyakarta by analyzing the impact of traffic and noise testing. Along this highway is an educational area and residential area. There are university areas, public schools, settlements and shops. Traffic density is surveyed at the intersection of Jl. Kusumanegara-Jl. Batikan, road section Jl. Batikan, intersection Jl. Babran-Jl. Batikan, intersection Jl. Tohpati-Jl. Batikan and Sinpang Jl. Veteran-Jl. Batikan.



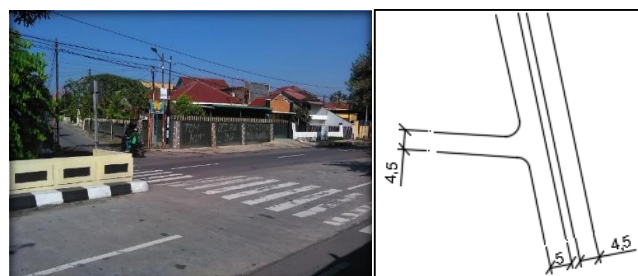
**Figure 1.** Signalized Fourth Intersection Jl. Kusumanegara - Jl. Batikan.



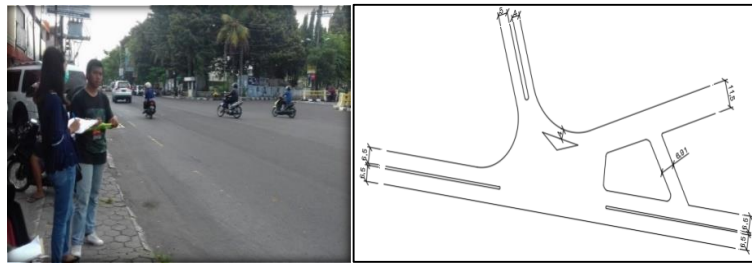
**Figure 2.** Batikan Road Section.



**Figure 3.** Signalized Third Intersection Jl. Babaran (Jl. Babaran - Jl. Batikan).



**Figure 4.** Non-Signalized Third Intersection Jl. Tohpati (Jl. Tohpati - Jl. Batikan).



**Figure 5.** Signalized Fourth Intersection Jl. Veteran - Jl Batikan.

The capacity calculation analysis process is carried out for each path on the observed road section. Calculations can be done using the formula:

$$C = C_o \times FC_W \times FC_{SP} \times FC_{SF} \times FC_{CS}$$

Where C is the capacity,  $C_o$  is the basic capacity (pcu / hour),  $FC_W$  is a factor in adjusting the width of the traffic lane,  $FC_{SP}$  is the adjustment factor of direction separation,  $FC_{SF}$  is a factor of adjustment of side barriers and  $FC_{CS}$  is a factor of city size adjustment. The process of analyzing traffic performance is an analysis of the calculation of the degree of saturation, speed and travel time and the level of service of a road. The formula used is:

$$DS = \frac{Q}{C}$$

Where Q is the traffic volume (pcu / hour), C is the capacity (pcu / hour) and DS is Degree of Saturation (degree of saturation).

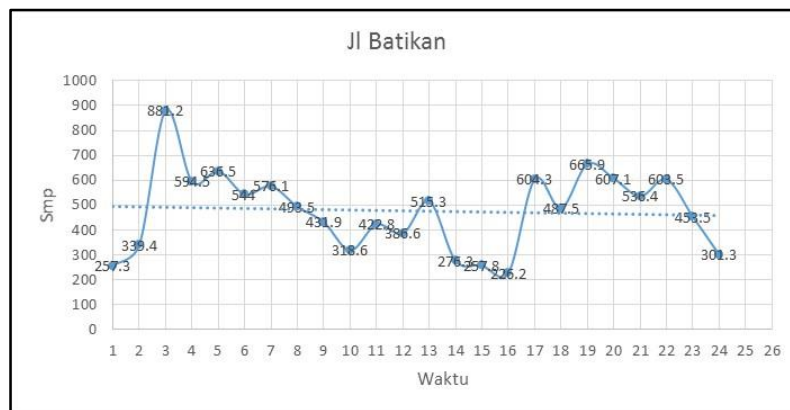
Air quality and noise testing is carried out at the location of Jl. Batikan. At this location right in the education area. This location was chosen because it had a direct impact on students who were studying, both physical and psychological impacts. At this location there are also residential areas, shops and other institutions.



**Figure 6.** Testing of Air Quality and Noise.

## 6. Results and discussion

Traffic density survey results at Jl. Cancel and intersect directly related to Jl. Batikan shows a high density at a certain time. The high density of motorized vehicle traffic causes noise that takes place continuously every day. Traffic density at Jl. Cancel each passing car every hour (pcu) can be seen in Fig. 7.



**Figure 7.** Survey Chart Jl Batikan.

The survey results show that at 6:30 a.m. - 7:30 a.m., 10:15 a.m. - 12:15 p.m. and 16:15 p.m. - 18:15 p.m. are the densest traffic conditions, so this is the basis for the analysis of the environmental impact of traffic congestion. Capacity Jl. Batikan is presented in Table 1 while the performance of the road section is presented in Table 2.

**Table 1.** Capacity of Batikan Road.

The width of the road (m)	Co	Correction Factor				Capacity (C)
		FC <sub>w</sub>	FC <sub>sf</sub>	FC <sub>sp</sub>	FC <sub>cs</sub>	
10	2900	1,29	0,93	1	0,9	3131,22

**Table 2.** Road Performance.

Roads	Time	2017		DS
		Q (smp/hour)	C (smp/hour)	
Jl. Batikan	06.15 – 07.15	2000,8	3131,22	0,639
	11.15 – 12.15	1828,9	3131,22	0,584
	16.15 – 17.15	2428,4	3131,22	0,775

At the signalized intersection Jl. Kusumanegara - Jl. Clear traffic volume analysis for all motorized vehicles and analysis of intersection capacity. In Table 3, an analysis of the volume of the vehicle is presented. For Table 4, the intersection capacity for passing vehicles is presented.

**Table 3.** Classified Traffic Volume of Signalized Fourth Intersection (pcu / hour) Jl. Kusumanegara - Jl. Batikan.

Kode Pendekat	Arah	ARUS LALU LINTAS KENDARAAN BERMOTOR (MV)														KEND. TAK BERMOTOR	
		Kendaraan ringan (LV)			Kendaraan berat (HV)			Sepeda Motor(MC)			Kendaraan bermotor total			Rasio berbelok		Arus UM	Rasio UM/MV
		emp terlindung = 1,0			emp terlindung = 1,3			emp terlindung = 0,2			Kendaraan bermotor total MV			Rasio berbelok			
		emp terlawan = 1,0			emp terlawan = 1,3			emp terlawan = 0,4									
		kend/jam	smpp/jam	Terlawan	kend/jam	smpp/jam	Terlawan	kend/jam	smpp/jam	Terlawan	kend/jam	smpp/jam	Terlawan	p LT	p RT		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)		
U	LT/LTOR	109	109	109	0	0	0	142	28	56	251	137	165	0.15		4	
	ST	208	208	208	1	1	1	1078	215	431	1287	424	640			2	
	RT	225	225	225	3	3	3	582	116	232	810	344	460		0.38	6	
	Total	542	542	542	4	4	4	1802	359	719	2348	905	1265			12	0.005
S	LT/LTOR	123	123	123	0	0	0	475	95	190	598	218	313	0.46		0	
	ST	0	0	0	0	0	0	0	0	0	0	0	0			6	
	RT	143	143	143	0	0	0	556	111	222	699	254	365		0.54	10	
	Total	266	266	266	0	0	0	1031	206	412	1297	472	678			16	0.012
T	LT/LTOR	114	114	114	7	9	9	1072	214	428	1193	337	551	0.24		7	
	ST	360	360	360	77	100	100	3098	619	1239	3535	1079	1699			57	
	RT	0	0	0	0	0	0	0	0	0	0	0	0		0.00	0	
	Total	474	474	474	84	109	109	4170	833	1667	4728	1416	2250			64	0.014
B	LT/LTOR	0	0	0	0	0	0	0	0	0	0	0	0	0.00		0	
	ST	215	215	215	0	0	0	1949	389	779	2164	604	994			78	
	RT	29	29	29	0	0	0	138	27	55	167	56	84		0.08	6	
	Total	244	244	244	0	0	0	2087	416	834	2331	660	1078			84	0.036

**Table 4.** Signalized Fourth Intersection Capacity and Performance Jl. Kusumanegara - Jl. Batikan.

Kode Pendekat	Arus lalu lintas smp/jam	Kapasitas smp/jam	Derajat kejenuhan DS = Q/C	Rasio hijau GR = g/c	Jumlah kendaraan antri (smp)				Panjang antrian (m)	Rasio kendaraan stop/smp	Jumlah kendaraan berhenti smp/jam	Tundaan			
					N 1	N 2	Total NQ1 + NQ2 = NQ	NQ max				Tundaan lalu lintas rata-rata det/smp	Tundaan geometrik rata-rata det/smp	Tundaan rata-rata det/smp	Tundaan total smp/det
					Rms. (34.1)	Rms. (35)	Rms. (37)	Gb E-2-2				Rms. (42)	Rms. (43)	(13) + (14)	(2) x (15)
					(6)	(7)	(8)	(9)				(13)	(14)	(15)	(16)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
U	905	628.81	1.44	0.36	1.46	26.33	27.78	15	42.86	0.66	597.23	41.62	3.42	45.04	40759.05
S	472	327.95	1.44	0.26	1.05	13.73	14.78	13	52.00	0.67	317.76	50.50	3.75	54.25	25607.03
T	1416	983.86	1.44	0.74	1.82	41.19	43.02	22	73.33	0.65	924.63	20.21	2.61	22.82	32313.00
B	660	458.58	1.44	0.33	1.24	19.20	20.44	20	66.67	0.67	439.45	44.91	2.83	47.74	31508.02
LTOR (semua)	692														
Arus kor. Qkor															
Arus total Qtot	3453														
Total :											2279.07	Total:			
Kendaraan terhenti rata-rata stop/smp											0.66	Tundaan simpang rata-rata (det/smp) :			
												130187.10			
												37.70			

At the signalized intersection Jl. Veteran - Jl. Clear traffic volume analysis for all motorized vehicles and analysis of intersection capacity. In Table 5, an analysis of the volume of vehicles passing through the intersection is presented. For Table 6, the amount of intersection capacity for each passing vehicle has been presented.

**Table 5.** Classified Traffic Volume of Signalized Fourth Intersection (pcu / hour) Jl. Veteran - Jl. Batikan.

Kode Pendekat	Arah	ARUS LALU LINTAS KENDARAAN BERMOTOR (MV)														KEND.TAK BERMOTOR	
		Kendaraan ringan (LV)			Kendaraan berat (HV)			Sepeda Motor(MC)			Kendaraan bermotor			Rasio berbelok		Arus UM	Rasio UM/MV
		emp terlindung = 1,0		emp terlindung = 1,3	emp terlindung = 1,3		emp terlindung = 0,2	emp terlindung = 0,2		total MV							
		emp terlawan = 1,0		emp terlawan = 1,3	emp terlawan = 1,3		emp terlawan = 0,4	emp terlawan = 0,4									
		kend/ jam	smp/jam	kend/ jam	smp/jam	kend/ jam	smp/jam	kend/ jam	smp/jam	kend/ jam	smp/jam	p LT Rms. (13)	p RT Rms. (14)				
(1)	(2)	(3)	(4)	Terlawan (5)	(6)	Terlindung (7)	Terlawan (8)	(9)	Terlindung (10)	Terlawan (11)	am (12)	Terlindung (13)	Terlawan (14)	(15)	(16)		
U	LT/LTOR	15	15	15	0	0	0	173	34	69	188	49	84	0.11		8	
	ST	113	113	113	2	2	2	523	104	209	638	219	324			4	
	RT	121	121	121	0	0	0	327	65	130	448	186	251		0.41	2	
	Total	249	249	249	2	2	2	1023	203	408	1274	454	659			14	0.011
S	LT/LTOR	180	180	180	13	16	16	1428	285	571	1621	481	767	0.49		28	
	ST	122	122	122	1	1	1	1370	274	548	1493	397	671			4	
	RT	34	34	34	6	7	7	360	72	144	400	113	185		0.11	1	
	Total	336	336	336	20	24	24	3158	631	1263	3514	991	1623			33	0.009
T	LT/LTOR	16	16	16	5	6	6	337	67	134	358	89	156	0.11		0	
	ST	267	267	267	11	14	14	1813	362	725	2091	643	1006			8	
	RT	20	20	20	0	0	0	139	27	55	159	47	75		0.06	0	
	Total	303	303	303	16	20	20	2289	456	914	2608	779	1237			8	0.003
B	LT/LTOR	44	44	44	3	3	3	75	15	30	122	62	77	0.13		3	
	ST	121	121	121	8	10	10	608	121	243	737	252	374			4	
	RT	77	77	77	11	14	14	383	76	153	471	167	244		0.35	4	
	Total	242	242	242	22	27	27	1066	212	426	1330	481	695			11	0.008

**Table 6.** Signalized Fourth Intersection Capacity and Performance Jl. Veteran - Jl. Batikan.

Kode Pendekat	Arus lalu lintas smp/jam	Kapasitas smp/jam	Derajat kejenuhan  DS = Q/C	Rasio hijau GR = g/c	Jumlah kendaraan antri (smp)				Panjang antrian (m)	Rasio kendaraan stop/smp	Jumlah kendaraan terhenti smp/jam	Tundaan			
					N 1	N 2	Total NQ1 + NQ2 = NQ	NQ MAX				Tundaan lalu lintas rata det/smp	Tundaan geometrik rata det/smp	Tundaan rata-rata det/smp = D	Tundaan total smp/det
(1)	(2)	(3)	(4)	(5)	Rms.(34.1) (6)	Rms.(35) (7)	Rms.(37) (8)	Gb.E-2:2 (9)	Rms.(38) (10)	Rms.(39) (11)	Rms.(40) (12)	Rms.(42) (13)	Rms.(43) (14)	(13) + (14) (15)	(2) x (15) (16)
U	454	362.25	1.25	0.51	0.19	12.42	12.61	15	85.71	0.73	331.01	25.99	3.58	29.58	13427.94
S	991	790.73	1.25	0.61	0.28	27.10	27.38	13	37.14	0.73	719.02	20.45	3.09	23.54	23327.02
T	779	621.57	1.25	0.58	0.25	21.30	21.55	22	80.00	0.73	565.94	22.03	3.01	25.03	19501.37
B	481	383.79	1.25	0.31	0.20	13.15	13.35	20	66.67	0.73	350.54	35.76	3.48	39.24	18874.83
LTOR (semua)	681														
Arus kor. Okor															
Arus total Qtot	2705														
											Total :	1966.51	Total:		75131.16
												0.73 Tundaan simpang rata-rata (det/smp) :			27.77

The result of noise testing using MU.04 / SLM / 04 tool (Sound Level Meter) shows 62.1 dBA from the normal limit of 55 dBA. Shows the level of noise pollution has been disturbing. To minimize the impact of noise in the city of Yogyakarta, it is urgent to plant bamboo vegetation along the road. Because bamboo grows quickly and without special care.

## 7. Conclusion

The density of traffic in the city of Yogyakarta Indonesia has caused an increase in air pollution and noise pollution. In the education area noise pollution has experienced a significant increase that is disturbing. This noise disturbance can conclude the impact of physical and psychological disorders.

It is urgent to plant vegetation that is able to absorb noise along the roads in the city of Yogyakarta, especially in the education area. The fast growing and able to reduce noise is bamboo. Bamboo easily grows quickly, and grows without requiring special maintenance. Bamboo plants are also able to bind more carbon to the road than tree plants. With the planting of bamboo vegetation, in addition to beautifying urban scenery also creates a comfortable, beautiful and shady city environment.

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