Reduction of traffic noise due to improved road conditions: Evidence from Matara & Hambantota, Sri Lanka

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Abstract

"Road traffic noise" is becoming a serious problem for civilians living close to roads with heavy traffic in Sri Lanka. According to the statistics of Department of Motor Traffic, Sri Lanka, the total number of registered vehicles has been increased up to 5.07 million by the end of July-2013. The increase of motor vehicles with inadequate road conditions would contribute to enhance the noise pollution. Previous studies had found that some citizens living in urban areas exposing to heavy noise have developed hearing disorders. This matter has been often overlooked in developing countries, in contrary, some developed countries which have better road conditions, have started to use materials that produce low tire noise and good sound absorption surface layers for roads. In this study, a comparison of noise level is performed before and after the improvement of road conditions in selected urban areas in southern region of Sri Lanka. All measurements were carried out before and after rehabilitation and widening of respective roads. B&K Type-2250 hand held analyser was used to measure noise level and experiments were carried out in 2013, before the rehabilitation, and 2014, after the rehabilitation, respectively. Traffic volume of the roads studied was counted manually. Noise data were recorded at distances of 200 m for Class A and 400 m for Class B roads along the sides of selected roads. A-weighted equivalent continuous sound pressure level at each location, L_{Aeq}, for 15 minutes time period was measured. An internationally recommended IMMI noise mapping software was used to map the noise distribution. Noise maps constructed before and after the rehabilitation of roads were compared. The average noise levels in the vicinity of Class A and Class B roads studied have decreased the noise level by 0.35 - 12.03 % after widening/improving the roads. The maximum drop of noise contour for Class A highway was found to be 3.5 dB or 6.2 % even with the increase of traffic volume by 61.5% during the period studied. For Class B roads a maximum of 5.8 dB or 12.0 % drop of traffic noise level was recorded. The width of the highest noise contour (having L_{Aeq} = 75-80 dB) was decreased by 74.3 % and 30.3 % for Class A and Class B roads respectively. It can be concluded that widening and improving the conditions of the roads have effectively reduced the traffic noise pollution, even though the volume of traffic has been increased. It also proves the importance of using noise maps for the development and redesign of cities as the removal of noise-pollution could contribute so much to better quality of life in Sri Lankan urban cities.

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Introduction & Literature Review

Unwanted sound disturbing humans is called noise. Noise may have the most pervasive environmental impact on people. Long term and short term exposure to high noise levels causes adverse health effects, disturbing their normal activities and ultimately degrading the quality of life (Guidelines for community noise 1999; Ishiyama and Hashimoto, 2000; Onuu 2000; Stansfeld and Matheson, 2003).

Noise pollution has been a problem in many urban cities in the world and vehicular traffic noise is known to be the most prominent noise in cities. The effects of traffic noise on civilians are one of the concerns in developed countries in the world. Technically, the quantity L_{Aeq} (A-weighted equivalent continuous sound pressure level) has been almost universally adopted for traffic noise assessment (European Union, 2000). Noise level contour maps drawn using the quantity L_{Aeq} (Subramani *et al.*, 2012) have been produced for many cities in order to analyse Noise Level Variation (NLV) and used for improvements/widening of roads as well as for the development of cities. Internationally, noise level investigations by noise mapping are adopted by Environmental Impact Assessment (EIA) in urban planning and design. Many developing countries have often overlooked traffic noise pollution in their cities.

At the international level, the World Health Organization (WHO) together with the Organization for Economic Co-operation and Development (OECD) are the main bodies that have collected data and developed their own assessments on the effects of exposure to environmental noise (Green Paper, 1996). OECD has reported the thresholds for noise nuisance as follows (in day-time L_{Aeq}); at 55-60 dB (A) noise creates annoyance; at 60-65 dB(A) annoyance increases considerably; above 65 dB (A) constrained behaviour patterns, symptomatic of serious damage caused by noise arise. WHO has suggested a standard guideline value for average outdoor noise levels of 55 dB (A), applied during normal daytime in order to prevent significant interference with the normal activities of local communities. The National Environment act 47, 1980, has given the maximum permissible noise level in day time as 63 dB for "mixed residential areas", which means an area consisting of residences and commercial establishments. For the first time in Sri Lanka, the authors had produced a noise contour map of the city of Matara, which clearly identified areas of high noise pollution (besides roads A2, A24 & B275) in the city, exceeding the maximum allowed level of 63 dB (Sethunga *et al*., 2013). A recent study has reported a degradation of the hearing level of workers who had exposed to a long period of heavy noise at the Matara bus stand, which is located within the day time noise level contour of 75-80 dB (A) of the Matara noise map (Sethunga *et al*., 2014).

The noise produced by vehicles has been categorized into two types, namely, “engine noise” which dominates at low speeds and “tire noise” at high speeds. The cross over speed for constant-speed driving is often referred to as 40-50 km/h for cars and 60-70 km/h for trucks; implying that tire/road noise dominates at all highways and motorways driving conditions and power unit noise dominates in urban driving (Sandberg, 2001). Some literature in early 1970’s, the transition speed had been stated as 50-70 km/h for cars and 70-90 km/h for trucks, which may be due to the low quality of vehicles used in 1970’s. Tire noise often spread in low frequency broadband (600-1000 Hz) in broad band spectrum of 0-20 kHz (Hanson *et al*., 2004). The frequency spectrum depends on the design of the tire and the nature of road surface.

Different road surfaces emit different frequency patterns and therefore, the information on the road conditions, such as asphalt, concrete, gravel etc. have to be considered in noise analysis and prediction models. A great deal of research work has been investigated in developing a road surface that reduces tire noise generation and propagation. A useful overview on low noise road surfaces has been written by Losa *et al*., in 2001 and a more recent in-depth review has been made by Sandberg *et al.,* in 2013.

Developed countries having better roads and vehicles with low noise emission are mainly interested on reducing "tire noise". Recent research and experiences in the United States and European countries have shown the interest on quiet pavements for noise mitigation (Morgan, 2006). Quiet pavement can be an alternative or a supplement to more traditional noise abatement types such as wall type noise barriers and vegetation type noise berms used in many countries. Road improvement for noise mitigation often becomes an attractive solution when considering the initial cost, sanitation, or aesthetics (TR News, 2005).

In Sri Lanka "engine noise" and the noise due to bad driving habits dominates in many cities. Under poor road conditions, vehicles are forced to run at lower speeds, in low gears, with accelerated engines over long periods of time. Especially, when drivers waste more time at a traffic bottleneck, some of them behave unethically ringing the horn and accelerating engines. Body vibrations of older vehicles also contribute to noise under poor road conditions. Therefore, better road conditions for smooth traffic flow undoubtedly should reduce the traffic noise on Sri Lankan roads. By having high-speed runways (Express-ways or free-ways) for long-distance commuters may have consequences of increasing noise, especially tire noise, however, such roads more often run through remote areas with not much impact on civilians (TR News, 2005).

According to the statistics published by the Department of Motor Traffic, Sri Lanka, the traffic volume in the country has been increased by 10% annually since 2005 and 5.07 million vehicles have been registered by July, 2013 (RMV statistics, 2014). Therefore, it is essential to take actions to improve the traffic flow in all cities, as already started in many cities in Sri Lanka. In this context, it is highly advisable to study the noise contour maps of cities in re-designing road structure of urban cities. Due to the construction of Southern Expressway and, new airport and sea port at Hambanthota, most of the access roads have been developed. This paper presents the results of a study on the comparison of noise level before and after the improvement of road network of Class A and Class B roads in selected areas in Matara and Hambanthota cities in Southern Province of Sri Lanka. The objective of this study is to highlight the importance of strategic city planning to improve the life pattern and health condition of civilians by reducing exposure to heavy noise over a long period in addition to the enhancement of aesthetic value of the cities.

Methodology

Traffic noise level measurements were carried out at some selected locations of main roads in Gandara; A2 (Matara Tangalle road), in Matara city; A24 (Matara-Akuressa road) and B275 (Matara–Hakmana road), and in Hambanthota; B562 (Mirijjawila–Sooriyawewa road), B622 (Hungama-Middeniya main) and B631 (Hambantota – Gonnoruwa – Meegahajandura road. Noise level measurements and traffic count at each location were taken before and after the completion of reconstructions of the road. Traffic count was recorded manually before and after each measurement. The number of lanes and nature of road surface was also recorded.

Traffic noise measurements were carried out using Bruel & Kjaer (B&K) Type-2250 hand held analyser (IEC 61672-1; 2002 Class1) and the instrument was suitably calibrated using type 4231, B&K sound level calibrator ('Instruction Manual', 2004). The analyser was placed on the centre line of the carriageway, i.e., 5m from the centre of 2-way A or B type road and 10 m from the centre of 4-way A or B type roads. In order to avoid the interference with the reflected sound from ground the analyser was fixed 1.2 m above the ground level. A-weighted sound pressure levels (L_{Aeq}) were recorded in sound level meter in decibels for a total 15 minutes; i.e. 5 minutes continuously in automatic mode and repeated three times at each location. Same procedure was followed for all selected locations in Class A and B roads. Measurements were taken at distances of about 200 m along Class A roads and about 400 m along Class B roads to study the noise level variation (NLV). Garmin e-Trex 20 hand-held GPS navigator was used to locate the positions.

Irregular noises such as passing of an ambulance, dog barking, sound of low flying planes, and other emergency vehicles was rejected. Especially, noise emitted from modified exhaust systems of vehicles and some vehicle horns were separately marked. Noise data were not studied in rainy days and festival days. Rainy days were avoided to disregard the noise generations due to tyre-road interactions. As the wind speed could significantly affect the accuracy of data, UA 1650 90mm wind windscreen, spherical shaped porous foam plastic material, was used to minimize the wind effect. Atmospheric data such as wind velocity (ms^{-1}), humidity (%) and atmospheric temperature (^0C) were measured at the time of measurement using Kestrel 4500 pocket weather tracker.

Computer aided noise calculation (IMMI) software, which incorporates the methodology outlined in the XP S 31-133 elementary library in IMMI software, was used to map the noise level. The measurements were fed into the programme. The factors, number of lanes, distance edge of carriageway to road centreline, driving direction, attenuation areas and reflections were considered during the noise calculation in IMMI software. The relevant guidelines given for noise mapping in the manual ('Instruction Manual', 2004) were followed.

Findings, Analysis & Discussion

Recorded noise data were categorized according to the road types (Class A, Class B, etc.) and analysed separately. Noise maps at the vicinity of sections of the selected roads were prepared using the output of the software.

Two noise maps constructed for 4 km portion along the main road A24 and 3 km portion of the road B275 in Matara city, before and after road improvements are shown in Figure 1 and Figure 2 respectively. Here the measurements taken in September-2013 (before the improvement) and in March-2014 (after the improvement) were compared. Note that the circled portions (Black circle) of both roads in Figure 2 were not improved at the time of this study. Therefore, these portions were not considered in the comparison. However, the measurements in these two portions of the roads were included in last two columns (under without road improvements) of Table 1. The traffic volume on road A24 has been increased by 420 vehicles per hour during this period, which is after the opening of the southern highway. However, after the reconstruction of the road, the highest noise contour, 75-80 dB, along the road has been shifted to lower value, 70-75 dB, except at the circled area. The relative average spreading of noise contours (noise contour width) has been decreased by 6.20%. This was the result of converting 2-way asphalt A24 road to a 4-way asphalt road of better condition, widened with sidewalks and carpeted.

The traffic volume of B275 road, drawn in the same figures, has been increased by 360 vehicles per hour during this period. The road improvement (except the circled area) of B275 was only layering of asphalt and no significant increase of road width or number of lanes. Figure 1 & 2 shows that there is no any shift of traffic contours but its overall relative width have increased. However, the width of the highest noise level contour, 75-80 dB, has been reduced due to the improvement of road condition. Therefore, such a highly saturated road the improvement of road condition alone is not sufficient to completely control the noise pollution level. More details of shifting of noise contours and its spread besides of A24 and B275 are given in Table 1. Last two columns of Table 1 show the measurement taken in circled (no improvements) portions of the road.

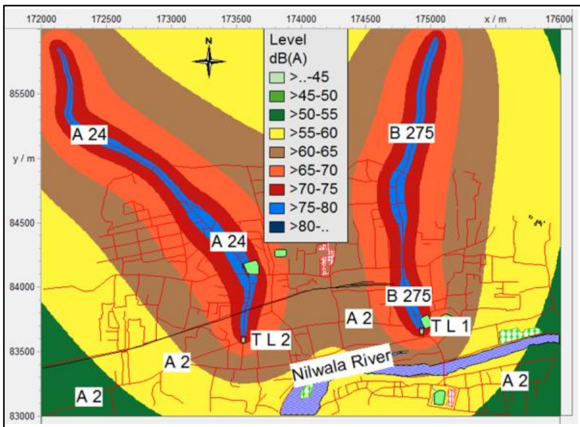

Fig 1: NLV beside the A24 and B275 road before improve the road condition. Source: author

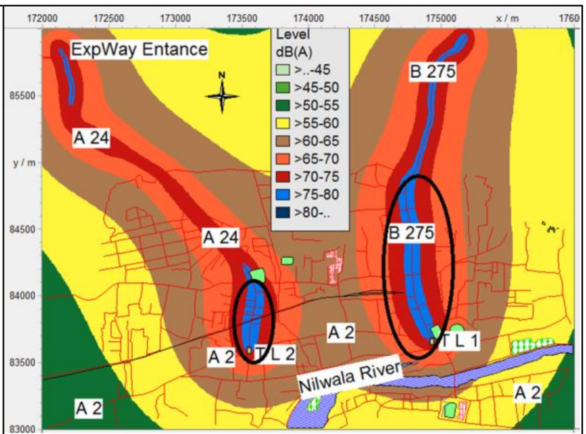

Fig 2: NLV beside the A24 and B275 road after improve the road condition. Source: author

Table 1: Different NC vs. Distance Spreading beside the A24 and B275.

Road	Status	NC in (dB)	With road improvement		Without road improvement	
			MNCW (B)	MNCW (A)	MNCW (B)	MNCW (A)
A24	Numbers of tracks were	80 <	10	-	-	-
	increased from 2 to 4 with	75-80	70	18	30	70
	the road improvements.	70-75	115	52	90	110
	ATV (B) = 780	65-70	208	175	170	188
	ATV (A) = 1200	60-65	370	320	320	390
		55-60	620	570	545	700<
B275	Numbers of tracks were	75-80	33	23	58	65
	not changed.	70-75	86	80	108	125
	ATV (B) = 630	65-70	172	**175**	205	245
	ATV (A) = 990	60-65	285	**345**	345	365
		55-60	480	**530**	600	630

ATV (B) - Average TV (Vehicles per hour) 'Before' road improvements
ATV (A) - Average TV (Vehicles per hour) 'After' road improvements
MNCW (B) - Maximum Noise Contour Width in metres 'Before' improvement
MNCW (A) - Maximum Noise Contour Width in metres 'After' improvement
Last two columns compare the circled portions (without road improvement)

The circled portioned of the A24 and B275 roads in Figure 2 were not developed at the time of data collecting period. According to Figure 1 and Figure 2 noise levels at unimproved road sections (circled area) of A24 and B275 have increased due to the increase of traffic volume. It can be easily identified that the width of noise contour bands in circled areas has increased considerably due to traffic volume. After improvements the width of the highest noise contour (having L_{Aeq} = 75-80 dB) was decreased by 74.3 % and 30.3 % for class A and class B roads respectively.

Figures 3, 4, 5 & 6 is further evident that the noise level and width of higher noise contours besides two way main roads have decreased after their improvements, even though traffic volume has increased with time. These roads are still not saturated with its traffic volume. The circled area in Figure 3 was well improved and the noise level is decreased significantly in compared with non-improved part of the same road for same traffic volume. Figure 5 & 6 shows an improved portion of road near Middeniya town. Their relative noise contour and its width have decreased and average L_{Aeq} values are given in Table 2.

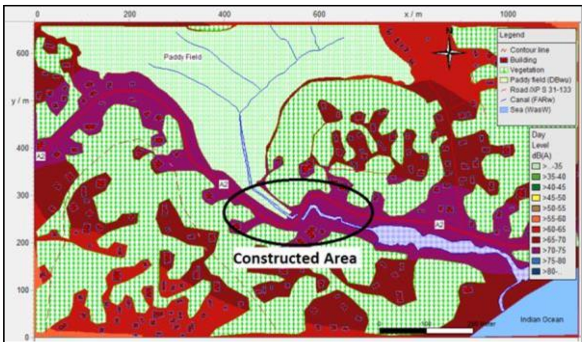

Fig 3: Before road improvement between 171-172 km post in A2 highway. Source: author

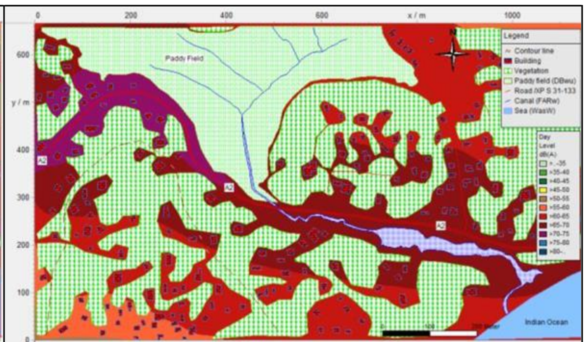

Fig 4: After road improvement between 171-172 km post in A2 highway. Source: author

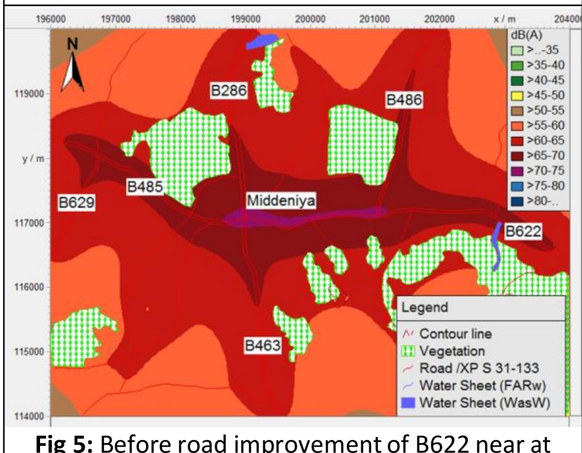

Fig 5: Before road improvement of B622 near at Middeniya Town. Source: author

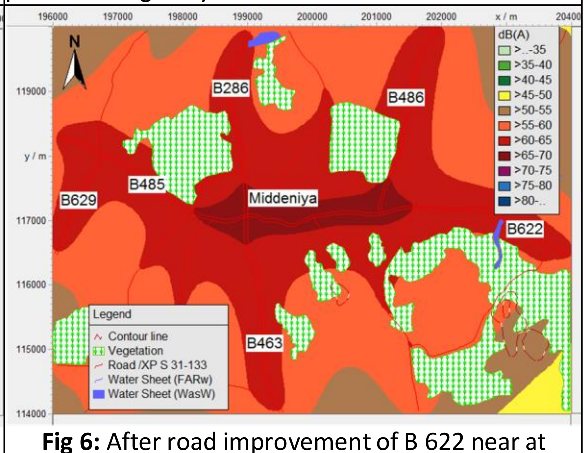

Fig 6: After road improvement of B 622 near at Middeniya Town. Source: author

Roads given in fig. 7, 8, 9 & 10 are B562 & B631, very recently developed access roads to “Mattala Mahinda Rajapaksa International Airport” (MMRIA) and Hambantota Sea Port. Those Roads were improved to four way tracks from two way tracks. Figures show that, the road improvements have decreased the noise levels besides four-way main roads, even though traffic volume has increased.

More quantitative information for all cases discussed above is summarized in Table 2. Only the portions of the roads with improved conditions are considered in this comparison. It is clear that the average road traffic noise level has decreased with the road improvements, even though the average traffic volume has increased. B275 road is at the margin and the number of lanes has to be increased for further reduction of traffic noise.

Table 2: The percentage value of NLV and its spreading

Road	Num. of tracks		Ave. TV		L $_{Min}$		L $_{Max}$		L $_{Ave}$		St. Dev.	Average NLV (%)
	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.		
A2	2	2	750	780	53.8	41.6	73.1	75.6	67.3	52.9	7.15	-3.27
A24	2	4	780	1260	44.1	41.6	79.6	75.6	56.4	52.9	7.10	-6.20
B275	2	2	630	990	47.2	46.3	77.7	79.6	57.1	56.9	6.54	-0.35
B562	2	4	330	450	41.1	38.2	84.2	79.6	52.9	50.4	6.39	-4.73
B622	2	2	330	390	49.5	47.2	70.9	67.8	60.7	58.6	3.85	-3.46
B631	2	4	270	510	36.5	29.2	72.9	63.7	48.2	42.4	6.94	-12.03

Ave. TV – Average Traffic Volume, Bef. – Before road widening/improvements, Aft.– After road widening/improvements, St. Dev. – Standard Deviation, NLV – Noise Level Variation.

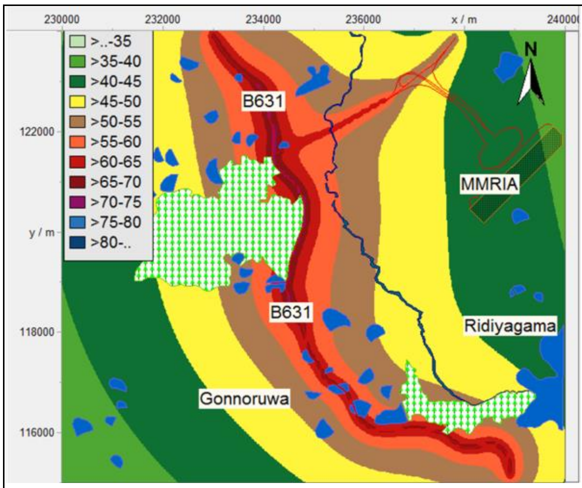

Fig 7: Before widening of B631 road.
Source: author

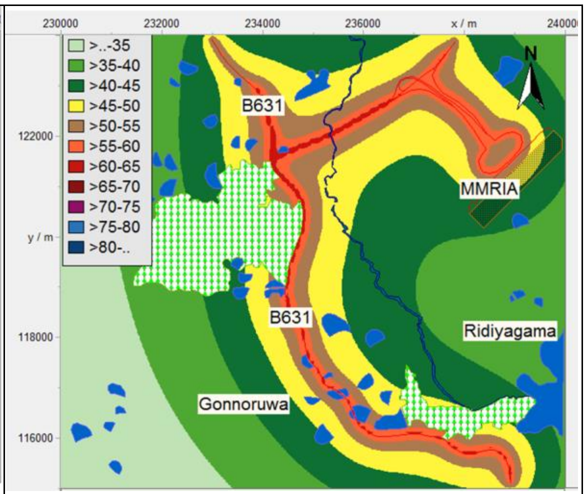

Fig 8: After widening of B631 road.
Source: author

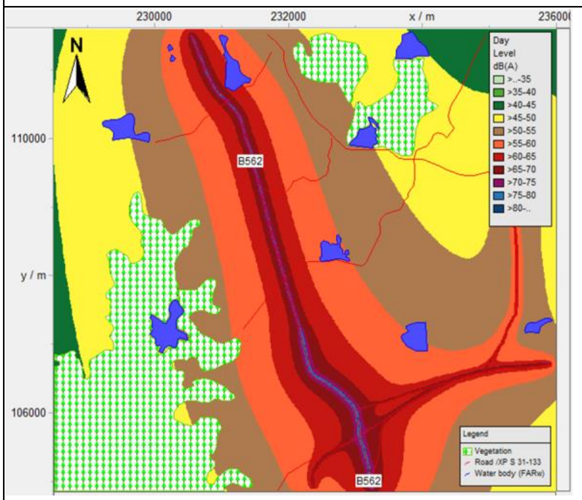

Fig 9: Before widening B562 road.
Source: author

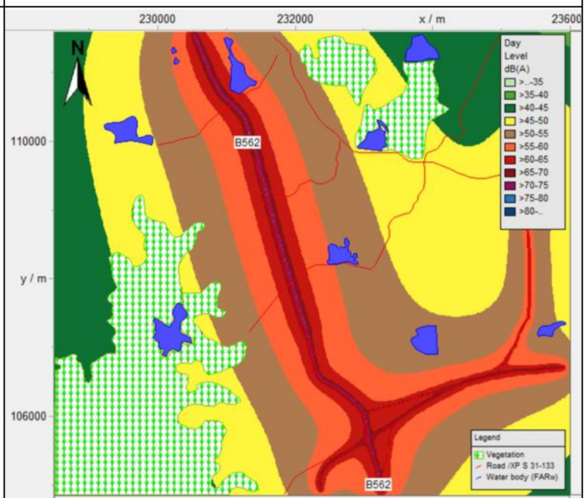

Fig 10: After widening B562 road.
Source: author

According to Table 2, the results revel that the road traffic NLV besides the Class A and Class B roads have reduced due to road widening/improvement even though road traffic volume has increased (TV in Table 2) with time. The last column in Table 2 shows the percentage decrease (- sign) of average noise level due to widening/improvement of roads. It clearly shows that the increase of number of tracks has caused the highest drop of noise level as expected.

Conclusion

The average noise level is found to be reduced in the vicinity of roads studied after widening/improving the roads, even though the traffic volume has been significantly increased. The highest drop of noise level of Class A roads was found to be 3.5 dB or 6.2 % of A24 road even with the increase of traffic volume by 61.5%. For Class B roads, the maximum drop of noise levels was recorded to be 5.8 dB or 12.0 %. Minimum drop of traffic noise level of Class A and Class B roads were found to be 2.2 dB or 3.27 % and 0.2 dB or 0.35 % respectively. The width of the highest noise contour (having L_{Aeq} = 75-80 dB) was decreased by 74.3 % and 30.3 % for Class A and Class B roads respectively. The increase of number of lanes has effectively reduce the traffic noise level.

Although, the improvement of road condition reduces the noise pollution, when the traffic volume is increased beyond a certain value the number of lanes has to be increased to reduce the traffic noise. It clearly indicates that a good traffic flow has to be maintained on roads to maintain a low noise level. This would be the case for most roads in urban cities in Sri Lanka, because the engine noise dominates the noise level produced. The tire noise would be important only when the road conditions are improved and vehicles move at high speeds. As an example, if the highway traffic noise, which would be dominated by tire noise, has to be reduced, the quality of the surface of the road has to be improved with a suitable surface layers. It can be concluded that the noise pollution has to be studied and noise maps of cities have to be considered in planning and designing development of roads in cities in order to maintain the noise level at the recommended levels.

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