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Residential exposure to port noise: a case study of Dublin, Ireland

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Abstract. The World Health Organisation (WHO) has recently acknowledged that contrary to the trend for other environmental stressors, noise exposure is increasing in Europe. While a considerable amount of research has recently been undertaken assessing the extent of noise from road, rail and air transportation in the EU, relatively little research has been conducted internationally assessing the extent of environmental noise within the vicinity of major European shipping ports. Accordingly, this paper reports on research examining the extent of noise exposure for residents within the vicinity of Dublin Port, Ireland using the nation's largest port terminal as a proxy for port noise. Three gantries were erected without planning permission in 2002 but no enforcement proceedings were brought against the operating company prior to a seven-year enforcement period under planning laws expiring. Thus, operational hours and noise levels remain relatively unregulated. In order to assess the level of exposure in the area, a series of long-term measurements were undertaken at the most exposed façade of local resident's homes to determine whether the extent of day-time and night-time exposure was above levels recommended by the WHO. The results show that exposure is significant and well-above guideline limits considered detrimental to human health and quality of life. They also suggest that there may be a low-frequency noise problem in the study area.

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1 INTRODUCTION

Noise has become a major environmental health and policy issue, most notably in urban areas where noise, primarily from transportation but also industrial sources, is generally high. In the European Union (EU), problems with noise pollution have often been given similar concern ratings as those for global warming[1]. In fact, the *Environmental Burden of Disease in Europe* study conducted in six European countries showed that traffic noise ranked second among environmental stressors for their public health impact in European countries[2]. The World Health Organisation[2] has acknowledged that contrary to the trend for other environmental stressors (e.g. second hand smoke, dioxins and benzene), noise exposure is increasing in Europe. Recent estimates of population exposure to noise in the EU put the figure at 41 million highlighting the scale of the acoustic problem.

In Ireland and internationally, Murphy and King[3-4] among others have already pointed to the problem of environmental noise from transportation. However, little research has been conducted internationally as to the extent of shipping-related noise in urban areas and particularly within the vicinity of the major shipping ports. Accordingly, this paper provides preliminary results from an ongoing study investigating the extent of noise exposure within the vicinity of a residential location adjacent to Dublin Port. We also investigate the difference in A and C-weighted noise[5] to provide some indication as to whether a low frequency noise problem exists in the area.

2 RELEVANT LITERATURE

The relationship between noise pollution and human health has been the subject of much research over the last two decades. To a large degree, the primary focus of this research has analysed the impact of noise on the auditory system with the result that it is now well established that prolonged exposure to excessive noise levels can lead to direct hearing loss and/or hearing impairment[6-7]. However, the bulk of the most recent research has tended to concentrate on the non-auditory effects of prolonged noise exposure. A considerable amount of social survey data has demonstrated that the most important non-auditory effects of environmental noise exposure are annoyance and sleep disturbance. In fact, studies have shown that annoyance from transportation noise produces a series of negative emotions some of which include anger, disappointment, unhappiness, anxiety and clinical depression[8-10]. Carter[11] has demonstrated that exposure during the night-time period can cause considerable disruption in stages of the sleep cycle[12] and particularly affects deep sleep stages which are important for physical recuperation. A more serious public health concern is the link between excessive exposure and negative cardio-vascular outcomes such as ischaemic heart disease[13-15]. Indeed, the WHO estimate that 'the burden of disease from environmental noise is approximately 61,000 years[1] for ischaemic heart disease in high-income European countries'[2]. However, this is not the only population cohort at risk; children appear to be particularly susceptible to excessive noise exposure. The most consistent impacts on children exposed to excessive noise levels are considered to be in the arena of cognitive impairments. In particular, tasks involving central processing and language comprehension, including reading, attention span, problem solving and memory appear to be most negatively affected from exposure[16-17]. Adding to this, the reduced motivation of children inside and outside learning settings is also a considerable problem[18].

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[1] Calculated in DALY's (disability-adjusted life-years)

Recognising growing evidence for public health concerns, the EU passed Directive 2002/49/EC - the Environmental Noise Directive (END) - to establish a framework for environmental noise planning and mitigation in 2002. It seeks to develop a common approach towards avoidance, prevention and reduction of the harmful effects (including annoyance) of exposure to environmental noise, on a prioritised basis, using a strategic noise mapping process. In response to the Directive, large scale noise mapping and exposure studies were completed for the first time in many Member States in 2007; the second phase will be completed in 2012 and will be undertaken every five years thereafter. As part of the Directive, information on the extent of population exposure to industrial noise in urban agglomerations was also to be provided.

There is a significant number of studies in the literature investigate the impact population exposure to road transportation noise[4,19] in particular but there are very few studies looking at residential exposure to noise from industrial sources as a result of the requirements of the Directive. In the Irish case, no information on industrial noise sources was presented as part of the first phase of the Directive[20]. This was due to the fact that the City Council found that industrial point sources had no strategic impact on overall noise levels within the Dublin City Council area – quite remarkable given the size of the area. Moreover, this assumption was carried forward for the entire agglomeration[20-21]. Thus, by simply stating that no strategic industrial noise sources exist in the area, the requirements of the Directive were by-passed in this regard.

There have been few noise studies at shipping ports which examine the extent of a low-frequency noise problem in these areas. However, in the literature the relationship between low frequency noise and health has been given considerable attention. Moller and Lydolf[22] analysed the complaints of low frequency noise on 198 persons in Denmark. They found that low frequency sound disturbed and irritated people during most activities and many considered its presence as a torment. In addition, many respondents reported numerous secondary effects including insomnia, headaches and palpitations. Research by Persson et al.[23] found that the annoyance from the low frequency noise was greater than that from the higher frequency noise at the same A-weighted level while Mirowska and Mroz[24] found that subjects exposed to low frequency noise suffered from annoyance and sleep disturbance.

3 STUDY AREA AND OBJECTIVES

Dublin port is Ireland's largest port by volume of tonnage handles and number of vessels received on an annual basis (see Table 1). The port is a state-owned commercial company charged with operating and developing Dublin Port. In an Irish context Dublin Port is unique in that all cargo handling activities are provided by private sector companies who compete against each other. Activity at the port has increased dramatically over the last twenty years and the recent Dublin Port Master Plan, 2012-2040 envisages conservative estimates of throughput growth of 2.5% per annum until 2040 handling up to 60 million tonnes of goods at that point[25].

In Dublin, Marine terminals Ltd (MTL) operate a terminal for the Dublin Port Authority at Pigeon House Road in Dublin Docklands. It is a Lo/Lo (lift on/lift off) container terminal and is Ireland's 'largest and most modern container terminal'[26] with three (45 tonne) ship to shore gantry cranes which can handle up to and including Panamax size vessels. Secondary handling of cargo is carried out by four (40 tonne) rail mounted gantries (RMG's) which are aided by various ground-handling equipment and there are also 300 reefer points[2]. The berth is 700 metres long (see Figure 1). The facility is located directly across from an area where 11 residents have their

[2] A reefer point is the power supply that a refrigerated container plugs in to.

homes, many of them for a substantial number of years. Thus, they are highly susceptible to noise being emitted from the facility (see Figures 1-2).

Three gantries were erected without planning permission in 2002 but no enforcement proceedings were brought against the company prior to the seven-year period for enforcement under planning laws expiring[26]. Thus, much of the activities in terms of operational hours and excessive noise levels remain relatively unregulated. There has already been some evidence that the residents are suffering extensively from exposure to environmental noise including sleep deprivation and the associated secondary health stressors of that exposure. It is within this context that the current research is being carried out.

Bearing that in mind, the objective of the study was to determine the extent of noise exposure to residents in the vicinity of Dublin Port using the Pigeon House Road terminal as a proxy for shipping-related port noise. In addition, the study also sought to investigate the extent of low frequency noise in the study and assess the noise exposure dose-effect relations.

4 METHODS

In order to assess residential exposure to noise in the study area a series of long term measurements were carried out at the port terminal. Figure 1 shows a map of the study location, the port area operated by MTL, the Coastguard resident's area as well as the location of the sound level metre (SLM) erected for long term measurement.

There was particular concern with the number of noise sources at the location (and their height); these included operations which lead to noise emissions including:

- Movement of cranes along the crane rails
- Reversing sirens of the cranes
- Engine noise
- Banging of unloaded shipping containers
- Ground vehicle movement to support unloading and stacking of containers
- Other unidentified noise (perhaps LFN)

Thus, the calibrated SLM was erected at a secure location 1.5 metres from the building façade of a resident's home and at 4 metres above ground level (see Figure 3). The location of the SLM was directly across the road from the activity site (c. <10 metres). 24-hour noise measurements were taken for a period of 16 days between April 22nd and May 7th, 2012. Measurement intervals were taken in blocks of 15 minutes in accordance with ISO 1996:1 and noise was logged every 20 seconds during that period.

We were interested in acquiring information particularly on night-time noise at the study area and thus logged noise information relating to L_{90} (as a background noise indicator) as well as L_{eq} for the entire period. We also had co-operation from the residents association in logging night-time handling activity at the site which enabled us to gain a more complete picture of the data being logged and allowed for cross-checking of noise levels with related site activity.

Aside from the foregoing, we were also eager to investigate the potential for the site to emit low frequency noise. Given the nature of the noise sources at the site, we felt that the various A-weighted noise indicators night not provide a totally accurate picture of the night-time noise environment. In the literature, the difference between C and A-weighted noise levels have been considered as a predictor of annoyance[5,26] due to the difference being an indicator of the amount of low frequency energy in the noise. If the difference between the noise values for the two weightings is greater than 15 dB, there is potential for a low frequency noise problem and problems with this type of noise can be considered more annoying than A-weighted noise[5]. Thus,

we logged data on each of the various noise indicators in both the C and A- weighted frequency bands.

5 RESULTS

Tables 2 displays the A and C-weighted noise levels using the various indicators measured during the night-time period. They also show nights where known port activity was occurring. Table 2 reports only night-time noise activity; from a public health perspective, night-time noise-related annoyance and sleep disturbance are considered to be more detrimental to public health[2] than day-time exposure so we concentrated the analysis on these results. In addition, Figures 4-6 provide a graphical 24-hour time series of noise measurements ($L_{90,\ 8hrs}$ and $L_{eq,\ 8hrs}$) for each of the 15 nights under consideration.

For the A-weighted results, it can be seen that the $L_{90,\ 8hrs}$ values show us that background noise ranged from 30.1 – 42.1 dB over the 15 nights. It is worth noting that the latter value (42.1) was recorded during a night when there was registered terminal activity. Indeed, when the measured $L_{90,\ 8hrs}$ values are considered for nights with no activity (34.6) versus those with activity (39.6), an average difference of 5dB is evident indicating that activity at the site has a considerable impact on background noise levels. If we compare these values to the $L_{eq,\ 8hrs}$ values – which take account of sporadic noise events – we can see that, as expected, the range is higher (43.3 – 50.5). Moreover, the mean value during nights with activity was c. 2dB higher (47.3) when compared with nights of no activity at the site (45.2). The impact that activity has on the noise environment can be seen clearly in Figure 7 whereby averaged $L_{eq,\ 15mins}$ with activity is considerably above the corresponding value without activity. However, what is important to note here is that when we analyse data against the true background noise level (i.e. $L_{90,\ 8hrs}$ with no activity), it can be seen that noise during activity nights is c. 13 dB above true background levels. This indicates that activity significantly alters the quality of the sound environment in the area and in a negative manner. Ultimately the results imply that during nights where activity is present, the noise level exceeds the WHO night-noise guideline limit (40 dB(A)) by more than 7 dB(A). Even if the Irish EPA[28] onset guideline values for triggering a noise mitigation response (which were used under the first phase of the END) are considered (45 dB(A), L_{night}), the problem is considerable enough to warrant a mitigation response.

Turning to the C-weighted measures, it can be seen that, as expected, the values are higher. In analysing the results, we were eager to investigate whether the measured values suggested that a low frequency noise problem might exist. The work of Kjellberg et al.[5] has suggested that if the difference between A and C-weighted values exceeds 15dB then a low frequency noise problem may exist. While this does not provide definitive proof of a low frequency noise problem, it points to the need for further investigation within narrower frequency bands. Our results show that during nights where activity exists the dB(C)-dB(A) value exceeds the 15 dB threshold for three out of the four nights (Table 2). By way of contrast, the dB(C)-dB(A) value only excees 15dB for one of the nights when there is no activity and this night can be discounted as an outlier due to high winds on that particular night (night 4). Figure 8 also shows a comparison between dB(C)-dB(A) values where it is evident that a considerable difference – almost always above the 15 dB threshold - exists between the A and C-weighted values during activity versus non-activity. This implies that a low frequency noise problem may exist in the area and highlights the need for further investigation of the noise environment within the narrower frequency bands.

The research of Kjellberg et al[5] suggests that if a low frequency noise problem exists a useful rule of thumb is to add 6 dB to the corresponding A-weighted value. If this were applied

to our results during nights with site activity then the real mean night-noise value for $L_{eq,\ 8hrs}$ is actually 53.3 dB(A). This implies an even more serious noise nuisance problem in the area during nights where site activity exists with A-weighted values of more than 13dB above guideline limits outlined by the WHO.

6 CONCLUSIONS

It is important to note that the results from the current research are preliminary and form part of a wider investigation into port noise and residential exposure at the study location. Nevertheless, the research points to some tentative conclusions. First, average $L_{eq,\ 8hrs}$ noise levels in the study area during activity nights exceeds 47 dB(A) more than 7 dB(A) above the recommended levels above which the WHO consider levels to be detrimental to human health. This implies that the scale of the noise problem in the area is considerable.

Second, when the vales for C-weighted noise were consulted we found that the differential between dB(C)-dB(A) values more or less consistently exceeded the threshold of 15 dB which Kjellberg et al[5]suggests could be indicative of a low frequency noise problem. Moreover, this suggests that 6 dB should be added to the A-weighted indicators implying that the mean $L_{eq,\ 8hrs}$ value when site activity exists is more than 13 dB(A) above the WHO limit; this indicates more than a doubling of the sound pressure in the area over the recommended level. This is quite a serious issue especially when one considers that noise in the area results from activity at an adjacent site which may be unlawful development.

Finally, the preliminary results point, in particular, to the need for further research in the narrower frequency bands in order to investigate more thoroughly whether a low frequency noise problem exists in the area. Future research will also include further long-term measurements as well as an assessment of dose-effect relationships in the area.

7 ACKNOWLEDGEMENTS

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6 REFERENCES

1. CALM (2007) Research for a quieter Europe in 2020. Strategy paper of the CALM II network; 2007.

2. World Health Organisation (2011) Burden of disease from environmental noise, Bonn: WHO and JRC.

3. Murphy, E. and King, E.A. (2010) Strategic environmental noise mapping: methodological issues concerning the implementation of the EU Environmental Noise Directive and their policy implications'. Environment International, 36 (3):290-298.

4. Murphy, E. and King, E.A. (2011) Scenario analysis and noise action planning: modelling the impact of mitigation measures on population exposure. Applied Acoustics, 72 (8):487-494.

5. Kjellberg, A., Tesarz, M., Holmberg, K., Landstrom, U. (1997) Evaluation of frequency-weighted sound level measurements for prediction of low-frequency noise annoyance. Environment International, 23, 519-527.

6. Prasher D. (2003) Estimation of hearing damage from noise exposure. World Health Organisation and European Centre for Environment and Heath Report on the Technical meeting of exposure-response relationships of noise on health, Bonn, Germany, 17–19 September 2002.

7. Ingle, S.T., Pachpande, B.G., Wagh, N.D., Attarde, S.B. (2005) Noise exposure and hearing loss among the traffic policemen working at busy streets of Jalgaon urban centre, Transportation Research D, 10, 69-75.

8. Fields JM. (1998) Reactions to environmental noise in an ambient noise context in residential areas. Journal of Acoustical Society of America, 1998, 104, 2245–60.

9. Miedema M.E. (2003) Relationship between exposure to single or multiple transportation noise sources and noise annoyance. World Health Organisation and European Centre for Environment and Health Report on the Technical meeting of exposure–response relationships of noise on health. Germany: Bonn.

10. Michaud DS, Keith SE, McMurchy D. (2005) Noise annoyance in Canada. Noise Health, 7, 39–47.

11. Carter, N.L. (1996) Transportation noise, sleep, and possible after-effects, Environment International, 22, 105-116.

12. Thiessen, GJ. Effect of traffic noise on the cyclical nature of sleep. Journal of the Acoustical Society of America 1988; 84:1741-1743.

13. Babisch W, Ising H, Gallacher JEJ. (2003) Health status as a potential effect modifier of the relation between noise annoyance and incidence of ischaemic heart disease. Occupational and Environmental Medicine, 60, 739–745.

14. Babisch W, Beule B, Schust M, Kersten N, Ising H. (2005) Traffic noise and risk of myocardial infarction. Epidemiology, 16, 33-40.

15. Belojevic G, Jakovljevic B, Stojanov V, Paunovic K, Ilic J. Urban road-traffic noise and blood pressure and heart rate in preschool children. Environment International, 34, 226-231.

16. Evans GW, Lepore SJ. (1993) Nonauditory effects of noise on children, Children's Environment, 10, 31–51.

17. Evans GW, Maxwell L. (2005) Chronic noise exposure and reading deficits: The meditating effects of language acquisition. Environment and Behaviour, 29, 1514–1523.

18. Evans GW, Lercher P, Meis M, Ising H, Kolfer WW. (2001) Community noise exposure and stress in children. Journal of Acoustical Society of America, 109 (3), 1023–1027.

19. Murphy, E., King, E.A. and Rice, H.J.; (2009) 'Estimating human exposure to transport noise in central Dublin, Ireland'. Environment International, 35 (2):298-302.

20. King, E.A., Murphy, E. and Rice, H.J.; (2011) 'Implementation of the EU Environmental Noise Directive: Lessons from the first phase of strategic noise mapping and action planning in Ireland'. Journal of Environmental Management, 96 (3):756-764.

21. Dublin City Council (2007) Dubli City Council Noise Mapping Project: Noise Maps, Reports and Statistics. Dublin City Council Noise Mapping Project, Traffic Noise and Air Quality Unit.

22. Møller, H., and Lydolf, M. (2002): A questionnaire survey of complaints of infrasound and low frequency noise. Journal of Low Frequency Noise and Vibration, 21, 53 - 65.

23. Persson, K., Björkman, M., and Rylander, R. (1985): An experimental evaluation of annoyance due to low frequency noise. Journal of Low Frequency Noise and Vibration, 4, 145-153.

24. Mirowska, M., and Mroz, E. (2000): Effect of low frequency noise at low levels on human health in light of questionnaire investigation. Proceedings of Inter-Noise 2000, 5, 2809 - 2812.

25. Dublin Port Company (2012) Dublin port company masterplan, 2012-2040. Dublin: Dublin Port Company.

27. Broner, N. (1978) The effects of low frequency noise on people: A review, Journal of Sound and Vibration, 58, 483-500.

26. McDonald, F. Residents complain of noise at night, Irish Times, May 16th 2011.

28. Environmental Protection Agency (2009) Guidance Note for Noise Action Planning for the First Round of the Environmental Noise Regulations 2006. Environmental Protection Agency, Ireland.

Table 1 - Dublin Port Tonnage and Arrival Statistics

	2004	2005	2006	2007	2008	2009	2010
Tonnage ('000)	47720	52146	53318	54139	51081	41836	45071
Arrivals	7502	7579	7427	7872	7621	7379	7579

Source: CSO and dublinport.ie

Table 2 - Results of long-term measurements using A and C-weighted indicators

	$L_{90,\ 8hrs}$ (A)	$L_{eq,\ 8hrs}$ (A)	$L_{90,\ 8hrs}$ (C)	$L_{eq,\ 8hrs}$ (C)	$L_{eq,\ 8hrs}$ dB(C)-(A)	
Night 1	30.3	45.0	42.5	55.8	10.8	
Night 2	30.1	44.5	44.5	56.2	11.7	
Night 3	36.0	44.6	48.3	58.9	14.3	
Night 4	40.0	47.8	51.4	68.4	20.6	
Night 5	33.5	46.7	48.1	58.4	11.7	
Night 6	41.4	47.5	56.1	60.6	13.1	
Night 7	39.0	46.9	54.2	64.2	17.3	Activity
Night 8	39.0	47.4	54.3	68.1	20.7	Activity
Night 9	42.1	50.5	54.8	63.3	12.8	Activity
Night 10	35.5	44.7	48.1	56.7	12.0	
Night 11	31.3	44.6	49.5	59.1	14.5	
Night 12	31.0	44.8	44.8	56.2	11.4	
Night 13	38.2	43.3	48.5	56.3	13.0	
Night 14	33.5	43.8	47.3	57.6	13.8	
Night 15	38.3	44.2	48.8	61.1	16.9	Activity

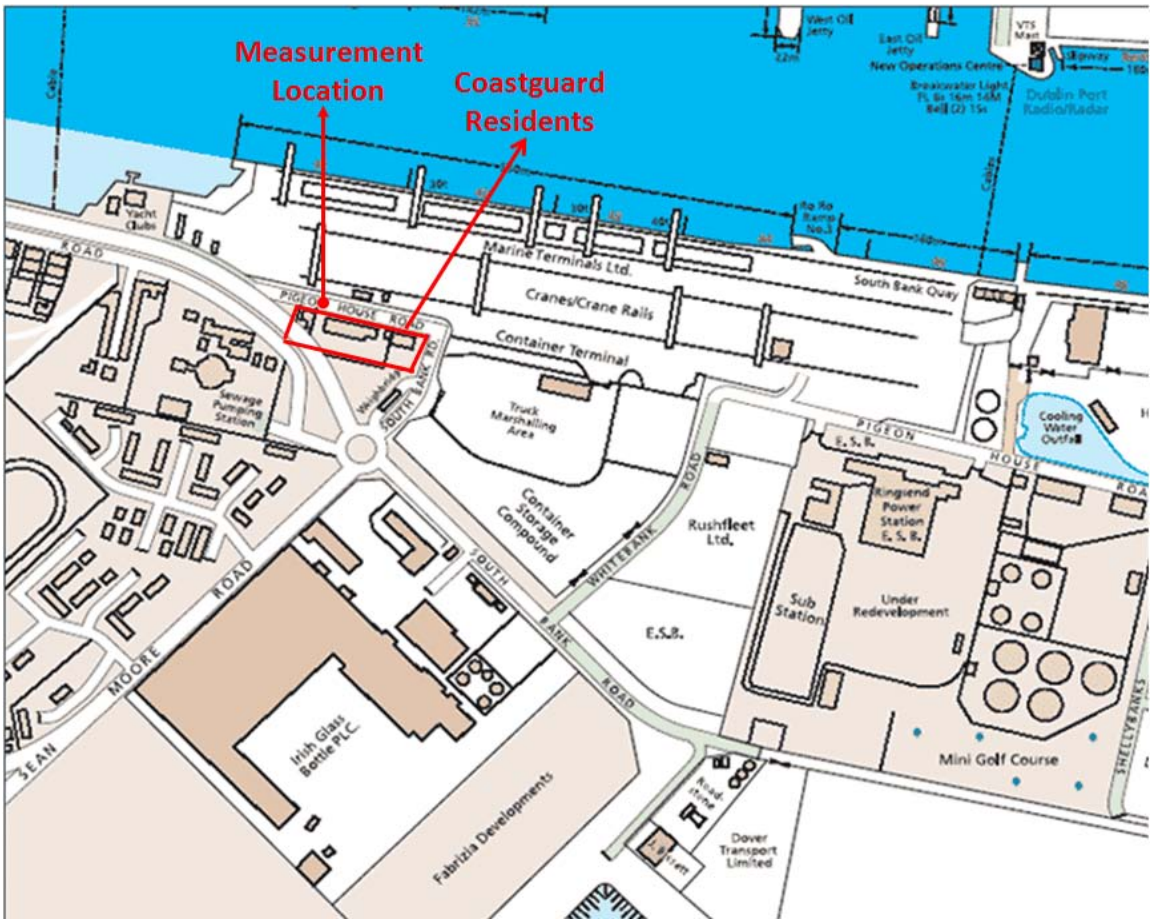

Figure 1 - Study area, SLM and Coastguard Residents' location

Figure 2 - Gantry cranes at MTL Ltd. Terminal, Pigeon House Road, Dublin Port

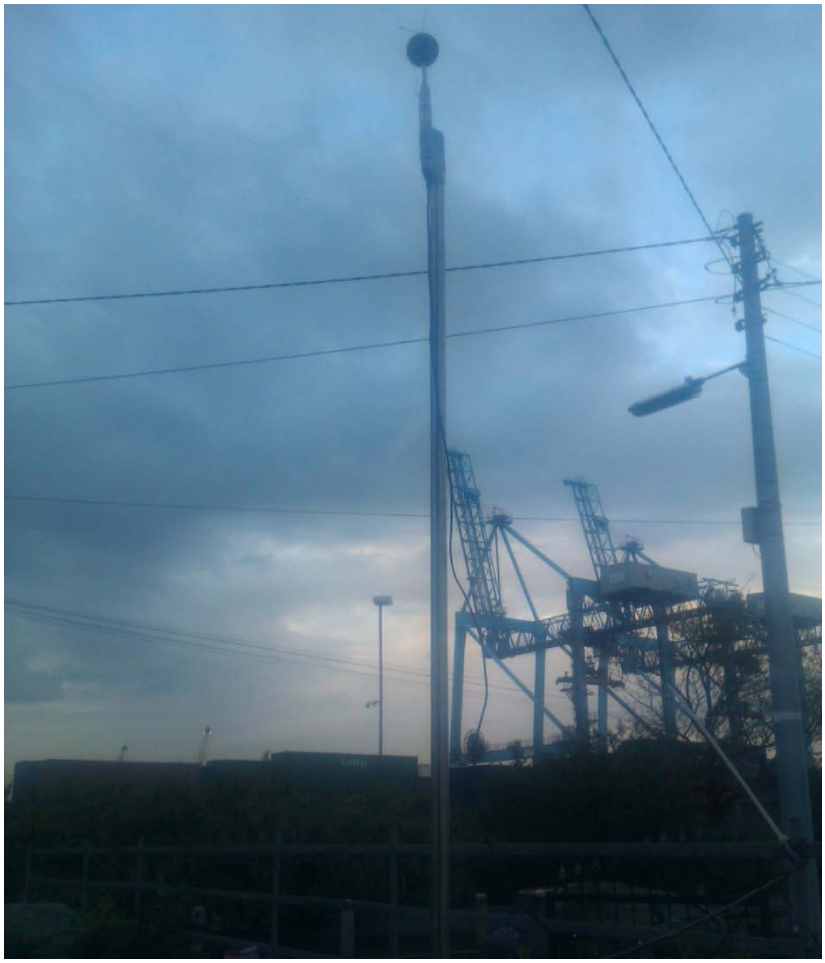
Figure 3- Microphone mounted at the study site with gantry in the background

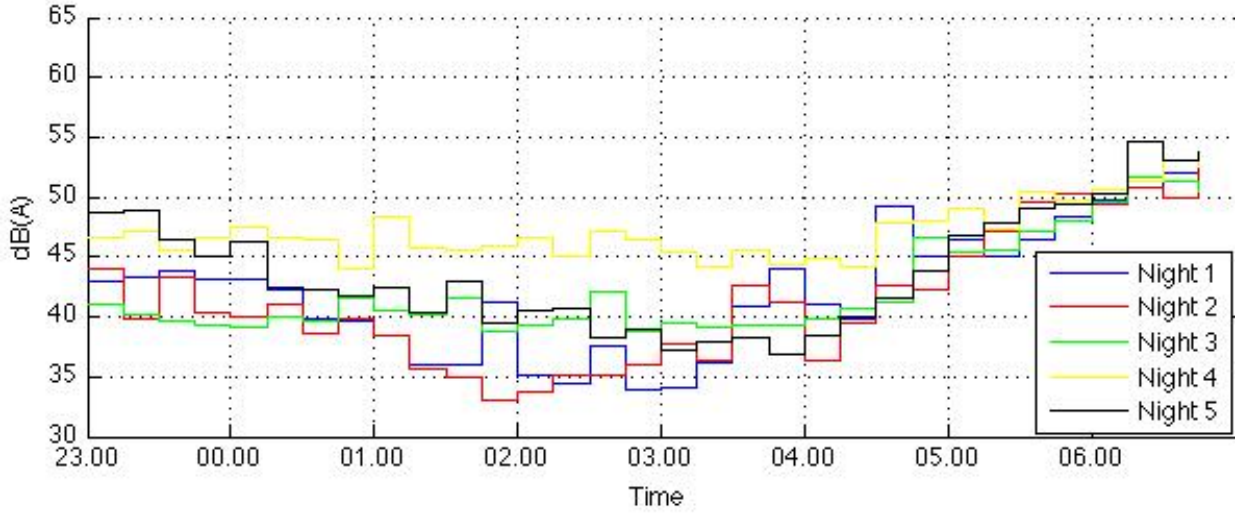

Figure 4 – $L_{eq,\ 8hrs}$ *Results for Nights 1-5*

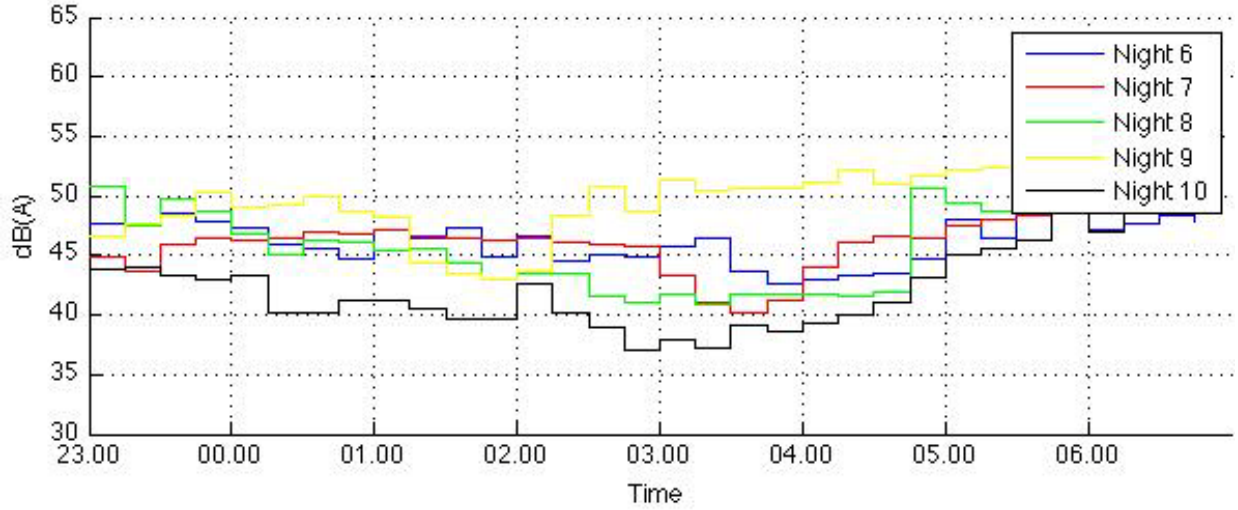

Figure 5 - $L_{eq,\ 8hrs}$ *Results for Nights 6-10*

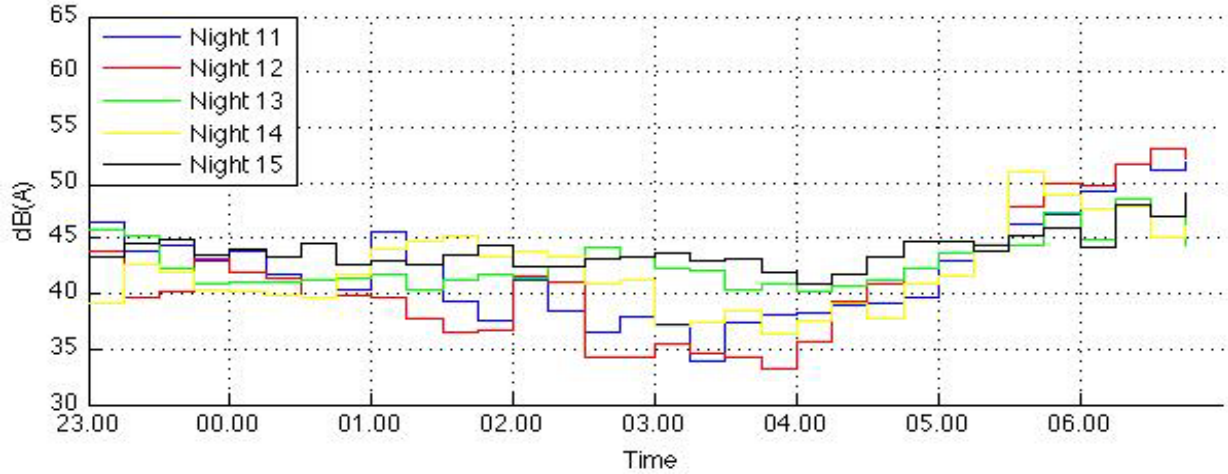

Figure 6 - $L_{eq,\ 8hrs}$ *Results for Nights 11-15*

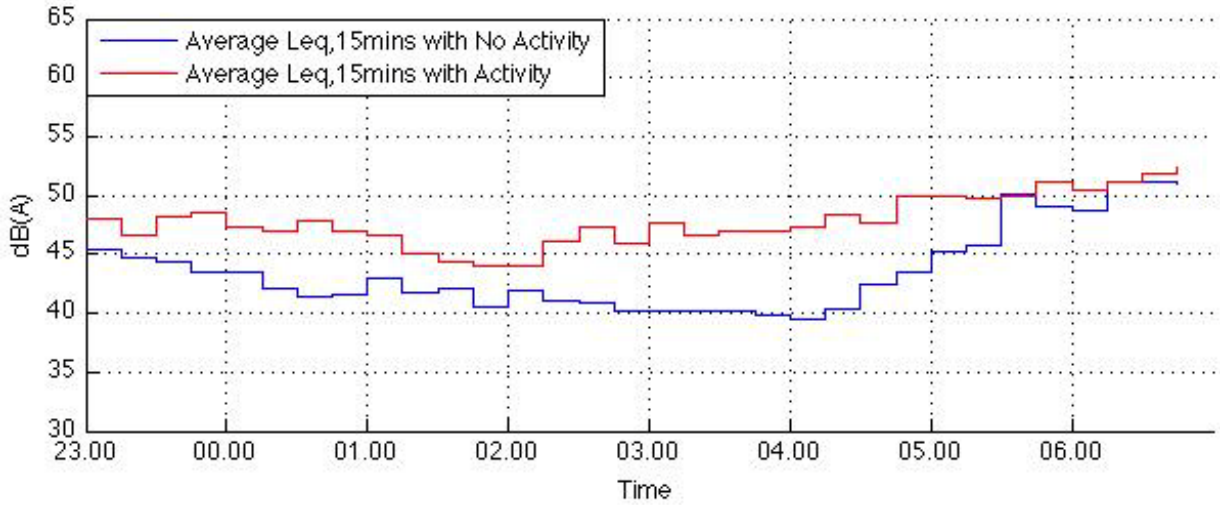

Figure 7 - $L_{eq,\ 15mins}$ *Results for A-weighted Results for Night-time Noise*

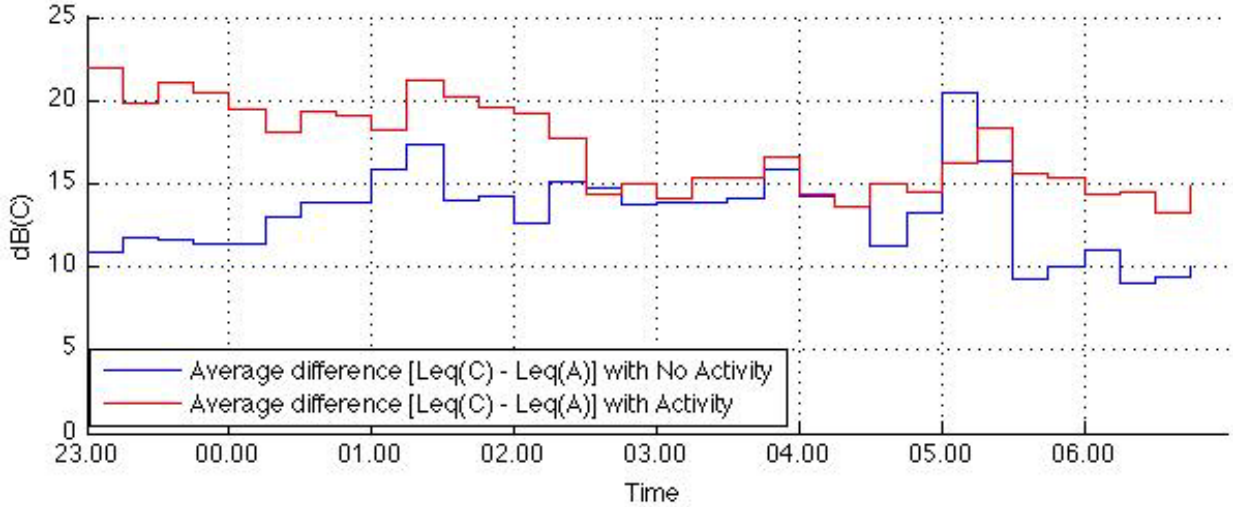

Figure 8 - $L_{eq,\ 8hrs}$ *Results for A and C-weighted Night-time Noise*