Assessment of Noise Levels from Anthropogenic Activities and its Impacts around the Federal Lighter Terminal, Onne, Nigeria

Gbarato, O. L., Nte, F. U. and Abumere, O.E.

Abstract

This study is aimed at assessing the emitted noise levels from the Quayside apron at the Federal Lighter Terminal, Onne, Nigeria. Noise levels and Geographical Position measurements were undertaken with the TES 1350 Sound Level Meter and a suitable Geographical Positioning System (GPS). Mapping of the measured noise levels were undertaken using combination of the emitted noise levels and their corresponding geographical positions at each of the measurement points. The result of the noise level measurement showed that the emitted noise levels range between 98.80dBA at the centre of this expansive quayside appron to 48.80dBA at radial distance of 50.0m from this facility. The measured noise levels within this facility and those at radial distances up to 15m were higher than the level specified by the provisions of the applicable regulation. The responses from the exposed workers indicate that the emitted noise negatively impacts their cardiovascular health conditions, hearing, sleep and cognition/concentration as well as causes stress. Similarly, the result of the Chi Square analysis, at .05 level of significance, shows significant association between the emitted noise levels and its impacts on the psychological and physiological health conditions of the exposed personnel using the responses of these personnel. These responses have a calculated Chi Square value of 22.67 against a critical value of 18.31. Following the results of this study, it is recommended that the provisions of the applicable legislation should be adequately enforced to ensure that appropriate technical measures are put in place to have reduction in the emitted noise levels and/or reduction in exposure time**.**

Keywords: Assessment, Noise Levels, Anthropogenic, Activities, Impacts, Federal Lighter Terminal, Quayside.

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Introduction

Ports and harbours form integral part of an efficient transport system that allows for economical voyage of bulk goods, resources and humans for the purpose of expanding world trade and for globalization. This realization of the significant roles played by ports and harbours in exploiting the economic potentials of any nation and position its economy on a sound footing is achieved through establishment and institutionalization of effective and efficient transport and communication mechanism for trade and globalization.

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The need for effective and efficient ports and harbour facilities and operational systems for the enhancement of trade and globalization has led to the actualizations, since the 20th century, of wide range of innovations that has culminated into inventions of technologies such as cars, airplanes, large bulk careers and container ships [1], which has greatly increased participations in world trade and globalization through establishment of global shipping networks, constructions of various port infrastructures and institutions of port reforms. Reforms such as deregulation of port operations and transportation infrastructures as well as increased corporatization and privatization of port management will greatly improve efficiencies in activities and operations within the port. This increased participation in trade and globalization owe its increase and expansion to the oil boom of about 6 decades ago.

In spite of the economic potentialities of sea ports, harbours and container terminals in terms of its role in the enhancement of trade and globalization, ports operations have been known to be a significant source of noise emission to its immediate environment. The noise emission from operations and activities with these transportation infrastructures result from the varying and complex nature of its activities and operations, which in most cases, makes the oceans within and around the port areas, a complicated freight hub with some accompanying container complexes. Schenone [2] emphasized that this scenario makes noise emissions around ports and harbours the product of a complex web of sound sources having varying characteristics. Some of the significant sources of noise pollution around ports and harbours include noise from ferries, ships and container loading/offloading operations. Similar position was taken with regard to the characteristics and/or complexities of the noise from transportation infrastructures by Khoo and Nguyen [3] and Khoo and

Nguyen [4] in their positionss that noise levels generated during container terminal operation at ports vary depending on the type of equipment and the nature of the work being performed and further classified noise sources around ports and container terminals into specific noise sources, consisting of noise from warning sirens on cranes, straddle carrier ship horns etc., and the general plant noise sources resulting from noise from electric motors attached to gantry cranes, ship generators, forklifts, yard tractors etc. For instance the terrestrial and underwater acoustic output produced from a combination of ship, its accompanying straddle carriers, cranes, forklifts, trucks as well as other subsidiary activities and operations contribute significantly to the ambient noise levels within these facilities and its environment. For this reason, Di Bella and Remiji [5] and Hyrynen, et al [6] described port areas as having a complicated geometry characterized with a complexity of sources that are present within its confinement. In a similar report produced by the Danish Environmental Protection Agency (Danish EPA) [7], it was shown that significant noise levels are produced from diesel generator engine exhausts, ventilation systems and from secondary sources within ships at berth within the port. The orientation and height of diesel engine exhausts, used for power generation on board ships and other ocean-going vessels usually makes them produce enormous noise levels which, usually propagate over large distances. Other sources of noise emissions within ships such as its ventilation systems (including engine room ventilation systems, cargo ventilation systems, Air conditioning systems and fans) as well as secondary sources like the diesel generator used for power generation and noise from hydraulic pumps, similarly makes ships predominant noise sources during berth. Calton and Vlasic [8] also enumerated the sources of noise and vibrations to resulting from ships to include the shaft line dynamics, propeller-radiated pressure and bearing forces, air-conditioning systems, maneuvering devices (such as its transverse propulsion units), cargo handling mechanisms, intake and exhausts and slamming phenomena. McKenna et al. [9] had earlier posited that most of the generated noise from large ships emanate from propeller cavitation as a result of formation of bubbles at the propeller blade tip. From the foregoing, it can be seen that underwater ship noise are incidental by-product of standard ships/shipping operations, especially from propeller cavitation, “[10],[11]”. In addition to several noise-emission mechanisms of individual ships and other marine vessels, McKenna et al [12] attributed the increase in the noise levels from such ships and other water-going vessels to increase in the number, size, propulsion power and to other embedded and complex sophistication mechanisms inherent within these water transport machinery.

From the foregoing, it is clear that port areas contain several noise sources in various sectors with varying characteristics including ferries, ships and trade operations, industrial and shipyards as well as other ancillary services which strongly impact the environment of the surrounding port area, and consequently the port personnel, local population and the terrestrial and marine ecosystems. The strength of the impact from exposure to sure noise level depends largely on the sound pressure at the receiver from exposure to noise such noise source. In a report Danish EPA [7], it was shown that the basic propagation model depicting the sound pressure level (L_P $in\ dB\ re\ 2\mu Pa$) at a receiving position from a sound source is given by

$$L_P = L_W - 10log_{10}(4\pi r^2) \qquad (1)$$

Where L_W is the sound power level of the source ($re\ 10^{-12}$) and r is distance from the source (in metres). It should be noted that equation (1) is applicable to spherical sources in which the sound source has equal intensities in all directions as it is the case with ships in ports and imply that the further away from these ocean-going vessels a receiver is positioned, the lower the sound pressure level that will be received and vice versa. This clearly shows that port personnel and other port users as well as marine living organisms within and around these vessels, especially during berth, are at higher risks of serious physiological and psychological health hazards.

Studies have shown that apart from causing annoyance, noise from ships and shipping operations and activities in harbours, ports and container terminals can similar result to more severe health effects such as cardiovascular diseases, sleep disorders, hearing impairment, high blood pressures, reduced performances and aggressive behaviours, due to long term exposure. The World Health Organisation [13] stated that at least one million life years are lost annually to exposure to noise pollution in Europe. This consciousness about the health effects of noise on both humans and marine fauna has made noise to be one of the prioritized environmental issues for seaports, harbours and container terminals resulting in tightening regulations and various researches studies aimed at unraveling more information about its risk factors in different aspects and areas of ship operations. A study by Curcuruto et al [14] showed that exposure to noise levels above $85dB$ for prolonged time period will produce severe negative impacts on both the ecosystem, urban population and the port personnel and will result in harmful effects and damages on human health (such as hearing and cardiovascular disturbances, high blood pressure, sleep disturbances, reduction in efficiency, annoyance, mental stress and lack of concentration). Niemann et al [15], Sust and Lazarus [16] had through separately studies, posited, that noise has severe impacts on health, interrupts activities and disrupt normal cognitive process. An evidence-base report showing the extent to which noise pollution is a serious public health concern was strongly emphasized by the World Health Organisation Report [13] in which noise pollution was ranked second among a series of environmental stressors following their public health impacts. In addition to elucidating on the extent of this public health menace, this report similarly gave a quantifiable overview of the extent of this problem by estimating that about 45000 years are lost for cognitive impairment in children in Europe, 903000 years for sleep disturbance, 21000 years for tinnitus and 587000 years for annoyance.

Underwater sound emissions also pose significant problem to marine living organisms by either directly disturbing their hearing or by modifying their behavioural patterns. The disturbing effects of these anthropogenic sounds is due to their unusually higher intensities and frequencies which are far above those of the natural sounds produced from biotic and abiotic sources within the marine environments and will therefore result to severe adverse impacts on marine species [17]. For this reason Badiuro et al [18] posited that noise from ships and other marine vessels similarly radiates into the marine environment to the extent that it generates same effects through its diffused sources thereby increasing the background noise levels of the oceans causing global alterations of the living conditions of marine fauna. Other reports have similarly emphasized the extent of anthropogenic sound from ships and other marine vessels on the marine ecosystem in terms of its impacts as sources of disturbance that causing marine animals to abandon their habitats, alterations of their behaviours or interfacing with their living routines by masking useful acoustic communication signals over large areas. Similar studies have shown that anthropogenic sounds have direct and indirect associations with acoustic masking of essential sounds [19], thereby causing cochlear damage causes alterations of individual and/or social behaviours [20], hampers body metabolism and hampers embryogenesis [21].

The Federal Lighter Terminal (FLT) is situated within the Onne Oil and Gas Free Zone (OGFA), Port Harcourt, Nigeria and significantly supports deep offshore oil and gas production and exploration operations. This terminal is a serious oil and gas business hub with total boundary area of 3,580,000 Sq. metres; total industrial area of 2,290,894 Sq. metres; total quay apron area of 61,305 Sq. metres; warehouse covering 93,680 sq. metres and offices covering 22,745 sq. metres. With regard to equipment, the terminal accommodates 56 cranes (including the 124T, 144T and 208T mobile harbor cranes); 95 forklifts (including 16-40T forklifts, Reach Stackers and Pettibone Pipe Handlers); 85 Electric Power Generators (including 13 1001-2000 KVA diesel generators, 2 501-1000 KVA diesel generators) and other ancillary equipment that emits significant noise levels.

Materials and Methods

The Sound Pressure Levels around the quayside were measured with the aid of the TES-1350A Sound Level Meter within the plant (0.00m) and at radial distances of 5.00m, 10.0m, 15.0m, 20.0m, 25.0m, 30.0m, 35.0m, 40.0m, 45.0m and 50.0m away respectively. The Sound Level measurements were taken at heights of 1.5m above normal ground (ISO 8297) [22]. The sound level meter was held steadily as far away from the body as possible and far from hard reflecting surfaces during the measurements. The meter function selector was set on 'slow' and the weighting network set on 'A' for the dBA scale reading.

Contour maps of the measured noise levels at each of the radial distances were also drawn to give a pictorial distribution of the noise levels by taking measurements of the emitted noise level and the geophysical positions at the centre of the apron with the use of a Geographical Positioning System (GPS). Measurements of the noise levels and geographical positions were repeated at radial distances of 5.0m, 10.0m, 15.0m, 20.0m, 25.0m, 30.0m, 35.0m, 40.0m, 45.0m and 50.0m. The combined noise level and geographical positions established within the quayside and at the aforementioned radial distances were then joined up to form a contour map of the emitted noise level.

An Exposure-Impact Evaluation (EIE), involving the use of adequately-structured questionnaires issued to personnel of the safety, operations, utility and engineering departments working within and around this expansive quayside apron, was similarly undertaken. Three Hundred and Eight (308) questionnaires were issued to elicit response on the effects of the emitted noise level on their physiological and psychological well- being. Specifically, the questionnaire items were premised on evaluating the effects of the emitted noise levels on stress, tinnitus/hearing impairment, cognitive impairment, sleep disturbances and cardiovascular disorder. The questionnaires were issued to personnel who have spent between 2 to 5 years working within and around this facility. Some of the respondents completed the questionnaires without assistance while others were assisted by the researcher to enable them have proper understanding of the items so as to avoid misunderstanding, incomplete responses and non-return of the questionnaires. The questionnaires were analyzed using descriptive statistics such as mean, standard deviation (SD) and coefficients of variability (CV) while the chi-squared (X^2) test was utilized to test for associations between responses and the effects of the emitted noise levels. The smaller the CV values, the more the coherence in the responses and vice versa.

Results and Discussions

Table (1) and figures (1) and (2) show the results the noise level measurements and their corresponding Geographical Positions as well as those of the noise level mapping at the aforementioned radial distances. The measured noise levels range from 98.80dBA at the centre of the quayside apron to 93.50dBA at a radial distance of 5m, 87.30dBA at 10m, 82.90dBA at 15m, 76.50dBA at 20m, 70.15dBA at 25m, 65.90dBA at 30m, 61.70dBA at 35m, 56.80dBA at 40m, 52.70dBA at 45m to 48.80dBA at 50m away from the apron. The results show that the noise levels within the quayside to which personnel are exposed exceed permissible maximum exposure limit by the National Environmental (Noise Standards and Control) Regulation, 2009 of the National Environmental Standards Regulations and

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Enforcement Agency (NESREA)[23] which stipulates a maximum exposure level of 90 dBA for an 8hr working period. This exposure level shows that there is a high possibility of developing some psychological and physiological health conditions following continuous exposure to these high noise levels.

Table (1)

Sound Level and geographical Position at the FLT Quay Side Onne

Distance (m)	Geographical Positions North	East	Sound Level $dB(A)$
0.00	N 04^0 38’ 38.6”	E007^0 08’17.6”	98.80
5.00	N 04^0 38’ 43.20” E007^0 08’17.6”	E007^0 08’21.30” N 04^0 38’ 38.6”	93.50
10.00	N 04^0 38’ 47.50” E007^0 08’17.6”	E007^0 08’25.70” N 04^0 38’ 38.6”	87.30
15.00	N 04^0 38’ 51.30” E007^0 08’17.6”	E007^0 08’29.90” N 04^0 38’ 38.6”	82.90
20.00	N 04^0 38’ 55.30” E007^0 08’17.6”	E007^0 08’34.70” N 04^0 38’ 38.6”	76.50
25.00	N 04^0 38’ 59.20” E007^0 08’17.6”	E007^0 08’39.50” N 04^0 38’ 38.6”	70.15
30.00	N 04^0 39’ 03.10” E007^0 08’17.6”	E007^0 08’ 44.30” N 04^0 38’ 38.6”	65.90
35.00	N 04^0 39’ 08.30” E007^0 08’17.6”	E007^0 08’48.90” N 04^0 38’ 38.6”	61.70
40.00	N 04^0 39’ 12.50” E007^0 08’17.6”	E007^0 08’53.70” N 04^0 38’ 38.6”	56.80
45.00	N 04^0 39’ 17.20” E007^0 08’17.6”	E007^0 08’ 57.20” N 04^0 38’ 38.6”	52.70
50.00	N 04^0 39’ 11.80” E007^0 08’17.6”	E007^0 09’ 01.70” N 04^0 38’ 38.6”	48.80

Contour maps of the measured noise levels using the provisions of the relevant regulations [23] are as shown in figures (1) and (2). The mapped noise levels revealed pictorially that noise levels of 98.80 dBA to 82.90 dBA from the centre of the quayside apron to a radial distance of 10m from the plant are highly hazardous. Noise levels of 76.50 dBA at a radial distance of 20m from the quayside to levels of 61.70 dBA at 35m from the quayside are potentially hazardous following continuous exposure while levels below 60.0 at radial distance of 40m and beyond are safer for the exposed personnel.

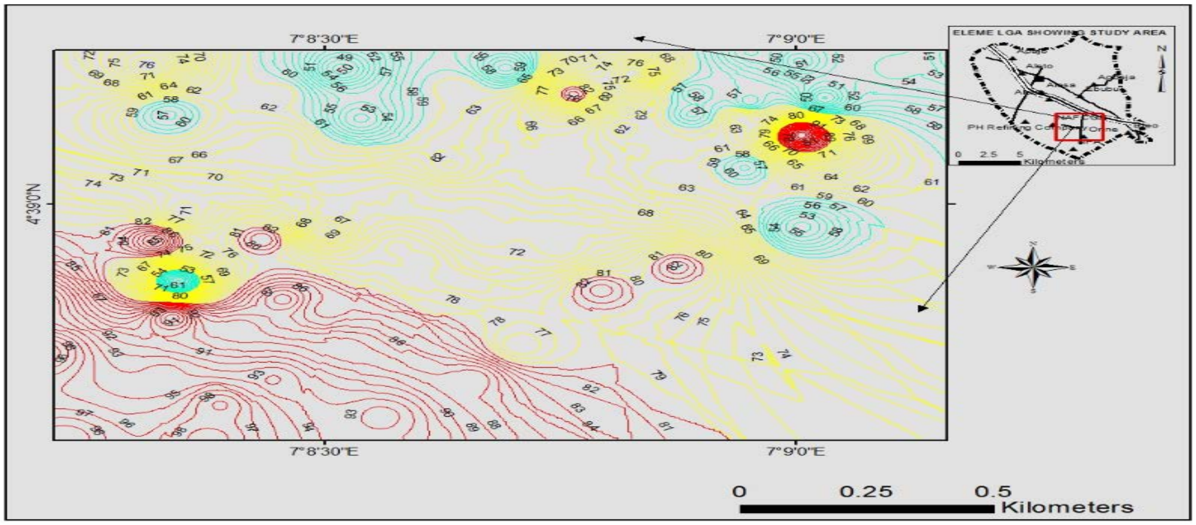

Fig. (1): Gridded Map of the Measured Noise Levels around the FLT Appron.

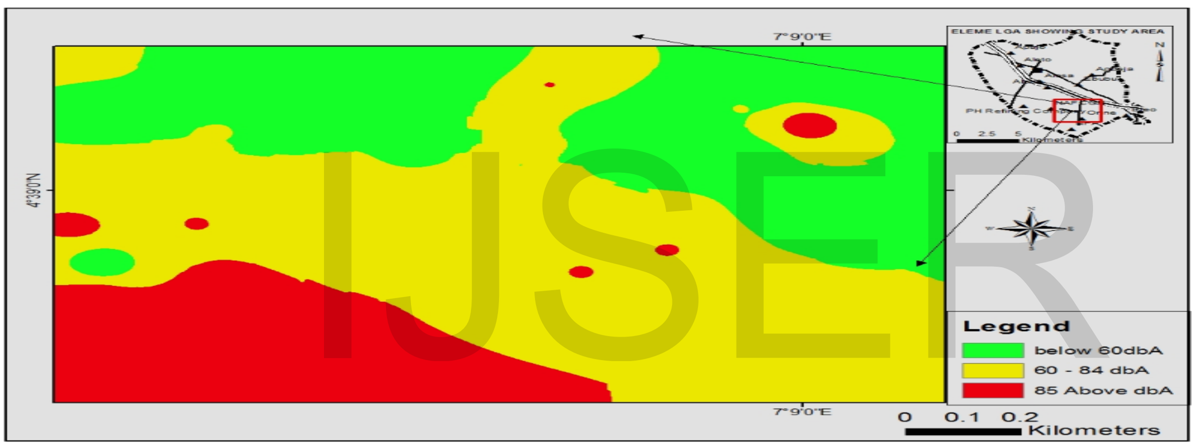

Fig. (2): Ungridded Map of the measured Noise Levels around the FLT Appron

The ranges of values obtained from the Exposure-Impact Evaluation (Appendix) indicate that the emitted noise levels have some physiological and psychological impacts on the health of the exposed personnel. These effects are as shown by the range of values obtained for the mean and coefficients of variability for each class of effects shown by the respondents to result from the emitted noise levels. Specifically, mean values between 2.94 and 2.99 and coefficient of variability values ranging between 0.33 and 0.35 were obtained from the responses on the impact of the emitted noise on cardiovascular health; means values between 2.99 and 3.09 and coefficient of variability values ranging between 0.30 and 0.35 obtained on the impact of the emitted noise on sleep disturbance; mean values of 2.93 and 3.08 and coefficient of variability values between 0.30 and 0.37 obtained on the impact of the emitted noise on cognitive impairment; mean values between 2.81 and 2.94 and coefficient of variability ranging between 0.35 and 0.39 obtained on impact of the emitted noise on tinnitus/hearing problem; while the responses on the impacts of the emitted noise on stress has mean values ranging between 2.89 and 2.94 and coefficient of variability values between 0.33 and 0.39 respectively. The range of values obtained for the coefficients of variability show consensus in the responses on the impacts of the emitted noise levels on the physiological and psychological health of the exposed personnel.

Similarly, the result of the chi Square (X^2) analysis (table 2) show significant association between the emitted noise level and the responses of the exposed personnel with a calculated value of 22.67 at .05 level of significance as against a critical value of 18.31.

Table (7)
Chi Square Analysis of the Relationship between Measured Noise Level and the Responses at the FLT

	Outcome						
Depart.	Stress	Tinnitus/Hear. Problem	Cognitive Impair.	Sleep Disturb.	Cardiovasc. Disorder	No Effect	Total
Safety	10 (11.72)	02 (4.32)	03 (2.84)	11 (12.34)	08 (3.58)	04 (3.21)	38
Operatn	36 (45.96)	21 (16.93)	13 (11.13)	48 (48.37)	17 (14.03)	14 (12.58)	149
Utility	49 (37.32)	12 (13.75)	07 (9.04)	41 (39.29)	04 (11.39)	08 (10.21)	121
Total	95	35	23	100	29	26	308

$$\chi^2_{10} = 22.67 \quad \alpha = .05 \ \chi^2_{critical} = 18.31$$

The findings from this study clearly show that the emitted noise levels from the expansive quayside apron in this terminal is higher than the regulatory permissible noise level of 90dBA for an 8 hour working period per day. The workforce exposed to this high noise levels are at risk of developing cardiovascular health problems, noise-induced hearing problems and other associated psychological health problems from prolonged exposure. The provisions of the NESREA's National Environmental (Noise Standards and Control) Regulations, 2009 should be adequately enforced, by the relevant agencies, to ensure reduction in exposure period and/or reduction in the noise level. Adequate strategies geared towards ensuring continuous use of the appropriate Personal Protective Equipment (PPE) and creating of awareness about the adverse effects of noise among the workers should be established. Engineering strategies that will ensure reduction in the noise level at source should be given priority over other strategies.

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Appendix A

Table (A1)
Responses on the Impact of Vessel Noise on Cardiovascular Disorder around the FLT Quayside

S/ No	Statement	SA (4)	A (3)	D (2)	SD (1)	CR	N	$\bar{X}$	SD	CV
1.	Exposure to generator/vessel noise causes dizziness, nausea or vomiting	118	98	51	41	909	308	2.95	1.04	0.35
2.	Exposure to generator/vessel noise for longer period sometimes results to numbness and weakness in the arm	102	122	60	24	918	308	2.98	0.92	0.33
3.	Continuous exposure to generator/vessel noise sometimes increases the risk of confusion or disorientation.	112	102	56	38	904	308	2.94	1.02	0.35
4.	Long-term exposure to generator/vessel noise result in difficulty in comprehension	115	111	45	37	920	308	2.99	1.00	0.33
5.	Continuous exposure to generator/vessel noise increases the risk of High Blood Pressure.	108	112	48	40	904	308	2.94	1.01	0.34

Table (A2)

Responses on the Impact of Vessel Noise on Sleep Disturbance around the FLT Quayside

S/No	Statement	SA (4)	A (3)	D (2)	SD (1)	CR	N	X	SD	CV
1.	Exposure to generator/vessel noise reduce the restorative power of my sleep	123	97	51	37	922	308	2.99	1.02	0.34
2.	Continuous exposure to generator/vessel noise increases the risk of acute and chronic sleep restriction.	125	101	65	17	980	308	3.08	0.91	0.30
3.	Exposure to generator/vessel noise increases the risk of chronic sleep disturbance.	124	108	47	29	960	308	3.06	0.96	0.31
4	Continuous exposure to generator/vessel noise increases the risk of arousal, autonomous responses and body movement while asleep.	129	93	51	35	932	308	3.02	1.02	0.33
5.	Long-term exposure to generator/vessel noise increases risk-taking behaviours due to poor signal detection	118	97	69	24	969	308	3.09	0.96	0.31

Table (A3)

Responses on the Impact of Vessel Noise on Cognitive Impairment around FLT Quayside

S/ No	Statement	SA (4)	A (3)	D (2)	SD (1)	CR	N	$\bar{X}$	SD	CV
1.	Exposure to generator/vessel noise causes distraction and loss of concentration	109	113	46	40	907	308	2.94	1.01	0.34
2.	Exposure to generator/vessel noise on a continuous basis causes dissatisfaction and disappointment	113	112	35	48	906	308	2.94	1.05	0.36
3.	Continuous exposure to generator/vessel noise increases the risk of depression	115	107	55	31	934	308	2.99	0.98	0.33
4.	Exposure to high level generator/vessel noise on a continuous basis causes increased tension.	121	97	38	52	903	308	2.93	1.09	0.37
5.	Exposure to generator/vessel noise causes loss of concentration and cognitive function deterioration.	117	123	43	25	948	308	3.08	0.92	0.30

Table (A4)
Responses on the Impact of Vessel Noise on Tinnitus/Hearing Problem around FLT Quayside

S/ No	STATEMENT	SA (4)	A (3)	D (2)	SD (1)	CR	N	$\bar{X}$	SD	CV
1.	Exposure to generator/vessel noise makes me perceive constant roaring, hissing or ringing even after leaving the workplace.	113	103	41	51	895	308	2.90	1.08	0.37
2.	Exposure to generator/vessel noise on a continuous basis makes it difficult for me to listen to or hear low level sounds.	111	97	61	39	896	308	2.91	1.03	0.35
3.	Exposure to generator/vessel noise makes me have pain in one or both ears	109	101	48	50	885	308	2.87	1.07	0.37
4.	Exposure to generator/vessel noise makes me have pressure or fullness in one or both ears.	106	96	47	59	865	308	2.81	1.11	0.39
5.	Exposure to generator/vessel noise causes a loss of hearing for several hours or more after exposure to the noise.	111	108	48	41	905	308	2.94	1.02	0.35

Table (A5)
Responses on the Impact of Vessel Noise on Stress around the FLT Quayside

S/ No	Statement	SA (4)	A (3)	D (2)	SD (1)	CR	N	$\bar{X}$	SD	CV
1.	Exposure to generator/vessel noise increases my heart rate.	112	109	46	41	932	308	2.95	1.02	0.35
2.	Exposure to generator/vessel noise for longer time period makes my breathing faster.	116	101	49	42	927	308	2.94	1.04	0.35
3.	Exposure to generator/vessel noise makes me sweat faster than normal.	119	102	47	40	916	308	2.97	1.03	0.35
4.	Exposure to generator/vessel noise leads to difficulty in concentrating on mental tasks.	113	118	38	39	921	308	2.99	1.00	0.33
5.	Exposure to generator/vessel noise makes me feel more nervous.	118	101	41	48	905	308	2.94	1.07	0.36
6	Exposure to generator/vessel noise makes me forgetful, confused and disorganized.	121	95	34	58	891	308	2.89	1.12	0.39