



Assessment of noise pollution and its effects on human health in industrial hub of Pakistan

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Abstract

Faisalabad is one of the major industrial cities of Pakistan, which may cause noise pollution to the local residents due to the development of robust industrial and transport systems. This study aimed at (i) mapping the noise pollution levels at various locations of Faisalabad city; (ii) comparing noise pollution levels in the morning, the afternoon, and the evening for each source; and (iii) assessing nonauditory effects of noise on human health. Two industries and 43 famous/busy locations of Faisalabad Sadar were selected to study noise pollution by using the sound level meter for the period of 24 h. A questionnaire-based survey was carried out near the sampling points to get a public perception about the health impacts of noise pollution. The measured equivalent sound pressure levels (SPL_{eq}) were higher than the permissible limits at all the sampling locations during morning, afternoon, and evening hours. The maximum sound pressure level (SPL_{max}) was 102 dB inside the production unit in the afternoon at Mian Muhammad Siddiq Textile Loom industry. The average SPL was found at State Bank road (102 dB), Children's Hospital (101 dB), Jhang Bazar (100 dB) in the afternoon and at Punjab Medical College in the evening (97 dB). Based on the survey, 94% of respondents reported headache, 76% sleeplessness, 74% hypertension, 74% physiological stress, 64% elevated blood pressure levels, and 60% dizziness due to noise. Noise pollution is higher than the standard limits and causes auditory as well as nonauditory effects on humans. The vehicles and industrial machinery should be maintained, and sound proofing and protection equipment should be provided to the workforce in order to protect them from extreme noise levels.

Keywords Annoyance · Noise pollution · Nonauditory effects · Occupational health · Community survey

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Introduction

Noise is a type of sound, which is listed as one of the most common environmental pollutants with adverse health impacts (Ravindra et al. 2016; Ilic et al. 2018). The Latin word “nausea” means seasickness and the word “noise” was later derived from it. Technically, noise is any unwanted, unpleasant, unexpected, and louder sound than threshold limits (Ryherd 2016; Farina 2017). Its elevated levels are causing health effects ranging from minor to major health effects as well as quality of lives. It has been recognized as one of the major environmental threats resulting from the robust industrial development and transport systems over the years (WHO 2018). Noise pollution levels are presented by measuring its loudness using a logarithmic decibel (dB) scale (King et al. 2012). It is equally a big problem in developed and developing countries like Pakistan and India (Mehdi et al. 2012; Ravindra et al. 2016). With the increase in industrial development and population, noise pollution is gradually increasing. It is

significantly different from soil, water, and air pollution due to its widespread and unique sources, which adversely affect the public health, especially in urban and suburban areas. Anthropogenic activities are the biggest source of noise pollution (Templeton et al. 2016). Traffic noise is a worldwide problem, which has associated with industrial progress (Bhosale et al. 2010; Caciari et al. 2013).

The effects of industrial and traffic noise include different auditory and nonauditory effects like hearing loss (Halonen et al. 2016), psychological problems, high blood pressure, irregular heart rhythms (Zijlema et al. 2016; Potgieter et al. 2018), difficulty in sleeping, irritation and stress, reduction of work efficiency, and understanding the things which are heard from conversation (Basner et al. 2014; Bilenko et al. 2015; Zhang et al. 2015; Kageyama et al. 2016; ElAarbaoui et al. 2017). Although some of the studies have reported deleterious effects of noise pollution on human health, scanty information is available about noise pollution in Pakistan. Therefore, this study aimed at (i) mapping noise pollution levels at various locations of Faisalabad Sadar, (ii) comparing the existing levels of noise pollution in the morning, the afternoon, and the evening for each source and (iii) assessing its nonauditory effects on human health. This study indicates sources and levels of noise pollution and thus helps to minimize its impact on human health.

Materials and methods

Study area

Faisalabad is the second largest city of Punjab and third most populated city in Pakistan. It contributes to over 6% of the gross domestic production and is known as the Manchester of Pakistan, due to its massive textile industry. Industrialization plays a vital role in attracting numerous people from other cities to better job opportunities, which leads to urbanization. According to the City District Government Faisalabad, this city has about 2.5 million population. Due to which, traffic jam and occupational noise are so common during the daytime because of industries and narrow width of roads for large traffic and heavy vehicles. While 70% of passengers travel within the city by using motorbikes and busses, which is a significant factor to produce much noise and influence inhabitants.

Measurement of noise pollution

Manual field measurements were taken to obtain information about the noise level and traffic pattern in Faisalabad. Areas selected for the study included industrial area especially power loom areas along Sargodha road, Rasheed Abad, Jhang road, and Sadhar Bypass, in addition medical, commercial,

residential, and educational institutions, bus/railway stations, and other famous points in the city to monitor noise level (Fig. 1). This approach was used to assess the harmful effects of noise on exposed workers and residents of the area. A survey was conducted from all the 45 sampling locations of Faisalabad Sadar, and intensity of noise was measured one by one in the morning (7:00–11:00 am), the afternoon (1:00–5:00 pm), and the evening hours (5:00–9:00 pm) for three times a day for 5 min per reading per location by using integrated sound level meter (SLM). The sound level was measured as A-weighting using SLM model TES-1351B type 2 with a frequency range of 20–8000 Hz and accuracy of ± 1.0 dB (ref. 94 dB @1 kHz). The sound level meter was calibrated by the internal oscillator at the rate of 1 kHz sine wave general (94 dB). For measuring noise, the sound level meter was placed 1.2 m above the ground level and 3.5 m far from the noise source to measure the noise from all sites (Farooqi et al. 2017). The noise level was described as an equivalent sound pressure level (SPL_{eq}).

Traffic density measurement

Traffic density was measured as the number of vehicles/h that occupied a segment of a road. The traffic density was calculated as vehicles per hour by simple calculation as used by Paunovic et al. (2013) in which the number of vehicles was counted for 5 min simultaneously with noise measurements.

Community survey

A questionnaire-based survey was conducted in and around all the sampling locations of Faisalabad city to get the perception of residents exposed to noise about its effects on human health. The respondents were divided into four age groups (< 20, < 40, < 60, < 80 years), and responses were recorded as agree, disagree, and no comments. The questionnaire was available as a [supplementary](#) file. It was made sure that the respondents should not have any type of head injury and hearing loss.

Statistical analysis

Descriptive statistics were applied to analyze collected noise data. The noise level was presented as minimum or maximum values and means \pm standard error. The noise level was categorized as safe (≤ 66 dB), tolerable (67–71 dB), low risk (72–76 dB), moderate risk (77–81 dB), high risk (82–86), extremely high (≥ 87 dB) risk as used by Banerjee et al. (2008). The noise level classification was developed by the Banerjee et al. (2008) based on the human health factor. It was developed according to the noise intensity levels, and this criterion is useful in the assessment of the extent and noise exposure of the area and helps in the identification of noise hotspots.

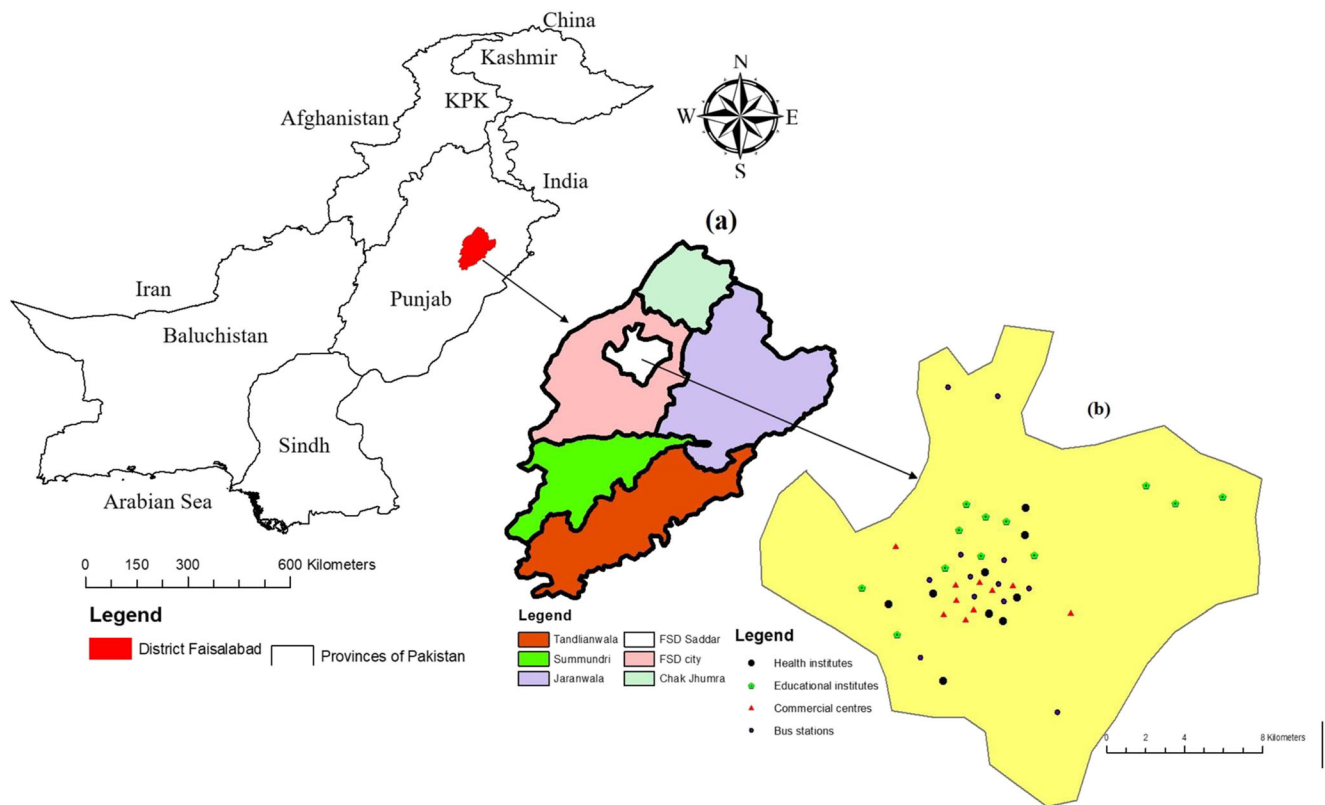


Fig. 1 Sampling locations of Faisalabad city including Faisalabad Sadar for determination of noise level. Part (a) shows main study area and its neighboring places, and (b) indicates main sampling locations present in Faisalabad Sadar (43)

ArcGIS software (version 10.4.1) was used to produce the maps presented in this study. Inverse distance weighted (IDW) interpolation of the noise data was performed to find the noise levels around the sampling locations on the basis of noise levels at sampled locations.

Results

Noise pollution inside and around the industry

Mian Muhammad Siddiq Textile Loom is located at Jhang road, Faisalabad, where the industrial and commercial area is mixed with the residential area. The maximum sound pressure level (L_{max}) was found 102 dB inside the production unit, 94 dB outside production unit, and 99 dB outside the industry in the afternoon (Table 1). The L_{max} at Mian Wajid Weaving Mill was found 98 dB inside production unit in the afternoon, 90 dB outside production unit in the evening, and 101 dB outside the industry in the afternoon (Table 2). The average sound pressure level (L_{ave}) showed that noise level was higher in the afternoon hours at Mian Muhammad Siddiq Textile Loom (L_{ave} = 89 to 96 dB) while in the evening hours at Mian Wajid Weaving Mill (L_{ave} = 85 to 95 dB). The noise level was

greater than the permissible limit (L_{ave} > 75 dB) at inside, outside the production units, and outside industry in both industries.

Noise pollution at famous locations of the city

The average values of the noise level of bus stations (12 locations) and educational institutes (12 locations) were recorded in the morning, afternoon, and evening hours. The average noise level was recorded (L_{ave} = 102 dB in the afternoon) followed by (L_{ave} = 99 dB in the evening) at State Bank road. Based on L_{ave} at various bus stations, the following stations have noise level well above than permissible limits (L_{ave} = 75 dB) in morning (Metro Cash and Carry, L_{ave} = 86 dB), in afternoon (GBS, L_{ave} = 86 dB; Nadir Travels, L_{ave} = 90 dB; Railway Station, L_{ave} = 93 dB; State Bank road, L_{ave} = 102 dB; BISE Office, L_{ave} = 86 dB; Metro Cash and Carry, L_{ave} = 86 dB), and in evening (GTS square, L_{ave} = 91 dB; GBS, L_{ave} = 90 dB; State Bank road, L_{ave} = 99 dB; Satyana road, L_{ave} = 86 dB) (Table 3). The average noise level at different educational institutes of Faisalabad was recorded, and L_{ave} values of all locations in the morning, afternoon, and evening have noise level well above than permissible limits (L_{ave} = 50 dB) with the highest level (L_{ave} = 97 dB) found at Punjab Medical College in the evening (Table 3). Twelve

Table 1 Noise levels (dB) at inside, outside production unit, and outside Mian Muhammad Siddiq Textile Loom industry at different times of the day

Shift	Time hours	Inside production unit			Outside production unit			Outside industry		
		Min	Max	Means \pm SE*	Min	Max	Means \pm SE*	Min	Max	Means \pm SE*
Morning (am)	7:00–9:00	82	94	88 \pm 2.90	80	86	83 \pm 1.46	78	93	86 \pm 3.65
	9:00–11:00	83	99	91 \pm 3.81	79	89	84 \pm 2.89	73	87	80 \pm 3.27
Afternoon (pm)	1:00–3:00	90	102	96 \pm 2.90	83	90	87 \pm 1.86	68	79	74 \pm 2.45
	3:00–5:00	85	95	90 \pm 2.42	83	94	89 \pm 2.69	87	99	93 \pm 2.80
Evening (pm)	5:00–7:00	83	87	85 \pm 0.99	80	85	83 \pm 1.13	70	82	76 \pm 2.73
	7:00–9:00	83	97	90 \pm 3.30	82	90	86 \pm 1.81	84	97	91 \pm 3.20
Standard level		75 (NEQS-Pak), 70 (EPA-USA), 65 (WHO)								

*Standard error

locations of bus stations following increasing trend of average noise level during day hours (afternoon 87 dB > evening 79 dB > morning 70 dB) whereas ten locations of commercial city centers following (evening 91 dB > afternoon 87 dB > morning 67 dB).

Noise level at health institutes (9 locations) and commercial city centers (10 locations) was monitored in the morning, afternoon, and evening hours to get the intensity of noise pollution at these locations. All the health institutes had a higher level of noise (L_{ave} = 61–75 dB in the morning, L_{ave} = 70–101 dB in the afternoon, and L_{ave} = 69–94 dB in evening hours) than permissible limit (L_{ave} = 30 dB). Similarly, all commercial city centers except Kohinor City (L_{ave} = 58 dB) had higher level of noise (L_{ave} = 60–72 dB in morning, L_{ave} = 82–100 dB in afternoon, and L_{ave} = 81–99 dB in evening hours) than permissible limit (L_{ave} = 65 dB) (Table 4). Nine locations of health institutes following increasing trend of average noise level during day hours (afternoon 87 dB > evening 79 dB > morning 70 dB), whereas ten locations of commercial city centers following (evening 91 dB > afternoon 87 dB > morning 67 dB).

Effect of noise pollution on human health

The participants in this study were men working as laborers in Textile Looms. Their age was ranged from 20 to 80 years. Based on survey results, all the respondents suffered from many health problems caused by noise: 94% of respondents reported headache, 76% sleeplessness, 74% hypertension, 74% physiological stress, 64% high blood pressure, 60% dizziness, and 56% loss of hearing due to noise (Table 5).

Discussion

Noise pollution at both industries either inside (L_{ave} : 88–96 dB), outside (L_{ave} : 78–89 dB) production unit, or outside the industry (L_{ave} : 74–93 dB) was higher than the permissible limits set by WHO (65 dB), EPS-USA (70 dB), and NEQS, Pak (75 dB). All these values are indicating serious noise level inside or outside the industry. Industries must provide different personal protection equipment to the workers, provide training to their staff, and follow WHO guidelines in order to protect their workers from extreme level of noise (WHO

Table 2 Noise levels (dB) at inside, outside production unit, and outside Mian Wajid Weaving industry at different times of the day

Shift	Time hours	Inside production unit			Outside production unit			Outside industry		
		Min	Max	Means \pm SE*	Min	Max	Means \pm SE*	Min	Max	Means \pm SE*
Morning (am)	7:00–9:00	84	91	88 \pm 1.58	73	82	79 \pm 1.20	80	94	86 \pm 4.05
	9:00–11:00	89	93	91 \pm 0.99	75	83	78 \pm 2.40	72	84	76 \pm 3.84
Afternoon (pm)	1:00–3:00	90	98	94 \pm 1.83	80	89	84 \pm 2.60	81	101	93 \pm 6.35
	3:00–5:00	90	97	94 \pm 1.60	81	90	84 \pm 2.72	72	84	77 \pm 3.48
Evening (pm)	5:00–7:00	91	97	94 \pm 1.34	79	89	85 \pm 3.05	88	96	91 \pm 2.40
	7:00–9:00	93	96	95 \pm 0.75	79	90	84 \pm 2.71	78	83	81 \pm 1.13
Standard level		75 (NEQS-Pak), 70 (EPA-USA), 65 (WHO)								

*Standard error

Table 3 Noise level (dB) and traffic density (vehicles/h) at different bus stations and educational institutes of Faisalabad city

Bus stations	Avg. noise level			Avg. traffic density	Educational institutes	Avg. noise level			Avg. traffic density
	M	A	E			M	A	E	
Airport Rd.	77	83	84	4272	Ayub Agricultural Research Institute	89	95	79	3276
GTS Square	81	83	91	4464	Aziz Fatima Medical and Dental College	68	87	84	2352
GBS	83	86	90	4092	Beaconhouse School System	92	90	83	2472
Nadir Travels	80	90	79	3552	College of Physician and Surgeons	80	87	90	3648
Railway Station	83	93	83	3372	Divisional Model College	79	87	71	2628
Chenab Club Rd.	69	79	81	2976	Divisional Model School and College	69	86	78	2868
State Bank Rd.	83	102	99	4536	GC University	93	71	88	4764
Satyana Rd.	70	79	86	2652	Independent Medical College	96	87	81	4116
BISE Office	80	86	82	3456	National Textile University	93	87	82	4812
McDonalds Rd.	82	84	85	5796	Punjab College	78	91	87	4776
Iqbal Stadium	83	85	85	2460	Punjab Medical College	94	93	97	3636
Metro Cash and Carry	86	88	71	2364	University of Agriculture	81	89	86	4668
Mean	70	87	79	4644	Mean	67	87	91	2768
Min	61	81	69	3516	Min	58	82	81	1116
Max	75	101	94	5868	Max	72	100	99	4452
SD	4.02	6.15	9.66	725.6	SD	4.91	5.29	4.82	921.0
Standard value	65 (NESQS-Pak)				Standard value	50 (NESQS-Pak), 45 (WHO)			

M morning, A afternoon, E evening

2018). Mohammadzadeh et al. (2015) reported similar results. They monitored the noise level in different sections of flour mill, where the noise level exceeds 85 dB which caused hearing loss to workers.

As indicated in the results of the present study, majority of the respondents reported disturbance during sleeping, annoyance, anger, irritation and headache, loss of sleep, sleep deprivation, negative effects on the cardiovascular system,

Table 4 Noise level (dB) and traffic density (vehicles/h) at different commercial centers and health institutes of Faisalabad city

Health institutes	Avg. noise level			Avg. traffic density	Commercial centers	Avg. noise level			Avg. traffic density
	M	A	E			M	A	E	
Allied Hospital	69	89	93	5868	Aminpur Bazar	60	84	91	2244
Aziz Fatima Memorial Hospital	61	86	84	3516	Bhowana Bazar	61	85	92	2412
Children’s Hospital	71	101	69	4728	Chiniot Bazar	69	88	99	1116
Faisalabad Institute of Cardiology	73	83	71	3888	Clock Tower	72	84	81	2556
Faisalabad Heart Centre	68	70	70	3372	Jhnag Bazar	71	100	88	2400
Govt. General Hospital	70	86	74	4644	Kachahri Bazar	69	88	89	3756
Hilal-e-Ahmar Hospital	72	82	74	4812	Kohinoor City Plaza	58	90	91	2772
National Hospital	73	83	81	4512	Montgomery Bazar	68	82	97	3444
Social Security Hospital	75	91	94	5184	Rail Bazar	68	91	89	4452
					Sadar Bazar	69	83	92	2532
Mean	70	87.4	78.8	4644	Mean	67	87	91	2768
Min	61	81.5	69.3	3516	Min	58	82	81	1116
Max	75	100.5	93.9	5868	Max	72	100	99	4452
SD	4.02	6.15	9.66	725.6	SD	4.91	5.29	4.82	921.0
Standard value	50 (NESQS-Pak), 45 (WHO)				Standard value	65 (NESQS-Pak), 60 (WHO)			

M morning, A afternoon, E evening

Table 5 Workers response about health impacts caused by noise pollution of power looms

Health impact	Age group of workers											
	Agree (%)				Disagree (%)				No comments (%)			
	≤ 20	≤ 40	≤ 60	≤ 80	≤ 20	≤ 40	≤ 60	≤ 80	≤ 20	≤ 40	≤ 60	≤ 80
Annoyance	8	16	14	10	12	22	10	2	4	0	2	0
Depression	0	20	22	12	0	16	8	2	8	4	8	0
Dizziness	4	24	18	14	4	10	12	4	0	2	8	0
Headache	8	36	32	18	0	2	4	0	0	0	0	0
High blood pressure	0	16	36	12	0	20	4	0	8	2	2	0
Hypertension	2	28	34	10	6	6	4	2	0	4	4	0
Induced hearing loss	0	14	30	12	0	14	8	0	8	10	4	0
Physiological stress	6	24	32	12	2	10	10	0	0	4	4	0
Sleeplessness	4	32	32	8	4	6	8	4	0	0	2	0

obesity, diabetes and impaired glucose tolerance, and anxiety disorders. Our results corroborated the previous studies conducted in other geographical zones of the world (Table 6); for instance, several studies have described the negative impact of noise levels on the nearby community (Banerjee et al. 2008; Islam et al. 2015; Miguel et al. 2018). Results indicated that there is a strong relationship between the machine operation and the noise produced as it is originated from machine operations. Machines observed in the study area are of Sulzer Looms of outdated technology and create more noise as compared to the modern machines. Transportation vehicles used by industry are also not in good condition, and they create noise during transportation and loading within the industry. Moreover, machines' operator workers are not provided with the personal protective equipment which can reduce the risk of noise to the exposed workers.

Results revealed that 94% of the industrial workers reported that they have headache problems due to the industrial noise; 76% of the workers complained about sleeplessness after their work shift as they were much exposed to the high noise levels during their 8 h of the work shift. Noise is a significant factor to trigger a headache in workers due to sleeplessness (Sari et al. 2018); thereby, here we presumed that noise caused sleep disturbance and physiological stress and caused a tension-type headache. It is confirmed that 74% of the industrial workers were suffering from hypertension due to long exposure to higher noise levels. A total 64% of workers were also the patients of noise-induced high blood pressure disease as indicated by Hunashal and Patil (2012), 60% were patients of dizziness (Baliatsas et al. 2016), and 56% of the workers complained about the loss of hearing due to noise which is also shown by the study of Agarwal and Swami (2011).

As shown in the study, there was also a direct significant association between road traffic and high levels of noise (Essandoh and Armah 2011; Morelli et al. 2015). Chan et al. (2015) also found a positive association between traffic

vehicles and noise. The reasons of the high levels of noise in the categorized areas as traffic areas, educational, commercial, and medical were since they were at the bank of the busy roads and exposed to the high-intensity noise levels as previously reported (Cutiva and Burdorf 2015). High noise levels (by moaning and playing of children, footstep sound, door opening and closing) in the medical facilities can impair the patient's health (Juang et al. 2010) and can delay wound healing and gastric activity (Hsu et al. 2012). The commercial areas selected for this study are also the city's busiest commercial places, and noise levels in 95% of the places were above the limits since they were along the busy roads and always crowded with the people who came for shopping; our results are corroborated with the earlier findings (Banerjee et al. 2008). In educational and research institutions, the same condition was observed, and more than the permissible limits were recorded in all three times of the day which is probably due to the locations of these institutes as all are located within the city and on the banks of the busy roads as similar studies shown earlier (Lusk et al. 2017; MacCutcheon et al. 2018). Noise pollution in and outside the schools can disturb children's memory as reported by Therrien et al. (2018), learning ability (Koopmans et al. 2018), and hearing ability (Tiesler et al. 2013). The reasons behind the high levels of noise at afternoon times were the busy roads due to the off timings of the schools. Since most of the students in schools and colleges use bikes and auto rickshaws to move from home to school, so the noise levels in afternoon times were recorded high as compared to the morning and evening times as previously shown by Kaddoura and Nagel (2018). Noise has a significant impact on patient health and on staff well-being in hospitals and medical facilities. High sound levels dramatically impair the overall quality of care in these facilities (Bunn and Zannin 2016). Noise levels of 93.9 dB were recorded in hospitals, which is harmful to the patients and can cause serious health issues and aggravate their present health problem as stated by Zannin and

Table 6 Comparative overview of noise pollution monitoring and associated health risks

Study sites	Outcome	Key findings	References
New York city	Hearing problems	≥ 76 dB	Olson 2018
Along roads of Curitiba, Brazil	–	≥ 65 dB	Zannin et al. 2002
Different cities of Europe	Disturbance	≥ 70 dB	Bodin et al. 2015
Tehran, Iran	harmful effects on the citizens	≥ 82 dB	Abbaspour et al. 2015
Hospitals, roads, schools of Vadodara city	Damage to eardrum	≥ 80 dB	Patel et al. 2015
London	Hypertension, Angina, diabetes, etc.	≥ 60 and ≥ 65 dB	Tonne et al. 2016
Turkey	Nervous frailty, anxiety, dizziness, etc.	≥ 65 dB	Ozer et al. 2009
Ahvaz, Iran	Hypertension, sleep disturbance, etc.	76.28 ± 3.12 dB	Geravandi et al. 2015
Australia	Disturbance, annoyance	≥ 68 dB	Munro et al. 2018
Ota, Nigeria	Hypertension, hearing disturbance, high blood pressure, etc.	> 65 dB at day and >55 dB at night time > 97.60 dB	Usikalu and Kolawole 2018
India	–	80 dB	Bano et al. 2018
Pakistan	Hypertension, hearing disturbance, high blood pressure, headache, sleep disturbances, dizziness, etc.	> 101 dB	This study

Ferraz (2016) and Baqar et al. (2018). Noise level of all the sampling locations of Faisalabad city was presented in Fig. 2, indicating the intensity of noise in the central locations of the city (75–100 dB); while as we go in the surroundings of the city, noise intensity becomes low (45–72 dB).

In this study, the presented results seem surprising, but it should be noted that the question concerning noise levels and the associated problems is a fact and lasting condition. Noise results in negative health outcomes (Recio et al. 2016). It can also be noted that sleeping problems are the precursors to annoyance (Beutel et al. 2016; van Renterghem and

Botteldooren 2016), hearing loss (Sha and Schacht 2017), and many of the noise-related disorders (Buxton et al. 2017). In this survey, noise levels in most of the studied areas are well above the permissible limits, thereby causing sleeplessness, hypertension, cardiovascular diseases, blood pressure (Zijlema et al. 2016; Rapisarda et al. 2016), deafness (Chen et al. 2018), mental illnesses (Gruebner et al. 2017), and loss of memory (Koeritzer et al. 2018). These issues predominate in the society because the relations among noise levels and health-related problems are generally far stronger between irritation, annoyance, and human health (Dzhambov et al. 2017; Sakhvidi et al. 2018), demonstrating a different underlying track than previously anticipated by researchers. This condition highlights the need of including noise sensitivity as a vital environmental variable in the research on noise-human healthy relationships.

Conclusions

Based on the present study, it is determined that sound levels in the city and industrial units are found crossing the suggested or permissible noise levels, and the recorded noise level ranges from 60 dB (minimum) to above 102 dB (maximum). Furthermore, the movement of traffic vehicles and mechanical operation in the industry was responsible for the main sources of noise. This is because of the imprudent activities of industrialization. Due to this, humans are suffering through different types of diseases like high blood pressure, annoyance, depression, dizziness, and headache. The causes of noise pollution include an abrupt increase in population and

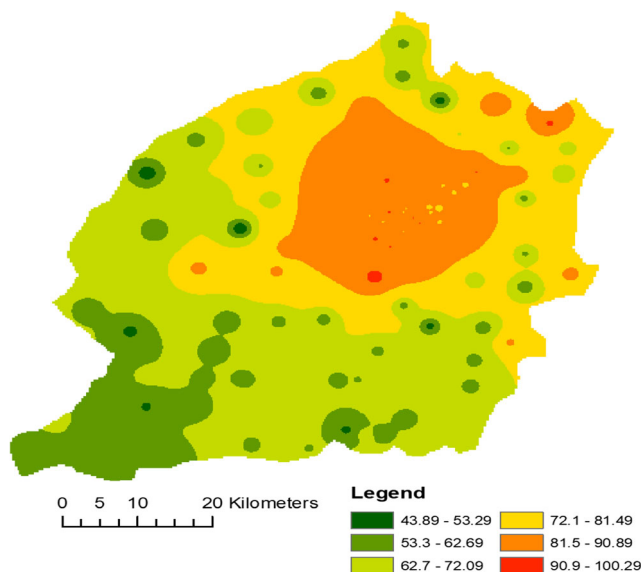


Fig. 2 Interpolation of noise level of Faisalabad Sadar (main study area) including its surroundings

urbanization. Based on the data presented in this study, it could be concluded that out-of-order machinery and increased traffic density cause noise pollution affecting the human health in different ways as noise is equally distributed in whole the city.

Recommendations

The present study has indicated that there is a need to develop the laws about workers safety and reinforcement of existing ones in order to ensure their safety and fitness. Different noise mitigation measures like installation of sound-absorbing ceiling tiles, soundproof rooms, and use of earplugs and noise mufflers can be made compulsory to ensure workers' mental and physical health (Abidin et al. 2018). Shelterbelts along roadsides can reduce the noise intensity by blocking the noise to travel to farther areas (Janku et al. 2016). Ban on traffic horns and checking of vehicular physical condition so that they produce minimum noise are also applicable options to reduce noise levels in residential, educational, and medical facilities (Zerihun et al. 2017). Some of the hospitals having modern facilities have installed traffic light like device which monitors and tells about current noise levels in the hospital (Ravindra et al. 2016) as we can monitor and reduce the noise by using them. Another study and patent show that fitting of rubber legs in furniture and replacing metallic chairs with plastic or couches can significantly reduce the noise levels (Tanno 2015). In addition to all the above measures, awareness campaigns for people should have a huge impact on noise reduction (Maffei et al. 2017).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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