Evaluation of Noise Levels inside a Local Manufacturing System in Benghazi City

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Abstract

Noise is that annoying and harmful sound that a person cannot hear and cannot tolerate, it is a rough, and irregular sound as it is high-frequency sound and leads to the vibration of the eardrum strongly. In this study, the noise level inside of the Al-Harabi Sweets factory in Benghazi was evaluated, and this was done by measuring the noise level of the machines in the factory (which are the vacuum, the mixer, and the twister) during the morning, and afternoon periods at two positions of each machine, and the results were analyzed by using of a T-test. Analysis of the results showed that all noise levels in this study are below 90 dB, which means that the noise levels do not affect hearing strength based on OSHA standards. The results also showed that there were some significant differences in the average values of noise levels between morning and afternoon periods for each machine in both positions. Some important points were concluded from the results and recommendations were made for any related work to be undertaken in the future.

Keywords: Noise levels, the vacuum, the mixer, the twister, and T-test hypothetical analysis.

الملخص:

الضوضاء هي تلك الأصوات المزعجة والمؤذية التي لا ينسجم لسماعها الإنسان و لا يتحملها، فهي إذا أصوات خشنة غير منتظمة حيث إنها الاصوات ذات التردد العالي و تؤدي إلى اهتزاز طبلة الآذن بشدة. في هذه الدراسة تم تقييم مستوى الضوضاء في مصنع الحرابي للحلويات في بنغازي، وتم ذلك عن طريق قياس مستوي ضوضاء الآلات في المصنع (وهي الشفاط، العجانة، والتويستر) خلال فترات الصباح وبعد الظهر، في موضعين مختلفين لكل آله، وقد تم تحليل النتائج

بواسطة إختبارT. حيث أظهرت تحليل النتائج أن جميع مستويات الضوضاء في هذه الدراسة أقل من 90 ديسبل، مما يعني أن مستويات الضوضاء لا تؤثر على السمع بناءً على معايير OSHA، أيضا أظهرت النتائج أن هناك بعض الإختلافات المهمة في متوسط مستويات الضوضاء بين فترات الصباح وفترات مابعد الظهر، لكل اله، في كلا الموضعين. واخيراً ويس اخراً تم أستنتاج بعض النقاط المهمة من خلال النتائج وإقتراح توصيات لإي عمل متعلق سيتم القيام به مستقبلاً.

1. Introduction

Many workers around the world are exposed to noise during their work. Noise, or unwanted sound, is one of the most common occupational hazards in workplaces. Exposure to high levels of noise may cause hearing loss, create physical and psychological stress, reduce productivity, interfere with communication, and contribute to accidents and injuries by making it difficult to hear warning signals (Occupational Noise Exposure: www.osha.gov, 2018; Xie and Shen, 2020). For this reason, studying noise, especially in industrial factories, and knowing its causes helps to develop a conceptualization to prevent or reduce it.

Confectionery factories are kind of factories where their workers are exposed to noise and its damages continuously due to their use of types of equipment/tools and machines that make very loud noises. Al Harabi Sweets factory is one of the factories located in Benghazi, where workers are exposed to a high level of noise.

The factory was chosen from the Chamber of Commerce and Industry list of factories available in Benghazi, and the management of this factory in Benghazi welcomed the conduct of this study.

The current study aims to evaluate the current situation of noise inside the sweets factory and try measuring the noise levels. Then, benchmark such levels with the standard levels of the noise, according to the international organizations of standards. Also, the study aims to offer important safety recommendations to reduce this phenomenon.

1.1. The Sources of Noise

The noise possibly comes from two main sources: industrial and non-industrial (Elammari and et al, 2015):

- **Industrial source of noise:**

  The industrial source of noise also called occupational noise includes noise from various industries and big machines working at a very high speed and high noise intensity. An occupational exposure limit of 85dB for 8 hours (Gongi and et al, 2015).

- **Non-industrial source of noise:**

  Non-industrial source of noise also called (community or environmental) noise, includes the noise created by transport / vehicular traffic, construction and neighborhood that comes from live or recorded music; from sporting events; from playgrounds and car parks.

1.2. The Noise Effects

Noise is a physical and social problem with several undesirable effects (Xie and Shen, 2020):

- Noise can damage the sensitivity of the inner ear and cause permanent or temporary “noise-induced hearing loss” (NIHL), annoying tinnitus, or ringing in the ears.
- Causes annoyance (a psychological effect) which can result in sleep disturbance, stress, tension, loss of performance.
- Noise interferes with activities, such as speech communication, which may annoy.
- Causes structural failures and injury.
- Influences consumers to buy competitors' quieter products.
- Noise-induced cardiovascular effects have been extensively studied in occupational.

Occupational safety and health administration (OSHA) standards for workplace noise exposure ensure that workers are protected from excessive noise levels as shown in figure1.

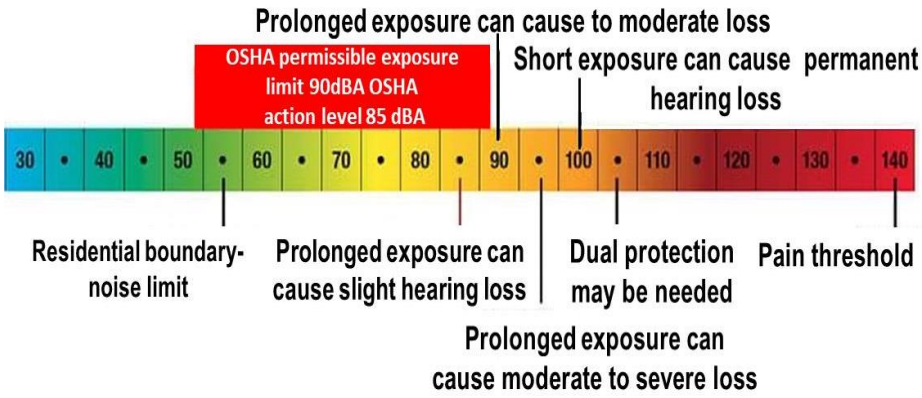

Figure 1. OSHA standards for noise (Applications to measure noise levels: www.healthhearing.com. 2018)

1.3. Factors Affecting Hearing Loss

The factors affecting hearing loss, as described in figure 2, are sound level, distance, and time.

Figure 2. Factors Affecting Hearing Loss (Noise: www.slideshare.net, 2019)

- Sound Level: Sound is measured in units called decibels. Any sound at or above 85 decibels can damage hearing.
- Distance: How close are you to the source of the sound. A sound gets louder near to the source and softer away from it.
- Time: The length of time is exposed to the sound. Limit exposure to sound at or above 100 decibels to no more than 15 minutes (Too loud, too long: www.noisyplanet.nidcd.nih.gov, 2019).

2. Measurement of Noise:

The intensity of sound is measured in terms of sound pressure level and the common unit is decibel. A decibel (dB) is the standard for the measurement of noise. The zero on a decibel scale is at the threshold of hearing, the lowest sound pressure that can be heard, on the scale. Decibel measures how intense is the sound as compared to reference intensity. The noise level in the decibel is measured with an instrument called a sound level meter. A sound meter is also known as a sound level meter, decibel (dB) meter, noise meter. (Noise: www.slideshare.net, 2019).

As a result of the unavailability of a sound meter device in the department to measure the noise level; an application called "Decibel X-dB Sound Level Meter and Noise Detector" was used. This application is available in the Play Store, and it was chosen due to the features of this application follow OSHA and NIOSH standards. Figure 3, shows the interface of the application while it is used, which was done Download it with Samsung A30.

Figure 3. Application Interface (Google play, 2019)

2.1 Calibration of The Used Application

As mentioned earlier, the application called "decibel X-dB sound level meter and noise detector" was used due to the unavailability of a device to measure and analyze the sound at the time of the study in the year 2018. But currently, the device called Hand-Held Analyzer 2250 Light, a type of 2250-L-D02 (manufactured by Bruel & Kjaer Company), is available in the department. It was necessary to ensure the accuracy and integrity of the measurements of the application used in its calibration with this device. The calibration process has been performed by considering the following:

1- Using the same sound source at the same volume level.

2- The distance between the sound source and both the application and the device is the same.

3- External sounds do not interfere.

4- The length of time to record sound for both the device and the application is the same.

The result was very close, with an error not exceeding 0.4%; this indicates the reliability of the readings obtained from the application.

3. Processing of Data Gathering and Analysis

The processes of data gathering and analysis depend on many points. These points have been achieved as planned in order of priority, and figure 4 illustrates them.

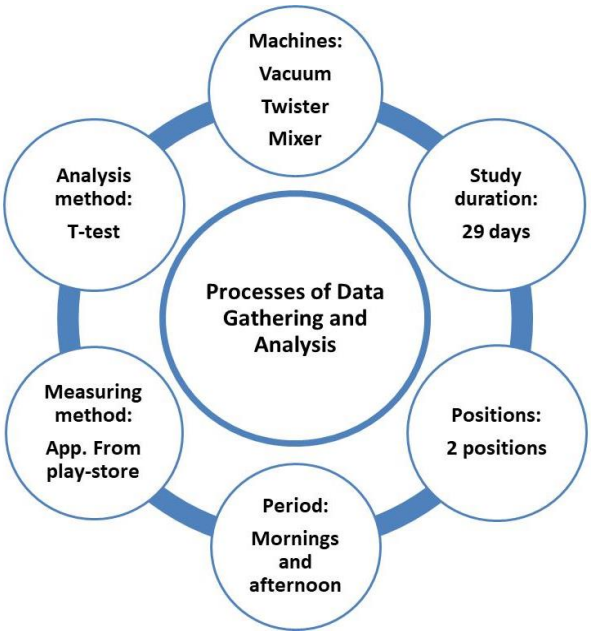

Figure 4. The process of data gathering

3.1. Study Duration:

Data were collected to measure the noise level of the three mentioned machines, and in two different periods: morning and afternoon. Additionally, the measurement is performed at two different positions, and the data collection has been started on 23rd of February 2019, and ended on 23rd of March 2019 (for 29 days), which is the period allowed for the study team to conduct the measurements inside the factory under the instructions and permission of the factory's management.

3.2. Measuring positions and data collection:

Two positions were selected to measure the noise level of the three machines. The first position I, which is close to the machine and the second position II, which is the farthest distance. The distances were determined according to the place layout for each floor. Table.1 shows these positions.

Table 1 Measurements positions for all machines (meters)

Machines					
Vacuum machine		**Mixer machine**		**Twister machine**	
Position I	Position II	Position I	Position II	Position I	Position II
2	10.3	1.4	13	2	4.2

Table 2 is an example of some collected data with their average and standard deviation.

Table 2 Example of some collected data

Date	**Time**	**Position I**					**Position II**				
		Measurement					**Measurement**				
		Samples			**Avg**	**SD**	**Samples**			**Avg**	**SD**
		1	**2**	**3**			**1**	**2**	**3**		
23/2/2019	11:00	74.5	76	74.7	75.1	0.81	70.4	73.1	69.9	71.1	1.72
	15:00	72.2	76.7	80	76.3	3.92	69.1	72.3	76.6	72.7	3.76
24/2/2019	11:00	76.9	78.8	75.7	77.1	1.56	70.7	72.3	69.9	70.9	1.22
	15:00	78.1	76.4	77.9	77.5	0.93	71.6	70.1	70.2	70.6	0.84

Tables 3 to 5 show the collected data (the average values) of the vacuum, mixer, and twister machines for two positions, respectively.

Table 3 Data of the vacuum machine

Position I				Position II			
AM	**PM**	**AM**	**PM**	**AM**	**PM**	**AM**	**PM**
71.03	63.3	72.2	70.2	64.53	65.33	70.23	66.63
71.36	63.66	71.46	68.3	64.86	71.83	67.9	66.86
71.86	64.06	71.93	64.73	63	70.1	66.06	69.16
70.73	64.86	71.33	66	66.06	69.43	65.73	70.1
66.73	67.36	70.53	64.55	60.53	69.13	62.53	71
71.4	66	71.53	69.1	66.93	70.03	69.1	70.5
71.63	66.03	73.2	68.16	66.1	69.8	69.93	69.66
70.9	67.16	73.8	56.91	64.76	68.76	66.73	70.3
70.3	64.33	76.1	69.9	62.3	69.96	70.15	70.1
70.8	64.06	74.3	66.31	62.76	70.1	63.91	72
70.4	63.96	74.8	69.61	63.53	70.16	69.32	71.56
73.23	69.83	72.11	69.41	69.66	67.23	70.13	70.5
73.06	68.7	73.3	69.92	70.2	68.3	69.63	71.2
72.03	70.23	74.18	66.33	66.3	68.23	71.12	73.1
		74.2	68.31			67.2	70.11

Table 4 Data of the mixer machine

Position I				Position II			
AM	**PM**	**AM**	**PM**	**AM**	**PM**	**AM**	**PM**
65.33	64.23	66.63	69.03	59.7	60.46	60.23	60.5
71.83	69.63	66.86	69.43	67.96	63.5	60.13	60.53
70.1	69.2	69.16	67.73	61.73	62.03	61.3	62.36
69.43	68.06	70.1	69.5	67	65.33	64.76	65.2
69.13	68.73	71	70.96	63.16	61.83	63.03	66.33
70.03	69.96	70.5	68.63	66.43	62.3	63.23	63.86
69.8	65.66	69.66	71	62.96	60.03	63.96	68.23
68.76	68.4	70.3	72.1	63.66	61.63	61.15	62.13
69.96	69.93	70.1	69.5	63.03	64.26	60.79	61.56
70.1	69.73	72	72.13	66.63	63.06	61.13	63.2
70.16	69.73	71.56	70.3	64.86	64.36	62.16	61.56
67.23	67.93	70.5	71.13	60.56	61.9	60.13	59.9
68.3	67.56	71.2	69.9	61.13	60.8	65.11	63.6
68.23	68.86	73.1	72.15	60.06	60.7	61.22	60.7
		70.11	71.12			61.33	60.9

Table 5 Data of the twister machine

Position I				Position II			
AM	**PM**	**AM**	**PM**	**AM**	**PM**	**AM**	**PM**
75.06	76.3	75.76	77.5	71.13	72.66	70.5	71.73
77.13	77.46	80.16	79.03	70.96	70.63	74.2	71.73
77.56	78.53	77.7	78	70.83	71.83	71.73	71.53
77.76	77.33	76.66	79.56	73.3	70.66	70.56	71.63
79.03	80.76	79.3	77.8	72.93	74.76	71.26	69.56
79.66	77.66	80.43	79.96	73.16	69.7	73.7	70.86
75.43	77.8	76.5	77.43	69.7	71.53	71.06	70.96
76.9	78.6	75.43	77.5	79.3	72.2	70.5	71.13
75.56	77.73	76.3	77.38	70.9	74	69.47	72.05
78.36	78.43	75.22	76.11	70.23	72.56	70.4	70.36
77.13	75.23	77.2	77.23	71.26	70.86	69.7	69.22
77.96	78.56	79.1	75.13	71.73	72.7	72.13	73.11
78.23	80.03	76.42	74.22	71.93	71.4	72.61	70.56
79.36	79.03	77.13	76.56	72.43	72.06	71.13	72.46
		76.4	75.93			70.12	71.63

3.3. Results Analysis:

To conduct the analysis, first, it is necessary to develop rational assumptions to verify them according to the nature of work in the Al-Harabi factory. There are two shifts, in the morning and at the afternoon periods. The noise level of the two periods have been studied, to notice, which is more effective. On this basis, the data were collected over 29 days for three machines (vacuum, mixer, & twister) and the verification processe has been conducted through the following hypothesis:

The null hypothesis H_0: $\mu_{AM} \leq \mu_{PM}$

"The averages of noise levels at the morning period are less than or equal to the averages at the afternoon period".

An alternative hypothesis H_1: $\mu_{AM} > \mu_{PM}$

"The averages of noise levels at the morning period are more than the averages at the afternoon period".

The possible reason to chose <, and > in the used hypothesis is that the amount of work to fulfill customers' requests in the morning and afternoon periods is different. Therefore, this means that the noise level differs. T-test was used to verify these hypotheses using the data analyzer feature in Microsoft Excel, The method of analysis used corresponds to several previous studies (Sahoo, 2014).

4. Results and Discussion

Based on the calculated average values of the noise levels for the three machines at the morning and afternoon periods; there is a difference between these values. This may be explained by the fact that the amount of work to fulfill customers' requests in the morning and afternoon period is different, and therefore the noise level differs. These can be seen clearly in figure 5 and figure 6, which describe the behavior of average values of the noise levels for all machines at different positions of measurements. Also, It could be noted from these figures that the error bars in terms of the standard deviation are consistent.

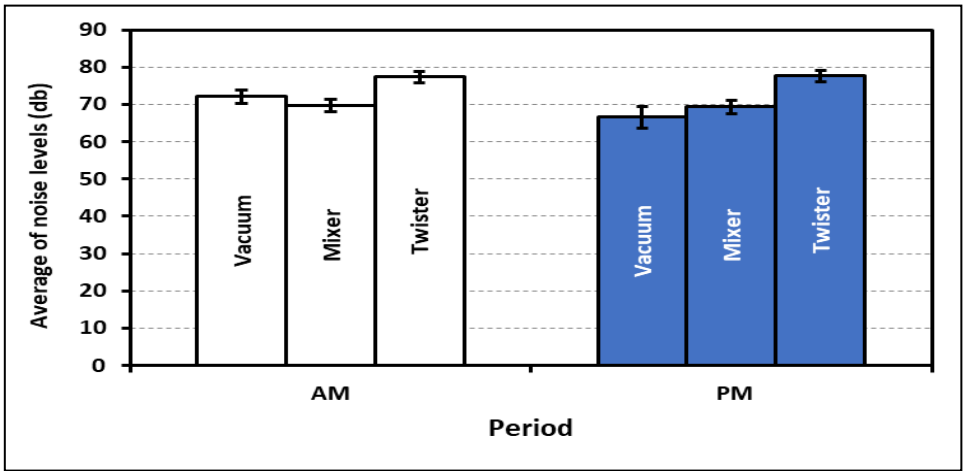

Figure 5. Average of noise levels for all machines at the position I

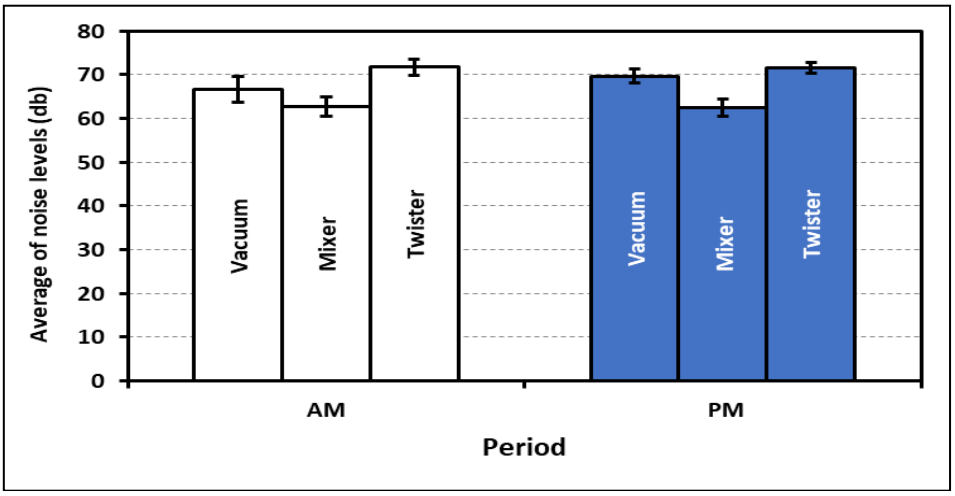

Figure 6. Average of noise levels for all machines at position II

Based on the p-value in the T-test results, there are insignificant differences between morning and evening periods for both of Mixer machine and Twister machine at all positions as shown in Tables 6 and 7. While there is a significant difference between the morning and evening

periods for the Vacuum machine at all positions, as shown in Tables 6, and 7. As explained earlier, the behavior of noise levels differences between the morning and afternoon periods for the machines, at all positions, may be explained by the fact that the amount of work to fulfill customers' requests in the morning and afternoon period is different, and therefore the noise level differs

Table 6 T-test results for all machines at the position I

Machine	**Vacuum**		**Twister**		**Mixer**	
Period	AM	PM	AM	PM	AM	PM
Mean	72.08	66.60	69.70	69.39	77.41	77.68
Variance	3.25	8.77	2.86	3.16	2.36	2.29
Observations	29.00	29.00	29.00	29.00	29.00	29.00
Pearson Correlation	0.25		0.68		0.45	
Hypothesized Mean Difference	0.00		0.00		0.00	
Df	28.00		28.00		28.00	
t Stat	9.64		1.19		-0.92	
P(T<=t) one-tail	1.07E-10		0.12		0.18	
t Critical one-tail	1.70		1.70		1.70	
P(T<=t) two-tail	2.14E-10		0.24		0.36	
t Critical two-tail	2.05		2.05		2.05	

Table 7 T-test results for all machines at the position II

Machine	**Vacuum**		**Twister**		**Mixer**	
Period	AM	PM	AM	PM	AM	PM
Mean	66.59	69.70	62.71	62.51	71.68	71.59
Variance	8.78	2.86	5.41	4.10	3.67	1.52
Observations	29.00	29.00	29.00	29.00	29.00	29.00
Pearson Correlation	-0.01		0.59		0.10	
Hypothesized Mean Difference	0.00		0.00		0.00	
Df	28.00		28.00		28.00	
t Stat	-4.87		0.54		0.24	
P(T<=t) one-tail	1.98E-05		0.30		0.41	
t Critical one-tail	1.70		1.70		1.70	
P(T<=t) two-tail	3.95E-05		0.59		0.81	
t Critical two-tail	2.05		2.05		2.05	

5. Conclusions:

The following conclusions have been arrived at through the results and discussions:

- It has been found that all noise levels measured in this study are less than 90 dB, which means the levels of noise are not affect the hearing strength based on OSHA standards.
- Based on T-test hypothetical analysis, the following can be summarized:
- Vacuum machine: the mean of the noise levels of the morning periods are less than or equal to that of the afternoon ones for both positions I, and II.
- Mixer and Twister machines: the mean of the noise levels of the morning periods are more than that of the afternoon ones for both positions I, and II.

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