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ARTICLE

NOISE REDUCTION AND HEARING LOSS IN PETROCHEMICAL WORKERS: A CASE STUDY

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ABSTRACT

The petrochemical plants workers have a high risk of noise induced hearing loss (NIHL). This study focused on the workers working for 10hrs daily in noisy environment of petrochemical plant. This study analyzed the data obtained, based on the survey queries of basic information and symptoms associated with noisy environment and the audiometery test of different noise situations. Workers exposed to high intensity of noise are suffering from many difficulties related to hearing loss. Out of 400 workers from the three plants of petrochemical plants, 44 were reported hearing loss as well as hearing difficulty. Analysis of the data also found that the workers who have been exposed to an excessive noise had a substantially poor audition and if they were exposed to noisy environment for a longer period of tone, there would be more chances of hearing loss. Among the affected workers only few were subjected to the test and the rest were went for there own protection. This means that substantially many workers were still passive in protecting their hearing ability. Moreover, as the company spent more on the noise prevention facilities to protect the worker's hearing ability, their audience ability gets no longer worse.

KEY WORDS
Schistosoma Hearing loss; Noise; Hearing ability; Exposure Noise induced hearing loss (NIHL); decibel (dB); temporary threshold shift (TTS); permanent threshold shift (PTS)

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INTRODUCTION

Noise has assumed alarming proportions and has become even more dangerous than water and air pollution. Noise pollution is a slow and insidious killer. It is a serious health hazard but still the noise level is rising higher and higher in modern societies. Thus, noise is no less pollutant than the toxic chemicals in our environment [1]. Noise arising from the petrochemical plants affects the efficacy of communications; interfere with public address and alarm systems or, at high levels, cause damage to employees' hearing. Exposure to high level of noise creates the hazard to human health and even produces hearing loss to the workers of heavy industries.

The word noise comes from the Latin word nausea meaning seasickness and is often used to mean – "Sound that is unwanted by the listeners" or it is a meaningless sound of greater than usual volume [2]. Noise is usually a complex a periodic sound wave having indefinite pitch that bears no information. In other words noise is defined as a signal that interferes with the detection of or quality of another signal because there is no instrument that can distinguish between a sound and a noise. However, noise can be detected by the human's reaction. Noise is generally originated by human activities like industrialization, urbanization and transportation. Fast industrialization not only made the society more affluent but it has also created the environmental pollution and industrial calamity, which has affected the health, behavior and safety of the people who are working in the industrial sites. However, people living in cities and near to industrial areas can also the victim of the noise problem [3,4]. People working in several industries like in petrochemical plants are directly exposed to the noise pollution sources. Noise pollution can cause annoyance and aggression, hypertension high stress level, hearing loss and adverse physiological and psychological impacts [5, 6]. High noise level can contribute to cardiovascular effects like coronary heart disease (CHD) which involves narrowing of small blood vessels that supply blood and oxygen to heart and its risk factor includes diabetes, high blood pressure altered blood lipid etc [7].

The other effect is noise induced hearing loss (NIHL) caused by chronic exposure to noise. NIHL is a sensorineural hearing loss. Prolonged exposure to high intensity noise can damage and destroys sensory hair cells of the inner ear leading to irreversible hearing loss [8]. Hearing damage is related to duration and intensity of noise exposure and it occurs at levels of 80dB or greater than that. Surveys indicated that more than half of industrial machines generate noise up to levels of 90dB or 100dB or above that which presents a definite health hazard to workers Noise having sound level below 80dB is reasonably safe [9]. If we have the exposure to high noise temporarily then we will loose hearing sound called as "temporary threshold shift (TTS)". When we get rest then it can be recovered, if the exposure is for a long time then we will have noise hearing impaired, called as "permanent threshold shift (PTS)" which cannot be recovered. Employee noise exposure can be assessed for the entire workforce by combining noise levels within areas or modules (either predicted or measured) with typical employee working patterns. Even though there are relevant safety rules to protect the workers, who are exposed to various noise levels, from getting hearing loss [4]. Numerous companies also showed a passive attitude with the investment to noise reduction. Many of the workers would not wear noise protecting equipments because of discomfort or nuisance. Thus lots of industrial workers exposed to high noise

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levels for a long time might get difficulty in hearing without hearing aids. This study will help in preventing from the hearing impaired on factory noises with the example of petrochemical plants in Korea.

The objective of the present study is to determine the effect of noise on human health and how to reduce its level. The aims of the study were (1) to determine the % frequency level of noise in the workers working in different companies of the petrochemical companies (2) to determine the effect of noise on human health, along with the diseases faced by the workers and (3) to establish the various methods of noise reduction.

MATERIALS AND METHODS

Study area description

This study was performed in the petrochemical industrial complex (PC-IC) in Ulsan, which is the second largest port city and the largest industrial city in Korea. The PC-IC zone has many oil refineries, chemical plants, propylene and epoxy resin production plants, dye and pigment production plants, waste treatment plants and landfills. The petrochemical outputs produced from Ulsan almost reached to 45% of the entire petrochemical production in Korea. A lot of people in Ulsan work at industrial complex (IC) including heavy industries like petrochemical plants and a large number of workers in these companies have been exposed to serious noise levels.

Three petrochemical plants (A, B and C) located in the PC-IC area were chosen for this study in Ulsan. Plant A is specific for producing raw materials of petrochemical products and the total numbers of workers were 40. This plant has only one process (process AA) and this was started lately in 1990's. Plant B was established in 1980 and is mainly comprised of producing three types of synthetic resins through three different processes (process BA, BB and BC) with the help of 250 workers .Plant C, started in late 1990's with 110 workers, mainly manufactures liquid products through three processes (processes CA, CB and CC).Each plant has different processes which are shown in [Table 1].

Table 1: Showing the production and the processes of the different plants (A, B, C).

Plant	Hearing difficulty workers	Number and fractions of NIHL workers				
		Low NIHL	Medium NIHL		High NIHL	
			One ear	Both ear	One ear	Both Ear
Plant A	8	8 (100%)	0	0	0	0
Plant B	20	11 (55%)	4 (20%)	4 (20%)	1 (5)	0
Plant C	16	9 (56.3%)	3 (18.8%)	3(18.8%)	1 (6.1%)	0
Total	44	28(63.6%)	7 (15.9%)	7 (15.9%)	2 (4.6%)	0

Noise measurement and protocols

The processes included in these plants were responsible for producing the loud noise which was found above the level of hearing capacity of a normal person. A survey was done on these workers and it was found that the behavior of some workers has changed; some are facing hearing difficulty and some were seen normal. Then a doctor's team was called to monitor those people who were showing the abnormal features and each person was kept on monitoring for a few years. Then at some frequency levels like 500, 1000, 2000 and 4000Hz their hearing capability of both the ears were measured to find out how much the people are affected by noise induced hearing loss (NIHL). A sound arresting meter (897 Dosimeter, Simpson) was utilized to examine the size of noise as well as hearing loss (NIHL) in the workers related to these plants. Workers involved in each process of each plant as well as those who were not involved in processes (e.g. people working in the supporting area of the plants) were also monitored for the test of NIHL. On the basis of above experiment the affected persons were selected and they were monitored for few days and their behavior and response against noise was observed at the above given each frequency level (produced in each process of their plant) continuously. Firstly test was done at low level of frequency and then after week by week frequency level and its period were increased. After the few weeks of observation the authors found that from each plant some workers were found affected by NIHL. Then these workers were kept on monitoring again and some queries were done related to the problems arising through the noise exposure. These series of analysis showed that plant A, B and C had 8, 20 and 16 affected workers, respectively, particularly including one worker who showed high NIHL.

RESULTS AND DISCUSSION

Average noise level and the effected workers

[Table 2, 3, 4] showed that the plant A has produced the average noise range of 84.8-94dB, among the total included workers 31 the affected were 8 in the AA process. The highest noise range was produced from a storage process and the supportive area has 58-65dB range noise with no effected persons.

Table 2. Company A: Average sound produced by different processes and % of effected workers.

Processes	Average Noise (dB)	Total number of workers	Number of effected workers	Effected workers (%)
AA process	84.8-94	31	8	25.8
Supportive area	58-65*	4	0	0
Average	84.8-94	35	8	22.9

* Supportive area average is not included in the total average

Table 3. Company B: Average sound produced by different processes and % of effected workers

Processes	Average Noise (dB)	Total number of workers	Number of effected workers	Effected workers (%)
BA process	73.5-84.6	25	7	28.0
BB process	87.8-93.1	28	5	17.9
BC process	85.6-89.3	57	6	10.5
Supportive area of the plant	62-70*	140	2	1.4
Average	82.1-89.0	250	20	8.0

* Supportive area average is not included in the total average

Table 4: Company C: Average sound produced by different processes and % of effected workers

Processes	Average Noise (dB)	Total number of workers	Number of effected workers	Effected workers (%)
CA process	63.5	20	8	40.0
CB process	76.4	24	5	20.8
CC process	63.3	23	1	4.3
Supportive area	61-68*	40	2	5.0
Average	67.5	107	16	15.0

* Supportive area average is not included in the total average

Plant B which polymerizes synthetic resins showed average noise level of 82.1-89.0dB and 20 effected workers out of 250. Among three processes in plant B, process BA having lower average noise range 73.5-84.6dB, showed a higher rate of effected workers (28.0%) than those (17.9 and 10.5%) in process BB and BC, which had relatively, high average noise ranges (87.8-93.1dB and 85.6-89.3dB). This is because process BA include a separation process which showed the highest noise range 90-102dB than the cutting activity in process BB and BC which showed the highest noise level of 91-97dB. The supporting area having an average noise range 62-70dB, showed even 2 effected workers out of 140 (1.4%) to NIHL.

Plant C which produced liquid products by chemical reactions showed a large variation in fractions of effected workers to NIHL. Even though the average noise level 63.5dB in process CA was much lower as compared to those processes in plant B, its fraction of the effected workers to NIHL was much higher than those of other process in this study. Process CB for neutralization and refining showed average noise level of 76.4dB and 20.8% of effected workers to NIHL with the 2 effected workers out of 40 from the supportive area which showed noise range of 61-68Db which is a relatively higher rate as that in plant B. This showed that each process has their own sections which was responsible for producing the highest noise range that was affecting the workers involved in that process.

Noise induced hearing loss in the workers

[Table 5] showed the survey results of the noise hearing loss in both the ears of the workers who are directly related to the processes of each plant. This showed that workers of B and C plant have high NIHL of 5% and 6.1% respectively and the 100% lowest NIHL was shown by plant A 55% by plant B and 56.3% by plant C. These workers were working without any noise protecting equipment. Even though the noise levels observed in the plant A process were 84.8-94dB, all the effected workers only showed low NIHL. However, the effected workers in plant B with noise levels of 82.1-89Db showed low, medium and high NIHL of 55, 40 and 5%, respectively. Even though

the average noise levels were relatively lower than those in plant A the NIHL levels were much higher than those in plants B and C. This is because the workers in process BB and BC in plant B were exposed to high noise levels of 85.6-93.1dB, as compared to other processes. The workers in plant C with average noise levels of 67.5dB , which is much lower levels as compared to plants A and B, showed low, medium and high NIHL workers of 63.6, 31.8 and 4.6% to their total effected workers, respectively. Their medium and high NIHL fractions were slightly lower than those in plant B. This phenomenon may be associated with other factors, such as biological age and working periods to noise environment, rather than physical factors like noise levels.

Table 5: Showing the percentage of the workers having noise induced hearing loss (NIHL)

Plant	Hearing difficulty workers	Number and fractions of NIHL workers				
		Low NIHL	Medium NIHL		High NIHL	
			One ear	Both ear	One ear	Both Ear
Plant A	8	8 (100%)	0	0	0	0
Plant B	20	11 (55%)	4 (20%)	4 (20%)	1 (5)	0
Plant C	16	9 (56.3%)	3 (18.8%)	3(18.8%)	1 (6.1%)	0
Total	44	28(63.6%)	7 (15.9%)	7 (15.9%)	2 (4.6%)	0

Medical survey according to the Working time period and age of the workers

The workers who were found affected by NIHL their survey was done according to their working time period, age and their education. The detail is given in table 6. The total affected workers were 44 among 44, 43 persons were undergone through some tests and medical survey and the rest one doesn't want to have any test. From 43 the 3 persons were from supportive department and the rest 40 were from the different processes of plants A, B and C.

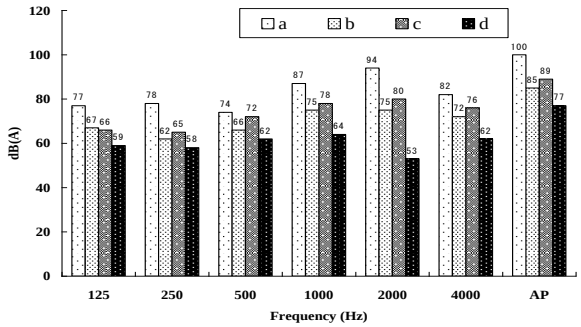
Table 6: Showing the detail of the affected workers according to age, education and working period

Plant	Working area		Age (years)			Education			Working period (years)		
	Process	Supportive area	40	40-50	50	Middle School	High School	College	5	5-10	10
Plant A	8	0	4	3	1	0	7	1	0	1	7
Plant B	18	2	2	18	0	0	16	4	0	1	19
Plant C	14	1	5	5	5	0	13	2	0	9	6
Total	40	3	11	26	6	0	36	7	0	11	32

So, the maximum affected persons were from the age between 40 to 50 yrs and their working period was more than 10 years. This means that the middle age workers are more sensitive towards the high level of noise and when they were exposed for many years they were found effected from NIHL. These total 43 workers were asked several questions regarding health, noise difficulty and noise level, protection equipments about NIHL and noise reduction as well as regarding the change of the department. Regarding the health checkup for noise in last year 90.7 to 97.7% were responded positively and when they were asked that were they facing any difficulty due to hearing loss and about it's cure then maximum (53.5- 88.4%) answered No. But still many (83.7%) were not ready for the cure for NIHL. Again they were questioned about the health effect due to exposure to noise then 41.9% workers were unaware of this and they were not able to assure about the problems they were facing due to noise exposure. Many workers were unknown from the effects of noise exposure and about the protection from NIHL (51.2%) still they were aware of their own protection and were themselves using the noise protecting equipment to protect them from NIHL, because when they were asked that were they forced by the manager to wear the equipment then 90.7% answered No but they (76.7%) never requested about any protection from noise at their work place. After knowing each and every thing still 95.3% denied to change their department. These queries and their result percentage showed these workers are conscious about their health and are coming forward so that their problems can be cured. The queries and their answer by the 43 workers are summarized below in [Table 7].

Noise protection / reduction Facilities

After survey and doctor's query plant A has established some noise protection facilities such as noise absorption wall to the workers of its plant, a detailed noise measurement was conducted with the help of some central frequencies. The noise level at each fixed frequency before protection facility detected at every central frequency of 125, 250, 500, 1000, 2000 and 4000Hz was 77, 78, 74, 87, 94 and 82dB respectively. The noise levels, after establishing the noise protection facilities, were measured with two different environment including blocking and unblocking the noise produced from surroundings. The change in noise levels before and after establishing the noise protection facilities was summarized in figure 1. After providing the noise protection facility to the workers, the identified noise levels without blocking the noise from surroundings showed the loss of 11dB at 125Hz, 13dB at 250Hz, 2dB at 500Hz, 9dB at 1000Hz, 14dB at 2000Hz and 10dB at 4000Hz. This is explained in [Table 8]. This result shows that noise protection equipment can reduce a great amount of noise in the workers.



a: Level before protection facility, **b:** Target noise level, **c:** Level after protection without covered surrounding, **d:** Level after protection with covered surrounding.

Fig: 1. Showing noise level difference before and after the establishment of noise protection facility

Table 7: Survey for the affected workers to noise

Questions asked to affected workers	Yes		No	
	No of people	%	No of people	%
1. Do you have special health check for noise last year?	41	95.3	2	4.7
2. Do you remember the results from the last year test?	42	97.7	1	2.3
3. Did the abnormal symptoms are observed from the test?	39	90.7	4	9.3
4. Are you facing any difficulty in your life due to hearing loss problems?	5	11.6	38	88.4
5. Do you think further hearing loss will occur in future?	20	46.5	23	53.5
6. As compared to your colleagues did they get the cure for hearing loss?	18	41.9	25	58.1
7. Do you think you need regular check up for special test of hearing ability?	36	83.7	7	16.3
8. Is the special test necessary for you?	32	74.4	11	25.6
9. Is NIHL be cured?	7	16.3	36	83.7
10. Could you explain well the health effect due to exposure to noise?	25	58.1	18	41.9
11. Were you measured the noise level at your work place?	37	86.0	6	14.0
12. Did you realize the noise level at your work place?	32	74.4	11	25.6
13. Could you tell the noise level?	27	62.8	16	37.2
14. Did you always take your hearing protection equipment during work?	36	83.7	7	16.3
15. Had you ever took out your equipment while working?	36	83.7	7	16.3
16. Is your manager force you to wear the protecting equipment?	4	9.3	39	90.7
17. Did you wear themselves the protecting equipment without the force of manager?	39	90.7	4	9.3
18. Is the hearing protection equipment effective?	40	93.0	3	7.0
19. Did you like the hearing protection equipment?	36	83.7	7	16.3
20. Did you have enough knowledge about the protection from NIHL?	21	48.8	22	51.2
21. Did you have any training or education?	31	72.1	12	27.9
22. Did you want any training or education?	34	79.1	9	20.9
23. Have you ever thought about the methods for noise reduction?	41	95.3	2	4.7
24. Did you try to avoid going at the noisy places?	27	62.8	16	37.2
25. Did you ever request to your manager for the protection from the noise at your work place?	10	23.3	33	76.7
26. Did you want to work in other department of the same plant because of the noise?	2	4.7	41	95.3
27. Even though the noise level is severe problem you have to work their because of your family living?	9	20.9	34	79.1

Table 8: Reduced noise level after providing the noise protecting equipment

Methods	Frequency in Hz						
	125	250	500	1000	2000	4000	All Pass
Level of noise before the Protection facility(dB)	77	78	4	87	94	82	100
Target (Db)	67	62	66	75	75	72	85
Delta of target and noise level Before protection (Db)	10	16	8	12	19	10	15
Noise level after protection in Closed area (Db)	59	58	62	64	53	62	77
Noise level after protection in open area (Db)	66	65	72	78	80	72	89
Difference between protection in closed area and before the protection	18	20	12	23	41	20	23
Difference between protection in open area and before the protection	11	13	2	9	14	10	11

Hearing test results before and after using protection

This study compares the hearing test results of the workers of plant A at 400Hz before and after establishing the noise protection facilities. In years 2002, 2003 and 2004 no protection facility was provided and in year 2005 the workers were provided with noise protecting facility. An average of noise levels of both the ears of effected workers was taken before the establishment of protection facilities and compared with the noise levels of the both the ears of the same workers after the establishment of protection facilities. On comparison of the noise levels at 400Hz a remarkable result was detected. There was relative decrease in the noise levels of the left ear of all the 7 workers after the establishment of noise protection facility, only one worker out of 8 did not show any difference on the left ear before and after the establishment of noise protection facility. For the right ear out of 8 workers 3 showed relative decreases in noise level and one did not show any difference but 3 workers showed a little increase in their noise level after the establishment of noise protection facility. This is explained in table 9. Overall result explains that noise protection facility decreases the noise level of the both the ears of the workers up to a large extent and is safe as well as helpful in protecting their ears from the exposure of noise.

Table 9: Hearing test results of Plant A workers

Persons	Frequency at 400Hz				Difference before and after noise protection facility	
	Average of noise levels of 3 years		Noise level of year 2005			
	Left ear	Right ear	Left ear	Right ear	Left ear	Right ear
Mr X	50	23.3	45	15	-5	-8
Mr Y	46.7	53.3	45	55	-2	+2
Mr XY	66.7	41.7	60	40	-7	-2
Mr XX	60	75	60	80	0	+5
Mr XZ	51.7	55	45	50	-7	-5
Mr YX	30	46.7	25	50	-5	+3
MrZ X	43.3	11.7	40	10	-3	-2
Mr YY	52.5	60	40	60	-12	0

CONCLUSION

The above study is helpful in explaining the noise induced hearing loss in the workers of petrochemical plants who have been exposed to high noise for a long time. These workers were working in noisy environment without the noise protection equipment and thus their both the ears were exposed continuously to the particular noise which lead them towards the noise induced hearing loss as well as other health defects. After establishing the noise protection facilities in the work place as well as to their ears, the noise level was much decreased and could minimize the noise pollution. Thus; this study explains that noise protection equipment as well as noise protection facilities are very much helpful to cope up with the dreadful condition of NIHL

CONFLICT OF INTEREST

There is no conflict of interest.

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None

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