ORIGINAL ARTICLE

Comparison of Pulmonary Functions in Residents Living Around 5km Radius of Oil Refinery: Duration of Exposure

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Abstract:

Background: Petroleum refineries are large industrial installations that are responsible for the emission of several pollutants into the atmosphere, exposed to these pollutants formed from crude oil has shown some effects on pulmonary functions. Oil refinery plants refine crude oil in different products from petrol to tar which also involves air pollution in surroundings. *Aim and Objectives:* The present study was planned to assess the pulmonary functions in residents living around a refinery who are continuously exposed to the particles generated from refinery and effects of duration of exposure. *Material and Methods*: The present study was done on 200 residents who were categorized into four groups containing 50 in each depending on duration of exposure, 50 healthy non-smoker males from the campus served as control group. Pulmonary Function Test (PFT) parameters: Forced Vital Capacity (FVC), Forced Expiratory Volume in First Second (FEV1), Forced Expiratory Volume in First Second by Forced Vital Capacity Ratio (FEV1/FVC%), Peak Expiratory Flow Rate (PEFR), Mean Forced Expiratory Flow between the 25% and 75% of the FVC (FEF25-75%), Forced Expiratory Volume in Third Second (FEV3), Forced Expiratory Volume in Third Second by Forced Vital Capacity Ratio (FEV3/FVC%), Forced Expiratory Volume in Sixth Second (FEV6) were analyzed in all groups and compared by ANOVAs test to test significance. *Results:* Both respiratory flow rates were decreased in study groups. The results suggest living near an oil refinery was associated with high prevalence of respiratory symptoms due to air pollution from the refinery. *Conclusion:* These findings contribute to the evidence supporting deleterious effects of air pollution on lung function of residents in a restrictive pattern. The pattern of respiratory impairment changes to mixed type as the duration of exposure increases. Following parameters PFT parameters were checked. Findings showed statistically significant decrease in values of FVC (Litres), FEV1 (Litres), Forced Expiratory Volume Percentage FEV1/FVC %, PEFR (Litres/S), Maximum Voluntary Ventilation [MVV (Litres/ min)), Forced Expiratory Flow Rate during 25% to 75% of expiration] FEF 25-75% (Litres/S), FEV3 (Litres), FEV3/FVC and FEV6 (Litres) in residents when compared to control groups.

Keywords: Duration of Exposure, Pulmonary Function Tests, Residents near Oil Refinery

Introduction:

Rapid industrialization, globalization and poor environmental conditions at residential places have created a lot of health related issues. Petroleum refineries and petrochemical plants are generally very large industrial installations which are associated with the emission of various organic compounds into the atmosphere and pollute surroundings, mainly originating from the production processes, the storage tanks and the waste areas [1].

In petrochemical industries, most of the volatile organic compounds are derived from crude petroleum fractions and actually from only a few basic hydrocarbons such as methane, ethane, propane, benzene, toluene, and xylene [2]. Petroleum refining includes physical, thermal and chemical separation of crude oil into its major distillation fractions. The primary products of the industry fall into three major categories: 1) Fuels (petrol, diesel, liquefied petroleum gas, jet fuel, residual fuel oil, kerosene and coke). 2) Finished non-fuel products (solvents, lubricating oils, greases, petroleum wax and jelly. 3) Chemical industry feedstocks (naphtha, ethane, propane, butane, ethylene, propylene, butylenes, butadiene, benzene, toluene and xylene). Leaks, burning of fuels in process heaters and various refinery processes are the emission sources in refineries [3]. Along with Volatile Organic Compounds (VOCs), various other gas pollutants (i.e. sulphur dioxide, carbon monoxide, nitrogen oxides and particulate matter) are emitted from petroleum refineries [4].

Several studies concluded that chronic exposure to low levels of hazardous pollutants were significantly related to adverse effects on respiratory and cardiovascular systems among the residents living closer to Gwangyang and Yeosu industrial complexes in Korea [5-6]. The World Health Organization (WHO) recently estimated that 35% of respiratory diseases could be attributable to the environment and proposed interventions in industrial, commercial, transport, housing/ community sectors to reduce population exposures to air pollution [7]. The present study was taken to investigate respiratory parameters in residents living within 5km range of Mathura Oil Refinery located in Mathura-Agra highway and any effect of duration of exposure on pulmonary functions. To the best of our knowledge, this is the first study in India to investigate populations residing near an oil refinery regarding their pulmonary health.

Materials and Methods:

Study type:

This cross-sectional study was conducted among the residents of nearby villages residing less than 5km of Mathura Oil Refinery located on Mathura-Agra highway during 1stJanuary-31stOctober 2019.

Sample size and sampling:

Participants were selected by random sampling from villages near refinery within 5 kilometres because of high risk zone [8]. Subjects were selected based on duration of exposure from six months to three years.

Study participants:

Study setting was residential neighbourhoods living <5 kilometres of oil refinery located near Mathura Oil Refinery on Mathura-Agra highway. Age and sex matched control group participants were selected from campus among paramedical and supporting staff.

Data collection:

Two hundred residents were randomly selected from resident villages of Mathura Oil Refinery who were male healthy and non-smokers and they were again divided into four study groups depending on their duration of exposure given in Table 1. Then they were compared with age matched healthy male non-smokers (control group) taken from staff residing in campus which is 80 kilometres away

were also enrolled. After getting proper ethical clearance from Institutional Ethics Committee, a comparative cross sectional study was conducted at the Department of Physiology, Kanti Devi Medical College Hospital and Research Centre. They were provided with written and verbal information involved in the research. Confidentiality of the subjects was maintained. Informed consent was obtained from each resident prior to study. Height and weight of each subject was measured. Pulmonary functions were measured by the electronic spirometer, model-RMS Helios P-702 in accordance with the strict standards of lung function testing of the American Thoracic Society/European Respiratory Society (ATS/ERS) [8]. Procedure was explained and demonstrated prior to the test to each subject till full familiarity was achieved upon the satisfaction of subject. All Pulmonary Function Tests (PFT) were done in sitting position and PFT measures included were Forced Vital Capacity (FVC), Forced Expiratory Volume in One Second (FEV1), the Ratio of Forced Expiratory Volume in One Second (FEV1), FEV1/ FVC %, Forced Expiratory Flow Rates FEF 25%-75%, Maximum Ventilatory Volume (MVV), Force Expiratory Volume in Third Second (FEV_3), FEV3/FVC%, Forced Expiratory Volume in Six Seconds (FEV_6) and Peak Expiratory Flow Rate (PEFR). A complete flow-volume loop was obtained and maximum three readings were recorded, if subject failings the satisfactory performance within five attempts were discontinued for the same day. Best of these three readings was considered for the study.

Statistical analysis:

Collected data were compiled by using Microsoft Excel™. Continuous data with normal distribution was analyzed by Analysis of Variance (ANOVA) test and Scheffe hoc test using Statistical Package for Social Sciences (SPSS) for inter group significance. *P* value of less than 0.05 was considered significant.

Results:

There were total of five groups in the present study. Five groups were divided depending upon the duration of exposure. There was no significant difference in the mean age, mean height and mean weight among groups.

Table 1: Sample Population of All Groups

Group-1 (n=50)	Residents living within 5 kilometres of Mathura Oil Refinery exposed for six months.
Group-2 (n=50)	Residents living within 5 kilometres of Mathura Oil Refinery exposed for one year.
Group-3 (n=50)	Residents living within 5 kilometres of Mathura Oil Refinery exposed for two years.
Group-4 (n=50)	Residents living within 5 kilometres of Mathura Oil Refinery exposed for three years.
Group-5 (n=50)	Control (age-sex matched from the employees living in the campus)

Table 2: Anthropometric Measurements of Study and Control Groups

Parameters	Control Group (n=50)	Distribution of Study Groups (Residents of Refinery) According to Duration of Exposure (n=200)			
		6 months (n=50)	1 year (n=50)	2 years (n=50)	3 years (n=50)
Age (Years)	33.1 ± 6.64	32.5 ± 6.47^{NS}	32.38 ±6.2^{NS}	35.3 ± 6.72^{NS}	34.9 ± 6.44^{NS}
Height (cm)	170.53±8.41	170.04 ±6.43^{NS}	169.12 ± 6.43^{NS}	169.02±6.44^{NS}	169.14±5.74^{NS}
Weight (kg)	71.26±10.58	72.78 ± 8.72^{NS}	72.1 ± 9.22^{NS}	70.8 ± 8.52^{NS}	72.5 ± 8.72^{NS}

NS - not significant compared with control

Table 3: Effects of Duration of Exposure on Pulmonary Functions in Residents Living Around the Oil Refinery

Variables	Control Group (n=50)	Study Group: PFT Values of Residents Based on Duration of Exposure				ANOVA
		6 Months (n=50)	1 year (n=50)	2 years (n=50)	3 years (n=50)	
FVC (L)	3.37 ± 0.43**	3.0 ± 0.13**	2.98 ± 0.19**	2.67±0.21**	2.69 ± 0.32**	31.32
FEV1 (L)	2.93 ± 0.40**	2.58 ± 0.11**	2.55 ± 0.15**	2.24±0.18**	2.26 ± 0.26**	50.37
FEV1/FVC %	87.25 ± 2.22**	85.99 ± 1.92**	85.67±1.73**	83.57±2.56**	83.89 ± 2.23**	17.81
PEFR (L/S)	8.44 ± 1.08**	7.94 ± 0.36**	7.94 ± 0.28**	7.39 ± 0.37**	7.44 ± 0.45**	33.26
MVV (L/M)	133.14±9.18**	122.64±3.59**	121.92±4.65**	111.3 ± 6.0**	111.96±7.75**	58.15
FEF_{25-75} (L/S)	4.22 ± 0.48**	3.98 ± 0.21**	3.93 ± 0.17**	3.51 ±0.30**	3.56 ± 0.26**	52.14
FEV3 (L)	3.24 ± 0.51**	2.91 ± 0.13**	2.90 ± 0.19**	2.59 ± 0.22**	2.59 ± 0.33**	31.65
FEV3/FVC %	97.27±0.59^{NS}	97.0 ± 0.12^{NS}	97.0 ± 0.13^{NS}	96.65±2.41^{NS}	96.08±2.79^{NS}	2.78
FEV 6 (L)	3.33 ± 0.49**	3.0 ± 0.13**	2.99 ± 0.19**	2.68 ± 0.22**	2.68 ± 0.32**	31.86

Pulmonary functions were significantly decreased in exposed residents as compared to control group. Pulmonary functions were increasingly affected with increase in duration of exposure.

*Note: **p<0.001- Highly Significant, NS- Not Significant. FVC-Forced Vital Capacity, FEV1-Forced Expiratory Volume in One Second, the Ratio of Percentage of Forced Expiratory Volume in Forced Vital Capacity FEV1/FVC %, FEF25%-75%-Forced expiratory flow rates, MVV- Maximum Ventilatory Volume,FEV_3- Force Expiratory Volume in Third Second, FEV3/FVC%, FEV_6-Force Expiratory Volume in Six Seconds and PEFR-Peak Expiratory Flow Rate.*

Discussion:

This study examined the respiratory health impacts of pollution caused by oil refinery on people living near Indian oil refinery located near Mathura on Mathura-Agra Highway. This study results clearly demonstrated that prolonged exposure markedly affects the pulmonary function in the exposed group towards lower relative to their matched controls. Various authors in different studies also reported decrease in parameters of PFTs in residents found in the form of deterioration in pulmonary health [9-11].

The probable cause of decrease in pulmonary functions in residents of refinery is due to air pollution from refinery. Because petroleum refineries are the major source of hazardous and toxic air pollutants such as compounds of Benzene, Toluene, Ethyl benzene and Xylene (BTEX) [12]. They are also a major source of criteria air pollutants like Particulate Matter (PM), Nitrogen Oxides (NOx), Carbon Monoxide (CO), Hydrogen Sulphide (H_2S) and Sulphur Dioxide (SO_2). Refineries also release less toxic hydrocarbons such as natural gas Methane (CH_4) and other light volatile fuels and oils. They aggravate severely some respiratory conditions such as childhood asthma [12]. Along with the possible health effects from exposure to these chemicals, these chemicals cause worry and fear among residents of surrounding communities. Air emissions can come from a number of sources within a petroleum refinery including: equipment leaks from valves or other devices, high-temperature combustion processes, heating of steam and process of crude oil [12]. Thousands of these pollutants are typically emitted into the environment over the course of a year through normal emissions, fugitive releases, accidental releases and some repairs in refinery plant. The combination of volatile hydrocarbons and oxides of nitrogen also contribute to ozone formation, one of the most important air pollution problems in the India [13].

There have been similar studies identifying an association between long-term exposure to air pollution and adverse effects on respiratory function, diseases, and allergy symptoms in the general population. The exposure to low levels of air pollution increases acute respiratory diseases, lung malfunction, blood pressure, and prevalence of respiratory diseases, with more frequent hospitalization. It exaggerates chronic respiratory diseases and increases the prevalence of asthma and asthma attacks [10, 14].

Air pollutants near oil refineries-specifically, NO_2, PM2.5µm and SO_2 - have been associated with increased respiratory illnesses among residents living proximal to the refineries. Research has documented increases in asthmatic episodes, wheezing symptoms, and an overall decrease in lung function in residents who live near the refinery [15-16, 18].

Based on data from the Philadelphia area, refinery monitoring conducted in other communities, it is apparent that communities within 5 kilometres of the refinery have much higher exposure than other distant areas of Philadelphia. [17]. Occupational solvents gets absorbed into body either through respiratory pathway or by dermal which disturbs the physiology of human body. Mainly lung volumes are affected by having their effect on cilia and clara cells which decrease the elastic recoil of lungs [19]. The pollutants emitted from oil refinery travel and remain in environment gets inhaled by

residents. As the duration increases the pollutants may get deposited more and more into the deeper portions which can affect the efficiency of lung functions. This confirms that people residing less than 5 km of refinery are under great threat and our study results have shown decreased pulmonary functions. Obviously as the duration of exposure increases the pollutants are accumulated more and more in deeper portions of lungs causing mixed pattern of deterioration of lung functions in residents.

Conclusion:

This research study depicted the significant difference in the pulmonary function tests results of residents near to refinery from the control group, mechanical properties of breathing are hampered due to chronic exposure to the air pollution.

Recommendation:

To minimize the health hazards, periodic health check along with pulmonary function tests at least every six months should be done. Health check-up camps should be arranged frequently at nearby places of refinery. Protective measures, lung function exercise may help reduce the burden of this hazard. Plantation can be done to prevent the movement and reduction of pollution near refineries.

Limitations:

There are few limitations of this study only people living nearby 5 km have been included. Females have been excluded from this study because maximum females are house hold workers living inside home. There might be deterioration in females also which has to be analysed. There are also other limitations of this study, like ambient air quality data level of respirable dangerous gases and suspended particulate matter could not be analyzed and percentage of people with obstructive and restrictive lung disease could not be calculated.

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