Healthy Workplace Occupational Health and Hygiene Consultants

A COMPREHENSIVE STUDY OF SILICOSIS AMONG SILICA SAND WORKERS IN KARAULI

A comprehensive study of silicosis among silica sand workers in Karauli

1.0 Background

Daang Vikas Sansthan, (DVS) is a Non-Government Organisation (NGO) working for welfare of stone mine workers and other social work in Karauli and nearby districts. The sansthan has been specifically active in highlighting relief and rehabilitation in silicosis affected mine workers and creating awareness among workers for prevention of silicosis. It is also working on livelihood programme and has contributed to relief operation during ongoing Covid pandemic.

Natural silica stone and silica sand deposit is present near Karauli town and in recent years number of silica stone crushing units have come up in the area producing silica sand for supply to industries in Rajasthan and nearby states. The silica stone mines and crushing units employ workers from nearby villages who may not be aware of possible health hazards.

In view of experience of Daang Vikas Sansthan in detection of silicosis among sand stone mine workers, DVS believed that exposure to silica dust in mining of silica stone and crushing to make silica sand powder which has high percentage of free silica, may also cause silicosis among workers employed in these mines and silica powder manufacturing units.

Hence, DVS requested M/s Healthy Workplace Occupational Health and Hygiene Consultants, Jaipur to conduct a comprehensive study to determine occurrence of silicosis among workers with history of work in silica stone mines and crushers.

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2.0 Introduction

Karauli is one of the Southern-Eastern district of state of Rajasthan bordering Madhya Pradesh and is primarily a hilly area under Aravali hills. It is bounded in the north by Dausa and Bharatpur districts, in the east by Dhaulpur district, south by state of Madhya Pradesh and by in the west Sawai Madhopur district. This district is part of four river basins namely "Gambhir River Basin", "Banas River Basin", "Chambal River Basin" and "Parbati River Basin". The geological formation of the district is Pre-Cumbrian metamorphic rocks rich in limestone, sandstone, silica sand, etc. Karauli is primarily famous for mining of pink coloured construction stone used for carvings and as stone slabs for roof and flooring. Livelihood of the rural population of this district is mainly dependent on agriculture, animal rearing and mining. (1)

3.0 Silica Stone and Silica Sand Mining and Deposits in Karauli

Silica stone and sand resources of about 332.46 million tonnes have been assesed in Rajasthan mainly in Bundi, Bikaner, Karauli, Sawai Madhopur, Kota, Baran, Jaisailmer, Jaipur and other districts. It is estimated that Karauli and Sawai Madhopur district have 0.73 million tonnes of silica sand resources. (2)

The indicated silica stone and sand reserves are only preliminary estimates and actual may be much more. The reserves of silica are available in Karauli and Sapotra tehsil confined to the area between Khirkhida -Sapotara Road and Gangapur – Keladevi Road. The silica stones are found in white and brownish colour which is mainly used for making glass bangles and artifacts.

The mines department has leased 34 mines in the district, which provide employment to approximately 500 workers on daily basis. Of these only 4-5 mines are currently operative but many more mines are operated illegally. The mines of silica stones and sand are located near Ramapur, Atalpura, Richhoti, Khirkhida, Gairai, Dhaoreta, Ghoreti, Kadhai, Gothra and Mijhaura villages in Karauli district. (3)

The composition of sand stone in Karauli area includes about Silica (SiO_2) 98.5%, Alumina (AL_2O_3) 1.0-1.5%, Potassium Oxide (K_2O) 0.2%, Titanium Oxide (TiO_2) 0.03%, Ferous Oxide (Fe_2O_3) 0.1-0.3% and other minor impurities. (4)

4.0 Mining of Silica Stone and Sand

Silica stone occurs as surface deposit and is mined either manually by pick-axes and shovels or with excavating machines. As the deposit is soft and brittle, no blasting is required and silica stone crumbles into sand during mining. The sand is manually sieved and prepared for despatch. Alternatively, large boulders of silica stone are manually broken and crushed in jaw crusher to make silica powder and filled into trucks for despatch. Silica stone is also transported to crushing units for manufacture of silica sand powder. (Fig 4-7)

5.0 Manufacture of silica sand powder

In silica sand powder making units, the silica stone or silica sand is crushed in jaw crusher and made into the requisite mesh size in accordance with commercial requirement by multistage sieving and filtering. The manufactured silica powder is filled either in HDPE bags or directly loaded into trucks for further transport to the industry. The whole process is inherently dusty and clouds of silica dust can be seen emanating from powder making unit and causing environmental pollution in nearby area. In most powder making units, there are no dust control or suppression measures. The manufacturing unit employs 5-20 persons depending on the size of operation, mostly migrant or villagers. (Fig. 8-11)

6.0 Uses of Silica Sand

Silica sand is valued for several useful properties. It has high melting point and low thermal expansion coefficient, which makes it a good choice for applications that involve high-temperature exposures.

Silica sand is primary component in the manufacturing of glass and is a very important raw material for standard and special glasses. It is also an essential part of the production of steel, ferrous and non-ferrous foundry industries for de-oxidation and grain refinement. It is also used in making of calcium silicate blocks, paints and coatings, ceramics and refractories and industrial abrasives. In oil and natural gas industry, it is used in drilling operations. (5)

Silica sand from Karauli is supplied to Delhi, Haryana, Uttar Pradesh, Uttranchal and other ststes of which 85-90 % is used in manufacture of glass for vehicles and 10 to 15 percent is used in feldspar and limestone industry.

7.0 Health Hazards in Silica Stone and Sand Mining and manufacturing

Silica stone and sand contains very high percentage of crystalline silica and persons working in silica stone and sand mining and processing are exposed to crystalline silica dust and are at the risk of developing silicosis. There is increasing evidence that silica exposure respirable crystalline silica also causes lung cancer, chronic obstructive pulmonary disease (COPD), and kidney disease. Exposure to respirable crystalline silica is also related to the development of autoimmune disorders and cardiovascular impairment, in addition to the risk of developing pulmonary tuberculosis and various other systemic diseases. However, the main heath risk to the workers remain occurrence of silicosis. (6)

7.1 Silicosis : An occupational Disease (7)

Silicosis is an occupational disease caused by inhalation of airborne dust of Silicon Dioxide or Silica in the crystalline form also known as quartz. In mines, workers are exposed to high concentration of silica dust almost at every stage of mining operation. However, drilling, blasting, loading – unloading of ore, crushing, etc. are some of the dustiest operations and thus, workers in mines are at the risk of developing silicosis. Occurrence of silicosis is directly related to the degree of exposure to silica dust and higher the exposure more is the chance of developing silicosis. Silicosis is generally seen in sub-acute and chronic form after exposure to silica dust for many years. However, very heavy exposure to silica dust is known to cause acute silicosis.

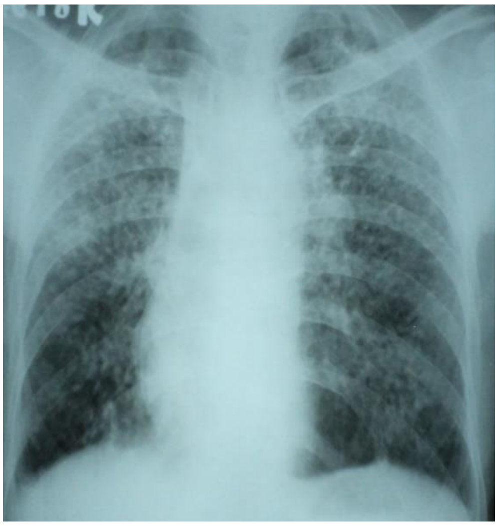

Fig 1 & 2 Cases of Simple Silicosis and Silicosis with Progressive Massive Fibrosis

Silicosis is a largely asymptomatic disease and there may be no symptoms even though the radiographic appearances may suggest fairly advanced silicosis till the onset of Progressive Massive Fibrosis (PMF). Dyspnoea or breathlessness on exertion is the most frequent and directly related symptom, although it is rarely complained of in the absence of complicating diseases such as tuberculosis or bronchitis. The severity of dyspnoea increases with the progress of disease. Slight unproductive cough may be present at initial stages, however, the quantity of sputum increases later on. The symptoms usually resemble chronic bronchitis. Chest pain and haemoptysis are invariably due to tuberculosis.

Chest radiography is the most important tool for the diagnosis of silicosis. The radiographic diagnosis of silicosis can only be made after appearance of nodules particularly in upper and middle zones of lungs. Silicotic opacities tend to increase even after cessation of exposure to silica dust. Pulmonary tuberculosis is the most frequent and an important complication of silicosis. The other common and terminal complication of silicosis include repeated pneumothorax associated with combination of fibrosis and bullae. Development of progressive massive fibrosis at any stage invariably carries poor prognosis.

7.2 Previous studies on Silica Sand Mining and its hazard

Very little information is available on silica stone and sand mining in literature from India or other countries. Most of the information is related to use of silica sand in sand blasting, use in glass making, construction industry and recently in use of artificial stone manufacture. In most cases occurrence of silicosis remains the main hazard depending on nature of work, both acute and chronic silicosis are known to occur in various industries.

8.0 Objectives

In view of the mining of silica stone and sand increasing number of silica stone crushing and silica sand powder manufacturing units have come up in the areas nearby Karauli town. No study has been conducted in the Karauli area to evaluate health hazards in silica stone and sand mining and manufacturing units of silica powder. Hence, Daang Vikas Sansthan decided to get a comprehensive study conducted on occurrence of silicosis among workers with history of work in silica stone and sand mines and manufacturing units.

Aims and objectives of the present study were

- To determine prevalence of silicosis if any, among workers with history of work in silica stone and sand mines

10.0 Health Screening of Workers

The fieled officials of Daang Vikas Sansthan identified persons with history of work in silica stone and sand mines and manufacturing units and suffering from respiratory ailments by conducting home surveys in nearby villages and requested them to report for medical screening at its office on 9th and 10th October, 2021. A written consent for participation in the study was taken from persons.

The medical examination of workers included a detailed history of work, general physical examination with special emphasis on chest examination and a full size digital chest radiograph taken at 300 mA. The chest radiographs were evaluated in accordance and as per the standards prescribed for ILO International Classification of Radiographs of Pneumoconioses. (8)

11.0 Material and Method

11.1 Distribution of workers according to age group

A total of 101 workers, 39 female and 62 with history of work in silica stone and sand mine. or silica powder manufacturing participated in the study.

Majority of the workers who presented for health screening had retired from work. The mean age of the workers was 51.3 ± 9.2 (S.D.) years. Table 1 shows distribution of workers in different age groups. As majority of workers had past history of work in these units, 81 % of were in the age group 40 years or above.

Table 1 Distribution of workers according to age group

Sl. No.	Age Group	No of workers
1.	< 20	0
2.	21-30	3
3.	31-40	17
4.	41-50	27
5.	51-60	37
6.	60+	17
	Total	101

11.2 Distribution of workers according to duration of work

Fig. 2 shows distribution of workers according to the number of years worked in silica sand industry. The average number of years worked was 19.3 ± 8.5 (S.D.) years. 90% of workers had worked for more than 10 years and 24% had worked for more than 20 years.

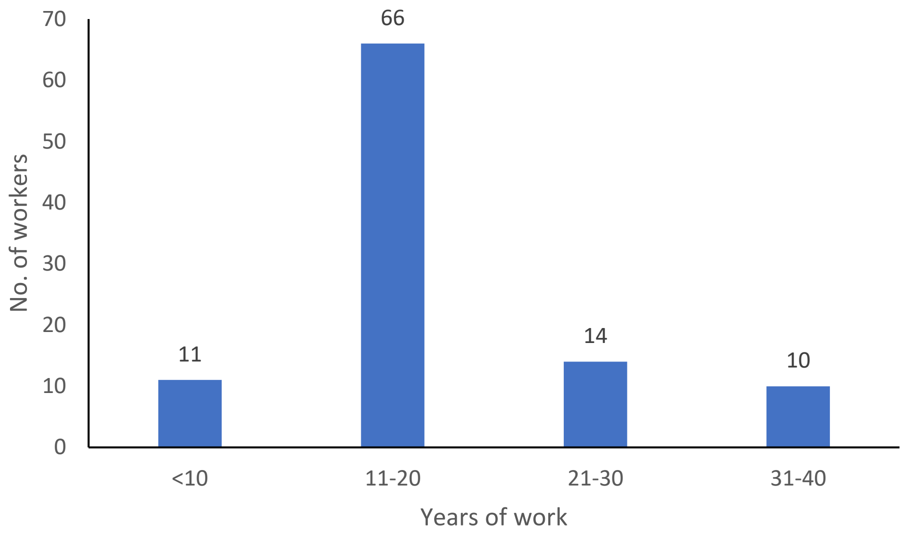

Fig 3 Distribution of workers according to duration of work

12.0 Results of Health Screening

Following are the results of health screening during the study.

12.1 Symptoms and complaints

During examination majority of the workers complained of one or other symptoms including cough, expectoration, breathlessness and chest pain. In 70% of workers breathlessness alone or in association with other symptoms was the main complaint. Chest pain and tightness being the other important complaint in 48% workers. In majority of workers, the symptoms had been for more than one year while in 43% workers, symptoms had been for more than 5 years.

Table 3 shows distribution of workers according to symptoms and complaints and their duration respectively.

Sl No.	Complaint	No of workers
1.	No complaints	02
2.	Only Cough	7
3.	Only Expectoration	11
4.	Only Breathlessness	47
5.	Hemoptysis	4
6.	Only Chest Pain	11

7.	Chest pain with other symptoms	37
8.	Cough with expectoration	02
9.	Cough with Breathlessness	11
10.	Cough, expectoration and Breathlessness	02

Table 3 Distribution of workers according to symptoms

Fig 2 shows distribution of workers according to the duration of symptoms in years.

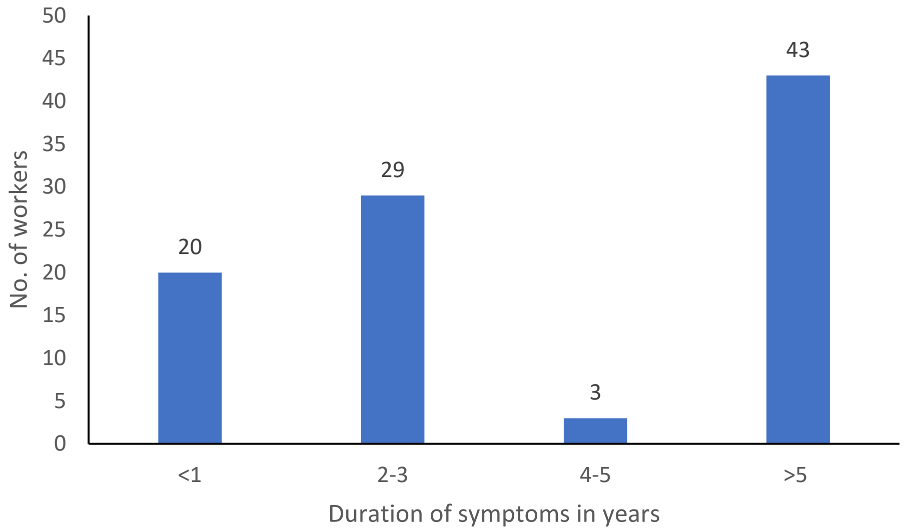

Fig. 4 Distribution of workers according to duration of complaints

Further analysis of data showed that 60% of workers complained of breathlessness with or without other associated symptoms and frequency of breathless increased with increasing number of years worked as shown in table 5.

Sl No.	Years of Work	No of workers	Breathlessness
1.	<10	11	5 (45.5)
2.	11-20	66	39 (59.0)
3.	21-30	14	10 (71.4)
4.	31-40	10	6 (60.0)
	Total	101	60 (60.0)

Note : figures in parentheses indicates percentage

Table 4 Correlation of years of work and Breathlessness

12.2 Abnormality on chest examination

Majority of workers 83%, did not show any abnormal signs on chest examination. While few workers had occasional ronchi, 5 workers showed bilateral coarse crepitations and 4 had bronchial breathing in infraclavicular region. Table 6 shows distribution of workers with chest findings.

Sl No.	Abnormal signs	No of workers
1.	No Signs	2
2.	NAD	83
3.	Bilateral coarse crepitations	5
4.	Bronchial Breathing	4

Table 5 Abnormal signs on chest examination

12.3 Abnormality on Chest Radiograph

Evaluation of chest radiograph of workers in accordance with ILO International Classification of Chest Radiographs of Pneumoconioses revealed that 62 (62%) workers did not have any abnormality while 20 (20%) worker showed small pneumoconiotic opacities consistent with silicosis and in another 5 (5%) cases presence of pneumoconiotic opacities could not be ruled out. The opacities were predominantly of type “p’ and “q”. In chest radiograph of 5 (5%) workers irregular opacities of type “s” and “t” were observed. In one case, the chest radiograph showed category 3/3 profusion of “t” type opacities typical of diffuse interstitial fibrosis. In chest radiograph of 5 workers there was associated fibrosis suggestive of pulmonary tuberculosis along with small regular pneumoconiotic opacities while chest radiograph of 14 other workers showed fibrosis due to pulmonary tuberculosis without any pneumoconiotic opacities. Fig. 3 shows details of profusion of pneumoconiotic opacities.

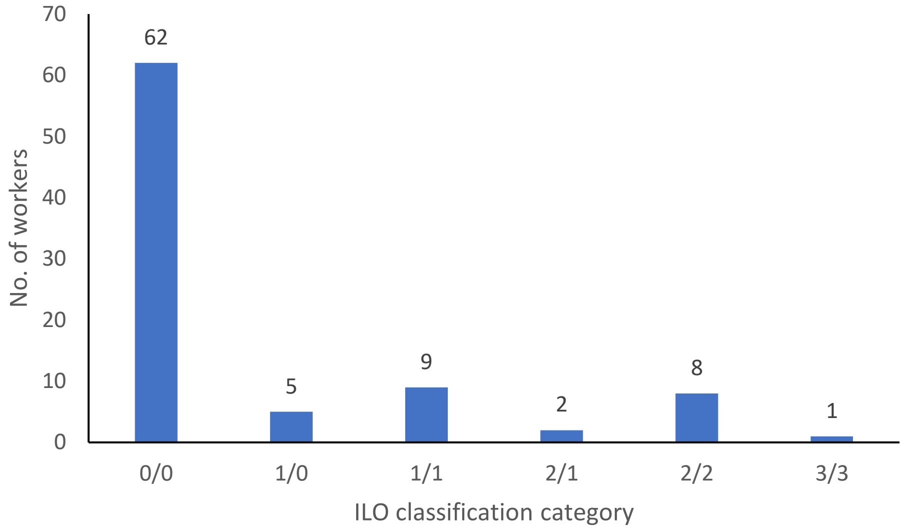

Fig. 5 Detail of ILO Classification of chest radiograph

12.4 Provisional diagnosis

Based on occupational history, general physical examination and evaluation of chest radiographs in accordance with the ILO classification, a provisional diagnosis has been suggested for abnormalities observed. The chest radiographs with no abnormality were classified as normal, the chest radiographs with small regular opacities of profusion 1/1 or more were classified as cases of silicosis, the chest Radiographs with large opacities were classified as Progressive Massive Fibrosis, the chest Radiographs with small regular opacities and features of active or healed tuberculosis were classified as silico-tuberculosis and chest radiographs with features of active or healed pulmonary tuberculosis were classified as case of pulmonary tuberculosis. Accordingly, table 8 gives details of workers with provisional diagnosis.

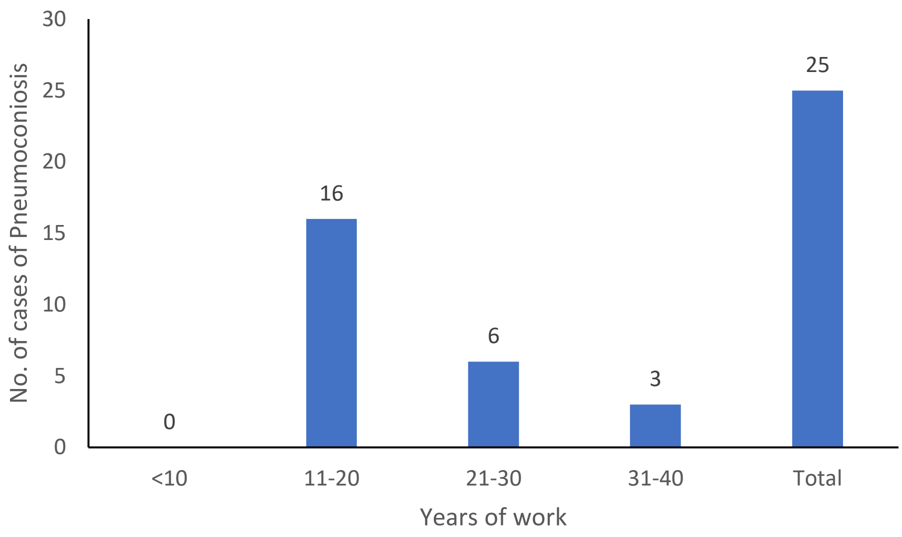

Fig. 6 Details of provisional diagnosis

The table 6 provides the correlation between number of years worked and provisional diagnosis.

Sl No.	Years of Work	No of workers	Cases of Silicosis
1.	<10	11	00 (00)
2.	11-20	66	16 (24.2)
3.	21-30	14	6 (23.3)
4.	31-40	10	3 (30)
	Total	101	25 (25)

Note : figures in parentheses indicates percentage

Table 6 Correlation of years of work and cases of pneumoconiosis

Further analysis of data suggested that though overall prevalence of silicosis was 20%, the prevalence was 27.8 % among workers who had worked for more than 10 years and the prevalence increased with years of work. Table 5 shows the relationship between complaint of breathlessness and years of work.

13.0 Discussion

Though silica sand mining is carried out in most countries, very few studies are available in literature on prevalence of silicosis or other health hazards in silica sand or silica stone mining presumably because of large size of silica particles in the nature. The present study of 101 workers including 39 female and 62 males was conducted to determine prevalence of silicosis among silica stone and silica sand mining workers in Karauli area in Rajasthan. Most of the workers who reported for medical examinations had retired from the work and very few workers were presently working in the silica stone or silica sand mines

During health screening examination 99 of 101 workers complained of one or other symptoms, 60% of workers complained of breathlessness and tightness or chest pain was the complaint in 48% of the workers.

The study shows that on health screening, 20% of the workers had small opacities suggestive of a silicosis while in 5% cases, silicosis could not be ruled out. The study also reveals that chest radiographs of 5 workers had predominantly irregular opacities of “s” and “t “ type which are not normally associated with silicosis. Irregular opacities were also present in radiographs of many other workers though they were not predominant. Typical “r” type of opacities associated with chronic silicosis were rare among workers. No cases of large opacities suggestive of Progressive Massive Fibrosis (PMF) was observed during the study. Chest radiograph of 14% workers showed evidence of active or healed tuberculosis while 5% other workers had evidence of silicosis associated with tuberculosis.

14.0 Conclusions

On the basis of this exploratory study it can be said that among silica stone and silica sand mine workers, a large proportion of workers suffered from symptoms and a significant amount of workers showed changes suggestive of silicosis on chest radiograph. It is not surprising in view of the primitive working conditions, presence of over 98 % free silica in the dust and exposure to high concentration of crystalline silica dust in these mines that workers are at risk of developing silicosis and predisposition of pulmonary tuberculosis.

The present study is only an exploratory in nature and its findings cannot be generalised. It is quite possible that many of the workers who had suffered from silicosis might have succumbed to the disease and the present study shows the prevalence of silicosis among surviving workers. In conclusion, it can be said that workers in silica stone and silica sand mines are at the high risk of developing silicosis and other related diseases. However, a large study is required to substantiate the exact prevalence of silicosis among silica stone and silica sand mine workers.

Most of the silica stone and silica sand is used for making high grade silica powder and working conditions in these units are primitive leading to very high exposure to silica dust among workers, it will be useful to also conduct a study of workers engaged in silica powder making units.

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Annexures - 1 Photographs of Silica Stone and Sand Mine

Fig 7 A Silica Stone and Sand Mine front

Fig. 8 A sample of silica stone

Fig. 9   Loading of Silica Stone in a dump truck

Fig. 10 A typical silica stone boulder crusher unit at mine

Annexure – 2 Photographs of Silica Sand Manufacturing Plant

Fig. 11 Pile of silica stone boulder at powder manufacturing unit

Fig. 12 Dusty environment inside of silica sand manufacturing plant

Fig. 13 Workers carrying silica powder in manufacturing plant

Fig. 14 Pile of silica sand outside silica sand manufacturing plant

Annexure – 3 Health Screening Form

Healthy Workplace

Occupational Health and Hygiene Consultancy Services

Health Screening Form

Photograph

Registration No.____________________ Aadhar Card No.______________________

Name of Beneficiary ______________________Age_______________ Sex___________

Address____

Mobile No._____________________________

(Signature / Thumb Impression)

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1.0 History

1.1 Past Occupation

Sector	Stone Carving	Stone Mines	Sand Mine	Sand Crusher
Period in Years				

1.2 Present Occupation : Driller / Mazdoor/ Supervisor

1.3 History of Tuberculosis : Yes / No History of Smoking : Nil /Mild / Moderate / Heavy

1.4 Complaints : Nil / Cough / Sputum / Breathlessness / Blood in Sputum / Chest Pain

1.5 Suffering for Years : < 1year / 1-3 / 4-5 / 5+

2.0 General Physical Examination :-

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3.0 Chest X- Evaluation Report (ILO Classification)

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4.0 Provisional Diagnosis:-

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(Dr P K Sishodiya)

Annexure – 4 Radiograph Reading Sheet

Healthy Workplace

Occupational Health and Hygiene Consultancy Services

Radiograph Reading Sheet

(ILO International Classification for Chest Radiographs of Pneumoconioses, 2000)

NAME ____________________________ RADIOGRAPH NUMBER ______________

DATE OF RADIOGRAPH ____________________

1.0 TECHNICAL QUALITY

(Grade 1, 2, 3 or 4) (Mark appropriate box) [1] [2] [3] [4]

If not grade 1, **tick mark defects**

Technical Quality Defect: (list of defects provided)

1	2	3	4	5	6	7	8	9	10

2.0 PARENCHYMAL ABNORMALITIES Yes [ ] No [ ]

2.1 Small Opacities [0/-] [0/0] [0/1]

2.1.1 Profusion (12 Point scale) [1/0] [1/1] [1/2]

(0/-, 0/0, 0/1, 1/0, 1/1, 1/2, 2/1, 2/2, 2/3, 3/2, 3/3, 3/+) [2/1] [2/2] [2/3] [3/2] [3/3] [3/+]

2.1.2 Extent : Affected Zones

(Mark **<u>ALL</u>** affected zones)

	R	L
Upper	[ ]	[ ]
Middle	[ ]	[ ]
Lower	[ ]	[ ]

Shape and Size : p, q, r, s, t or u

(Two symbols required; mark one primary and one secondary.)

Primary		Secondary	
p	s	p	s
q	t	q	t
r	u	r	u

2.2 Large Opacities (Mark O for none or mark A, B, or C) [O] [A] [B] [C]

4.0 Symbols Yes [ ] No [ ]

aa	at	ax	bu	ca	cg	cn	co	cp	cv	di	ef	em	es	
fr	hi	ho	id	ih	kl	me	pa	pb	pi	px	ra	rp	tb	od

(tick as appropriate; if "od" ticked,comment must be made below)

4.1 Comments Yes [ ] No [ ]

(Dr. P. K. Sishodiya)

Annexure – 5 Photographs of Health Screening of Silica Sand Workers

Fig 15 Taking history of work and noting symptoms

Fig 16 Medical examination of female workers

Annexure 6 Chest radiographs of silica sand workers

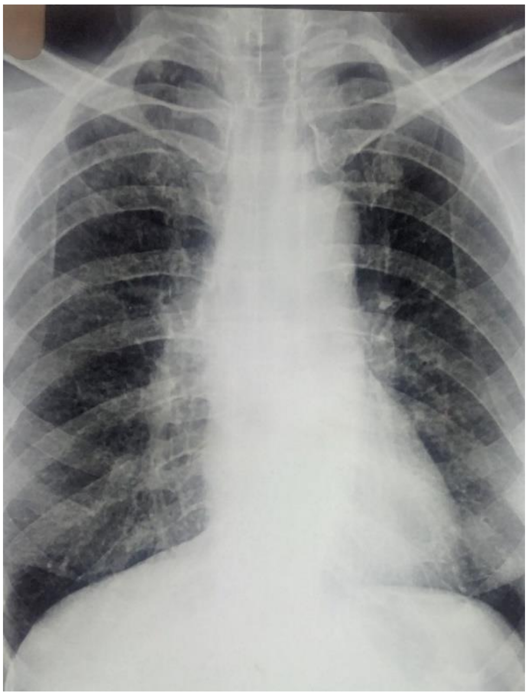

Fig 17 Pneumoconiosis, Profusion Category 2/2, q/q

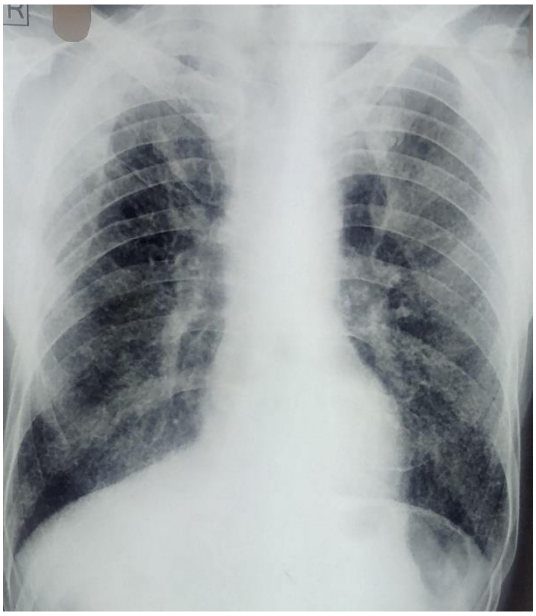

Fig 18 Pneumoconiosis, Profusion Category 3/3, t/t