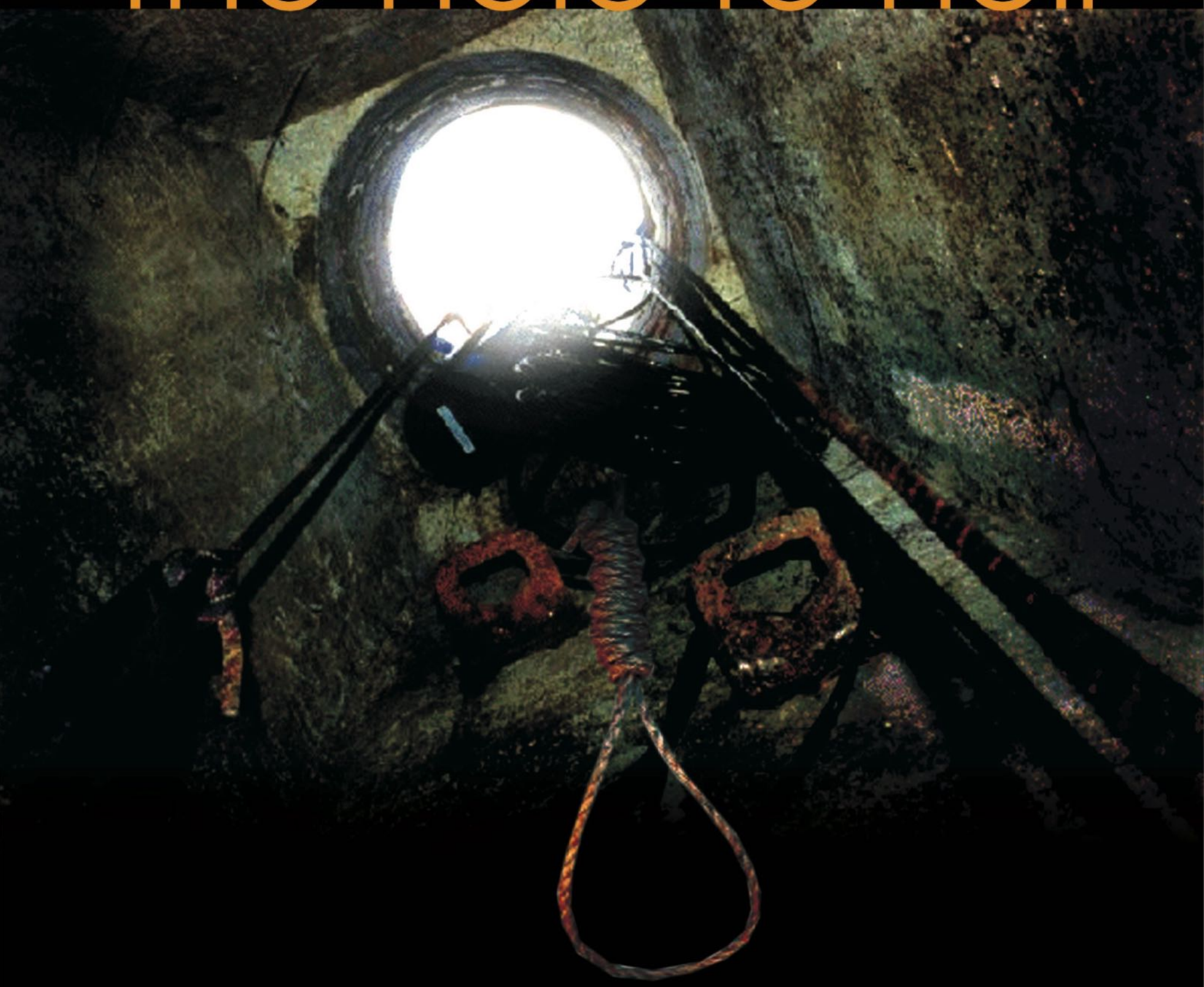
The hole to hell



A Study on

Health & Safety Status of Sewage Workers in Delhi

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Centre for Education and Communication

ISBN: 81-88160-14-8

Published: January 2006

e-publication: January 2007

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Photographs: Pranjal Jyoti Goswami
Design: Pravin Mishra
Additional Inputs: Shweta Singh

Contributory Price (Print edition): Rs.70

Printed at
SM Graphics
8, LSC, M-1 Block
DDA Market
Vikaspuri
New Delhi-18

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Foreword

The Centre for Education and Communication (CEC) is a labour resource organisation. The Centre works towards the enhancement of the dignity of labour through various activities and evolves strategies, in collaboration with trade unions and labour organisations. Labour Rights, Gender Rights and the Right against Social Discrimination are the cross-cutting themes of work that CEC undertakes.

The hazardous nature of work as evident from a number of fatal accidents during sewer cleaning operations together with the social exclusion faced by the sewage workers impelled CEC to commence a research to obtain baseline data on the health and safety status of sewage workers in Delhi. In India, health and safety at work have rarely been considered a labour right, and marginalised workers are being compelled to work in dangerous conditions. The presence of toxic elements in the sewage and exposure to a range of hazards during sewer maintenance work is well documented in developed countries. But no comprehensive policy has been developed in India to protect sewage workers from hazardous exposures. Occupational diseases and disabilities are also ignored. A majority of the workers are deprived of any legal coverage for protection and compensation. The efficiency of the healthcare and other facilities provided to workers is always suspect as most of the workers are not in a position to utilise these facilities.

Sewage work in India is a modern day extension of 'manual scavenging' or the age-old practice of 'untouchables' being made to carry human faeces from dry latrines. The Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, 1993, ostensibly prevents the practice of manual scavenging, but the social stigma and indignity of work is now extended to conservancy workers and sanitary workers such as the sweepers and the corporation workers in India's growing urban centres. Casteism is so ingrained in the Indian psyche that the sewage workers, who perform a critical job in the maintenance of urban living, are still considered untouchables. The Government

has been most callous in implementing essential steps to make the work of the sewage workers safe and their lives secure. Such insensitivity to human rights and human dignity is in spite of The National Human Rights Commission's notice in 1998 directing the Central Government to find a humane solution to the plight of sewage workers.

This publication, 'Health and Safety Status of Sewage Workers in Delhi', is dedicated to Mangal Das, Nanak and Hari Krishan, the sewage workers of Delhi Jal Board who died unexpectedly during the course of this study.

This report contains preliminary information on demographics, the socio-economic conditions of sewage workers in Delhi and detailed analyses of their present health and safety status. The report is to be utilised for the empowerment of sewage workers in their struggle for more dignified work. It is also hoped that this publication will help the sewage workers in achieving better working conditions and improving health and safety at work. We hope the Government takes cognisance of this report while designing policy to safeguard sewage workers from various hazards.

I would like to thank my colleagues, Mr. Pranjal Jyoti Goswami, Programme Officer, OSH and Labour Rights and Dr. Ashish Mittal, CEO, OHS-MCS, for undertaking this valuable study and finalising this report.

New Delhi
July 01, 2005

J. John
Executive Director

Preface

The death of several sewer workers while on the job in Delhi raised issues of safety standards and the hazardous nature of work involved in operating and maintaining sewage systems. More than thirty workers have died in just two years in various incidents in the capital alone. The pattern of tragedy in a majority of the cases was strikingly similar to each other. The causes of such accidents have never been investigated satisfactorily so that proper safety precautions may be initiated. The workers lost their lives because the concerned authorities grossly ignored the existence of inherent life-threatening hazards in underground sewer lines. No occupational health and safety policy has been developed to address the sewage workers' problems. The authorities have not considered providing suitable protective equipment to the workers. Authorities are more concerned about the commercial aspects of the sewage treatment system and water privatisation than saving the lives of poor, disposable and marginalised sewage workers.

Fatal sewer accidents are frequent but many more sewer workers die from chronic illnesses. According to information provided by senior trade union leaders, a large number of sewer workers die before retirement. The highest ranked known cause of such deaths is respiratory disease.

Working in filth and intrinsically dangerous situations are the occupational hazards of a sewer worker. Delhi's sewage contains a mixture of complex elements because there is no separation of domestic waste and industrial effluents. Everything goes to the same drain, be it from households, chemical industries or health care centres. The workers have primitive working conditions without any kind of protection or supervision. The safety equipment and personal protective equipment (PPE) are not adequately available. The workers do not know how to wear the protective gear properly nor have they been provided training on its correct application. Moreover, the protective gear provided does not ensure

protection against anticipated hazards inside the sewer lines. Given the quality of the gear, it would be foolish to expect desired protection from the gear alone.

Like many other labour intensive sectors in India, minimising the risk in sewage operation and maintenance work is given the last priority. The risk involved in such hazardous work has not even been assessed effectively. The exposure of workers to various harmful elements, such as chemical, biological and gaseous agents, and the subsequent health impact of these on the workers has been grossly neglected for years. Instead probable occupationally acquired health affects manifested in sewage workers are linked as outcomes of their personal habits.

T he workers do not have any voice to raise their concerns in society. The widespread perception about sewage workers is that they are doing the dirtiest work on earth and that these workers are untouchables and should be excluded from the mainstream. Most of these workers are Dalits and have been exploited for centuries. Is their legacy of 'dirty' work unchangeable? Will they ever be able to exercise their fundamental rights?

The study was conducted with the objective of gathering baseline information on the contemporary health and safety status of sewage workers in Delhi. Internationally, many reports are available on the health and safety of sewage workers. But it is difficult to extrapolate findings from developed countries to a country like India where the working conditions and practices are extremely dissimilar. As the use of protective gear is minimal and work practices are manual, there is a high probability of exposure to unsafe components during work. So special emphasis was given to assess the impact of hazardous elements on workers' health and attempt to establish the co-relation between exposure and health outcome with diagnostic and statistical interpretation.

The project became a reality due to sincere effort of many people. First and the foremost, we would like to thank Mr. J. John, Executive Director, Centre for Education and Communication (CEC), New Delhi, for giving us the opportunity to undertake the research study. It was under his able direction that this project was successfully carried out. His constant guidance and excellent suggestions

throughout the study were invaluable. We are also thankful to all our colleagues at CEC, who provided unconditional support during the course of the study. We express our deep gratitude to Mr. Hargyan Singh, President, Sewage Branch, All India Safai Mazdoor Congress, and the other members of the Congress, for their valuable support in facilitating the survey and also for their assistance and active interest in the investigation. A special word of appreciation should go to Dr. Jugal Kishore for his direction and support in data analysis. We are grateful to Mr. B.L. Sharma for his diligent contribution in conducting the interviews with the respondents. Our heartfelt thanks go to all the respondents who answered our queries and volunteered with blood and urine samples for laboratory analyses. Finally, we are thankful to Ms Sudha Shankar of Word-by-Word, who copy-edited the report.

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Executive Summary

Delhi generates large quantities of sewage. At present the total quantity of sewage generated is 2,871 (mld). Delhi Jal Board (DJB) is responsible for the treatment and disposal of wastewater through a network of about 5,600 km of internal, peripheral and trunk sewers. The workers who engage in the maintenance of the sewage system are known as beldars. Approximately 5,500 beldars are working for Delhi Jal Board.

Sewage contains numerous toxic substances that can pose risks to the worker's health. The working conditions maximise the exposure of the beldars to harmful ingredients, thereby increasing the mortality and morbidity rates of the workers at the workplace. Thirty-three workers have died in last two years owing in 2003-2005owing owin to accidents that took place while they worked on blocked sewer lines.

Very limited data on the occupational health and safety status of sewage workers is available in India. In order to assess the health and safety of sewage workers and association of disease symptoms with exposure to sewage work, a convenient sample of 200 beldars working at different places of Delhi was included in the present study. The participants included in the study were interviewed using a schedule designed to obtain information on the demography, personal habits (smoking/drinking/food habits), occupational exposure history, and safety methods used while working in an underground sewage. Each individual was subjected to physical examination, which included recording height, weight and blood pressure, and a general physical examination. Laboratory investigations included a complete haemogram and routine and microscopic urine examination for each participant. Kidney function tests (KFT) were done on randomly selected individuals. Some randomly selected workers were also subjected to Chest X-rays and a Pulmonary Function Test (PFT). Data

was analyzed using the Epi-Info computer software package of the WHO. The salient findings of the study are given below:

A steady decline in the number of beldars is witnessed with increasing age. This indicates that most of the workers do not complete the entire service period (60 years of age). Only 14 per cent of the surveyed workers were in the age group of 50-59. Two workers from this age group died during the course of the study due to chronic illness.

Among 82 daily wagers, 81.7 per cent workers have been working for more than six years and 14.6 per cent workers have been working for more than 10 years. Among the 118 permanent workers in the study group, permanent status was given to them after they had put in significant years as daily wagers.

Fifty-nine per cent of the workers enter underground sewer manholes more than 10 times a month and half of them have to work more than 8 hours a day. While working in underground pipelines, an overwhelming majority of them have had cuts or injuries, experienced irritation of eyes and suffered from skin rash. Forty-one workers have reported syncope, and other 24 reported temporary loss of consciousness. A little over one-third of the workers had been immunized against tetanus while none of them had been vaccinated against hepatitis-B.

Over three-fourths of the workers suffered from exhaustion and almost as many had a chronic cough. The other major chronic symptoms include headache (48.5 per cent), skin rash (45.5 per cent), skin irritation (41.5 per cent) and body ache (41.5 per cent).

Over half the workers had poor orodental hygiene, 33 per cent had pyorrhoea. Among 200 respondents 70 had chronic allergic conjunctivitis, 59 had coarse skin, 54 had rough skin and 49 have hyper-pigmented patched on the skin. Approximately 46 per cent of workers across all age groups are found to be underweight according to Body Mass Index (BMI) calculation. Thirteen workers were found to have added respiratory sounds (ronchi, crepts) on chest auscultation. Seven per cent had a history of physician-diagnosed asthma, 9 per cent had high blood pressure, 4.5 per cent had received anti tubercular treatment, and 4 per cent

were known cases of diabetes and ischaemic heart disease each. 8 per cent have been diagnosed earlier with various skin diseases.

Thirty-seven per cent of the workers had a low haemoglobin count; 8.5 per cent had more white blood cells than the normal upper limit; 11.7 per cent showed more ESR than the normal range. In spite of having normal leukocyte counts (91 per cent), 67.3 per cent had higher eosinophil counts (>6 per cent). None of the 50 randomly selected samples tested for Hepatitis-B Surface Antigen (HBsAg) were tested positive. Similarly random sample of 50 respondents tested for kidney function tests were essentially normal except finding of high urea (3 samples) and high creatinine (4 samples). Urine routine examinations indicated the presence of protein in 16.2 per cent samples, red blood cells (RBCs) in 7.6 per cent, glucose in 6.1 per cent, and leukocytes in 7.6 per cent.

Of 53 pulmonary function tests, over half were abnormal, 30.2 per cent had mild restrictive changes while 20.7 per cent showed changes ranging from moderate to severe restriction or obstruction. Of 35 Chest X-rays, 23 were normal. Six had the evidence of lung tuberculosis, five had evidence of infective lung disease, and one showed the presence of hypertensive heart changes.

None of the workers had been given any formal communication by the employer about the hazards of their work. None had been trained to provide first aid in case of any mishap. Almost all of them, however, were aware of the risk involved in their work and 88.5 per cent could recognise the toxic gases as the harmful agent. Forty-six per cent blamed sharp objects whereas 42 per cent attributed the risk factor to the chemicals present in the sewer

A majority of the workers (92.5 per cent) used safety belts while going inside the deep sewer. The percentage use of masks, safety shoes, skin protection (hand gloves) and eye protection was 12 per cent, 7.5 per cent, 7.5 per cent, and 0 per cent, respectively.

Twelve per cent of the 118 permanent workers were earning Rs. 3500-5000 per month. All daily wagers were earning approximately Rs. 2,950 per month without any other benefit. Approximately 75 per cent of the respondents have to take financial responsibility of more than 3 members in their families.

Three-fourths of the 200 workers were staying in their own houses; however, in most of the cases the owners of the houses were either their parents or some elder member of their families. Approximately 60 per cent of all the workers resided at a distance of more than 10 km from their workplaces. Most were married; 5 per cent had lost their spouses and only 1.5 per cent were single. An average of 3.37 children per family is seen with a fair distribution of male and female children among the couples.

A little over one-third of the workers were completely illiterate, and only 8.5 per cent workers have studied till tenth class or above. The rest had studied to below the tenth class.

A majority (68.5 per cent) of the workers declared that they were smokers and 94.3 per cent of the smokers smoked bidis. 22.1 per cent used smokeless tobacco products. Almost a similar number (65.5 per cent) of workers consumed alcohol. Most of them had started consuming of alcohol and smoking bidis only after joining sewer work.

P-values were calculated for acute and chronic symptoms arising from exposure (frequency of going inside sewer per month) for statistical significance. A significant statistical correlation was found for eye irritation, upper respiratory tract irritation, syncope, light-headedness, skin rash, high eosinophil count, and cut injuries. Tiredness, watering of eyes, burning of eyes, skin irritation, skin roughness, and skin rash were all correlated with the exposure. Chemosis, poor orodental hygiene and pyorrhea were also statistically correlated with the smoking habit of the workers.

The results and analyses establish a clear co-relation between exposure to sewage and health outcomes. Sewage workers suffer from high morbidity in Delhi. Although the symptoms of any severe illness are deceivingly absent in most of the workers, the high incidences of mortality after attaining 55 years of age, point significantly towards the irreversible damage such hazardous exposure does to the organ systems.

CHAPTER 1

Introduction

Historically, human waste was disposed of in cesspools or privies or carried in buckets to rivers. Garbage was often simply tossed into the street to be flushed away with the next storm. Many large cities had pigs and chickens that ate this garbage. Charles Dickens is said to have disliked New York City because of the estimated 20,000 pigs that ran loose in its streets.[1] These unsanitary conditions resulted in objectionable sights and odours and caused disease. This problem was solved in many European and North American cities by draining domestic wastes into the storm sewers. In 1842, Hamburg in Germany became the first western city that built a separate system of pipes for carrying human wastes. These early sewage systems dumped untreated human waste into nearby fields or rivers, resulting in the pollution of the surrounding waters. Sewage treatment plants were built to decrease the burden on the surrounding waterways.

With increasing demands on the wastewater systems and new environmental regulations, the transport and treatment of wastewater has increased in technical complexity. This development has resulted in new exposures for the sewage workers including the multitude of chemicals used in our homes and in the industries.

The term sewage is used for wastewater from community containing solid and liquid excreta derived from houses, street and yard washings, factories and industries carried in sewer lines. It resembles dirty water with an unpleasant smell. The term Sullage is applied to wastes from household sinks and showers but not toilets.

Sewage contains 99.9 per cent water. Solids, which comprise barely 0.1 per cent of the sewage, are both organic and inorganic. These solids are either in suspension or in solution form. The decomposition of organic matter in the sewage gives rise to offensive odours. In addition, sewage has numerous living microorganisms derived from the faeces; some of these are agents of disease. It is estimated that one gram of faeces may contain about 1,000 million E.coli, 10 to 100 million of faecal Streptococci, and 1 to 10 million spores of Cl. perfringens besides several others.[2]

To understand the working condition of sewage workers, an attempt is made to outlay the physical structure of the sewage system in the following paragraph:

Water Carriage System

The water carriage system or sewerage system collects and transports human excreta and wastewater from residential, commercial and industrial areas, by a network of underground pipes called sewers, to the place of ultimate disposal. There are two types of water carriage systems — the combined sewer system and the separate sewer system. In the combined system, the sewers carry both the sewage and surface water. The separate system is considered the system of choice today. Although the first sewers were laid in 1867 in Calcutta, the Mudaliar Committee (1962) reported that not more than 15 per cent of the urban population in India had a sewerage system facility. The problem was one of economics – a heavy outlay of capital was needed to install a water carriage system. Since water is needed for flushing the toilet and for conveying the human wastes, there can be no sewerage system without piped water supply.

The common components, which make the water carriage system, are:

1. Household sanitary fittings (plumbing system of building)
2. House sewers
3. Street sewers or trunk sewers
4. Sewer appurtenances: manholes, traps, etc.

1. Household sanitary fittings

Wherever a sewerage system exists, every house is expected to be connected to the nearest sewer. The usual household sanitary fittings are a) water closet, b) urinal c) wash basin.

Water closets may be broadly divided into two types: Indian squatting type and the Western commode type. The flushing cistern normally holds 15 litres (3 gallons) of water.

2. House drain

The hose drain is usually 10 cm (4 inches) in diameter and is laid in the courtyard about 15 cm (6 inches) below the ground level on a bed of cement concrete with sufficient gradient towards the main drain. The house drain empties the sewage into the main sewer or public drain.

3. Public sewer

The trunk sewers are not less than 22.5 cm (9 inches) in diameter: the bigger ones may be 2 to 3 m (8-10 feet) in diameter. They are laid on a bed of cement concrete about 3 m (10 foot) below the ground level, with sufficient gradient to ensure what is known as "self-cleansing" velocity, which varies from 2 to 3 feet per second. The trunk sewers collect sewage from several houses and transport to the main outfall or place of final disposal.

4. Sewer appurtenances

These are (a) manhole and (b) traps, which are installed in the sewerage system. Manholes are openings built into the sewerage system. They are placed a) whenever there is a change in the direction of sewers b) at the meeting point of two or more sewers and c) at distances of 100 m in long straight runs d) when there is change in the grade of a sewer pipe diameter. Manholes permit a man to enter the sewer for inspection, repairs and cleaning. Traps are of various kinds and are designed to prevent foul gases from entering the houses and to remove sand, grit and grease from the sewage. Traps are placed at three places a) under the basin of water closets b) where the house drain joins the public drain (intercepting trap) and c) where surface wastewater enters the drains.

The installation of a sewerage system is a huge engineering project. It involves considerable planning, designing, construction, operation, maintenance and administration - each calling for specialised skill. Sewerage systems are usually designed, like water supplies, to last for 30 years (one generation).[2]

Literature Review on Health Hazards of sewage workers

In 1700, the Italian physician Bernardini Ramazzini published his book in occupational medicine called De Morbis Artificum (Diseases of Workers). He reviewed the ailments known to affect a number of professions, including those of the latrine and sewer-tenders. Inflammation of the eyes was considered as the hallmark of these workers, and Ramazzini alleged that they even risked blindness. He presented a theory that some acid evaporating from the awful masses affected the eyes, and he advised workers to protect their eyes with a transparent bladder over the face, and to limit the duration of their shifts. In contrast to this theory that chemical exposure constituted the main occupational hazard to sewer workers, the risk of infectious disease was main issue during a good part of 20th century. However, in the recent decades there has been a new focus on health risks connected with the chemical exposure of sewage workers.

In 1954, more than two centuries after Ramazzini, the German physician Anders reported the result of a thorough retrospective examination of the health of 449 male sewer workers in West Berlin, and concluded that the chemicals and biological composition of the sewage did not present an undue risk to health. Since then, many studies, reflecting the different aspects of sewage-exposed workers, have been published.[4]

Hazards of Sewage Work:

Modern sewage is a complex mix of industrial chemicals, household waste and human excrement. This mix contains numerous toxic substances, many of which are volatile. As they decompose, sewage releases methane, hydrogen sulphide, and carbon dioxide. Since sewer maintenance and treatment plant personnel often work in confined spaces in intimate contact with raw or partially treated sewage, it

is not surprising that they will frequently inhale toxic gases, solvents, and aerosolised dust particles released from this sewage.[5]

A confined space has limited means of entry and egress, inadequate ventilation, and has not been designed for continuous human habitation. Hazards occur when the confined space has limited oxygen, the presence of toxic chemicals or engulfing materials, such as water. The decreased oxygen levels can be the result of a variety of conditions including (i) the replacement of oxygen with another gas, such as methane or hydrogen sulphide, (ii) the consumption of oxygen by the decay of organic material contained in the waste water or (iii) the scavenging of oxygen molecules in the rusting process of some structure within the confined space. Because low levels of oxygen in confined spaces cannot be detected by unaided human observation, it is extremely important to use instruments to determine the level of oxygen before entering any confined space.

When the percentage of oxygen in the air falls below about 16.5 per cent, breathing becomes more rapid and shallower, the heart rate increases and the person begin to lose coordination. Below about 11 per cent the person experiences nausea, vomiting, inability to move and unconsciousness. Emotional instability and impaired judgment may occur at oxygen levels somewhere between these two points. When individuals enter an atmosphere with oxygen levels below 16.5 per cent, they may immediately become too disoriented to get themselves out and eventually succumb to unconsciousness. If the oxygen depletion is great, individuals can become unconscious after one breath. They can die within minutes. Even if rescued and resuscitated, permanent damage can occur (Wilkenfeld et al. 1992).[3]

One of the most effective ways to control the hazards associated with low oxygen levels (below 19.5 per cent) and atmospheres contaminated with toxic chemicals is to ventilate the confined space thoroughly and adequately with mechanical ventilation prior to allowing anyone to enter it. This is usually done with a flexible duct through which outside air is blown into the confined space.

Lack of oxygen is not the only hazard in a confined space. Toxic gases can be present in a confined space at a concentration level high enough to do serious harm, even kill, despite adequate oxygen levels.

CHAPTER 2

Harmful Agents in Sewers

(A) Gases in sewers:

i. Hydrogen Sulphide

Hydrogen sulphide is an irritant and a chemical asphyxiant. Because it is heavier than air, hydrogen sulphide gas collects in the bottom of tanks, in pits and in enclosed spaces. Any situation in which the sewage is allowed to decompose under anaerobic conditions can result in the release of hydrogen sulphide. These conditions occur in sewage treatment plants and in the underground sewage system when a blockage or leakage of a pipe allows the sewage to become stagnant. Similar conditions exist on farms where manure gets collected in septic tanks. Hydrogen sulphide exposure can also occur during desludging operations in secondary sedimentation tanks, on the tops of sewage digestors, and during tanker loading and discharge.[6] Entering septic tanks or damaged sewage lines without first ensuring adequate ventilation and measuring hydrogen sulphide levels is thus extremely dangerous.

Hydrogen sulphide, also known as sewer gas, has a distinctive, unpleasant smell, often identified as rotten eggs. The human nose, however, quickly becomes accustomed to the smell. People who are exposed to hydrogen sulphide often lose their ability to detect its odour (i.e., olfactory fatigue). Furthermore, even if the olfactory system is able to detect hydrogen sulphide, it is not able to accurately judge its concentration in the atmosphere. Hydrogen sulphide interferes with the electron transport mechanism and blocks the utilization of oxygen at the molecular level. The result is asphyxiation and ultimately death due to the lack of oxygen in the brainstem cells that control the breathing rate. High levels of

hydrogen sulphide (greater than 100 ppm) can, and often do, occur in the confined spaces.

Exposure to very high levels of hydrogen sulphide can result in almost instantaneous suppression of the respiratory centre in the brainstem. The US National Institute for Occupational Safety and Health (NIOSH) has identified 100 ppm of hydrogen sulphide as immediately dangerous to life and health. Lower levels of hydrogen sulphide (less than 10 ppm) are almost always present in some areas of sewage treatment plants. At these lower levels, hydrogen sulphide can be irritating to the respiratory system, be associated with headaches and result in conjunctivitis (Smith 1986). Hydrogen sulphide is produced whenever organic matter decays and, industrially, during the production of paper (Kraft process), the tanning of leather (hair removal with sodium sulphide), and the production of heavy water for nuclear reactors.

ii. Other Toxic Gases

Toxic gases are categorised according to their clinical effect into simple asphyxiants, chemical asphyxiants, and irritants. The most prevalent gases released during sewage decomposition are the simple asphyxiants, carbon dioxide and methane. Simple asphyxiants act by displacing oxygen and creating an oxygen-poor atmosphere. Persons exposed to this environment suffer symptoms of hypoxia. Methane is another gas produced by the decomposition of organic matter. In addition to displacing oxygen, methane is explosive. Levels can be reached which result in an explosion when a spark or source of ignition is introduced. Methane has a characteristic unpleasant odour, but carbon dioxide and many other simple asphyxiants are odourless, so that the worker may be unaware of being exposed. All toxic gases act as simple asphyxiants when their concentration is high enough. Simple asphyxiants are immediately life threatening when the fraction of inspired oxygen is less than 10 per cent. Sewage workers may also be exposed to numerous other toxic gases. In the combined residential and industrial sewage of Zagreb, Croatia, investigators documented the presence of ammonia, carbon monoxide, carbon dioxide, hydrogen cyanide, hydrogen sulphide and methane.(7) Ammonia is an irritant while carbon monoxide and hydrogen cyanide are chemical asphyxiants.

(B) Solvents in Sewers

Industrial wastes frequently contain volatile hydrocarbon solvents. Dumping of solvents, fuels and any other substance into sewer systems presents a hazard to sewage workers not only because of the toxicity of the material dumped but also because the dumping is unanticipated. The mixture of gases in Zagreb's sewage contained trichloroethylene, butane, propane, ethylene and propylene.[7] Other studies have detected benzene and toluene in New York City sewage vapors.[8] zVapours from the sewage in an industrial section of Cincinnati, Ohio, were found to contain numerous volatile solvents including Stoddard solvent, trichloroethane, trichloroethylene, toluene, perchloroethylene, xylene and chlorobenzene. Sewer maintenance workers exposed to solvents have complained of eye and nose irritation, headache and a metallic taste in their mouths.[9] Sewage treatment plant workers exposed to solvents have developed light-headedness, fatigue, and headache.[8] These symptoms are consistent with solvent exposure.

(C) Aerosolised Bacteria and Endotoxins in Sewers:

Another special problem at sewage treatment plants is exposure to aerosolised bacteria and endotoxin. Gram-negative rods thrive in decomposing sewage and can become volatilised during various phases of sewage treatment. In sewage treatment plants in Sweden, concentrations of airborne bacteria ranged from 10 to 105 bacteria per cubic metre.[10] The highest concentrations occurred near areas where sewage was agitated. These bacteria may cause the “Sewer Worker's Syndrome”. Endotoxin has also been measured in high concentrations (more than 100 ng/m3) in wastewater treatment plants.[11] The mechanism of toxicity and the long-term effects after exposure to inhaled bacteria and endotoxin in this setting are incompletely understood. There is no accepted exposure limit for aerosolised bacteria or endotoxin, although a value of 30 ng/m3 has been proposed for endotoxin.[12] At levels above 300 ng/m3, endotoxin causes decreased FEV 1.[13]

Sewer workers are often exposed to micro-organisms contained in material splashed onto their skin and may make contact with the mucous membranes.

The three main categories of microbes relevant to this discussion are fungi, bacteria and viruses. All three of these can cause acute as well as chronic diseases.

Acute symptoms including respiratory distress, abdominal pains and diarrhoea have been reported in waste treatment workers (Crook, Bardos and Lacey 1988; Lundholm and Rylander 1980). Chronic diseases, such as asthma and allergic alveolitis, have been traditionally associated with exposure to high levels of airborne microbes and, recently, with microbial exposure during the treatment of domestic waste (Rosas et al. 1996; Johanning, Olmstead and Yang 1995).

In addition to inhalation, microbes can be transmitted through ingestion and through contact with skin that is not intact. Personal hygiene, including washing hands before eating, smoking and going to the bathroom, is important. All kind of Foods, drinks, eating utensils, cigarettes and anything that would be put into the mouth should be kept away from areas of possible microbial contamination.

(D) Miscellaneous agents in sewer:

Sewage workers may have skin or eye contact with liquid sewage or sewage dust. Many industries are required to pre-treat their wastewater before disposal in the sewage system. Unfortunately, such regulations are not always followed, and sewage workers may be exposed to any number of toxic industrial chemicals, depending on local industry. In addition, household chemicals including paints and solvents may be disposed of into the sewage system. Pollutants found in the sewage may include acids, alkalis, soaps, solvents, tars, phenol derivatives, heavy metals and organic matter. Chloride, ammonia, sulphate, nitrites, cyanide, chromium, copper, nickel, lead and cadmium were all detected in Zagreb sewage.(7) Compared to controls, workers exposed to this sewage had more chronic respiratory symptoms and decreased ventilatory capacity, as well as more frequent complaints of headache and dizziness. Industrial sewage in Cincinnati, which contains numerous solvents, had a pH as low as 1.(9) In Kentucky, the industrial chemical hexachlorocyclopentadiene was dumped into a municipal sewage system. Sewage treatment workers exposed to this sewage developed higher rates of eye irritation, headache and throat irritation. Several of the employees developed transient proteinuria and elevated lactate dehydrogenase after this exposure.[14] Sewage sludge farmers in India were found to have higher urine cadmium levels than controls, although no long-term effects of exposure to cadmium in this form have been documented.[15] The clinical effect of exposure to

these industrial pollutants is poorly understood. This is not surprising because the chemicals that contaminate sewage vary from day to day and city to city. Perhaps these pollutants are responsible for the increased risk of some types of cancer in sewage workers that some authors have reported.[16,17] Pollutants may be responsible for the urinary mutagens detected in the urine of sewage workers[18] and for the finding that spouses of sewage workers have an increased incidence of foetal loss.[19]

CHAPTER 3

Clinical Effect of Exposure to Sewage Hazards

(A) Sewer Worker's Syndrome

Compared to workers in other occupations, sewage treatment plant workers suffer more often from eye and skin irritation and nonspecific gastrointestinal, respiratory, and constitutional symptoms. Fever, chills, headache, fatigue, and malaise are commonly reported constitutional symptoms. Purulent ocular discharge and skin irritation are often reported, as are gastrointestinal symptoms including diarrhoea. Cough, purulent sputum, and throat irritation are common respiratory symptoms. The term sewer worker's syndrome was coined in 1976 to describe the fevers, chills, fatigue, purulent ocular discharge, and skin irritation in Swedish sewage treatment plant workers.(20) In another Swedish study, 30 per cent to 50 per cent of sewage workers suffered from attacks of fever or purulent ocular discharge, and 13 per cent reported episodes of diarrhoea. All these symptoms were related to periods of heavy dust exposure at work.[21]

The agents responsible for the sewer workers' syndrome are unknown. Several authors have found an association between these symptoms and exposure to sewage sludge dust and specifically to aerosolised bacteria and endotoxin.[10,11,22] Some authors have suggested that workers with these symptoms have increased immunoglobulin levels,[23] but not all studies have duplicated these findings.[10,24] A New York study found that sewage workers had a higher incidence of headache,

dizziness, sore throat, eye and skin irritation, and diarrhoea than controls. This study found an association between eye and skin irritation and exposure to mutagens, as documented by the presence of urinary mutagens.[25]

(B) Respiratory Effects

Sewage maintenance and sewage treatment plant workers have an increased incidence of respiratory complaints. Sewage treatment plant workers in Toronto were found to suffer more often than controls from cough, sputum production, wheezing, and sore throat. Those who worked near the sludge incinerator tended to have impaired lung function (decreased forced vital capacity and forced expiratory volume in 1 second), although this did not reach statistical significance.[31] In addition to the irritative complaints mentioned previously, sewer treatment workers may develop, though rarely, occupational asthma caused by exposure to sewer flies. Hypersensitivity symptoms including bronchospasm are common in persons exposed to midges, which are closely related to the sewer fly.[32]

Acute Respiratory Exposures

As the ambient oxygen concentration decreases, exposed persons suffer from symptoms of progressive hypoxia. Headache, malaise, and exertional fatigue are common. An atmosphere with less than 10 per cent oxygen is an immediate threat to life. Persons entering such an atmosphere rapidly lose consciousness and may suffer seizures or cardiopulmonary arrest. Irritant gases are classified according to their water solubility. The highly water-soluble gases include ammonia, sulphur dioxide, and hydrogen chloride gas. Ammonia is often released from decomposing sewage and manure. These gases are highly irritating and cause immediate irritation of nose, throat and eye. Because of these uncomfortable symptoms, exposure is typically self-limited. Persons who are unable to escape may develop severe sequelae, such as upper airway obstruction or pulmonary oedema. Ocular injury, including ulceration, may occur. The intermediate water-soluble gases such as chlorine cause less immediate irritation than the highly water-soluble gases but have the same overall clinical effect. The poor water-soluble irritants, including phosgene and nitrogen dioxide, are uncommon constituents of the sewer atmosphere. These agents are less irritating than the high water-soluble irritants and exposure tends to be prolonged. Pulmonary oedema and bronchiolitis

obliterans are common sequelae. Initial symptoms are often delayed for hours, and bronchiolitis obliterans typically occurs weeks after the original exposure.

Chemical asphyxiants cause systemic toxicity by interfering with oxygen delivery or utilization. Carbon monoxide interferes with oxygen delivery by forming carboxyhaemoglobin. In addition, carbon monoxide causes lipid peroxidation resulting in central nervous system injury. Hydrogen sulphide and cyanide interfere with mitochondrial utilization of oxygen. Hydrogen sulphide has a rotten egg odour that is detectable at concentrations as low as 0.02 ppm and becomes intense and unpleasant at 20 ppm. Exposure to hydrogen sulphide at concentrations above 50 ppm may cause keratoconjunctivitis. With continued exposure, ulcers develop, a condition known as the “gas eye”. Corneal scarring and permanently impaired vision may occur with severe exposure. Levels above 50 or 100 ppm cause upper respiratory tract irritation with rhinitis and bronchitis. Prolonged exposure can cause lower respiratory damage and pulmonary oedema. Even at low concentrations, hydrogen sulphide may cause increased airway reactivity in susceptible persons.[26] Respiratory symptoms in persons exposed to hydrogen sulphide include dyspneoa, cough, sore throat, and chest pain. Cyanosis and haemoptysis may occur.[26,27] At concentrations between 100 and 200 ppm, olfactory fatigue, followed by olfactory paralysis, occurs. At high concentrations, hydrogen sulphide causes systemic toxicity by binding to and inhibiting cytochrome oxidase and other enzymes. Exposure to concentrations above 500 ppm results in the rapid loss of consciousness ("knockdown"), and concentrations greater than 700 ppm cause immediate collapse with respiratory paralysis, cardiac arrhythmias and death. The Occupational Safety and Health Administration (OSHA) threshold limit values (TLV) for hydrogen sulphide is a time-weighted average of 10 ppm and a short-term exposure limit (STEL) of 15 ppm.

The brain and the lungs are the organ systems most affected by hydrogen sulphide exposure. Common clinical findings after exposure to hydrogen sulphide include syncope; headache, seizures, lethargy, dizziness, abnormal reflexes, sore throat, cough, dyspnoea, cyanosis, pulmonary oedema, haemoptysis, chest pain, eye irritation, weakness, nausea, vomiting, and malaise.[26,28] Of the 250 workers reporting hydrogen sulphide exposure in Alberta, 138 (54 per cent) lost

consciousness, and there were seven (2.8 per cent) deaths. The most common symptoms, besides syncope, were headache (26 per cent), nausea or vomiting (25 per cent), dyspnoea (23 per cent), and disequilibrium (22 per cent).[28]

Most persons who are exposed to hydrogen sulphide either die or recover completely.

(C) Gastrointestinal Effects

Sewage treatment plant workers often suffer from diarrhoea and other minor gastrointestinal complaints. Gastrointestinal symptoms are more common in newly employed workers. Symptoms tend to be minor and seldom result in time lost from work.[29] These symptoms are more common in workers with high exposure to sewage dust and are often related to specific jobs such as cleaning basins and servicing pumps. In these situations, the symptoms usually began a few hours after the work had started and got resolved by the following morning. Symptoms were also more likely to recur after return from a vacation period.[10]

Sewer workers are exposed to numerous bacteria, viruses, and parasites and may be at risk for infections from enteric pathogens. British sewage workers were found to have a 58 per cent incidence of antihepatitis A IgG compared with a 34 per cent incidence in controls (road workers).[30]

(D) Effects on Skin

Exposure to dust from dried sewage sludge causes an acute irritant dermatitis. This symptom is part of the sewer workers' syndrome.[10,23,25] The workers usually suffer from an erythematous, scaly dermatitis on the exposed skin. Infective skin (boils) is common due to bacterial contents of the sewage. However prolonged and repeated contact with sewage water, or sludge can cause many chronic skin diseases such as chronic eczema, hyper or hypopigmentation and thick, dry and course skin. Abrasions, cut injuries, ulcers and breaches in the intact skin expose the internal environment to harmful chemicals and disease producing biological agents.

(E) Reproductive Effects

There is a concern that sewer workers may be exposed to pollutants that cause reproductive toxicity, although the data on this are inconclusive. In a California study that included 210 pregnancies, the wives of male employees at a wastewater treatment plant were found to have an increased incidence of spontaneous abortions.[19]

(F) Carcinogenic Effects

Sewage treatment workers may be at increased risk for developing cancer, but the data on this are inconclusive. A retrospective study of a cohort of sewer workers from Buffalo, New York, identified an increased risk of death from cancers of the larynx and liver. Only the mortality rates from cancers of the larynx were identifiably work-related and statistically significant.[17] A retrospective study of a cohort of Swedish sewer workers found the mortality rate from cancer to be the same as the general population with a nonsignificant trend toward an increased incidence of brain, gastric, and renal cancers.[16] Although the data on deaths from cancer in sewage treatment workers are inconclusive, there is evidence that these workers are exposed to mutagens.

Prevention of harmful effects

The skin and eye symptoms in sewage treatment plant workers are associated with sewage sludge or dust contact. The sewer workers' syndrome is associated with inhalation of bacterial aerosols. For this reason, workers' contact with these agents should be minimised. Occupational hygiene measures terminated an outbreak of irritant dermatitis in a Toronto plant.[33] Personal measures to minimise contact with the dust in the treatment plant are important. They include using boots, gloves and masks, showering at the end of the workday, wearing clean clothes each day and washing hands before meals and before smoking.

Preventing injury by inhalation requires rigorous training and adherence to safety protocol for all persons who enter enclosed spaces. Briefly, OSHA, USA, guidelines include measuring concentrations of hazardous gases in the atmosphere and carrying a personal escape breathing apparatus to allow escape should conditions deteriorate. Because hydrogen sulphide is heavier than air and can

accumulate in pits and depressions, persons can be overcome without actually entering an enclosed space. Perhaps, the most important preventative measure is to keep rescuers from also becoming victims. When a worker collapses in an enclosed space, rescuers must obtain proper gear, including self-contained breathing apparatus, before entering that space. Having this gear readily available and training workers in its use prevent unnecessary exposures.

Safety requirements for sewage work

Before entering any enclosed space, workers must follow proper procedures to ensure the presence of a safe atmosphere. Unlike other enclosed spaces, the atmosphere in sewer may rapidly become hazardous as flammable or toxic gases are released from an ever-changing stream of sewage. Because of the constant danger involved, OSHA has specific recommendations for sewer entry.[34] The OSHA standards for sewer entry stipulate that only experienced persons well versed in proper procedure should enter the sewer system. These persons should be equipped with atmospheric monitoring equipment that has both a visible readout and an audible alarm that sounds when it detects hydrogen sulphide in concentrations — greater than 10 ppm, carbon monoxide greater than 35 ppm, oxygen concentration less than 19.5 percent or the presence of flammable gases.[35,36] In certain situations, additional safety equipment may include the use of an "escape" self-contained breathing apparatus, a device that gives a 10-minute supply of oxygen to allow escape, should atmospheric conditions deteriorate. Because these precautions are uniformly practised, there are few reports of sewer workers overcome by toxic gases; nevertheless, failure to follow these procedures or unforeseen circumstances may place them at risk.

CHAPTER 4

Drainage System in Delhi - an Overview

Delhi — the metro capital of the country is a densely populated city. With the official census (Population Census 2001) figure of 1.38 crores, Delhi supports approximately 10,000 people per square km. The migratory population from other states living without any authorised document in the capital make this figure around 2 crores unofficially. The 48 km x 53 km span of the capital, with an overburdened, fragmented and fractured infrastructure, is crumbling under the needs of the population. The quality of the air, water and other resources is giving way to the quantity demands. The sewage system being a mixture of newly laid sewer lines and the lines, which are decades old, pose a major operational and management problem.

The Storm Water Network of Delhi comprises of a hierarchy of drains — internal drains that collect the runoff at the residential layout level; these then find their way into peripheral drains and further discharge into main trunk drains. The discharge from peripheral drains may find its way into a larger main/trunk drain or directly into the River Yamuna.

Although this system is conventionally designed to carry storm water, a large quantity of untreated sewage finds its way into these storm water drains, as a result of an inadequate sewage disposal system, and thence ultimately into the river. This not only renders the water in these drains unfit for use but also results in polluting the river. Seventy per cent of the pollution in the river is caused by the dumping of sewage that is transported from the households to the river via these

channels, reducing them to the role of urban sewers in the absence of an adequate sewage collection and disposal system in large parts of the city.

The city of Delhi that constitutes only 2 per cent of the entire catchments area of the River Yamuna is responsible for 80 per cent of its pollution load. All along its journey through the city, 1,800 million litres of untreated domestic sewage along with 300 million litres of industrial waste find their way into the river predominantly through the 17 erstwhile storm water drains that now play the role of ganda nallahs, or dirty drains. Sewage contains Coliform bacteria at levels as high as 1,80,000 MPN (Most Probable Number)/100ml.

Delhi generates large quantities of sewage. At present, the total quantity of sewage generated is 2,871 mld whereas the total capacity of the sewage treatment plants in Delhi is 1,478 mld. The remaining 48 per cent untreated sewage (1,393 mld) finds its way into the River Yamuna through the 19 major drains that carry sewage and industrial effluents from the city. The sewerage facilities cover only about 75 per cent of the population. The sewage system is non-existent in large parts of the trans-Yamuna area, all the resettlement colonies and illegal settlements. Delhi Jal Board is responsible for the treatment and disposal of wastewater through a network of about 5,600 KMS of internal, peripheral and trunk-sewers. The capacity of sewage treatment plants has been raised from 376.4 MGD to 402.4 MGD during the year 2000-2001. This capacity is to be increased to 512.4 MGD. Of the 17 Sewage Treatment Plants (STPs) under construction, the work of 12 has been completed and the work of remaining 5 STPs is under progress.

The DJB has provided sewage facilities in all the approved colonies. Of the 567 unauthorised colonies, 414 colonies have been provided with sewage system and sewer lines have been laid in all re-settlement colonies also. Sewer lines have also been laid in 93 urban villages. (Source: DJB website)

For the purpose of operational management, Delhi has been divided into various zones/divisions and each one has around 10-12 sewer stores. Around 150 are the major stores while the others are substores of these main stores.

Sewage Workers in Delhi

The total number of beldars working with Delhi Jal Board (DJB) is approximately 5,500. This figure includes permanent as well as muster roll workers but does not include the contract workers working with the contractors/Municipal Corporation of Delhi (MCD) workers or New Delhi Municipal Corporation (NDMC) workers.

The job of the sewer worker is to inspect and maintain the underground network of pipes that make up the sewerage system. Storm drains have catch basins near their inlets that prevent solid garbage from entering the storm sewers. These catch basins must be periodically cleaned out. Where wastewater contains high concentrations of grit or suspended particles or where the sewage flow is slow, sewage pipes can become obstructed by sediment. Many of the pipes are too small for maintenance workers to enter and can be accessed only at certain points by manholes. These smaller pipes are cleaned with a water hose pulled from one manhole to the next. In this manner, silt is flushed out to a collection point, where it is carried to the surface. Sewer workers enter larger pipes to allow repair and the removal of sediment. Sediment is shoveled into buckets, which are dragged to the nearest manhole and then raised to the surface with winches. All of this maintenance work occurs in poorly ventilated spaces so that sewer workers may be exposed to toxic gases that volatilise from the sewage. Furthermore, skin contact with sewage may be unavoidable. Occasionally, sewage systems require emergency repair when a section of pipe becomes completely blocked or when a sewage leak has washed away the subsoil, causing the floor of the sewer to collapse. In these situations, the damaged section of pipe is isolated by blocking each end, and a smaller pipe is used to temporarily bypass the damaged section, which is then pumped dry to allow the repair to proceed. This repair work is particularly dangerous with a high risk of exposure to toxic gases, drowning if further structural damage to the sewage system occurs.

The misuse of the sewer facility causes much of the blockages. Common materials that causes line blockage are: waste construction material, dumping of solid sludge from industry, kitchen waste, sanitary pads, condoms, medical waste, and other household gadgets. The improper covering of manholes also

contributes to the blockage by allowing unwanted materials to go inside the sewer lines. Storm water should not mix with the sewage system. However, owing to improper management, storm water finds its way to sewage system and unnecessarily increases its load. Cow dung in the sewage is a major source of methane gas as compared to human excreta.

Most of the workers work without the requisite safety gear, and are frequently victim of accidents and a variety of other health problems.

A DJB study on the safety in sewage lines emphasised the use of safety equipment like bump helmets, gloves, barrier cream, gas masks, safety belts and air-respirators for the workers entering a manhole. The guidelines formulated by the National Human Rights Commission (NHRC) on 'Safety Code for Operation and Maintenance of Sewerage Systems' for the safety of workmen are being followed by the Delhi Jal Board and its contractors.

"For the 74 workers in this store, there are two masks, and safety belts," says Lakshman Das, 54, a beldar with the DJB for over 20 years. But Lakshman Das points out that when they go into holes more than five feet deep, they have to give a written statement stating they are doing so at their own risk.

The workers are provided with a rope and bucket to desilt the manhole manually. A spliced bamboo stick called khapachi is the 'sword' of these workers. It is pushed inside the blocked sewage to dislodge the blocking material. The workers clad in underpants only, may have to work on the blocked line for days together, till the blockage is removed. Jet machines are used for mechanically removing the blockage by using high-pressure water stream. However, this is seldom successful and thus rarely used

by these workers. Sometimes the workers have to hold their breath, plunge deep inside the sewer to remove the block. For the smooth working of the sewer lines, this desilting procedure should be done every third day, but is usually done only when the line is completely blocked.

Newspapers have been reporting how sewage workers are killed while cleaning foul, sludgy and crappy waste. Often they die from exposure to toxic gases. It is difficult to protect oneself from these gases using fancy gear, and many simply fall and drown in sewage. The Hindustan Times dated June, 26, 2003, reported an incident titled "Five workers killed in sewage plant tragedy". According to the report, five employees of a contractor of the Delhi Jal Board died by breathing in harmful gases in an underground tank at the Rithala sewage treatment plant in North-West Delhi.

Estimates say almost a hundred workers in Delhi alone are killed annually this way. In other words, every third day a life is lost, while numerous others suffer from various diseases. ('Sewage not just pollutes but kills', Earth Watch, Bharati Chaturvedi, New Delhi, July 19)

Most of the sewage workers are Dalits, belonging to the Balmiki Samaj caste. These workers face social discrimination because of the work they do and are considered 'untouchable'. Nowadays, many beldars are coming to work in Delhi from the nearby states.

Out of these 5,500 workers

in Delhi, only 4,000 workers are permanent and were employed before 1996. According to Mr. Hargyan Singh, President All India Safai Mazdoor Congress, Delhi Pradesh Shakha Sewer-Nala, Delhi Jal Board still follows the almost five-decade-old rule in terms of employment of the number of beldars. The rule states that there should be one beldar for each 1 mile of sewage line. However, there is no comparison between the present population density to the density 50 years back. At that time the sewage quantity in 1 mile was 10 buckets per day and now the quantity has increased thousandfold. But the rule has not been amended accordingly. He states that in 1997, the state government introduced a provision of 5 per cent reservation of new recruitment to the kin of deceased sewage worker, but this rule has not been implemented in the true sense. A survey of the trade union revealed that during the period of 1997 to 2001, only 23 persons were recruited under the reserved category. Till the 1970s there was a provision for employment of a son of a beldar, but that rule too had been abolished. Another survey conducted by the trade unions revealed that 80 per cent of the workers die before retirement and there were approximately 300 deaths in last 2-3 years. They attribute this high mortality rate to the dangerous work under the unnatural circumstances.

"Gas masks and cylinders are not available in adequate number in the stores. Most of these workers prefer to work without the mandatory gas cylinder, since it weighs 13 kg. It is cumbersome to go into a confined space with such heavy equipment," says Hargyan Singh. He also emphasised that the presence of gas inside a manhole can easily be determined by using dried sand, but this is never practised. The litmus paper test is also in the rules but never applied. Officials from the Jal Board are supposed to be present at the working site but they are

rarely present. Moreover, most of the officials are not trained to guide proper safety procedures and precautions.

A person appointed as a beldar, retires as a beldar at the age of 60 years. There is no provision of promotions for the beldars in Delhi Jal Board. Annual increments are only given to the permanent staff. The annual increment scheme is not applicable to the muster roll beldars. Although there is an internal hierarchy existing among the staff based on seniority, this system in not officially recognised.

Along with his pay, a permanent worker of DJB is entitled to a dirt allowance of Rs. 100 per month, a washing allowance of Rs. 15 per month, one bathing soap, a kilogram of detergent and a kilogram of mustard oil. However, in reality, the workers have to push hard to procure these for themselves. Their demand for a danger/risk allowance has never found favour with the DJB officials. There is no provident fund coverage for daily wagers, even though they have been employed by the DJB for over 7-8 years.

The permanent employees can avail of 12 days casual leave and 22 days earned leave in one year. Earlier, they were entitled to Rs. 40 medical allowance every month. This was withdrawn around 10 years back, after the DJB started the dispensary facility. The DJB medical dispensaries are open to all the workers, permanent or otherwise, and their families. There is no ESI (Employees State Insurance) coverage for any of the sewage workers. For tertiary-level medical care, around 36 large private and governmental hospitals are on the panel of DJB. There has been no scheduled training programme in First-Aid or safety for these workers.

Hargyan Singh admits that the workers are compensated for any minor injuries while on duty to the extent of Rs. 5,000. For major injuries, the compensation is more, but the concerned employee has to put in a lot of effort to get this compensation. Many a time, the Union has to intervene in such cases. Sometimes the employees have to seek legal recourse, a lengthy and expensive proposition. Many, therefore, prefer not to contest their cases in court.

The transfer policy of the DJB causes hardship to the sewage worker. When an acclimatised worker is transferred to a new area, it takes him time to understand the new area and exposes him to unknown risks and hazards peculiar to that area.

CHAPTER 5

The Study

Objectives

To determine the present status of health and safety as basic data.

To assess the needs of workers regarding health and safety.

Methods

Population

A convenient sample of beldars (numbering 200) working with the DJB at different stores of Delhi was included in the study. A list was prepared for a particular store and the workers whose job it was to maintain sewers were shortlisted. Those who are working as sewer masons were also included. Chowkidars (also designated as beldar only) were not included in the study as they had no direct contact with sewage maintenance and, therefore, had the least possibility of exposure to sewage hazards.

Questionnaire

The participants included in the study were interviewed using a schedule designed to obtain information on the demography, personal habits (smoking/drinking/food habits), occupational exposure history, and safety methods used while working in underground sewerage systems. Specific questions related to acute effects after the exposure like eye irritation, upper respiratory irritation, headache, nausea, vomiting, syncope, excessive fatigue, cuts and injuries, loss of consciousness was asked. Any chronic health impacts like cough/cough with sputum, wheezing, breathing difficulty, skin rashes, other skin problems, irritability, sleep disturbances, hearing loss and low backache were also asked for.

Personal Past history and family history of medical illness, and immunisation history against tetanus, hepatitis etc. was also enquired from the workers.

Medical Examination

Each individual was subjected to a general physical examination and his height, weight, blood pressure was recorded. Laboratory investigations included a complete haemogram and a routine and microscopic urine examination for each participant. Kidney function tests (KFT) were done on randomly selected individuals. Some randomly selected workers were also subjected to Chest X-rays. Fifty workers were tested for HBsAg with the help of a card test.

Table 1: Distribution of the study population in different areas and their percentage in various investigations.

Area	No. of Surveyed Workers	Haemo-gram	KFT	HIV	HBsAg	Urine R/E	PFT	X-ray Chest
Industrial	54 (27.0)	54 (100.0)	11(20.3)	11(20.3)	11(20.3)	54 (100.0)	21(38.9)	12 (22.2)
Residential	71 (35.5)	71 (100.0)	20 (28.2)	20(28.2)	20(28.2)	71 (100.0)	7 (10.0)	7(10.0)
Commercial	42 (21.0)	42 (100.0)	11(26.2)	11(26.2)	11(26.2)	42 (100.0)	10 (23.8)	9 (21.4)
Mixed	33 (16.5)	33 (100.0)	8 (24.2)	8 (24.2)	8 (24.2)	33 (100.0)	15 (45.4)	7 (21.2)
Total	200 (100)	200	50	50	50	200	53	35

Figures in parentheses are in per cent.

Spirometry [Pulmonary Function Test (PFT)]: Spirometery, or PFT, was performed on randomly selected workers. The largest values for the forced exploratory volume in one second (FEV1) and forced vital capacity (FVC) were recorded and compared with predicted values.

Statistical Analyses: The evaluation focused on the exposure to sewage content and to the frequency of going inside the sewerage and the symptoms suffered. All the collected data were analysed with the help of WHO software package, Epi Info 2002 version.

The symptoms were analysed with reference to area, the frequency of underground work, and the smoking habits etc.

Chi square test/Fischer's exact test was applied for evaluating the significance. Differences were considered significant at $p < 0.05$.

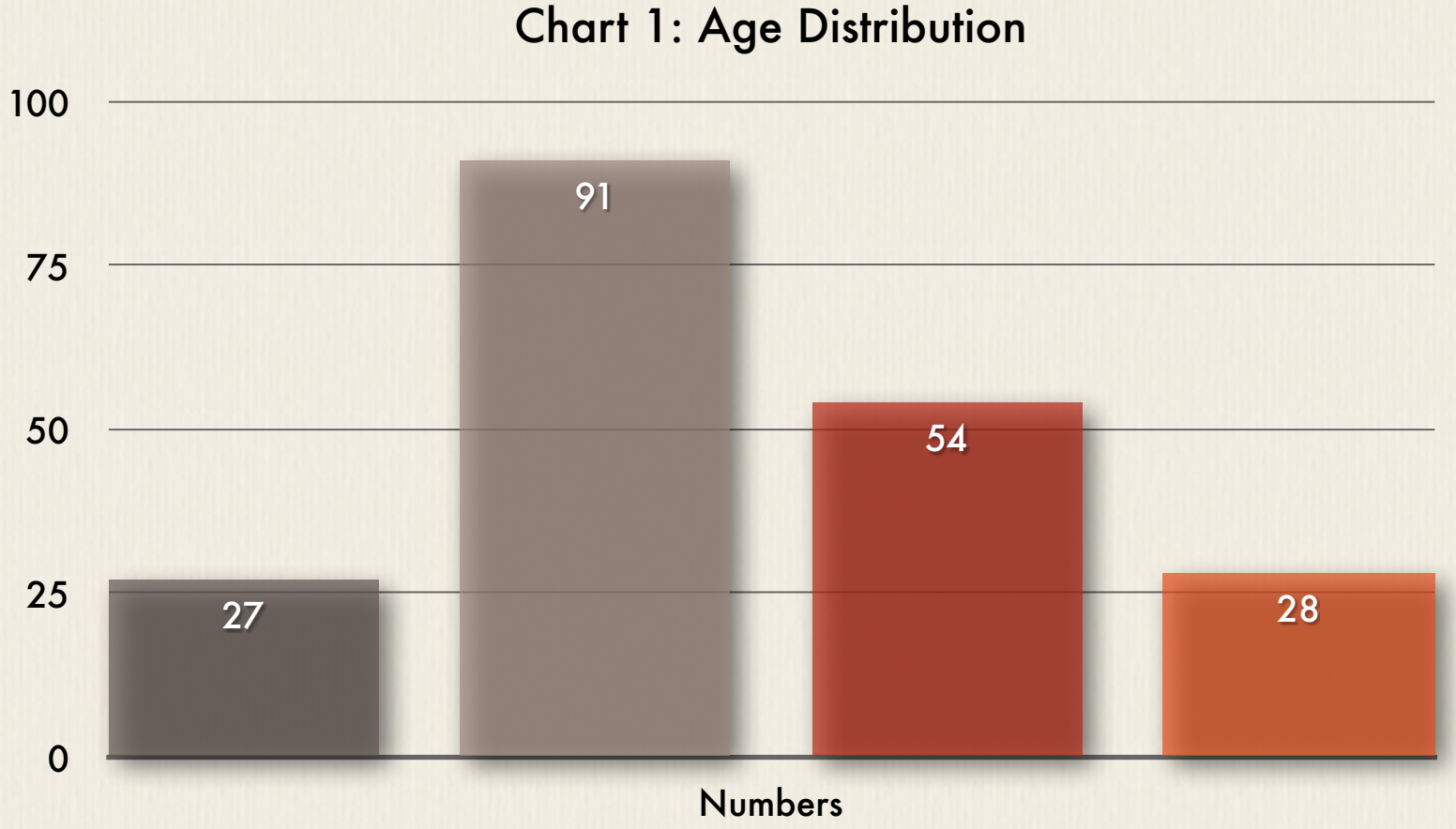
CHAPTER 6

Observations and Findings of the Study

A. Demographic characters

Out of the total of 200 workers, 71 workers (35.5 per cent) workers were from residential areas, while 54 (27.0 per cent) were from industrial areas. The workers from commercial areas made 21 per cent of the studied population while the workers from mixed geographical areas were 16.5 per cent.

Age Distribution



Total workers: 200 Mean Age: 38.3 years

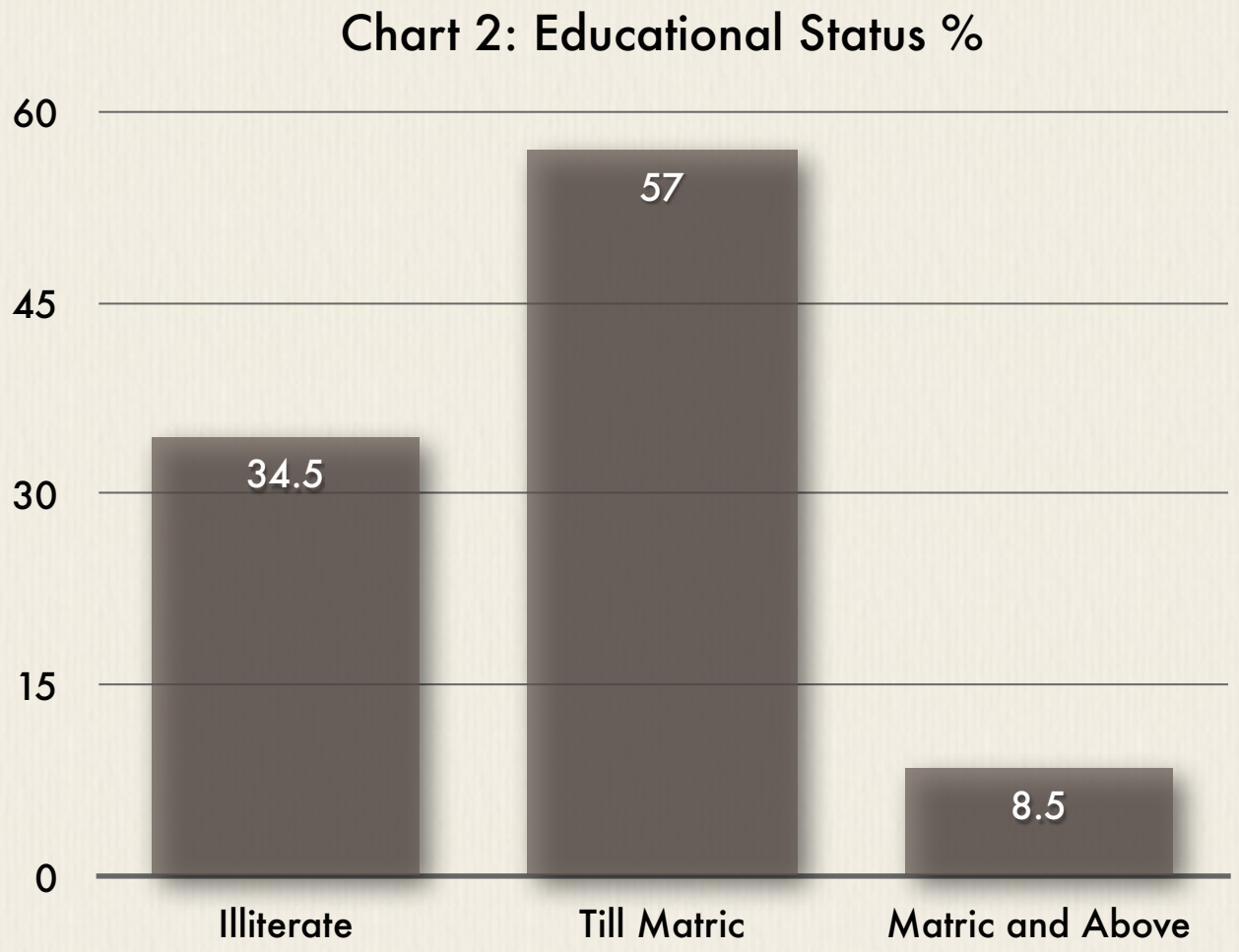
Minimum Age: 23 years Maximum Age: 59 years

Standard Deviation: 8.6925 Standard Error: 0.6147

Chart 1 shows that the maximum number, that is, 45.5 per cent of the workers, was in the age group of 30-39 years. The mean age of workers was 38.2 years (Standard Deviation 8.6925). The minimum age of the workers included in the study was 23 years while the maximum age was 59 years. Twenty-seven per cent of the studied population belonged to 40-49 years of age group. Out of 200 total workers selected for the study the extreme age groups of 20-29 and 50-59 years have only 27 (13.5 per cent) and 28 (14 per cent), respectively.

A steady decline of the number of beldars can be seen with increasing age. This indicates that most of the workers did not complete their entire service period (that is, 60 years). There may be various reasons for the declining number of workers in the age group 50-59. The most prominent one is the death of workers before 60 years. Another factor is that the workers develop physical disabilities. Unable to work, they opt out of their jobs. The most recent recruitment of beldars was carried out in the year 1996.

Educational Status



This chart shows that only 17 (8.5 per cent) workers have studied till the tenth class or above and 14 among them are below 40 years of age. Sixty-nine (34.5 per cent) of the interviewed group are illiterate. The remaining 114 workers had studied till different grades but all below the matriculation level.

A high number of illiterate workers signifies the social discrimination faced by these workers. Most of the workers could not avail the education facilities, having had little access to these. Their parents had not considered education as an essential requirement, having foreseen the nature of the work that their children would have to do in future. Various reasons can be attributed to the fact that many workers did not complete their high school education. The foremost one is the lack of financial support from their parents. Most of the workers left schools to provide additional earnings and support the financial position of their families. Many cited that they did not have enough opportunities to compete with other students and maintain the same standards. The social discrimination faced by some of these workers is another major factor that influenced the outcome of this query. Only a few got the opportunities to complete high school studies and higher secondary studies. This highlights the lack of proper policies to encourage higher education in socially and financially marginalised communities in India. Some of the beldars possess additional qualifications, such as being able to drive cars or operate machines, but their designation is always that of 'beldar'. It is significant to note that 5 respondents out of 27 in the 20-29 years category are illiterates.

Civil Status

Table 2: Civil Status

Status	Age Group (Year)				Total
	20-29	30-39	40-49	50-59	
Married	27	86	49	25	187 (93.5)
Unmarried	0	2	1	0	3 (1.5)
Widower	0	3	4	3	10 (5.0)
Working Female Partner	2	12	9	5	28

Figures in parentheses are in per cent.

This table reveals that 93.5 per cent of the workers are married, 5 per cent have lost their spouses and only 1.5 per cent of the beldars is single. All 27 respondents in the age group of 20-29 years included in the study have been married for at least couple of years. This indicates that there is a trend of early marriages in this community of workers. This trend can be correlated with the limited education status and customary tradition prevailing in the community.

It is significant to note that three respondents of the age group of 30-39 years lost their partners at an early stage. Wives of 4 respondents in the age group of 40-49 years have also died. Out of 187 married couples only 28 spouses are employed and contribute marginally to the total earning of the families. Most of these women either work as road sweepers or as domestic helps in and around Delhi.

Total Number of Children

Table 3: Total Number of Children

Number of Children	Number of Couples	Number of Children									Total	Ratio Female vs. Male
		Male				Female						
		1	2	3	4	1	2	3	4	0		
1	16 (8.4)	10	0	0	0	6	0	0	0	0	16	6/10
2	34 (17.8)	14	20	0	0	14	20	0	0	0	68	34/34
3	52 (27.2)	17	58	12	0	29	34	6	0	0	156	69/87
4	52 (27.2)	10	50	33	12	11	50	30	12	0	208	103/105
5	27 (14.1)	4	14	36	12	3	24	21	16	5	135	69/66
6	9 (4.7)	0	6	9	12	0	6	9	12	0	54	27/27
7	1 (0.5)	0	0	0	4	0	0	3	0	0	7	3/4
Total	191	333				311					644	311/333

Figures in parentheses are in per cent.

Table 3 shows that the total number of children of 191 respondents was 644 with an average of 3.37 children per family. Out of 644 children, 333 were male and 311 were female. It is seen that only 50 workers had 1 or 2 children. An equal

number (27.2 per cent each) was seen with 3 and 4 children. Whereas 14.1 per cent of the families had 5 children, 9 respondents had 6 children. One respondent had 7 children. The respondents were married only once.

It is seen that there is a fair distribution of male and female children among the couples (Refer Chart 3). Of 191 couples responded 141 couples had more than 2 children. This is a clear indication of not following the family planning norms stipulated by the government. The trend of early marriage may be a factor contributing to the higher number of children among the respondents. The poor socio-economic status of the sewer workers may be another probable cause for the higher number of children, stemming from a perception that more number of children meant more earnings.

Age Group vs Number of Children

Chart 3: Age Group vs. Number of Children

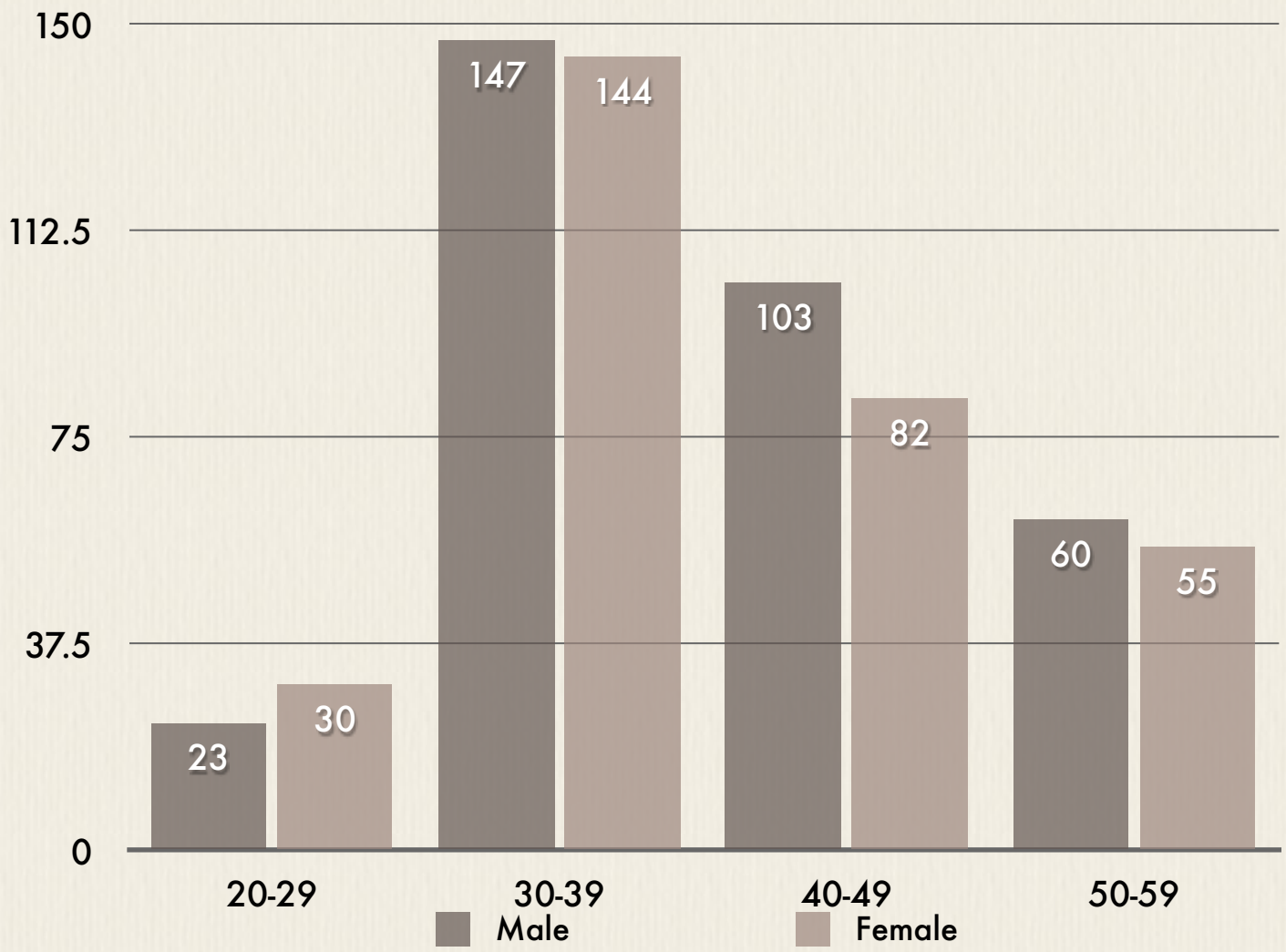


Chart 3 indicates that the highest number of children (291) belongs to the age group of 30-39 years. The number of female children is slightly less than the number of male children in all age groups except in the 20-29 years age group

where there are more girls than boys. It will be premature to comment on this trend as 20-29 years age group are still in the actively reproductive phase.

B. Occupational Health Status

The mainstay of this study report is to correlate the consequences of sewer work on the health of the individual who is exposed to toxic elements at the workplace. To assess the status of the occupational health, emphasis was given on obtaining information on various symptoms of diseases or disorders manifested during working life of workers. Signs and pathological laboratory indicators of exposure to particular / mixture of chemical, physical or biological hazards at workplace were also tried to evaluate.

The outcome of the exposure has been evaluated in (i) the acute form whereby the worker experiences the signs or symptoms on coming into contact with the toxic hazard (ii) the chronic form as frequent occurrence over a time period with or without recurrent/regular/repeated exposure.

Symptoms arising from exposure to asphyxiating gases, irritant gases, chemicals in liquid form, and biological contaminants were obtained from the sewer workers. The questionnaire was designed to obtain information on harmful effect on body organ system, due to exposure to chemical hazards through respiration, ingestion, or contact with skin or mucous membranes. The external signs and symptoms are the physiological dysfunctions caused by these hazardous substances. The initial damages of these physiological functions are reversible but these can become irreversible after prolonged and continuous exposure. Permanent disability can be prevented by removing/protecting the individual from exposure.

The following table (Table 4) computes the responses of the workers of the acute effects of exposure to underground sewage work. Workers were asked to affirm whether they experienced the symptoms while working in the sewage line. The responses are a qualitative evaluation only.

Acute Symptoms

Table 4: Acute Symptoms		
	Symptom	**Positive Response**
a.	Eye irritation	159 (79.5)
b.	Upper respiratory tract irritation	114 (57.0)
c.	Loss of consciousness	24 (12.0)
d.	Syncope	41 (20.5)
e.	Headache	68 (34.0)
f.	Nausea/Vomiting	70 (35.0)
g.	Difficulty in breathing	76 (38.0)
h.	Loss of body balance	16 (8.0)
i.	Metallic taste in mouth	54 (27.0)
j.	Light headedness	41 (20.5)
k.	Fatigue	34 (17.0)
l.	Skin rash	121 (60.5)
m.	Cut injury	183 (91.5)
n.	Loose motion	9 (4.5)
Figures in parentheses are in per cent		

Of the 200 workers, 183 (91.5 per cent) workers have affirmed that they had had cuts or injuries one or many times. The next highest reported symptom was eye irritation (79.5 per cent), and 121 (60.5 per cent) reported that they had suffered skin rash on contact with the sewage. Over half (57 per cent) had had nose, throat and the upper respiratory tract irritation. The irritant gases are responsible for a high percentage of symptoms of eye irritation, upper respiratory irritation, skin irritation and skin rashes. Forty-one workers reported syncope, and 24 reported loss of consciousness at one time or the other when exposed to sewage contents. This high percentage of work-related symptoms could be attributed to the inhalation of toxic gases present in the sewage. Other neurological effects included disequilibrium, headache, light-headedness and excessive fatigue in a substantially high number of workers. Gastrointestinal problems, in the form of nausea/vomiting (35 per cent), loose motions (4.5 per cent) and a metallic taste in the mouth (27 per cent) form another cohort of acute effects. Breathlessness was reported by 38 per cent of the workers.

Chronic Symptoms

The workers were questioned about the possible long-term effects of working with sewage. Each individual was given four options, on a continuous scale, depending upon the frequency of occurrence of these symptoms in their daily life. The four options were: frequently (2-3 times/week), sometimes (once/month), rarely (once every 6 months) or never. However, for the ease of statistical analysis and quantitative representation, the first three options were clubbed together in the form of affirmative responses while the option "never" was indicated as answer "no".

Table 5: Chronic symptoms

	Symptoms	Positive Response
a.	Fatigue	31 (15.5)
b.	Tiredness	152 (76.0)
c.	Body ache	83 (41.5)
d.	Headache	97 (48.5)
e.	Watering of eyes	73 (36.5)
f.	Burning of eyes	51 (25.5)
g.	Nausea/Vomiting	22 (11.0)
h.	Cough	145 (72.5)
i.	Cough with sputum	61 (30.5)
j.	Blood in sputum	2 (1.0)
k.	Wheezing	21 (10.5)
l.	Breathlessness	31 (15.5)
m.	Irritability	20 (10.0)
n.	Dizziness	34 (17.0)
o.	Confusion	6 (3.0)
p.	Sleep disturbances	17 (8.5)
q.	Skin irritation	83 (41.5)
r.	Skin roughness	72 (36.0)
s.	Skin rash	91 (45.5)
t.	Skin colour change	15 (7.5)
u.	Decreased hearing/loss	7 (3.5)
v.	Diarrhoea	9 (4.5)
w.	Low backache	54 (27.0)

Figures in parentheses are in per cent

Table 5 shows the responses of the workers, for the diseases/symptoms they suffered/or are suffering during the past 2-3 years.

The table indicates that the percentage of workers, claiming tiredness (76.0 per cent) and cough (72.5 per cent) as main chronic complaints is highly significant. The other major chronic symptoms include headache (48.5 per cent), skin rash (45.5 per cent), skin irritation (41.5 per cent) and body ache (41.5 per cent). Only 73 workers (36.5 per cent) affirmed the watering of eyes, 30.5 per cent have cough with sputum and 36 per cent have rough skin.

Medical Examination

Each individual was subjected to a general medical examination by a qualified medical practitioner. The main emphasis of the medical examination was to look for external evidence of allergies/infections. Poor orodental hygiene was the common finding among 107 workers. Inflammatory infection of the gums, either as primary disease of gums or secondary to dental infection, was seen in 66 workers. Smoking, tobacco chewing and lack of personal hygiene may have led to this and is responsible for many of the gastrointestinal diseases.

Seventy workers had chronic allergic conjunctivitis, characterised by inflamed, discoloured (usually muddy) and thick conjunctiva. These symptoms are clinically termed as chemosis. A visual examination of the skin (mainly of the hands, face and feet) concluded that 59 workers had coarse skin, 54 had rough skin and 49 had hyper-pigmented patches. Only 3 workers had hypo-pigmented patches. All these observations and findings may vitally relate to exposure to the different harmful components in sewage. Continuous and prolonged body contact with hazardous chemicals and gases due to lack of decontamination or washing facilities at the worksite or sewer stores contribute enormously to these health problems.

Chest auscultations revealed that 13 workers had altered respiratory sounds, which include ronchi, with crepts as added sounds. The probable causes for such respiratory findings may be due to occupational asthma, acute or chronic active lung infections, allergic bronchitis or pulmonary oedema. Direct exposure to irritating or hypoxic gases or desiccating organic matters in the sewage can directly damage the respiratory systems of the individuals working inside a sewer line. However a differentiation of the occupational causative agents from that of other environmental agents was not possible in the limited scope of the study and subject matter.

Past Medical History

Table 6 shows the significant past medical history of the 200 sewage workers. The diagnosed asthma cases were 7 per cent while 4.5 per cent had been treated for tuberculosis infection. Nine per cent were known cases of high blood pressure, 4 per cent had diabetes and 4 per cent suffered from ischaemic heart disease. Known skin affections were the second most diagnosed (8.0 per cent) ailments among the sewer workers. None of the workers had been diagnosed as having cancer.

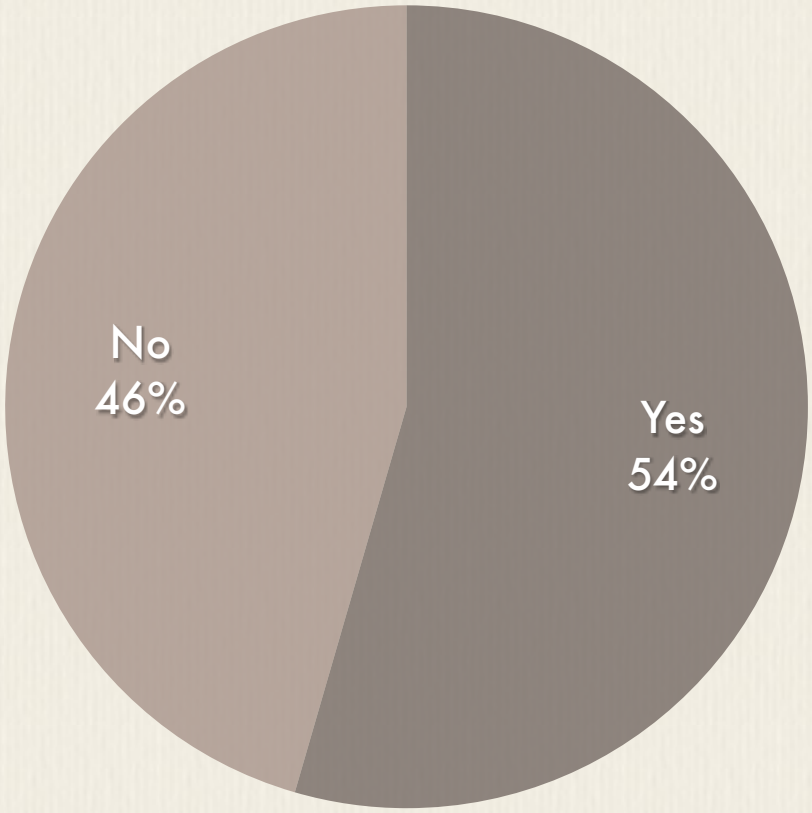
Table 6: Past Medical History

	Past History of	Positive
a	Asthma	14 (7.0)
b.	Tuberculosis	9 (4.5)
c.	Bronchitis	13 (6.5)
d.	Hypertension	18 (9.0)
e.	Ischaemic Heart Disease	4 (2.0)
f.	Diabetes Mellitis	4 (2.0)
g.	Jaundice/Hepatitis	9 (4.5)
h.	Dermatitis/ Ulceration/Colour change	16 (8.0)
i.	Allergy	7 (3.5)
j.	Cancer	0 (0.0)
Figures in parentheses are in per cent		

Immunization against Tetanus

Table 7A reveals that 46.5 per cent of the studied population had received injuries while working in the sewage line. But this chart indicates that only 35 per cent of the workers are immunised against tetanus. Apart from the injury vs. immunization status, which shows a negligent attitude to disease prevention, most of the workers could not recall any immunization done in their childhood. Enquiry into other well publicised vaccination programmes for Hepatitis-B immunization drew a blank. The counter enquiry as to why should anyone be vaccinated against a disease like jaundice reflected the ignorance of the workers. Sewage workers, although classified as vulnerable to different forms of hepatitis owing to the nature of work they perform, their negative immunisation status put

Chart 4: Immunization against tetanus



all the questions on the efficiency of government performance of national immunization programme.

C. Occupational Safety Status

Knowledge about Occupational Hazards

Table 7A: Knowledge about Occupational Hazards
N=200

Response	Awareness	Hazards			Route of Entry			
		Gas	Chemicals	Sharp Objects	Inhalation	Ingestion	Contact	Injury
Know	189 (94.5)	177 (88.5)	84 (42.0)	92 (46.0)	153 (76.5)	5 (2.5)	174 (87.0)	93 (46.5)
Don't Know	11 (5.5)	23 (11.5)	116 (58.0)	108 (54.0)	47 (23.5)	195 (97.5)	26 (13.0)	107 (53.5)

Figures in parentheses are in per cent.

Table 7A indicates that 189 (94.5 per cent) of the 200 workers have some awareness of the risk involved in their occupation. But a different picture emerged about their awareness of the specific hazards related to sewage work. A majority (177 out of 200, 88.5 per cent) responded that the presence of toxic gases is a health and safety concern in the sewage work whereas 23 (11.5 per cent) are not aware about the presence of harmful gases. Only 82 (42 per cent) workers are

aware of the fact that different chemicals in the sewer line may cause harm to them, contrary to 116 (58 per cent), who have no idea about the presence of harmful chemicals in the sewer line. Similar information is obtained from the respondents on sharp objects in the sewer line. Ninety-two (46 per cent) responded that they have encountered sharp objects while working in the underground line. Over three-fourths (76.5 per cent) of the workers know that they can inhale the gases. The response of the 195 (97.5 per cent) workers is that harmful agents cannot enter through the ingestion route. 174 (87 per cent) out of 200 respondents said that the harmful agents can cause harm on contact with the skin.

The workers do not know much about the potentially hazardous gases present in their work environments. Some of them have informed that acids and/or alkali in the sewer line may pose risks. But they have limited awareness about the existence of other harmful chemicals in the sewage. Workers encounter broken glass pieces, needles with syringes, nail and broken rods are the sharp objects. Sometimes they meet rats, cockroaches and dead-bodies of small animals.

Knowledge vs Age Group

Table 7B: Knowledge vs Age Group

Age Group	Gas		Chemical		Sharp	
	Yes	No	Yes	No	Yes	No
20-29	23 (85.2)	4 (14.8)	15 (55.6)	12 (44.2)	10 (37.0)	17 (63.0)
30-39	78 (85.7)	13 (14.3)	42 (46.2)	49 (53.8)	40 (44.0)	51 (56.0)
40-49	49 (90.7)	5 (9.3)	18 (33.3)	36 (66.7)	30 (55.6)	24 (44.4)
50-59	27 (96.4)	1 (3.6)	9 (32.1)	19 (67.9)	12 (42.9)	16 (57.1)
Total	177 (88.5)	23 (11.5)	84 (42.0)	116 (58.0)	92 (46.0)	108 (54.0)

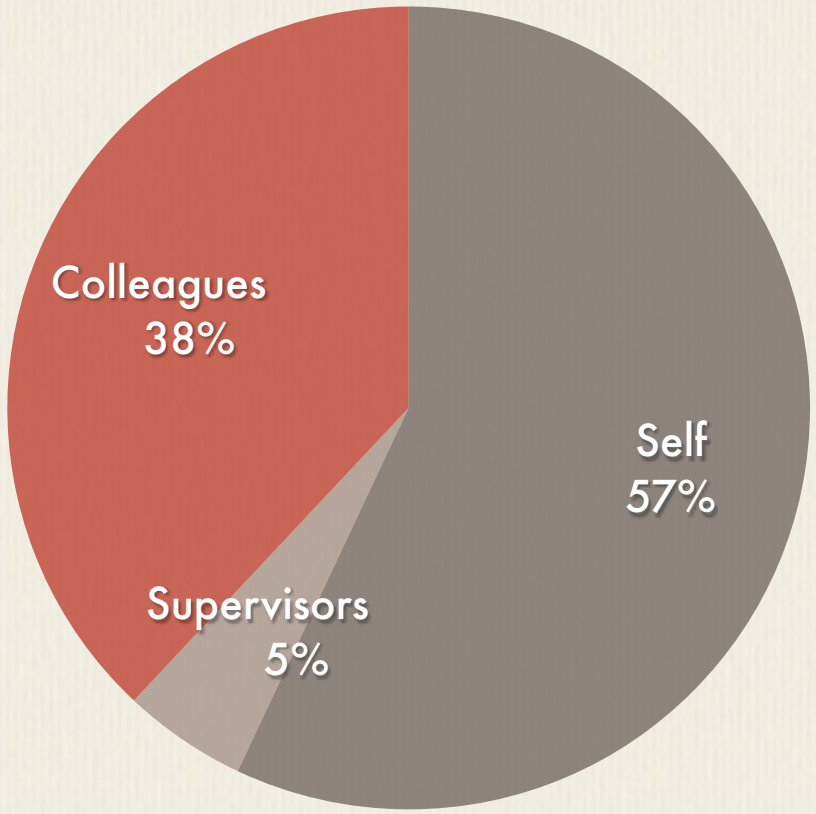
Figures in parentheses are in per cent.

Table 7B indicates that information about exposure to gases during the course of work is almost uniformly distributed among all age groups. The highest prevalence of information (96.4 per cent) has been observed in the 50-59 years of age group. The 20-29 years age group is more aware about the exposure to hazardous chemical agents than other age groups in the surveyed population. Workers in residential areas were more aware about chemical hazards than those

working in other areas. Awareness about chemical exposure among workers in industrial areas was significantly lower. This is a clear indication that workers were had never been informed about the potential hazards of their work.

Hazard Communication

Chart 5: Hazard Communication



This chart reveals the very poor hazard communication systems of the DJB. Only 5 per cent of the workers were given information about the potential hazards by the supervisor or other officials. No proper training is given to the workers on the hazards and other safety measures. Not a single beldar in the study group knew about first aid or had received training to deal with emergencies. Thirty-eight per cent of the selected group became aware about the various hazards from fellow workers. More than one-fourths (57 per cent) claimed that they learnt of the hazards of working in the sewers while on the job.

Usage of Safety and Protective Gear

Table 8: Usage of Safety and Protective Gear

Response	Mask	Shoe	Skin Protection	Eye Protection	Safety Belt
Uses	24 (12.0)	15 (7.5)	15 (7.5)	0 (0.0)	185 (92.5)
Don't use	176 (88.0)	185 (92.5)	185 (92.5)	200 (100)	15 (7.5)

Figures in parentheses are in per cent

Table 8 shows the use of personal protective gears by the sewage workers. Only 24 (12 per cent) out of 200 workers had used protective masks while working in underground sewer line. Moreover, they had little information about the type of the mask they are using. Safety shoes and skin protective measures (gloves) had been used by 15 workers. Not a single worker had ever used any eye protective gear. A majority (185, or 92.5 per cent) of the workers used safety belts during underground work in deep sewer lines. Inadequate supply of protective equipment had been observed in many sewer stores. There may be existence of only one mask among 20-25 workers. The workers were not instructed how to use respirators properly nor were they provided with proper training to use the mask. Workers often found the respirators uncomfortable to use. There was no clarity on the type of respirator provided to the workers because the sample respirator shown by the workers to the investigating team had a warning "Not to be used in oxygen deficit environment or in confined spaces". In reality, the respirator provided no protection to the user from toxic gases; on the other hand, the user found breathing difficult. No protective gear for the eyes was provided to the workers. Workers were provided with gumboots, which offered them little protection from the sharps and broken objects usually present in the sewage line.

D. Labour Employment Characteristics

Employment

Table 9: Employment									
Age	Employment		Duration of Employment (in Years)				Job Skill		Total
			<1	2-5	6-10	>10	Unskilled	Skilled	
20-29	Permanent	02 (7.4)	0	0	01 (50.0)	01 (50.0)	02 (100.0)	0	27
	Daily wages	25 (92.6)	0	03 (12.0)	21 (84.0)	01 (4.0)	21 (84.0)	04 (16.0)	
30-39	Permanent	36 (39.5)	01 (2.8)	0	02 (5.6)	33 (91.7)	30 (83.3)	06 (16.7)	91
	Daily wages	55 (60.5)	0	0	46 (83.6)	09 (16.4)	50 (90.9)	05 (9.1)	
40-49	Permanent	52 (96.3)	0	01 (1.9)	01 (1.9)	50 (96.2)	48 (92.3)	04 (7.7)	54
	Daily wages	02 (3.7)	0	0	0	02 (100.0)	02 (100.0)	0	
50-59	Permanent	28 (100.0)	0	01 (3.6)	0	27(96.4)	27 (96.4)	01 (3.6)	28
	Daily wages	0	0	0	0	0	0	0	
Figures in parentheses are in per cent									

In the study, of 200 respondents 59 per cent belonged to the permanent category and remaining 41 per cent were daily wagers, or muster roll employees. Twenty-five respondents out of 27 under the age of 30 years were daily wagers and 22 of them had been working for more than 5 years without any break. Similarly, a large number of respondents in the age group of 30-39 (55 out of 91) were employed on a daily wage basis and all of them had been working unremittingly for more than 5 years. The permanent workers had been working as beldars for more than 10 years. In most cases, permanent status was given after they worked significant years as muster roll workers. Of the 82 daily wagers, 67 (81.7 per cent) had been working for more than 6 years and 12 (14.6 per cent) had been working for more than 10 years. All these workers have been working continuously as beldars for such a long time without being regularized. This indicates a flagrant violation of labour and employment rights. Scant attention had been paid to the labour rights stated in the constitution and in various labour as well as employment acts. Furthermore, no identity cards had been issued to the daily wagers. There were neither appointment letters nor contracts for these workers. Daily wagers are not entitled to any leave other than one day weekly off

day. If they absent themselves from duty, they do not get paid for the period. The DJB has taken no steps to upgrade the status of these workers. For the authorities work is more important than who is working under which condition. This is sheer exploitation of workers, who perform a crucial service to society.

Of the 118 permanent workers 11 (9.3 per cent) workers are involving in jobs like driving and operating jet machines. The rest (107, 90.7 per cent) of the permanent workers are unskilled. Of the 82 muster roll workers, 9 (11 per cent) workers are skilled and 73 (89 per cent) are unskilled. Most of the workers acquired their skills unofficially from the senior colleagues. The DJB takes no initiative to provide specific skill-enhancement training to the workers. There is also no provision of interdepartmental promotion in this work. Except for the annual increment for the permanent workers, no other hierarchy exists among the beldars on the basis of seniority.

Work Load

Table 10: Work Load

Employment	Underground Entry (Times per Month)			Working Hour	
	>10	3-10	0-2	<8	>8
Permanent (n = 118)	70 (59.3)	43 (36.5)	5 (4.2)	65 (55.1)	53 (44.9)
Muster roll (n = 82)	48 (58.5)	26 (31.7)	8 (9.8)	39 (47.6)	43 (52.4)
Total (n = 200)	118 (59.0)	69 (34.5)	13 (6.5)	104 (52.0)	96 (48.0)
Figures in parentheses are in per cent					

.Table 10 summarizes the workload of the sewage workers. The workload is evenly balanced between permanent workers and daily wagers. Of the 118 permanent workers, 70 (59.3 per cent) have to enter manholes more than 10 times in a month. Forty-three (36.5 per cent) workers enter the underground sewage lines 3-10 times per month. Only 5 (4.2 per cent) workers enter the manhole 0-2 times in a month. Of the 82 muster roll workers, 48 (58.5 per cent) enter the underground sewer lines more than 10 times per month. Twenty-six (31.7 per cent) workers work inside the underground sewer system 3-10 times in a month and 8 (9.8 per cent) work inside manholes 0-2 times per month. As a whole, in the

study of 200 workers, 118 (59.0 per cent) of them work inside manholes more than 10 times a month, 69 (34.5 per cent) work 3-10 times a month and 13 (6.5 per cent) work 0-2 times a month.

Of the 200 workers studied, 104 (52.0 per cent) work less than 8 hours per day and 96 (48.0 per cent) work more than 8 hours per day. There is no overtime allowance for the workers who have to work more than 8 hours a day. Of the 118 permanent workers, 53, or 44.9 per cent and 43 (52.4 per cent) among 82 muster roll workers work more than 8 hours a day.

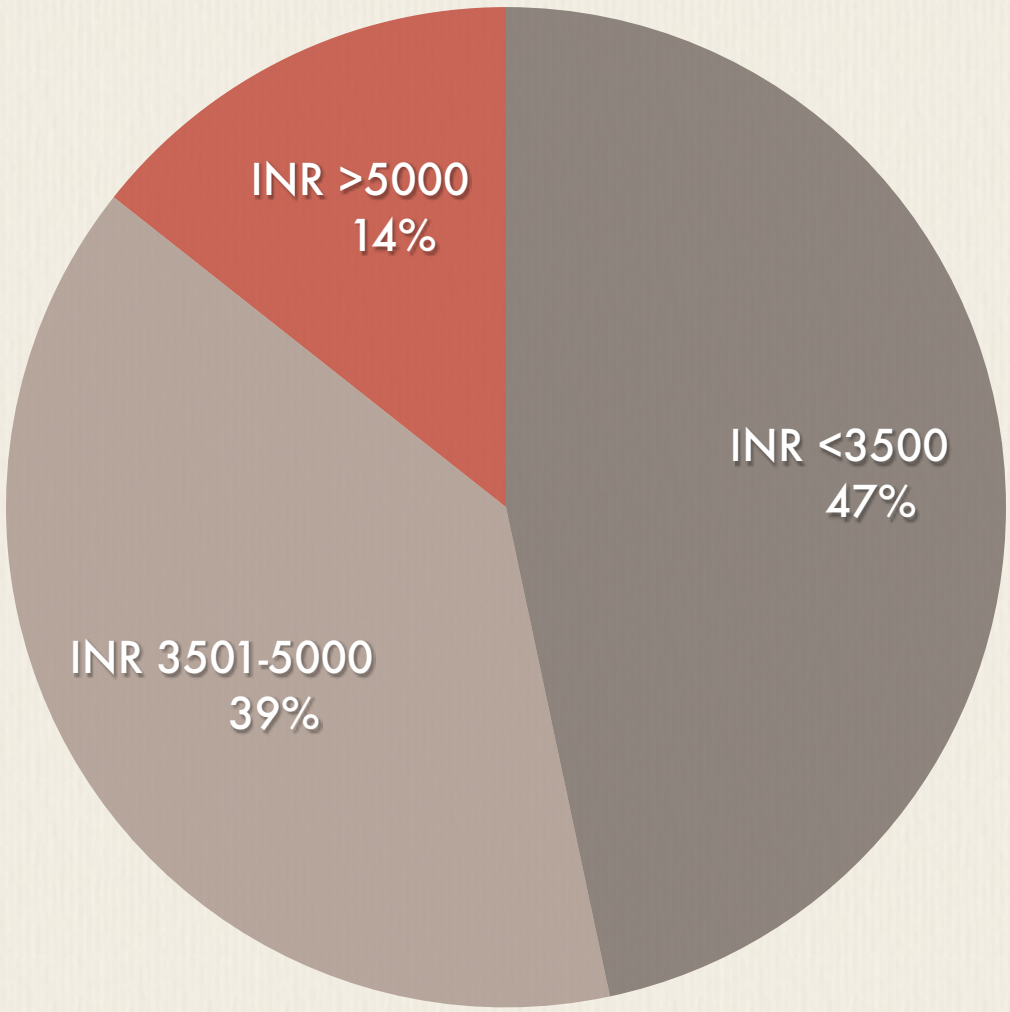
Generally, a team of beldars takes up any maintenance work in a sewer line of a particular location. The number of the team members varies depending on the requirement of the task. Usually a team comprises three beldars, one of whom goes inside the sewer line and other two help from the ground. One team may have to undertake many tasks daily.

E. Socio-economic Status and Personal Habits

Monthly Wage

All the workers on the muster roll, or daily wagers (41 per cent of the total) earned less than Rs. 3,500 per month whereas the permanent workers (47 per cent of total) were paid more than Rs. 5,000 per month. Twelve per cent of the permanent workers were earning between Rs. 3,500 and 5,000 per month. All daily wagers were getting a salary of approximately Rs. 2,950 per month without any other benefit. This disparity in the income is despite the similar nature of work done by them. The additional benefits of dirt allowance, washing allowance, GPF and insurance are available to the permanent workers only. There is no provision of annual increment to the daily workers who have been working continuously for several years. All the permanent workers are supposed to get washing soap, bathing soap, mustard oil, etc., from the authorities every month, but they seldom receive these on time. Contrarily, they have to struggle to get their materials. These materials are not available to the daily wage workers.

Chart 6: Monthly Wage



Per Capita Income

Table 11 indicates that 26 respondents had 1-2 dependents, 91 respondents had 3-4 dependents and 81 respondents had more than 4 dependents (two workers did not respond). Twenty-two (81.5 per cent) of the 27 respondents in the age group of 20-29 years had to take responsibility for more than 3 persons with their income and only 5 respondents had 1-2 dependents. Approximately 89 per cent of the respondents in the age group 20-29 had a per capita income (PCI) per month of between Rs. 501 and Rs. 1,500 whereas only 2 respondents in this age group had a PCI per month of less than Rs. 500. The financial situation of these workers was not enough to support their family and dependents. Almost 93 per cent of the respondents in the age group of 30-39 years had to take care of more than 3 persons in their families. For a majority of this group (72.2 per cent), the PCI per month was between Rs. 501 and Rs. 1,500. Twenty-two per cent of this age group had a PCI per month of less than Rs. 500. A similar trend was visible in the 40-49 years age group. Approximately 88 per cent of the group financially supported more than 3 dependents. This group had a better PCI per month than

the previous two groups. The last age group (50-59 years) had the best PCI per month among all the respondents. This is because all members of this group were permanent employees and had better monthly incomes.

Who are the dependents? The dependents are essentially members of their own family. Among the respondents below 40 years of age, the dependents are normally the parents, spouse and their children. Many have to take on the responsibility of their unemployed brothers and sisters. For respondents more than 40 years of age, the dependents are their spouse and children. The age and employment status of their children determine the dependency. In case of respondents who belong to a much older category, their dependents are most

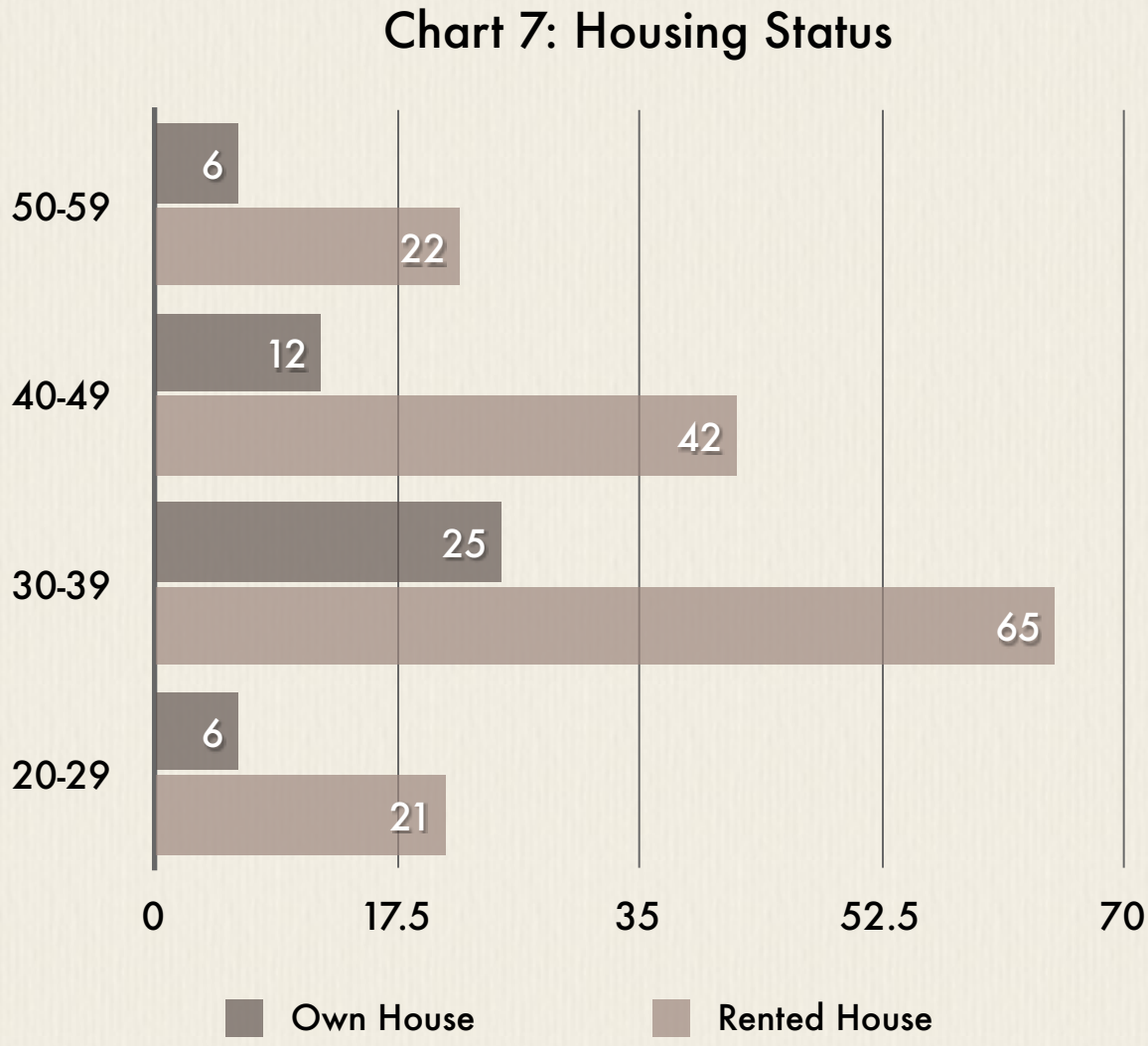
Table 11: Per Capita Income N=198

Age Group	Number of Dependents			Per Capita Income (PCI) in INR/Month			
	1-2	3-4	>4	<500	501-1500	1501-3000	>3001
20-29 (N = 27)	05 (18.5)	14 (51.8)	08 (29.7)	02 (7.4)	24 (88.9)	01 (3.7)	0
30-39 (N = 90)	06 (6.7)	40 (44.4)	44 (48.9)	20 (22.2)	65 (72.2)	05 (5.6)	0
40-49 (N = 53)	07 (13.2)	25 (47.2)	21 (39.6)	02 (3.8)	31 (58.5)	18 (33.9)	02 (3.8)
50-59 (N = 28)	08 (28.6)	12 (42.8)	08 (28.6)	0	10 (35.7)	12 (42.8)	06 (21.5)
Total	26	91	81	24	130	36	8
Figures in parentheses are in per cent							

usually the spouse and unmarried girl children. The high number of children and the limited prospects of employment for the siblings make the circumstances of dependency worst.

Housing Status

This chart indicates the housing status of the respondents across all the age groups. It is encouraging to state that 150 (75 per cent) of the 200 respondents stayed in their own houses while only 49 workers (24.5 per cent) stayed in rented accommodation (one respondent did not respond to this query). The ratio of the respondents staying in their own houses to rented houses is approximately the same in all age groups.



This finding is incongruous with some earlier statements on low income. The reason for such a strange discovery can be explained by the fact that most of the respondents are staying in their ancestral houses. However, the houses in which the respondents had been staying permanently were not in their own names. In most of the cases, the owners of the houses were either their parents or the elder members of the families. In the age group of 20-29 years, of 27 respondents, 21 lived in their own houses. With an income of less than Rs. 3,000 per month and without any other financial resources, it was quite impossible to construct their own houses in Delhi. Twenty (60 per cent) of the 27 respondents of this age group were staying at a distance of more than 10 km from their respective workplaces (Table 12).

Roughly 22 per cent of the cohort stayed at a distance of less than 5 km from their workplace. Most of the respondents were residents of villages situated far from the city area. A few of them also travelled from bordering states to work in Delhi. A higher proportion of respondents from all age groups travel more than 20 km to reach their workstations. Long distances of travelling along with a

Age Group	Distance from Home to Work (KM)			
	1-5	6-10	11-20	>20
20-29	6	1	5	15
30-39	16	24	23	28
40-49	18	9	12	15
50-59	5	5	8	10
Total	45	39	48	68

physically demanding job certainly affected the physical and mental well-being of the workers.

Distance and Transport

Table 13 indicates that of the 200 respondents, 45 (22.5 per cent) stayed at a distance of 1-5 km from the workplace and about half of this group used cycle for commuting. Others used public bus, motorcycles or other means for travelling. A few also came on foot. Thirty-nine (19.5 per cent) respondents of 200 stayed at a

Table 13: Distance and Transport

Distance (Km)	Housing		Mode of Commuting						
	Owned	Rented	Cycle	M. Cycle	Bus	Train	On foot	Multiple Means	Total
1-5	27 (60.0)	18 (40.7)	23 (51.1)	3 (6.7)	7 (15.6)	0 (0.0)	6 (13.3)	6 (13.3)	45 (22.5)
6-10	29 (74.3)	10 (25.7)	15 (38.5)	0 (0.0)	17 (43.6)	0 (0.0)	1 (2.6)	6 (15.4)	39 (19.5)
11-20	35 (73.0)	12 (27.0)	11 (22.9)	1 (2.1)	32 (66.7)	0 (0.0)	0 (0.0)	4 (8.3)	48 (24.0)
>20	59 (86.7)	9 (13.3)	4 (5.9)	1 (1.5)	25 (36.8)	11 (16.2)	0 (0.0)	27 (39.7)	68 (34.0)
Total			53 (26.5)	5 (2.5)	81 (40.5)	11 (5.5)	7 (3.5)	43 (21.5)	200 (100.0)

Figures in parentheses are in per cent

distance of 6-10 km from their respective workplaces. In this group, most respondents (17, 43.6 per cent) used public bus to travel and 15 (38.5 per cent) respondents commuted by cycle. The distance between residence and work place for 48 (24 per cent) respondents was 11-20 km. Thirty-two (66.7 per cent) of 48 respondents travelled by public bus and 11 (22.9 per cent) used cycles. The distance for the highest number of respondents (68, or 34.0 per cent) among total respondents is more than 20 km. Of these, 25 (36.8 per cent) commuted by public

bus and 27 (39.7 per cent) used multiple means to come to workplace. All the train users [11 (16.2 per cent)] in the cohort resided more than 20 km away from respective worksites. In this cohort of 200 individuals, 5 (2.5 per cent) respondents commuted by their own motor cycles as compared to 53 (26.5 per cent) respondents who commute by cycle. Of these 53 respondents, 15 respondents came from a distance that was more than 10 km from the workplaces. The highest number of respondents, that is, 81 (40.5 per cent) travel daily in public buses. Forty-three (21.5 per cent) respondents commuted by multiple modes whereas 7 (3.5 per cent) travelled on foot. Multiple modes include a combination of more than two options of commutating given in the table. These workers had been exposed to polluted air because of long-distance travel and were, therefore, more susceptible when exposed to occupational hazards.

Source of Drinking Water

Of the 200 respondents, 136 (68 per cent) responded that they availed of the drinking water facility provided by the DJB or by the respective municipal board

Table 14: Source of drinking water

Source	Source of Drinking Water					
	At Home	At Workplace				
		Industrial	Residential	Commercial	Mixed	Total
DJB/ Municipal Supply	136 (68.0)	27	71	42	33	173 (86.5)
Individual Hand Pump	46 (23.0)	0	0	0	0	0 (0.0)
Community Hand Pump	18 (9.0)	0	0	0	0	0 (0.0)
No Facility	0 (0.0)	27	0	0	0	27 (13.5)

Figures in parentheses are in per cent

at home. Forty-six (23 per cent) claimed to have installed individual hand pumps for drinking water and 18 (9 per cent) depended on community hand pumps in their residential areas.

The DJB supplied drinking water to 173 (86.5 per cent) of the respondents. All the residential, commercial and mixed (as defined under area of study) areas where the study was conducted had drinking water supplied to them by the DJB. But 27 (13.5 per cent), who declared that there was no facility for drinking water at the workplaces, were working in industrial areas. In most of the workplaces proper washing and bathing facilities were not available.

Potable quality check for the supplied water was not within the scope of this study. So, there is no clear indication of the quality of the drinking water provided in the workplaces or to the households. But the prevalence rate of probable water-borne diseases is very low within the intervened samples.

Personal Habits

When asked about their smoking habits, 137 (68.5 per cent) workers said they were current smokers while 59 (29.5 per cent) denied ever having smoked. Only 2 per cent (4 workers) have given up smoking. Of the 139 workers who responded to the query as to how long they had been addicted to smoking, 40 (28.8 per cent) said that they had been smoking for less than 5 years while 55 (39.6 per cent) were into it for more than 5 years but less than 15 years. A little over one-third (44, or 31.7 per cent) had been smoking for more than 16 years. Of the smokers, 94.3 per cent smoked bidis. Approximately 52 per cent of the total smokers belonged to less than 40 years of age.

Table 15A: Personal Habits

Addiction	Status				Duration (In years)			
	Current	Former	Never	Total	<5	6-15	>16	Total
Smoking	137 (68.5)	4 (2.0)	59 (29.5)	200	40 (28.8)	55 (39.6)	44 (31.7)	139
Alcohol Drinking	131 (65.5)	17 (8.5)	52 (26.0)	200	46 (46.0)	24 (24.0)	30 (30.0)	100
Smokeless Tobacco	42 (22.1)	0 (0.0)	148 (77.9)	190	30 (73.2)	8 (19.5)	3 (7.3)	41

Figures in parentheses are in per cent

Of 190 respondents, 42 (22.1 per cent) used smokeless tobacco products, which include chewing tobacco, khaini, surti, paan and gutka. Thirty respondents (73.2 per cent) had been using smokeless tobacco products for less than 5 years.

A little lesser number, that is, 131 (65.5 per cent) were consumers of alcohol, and 52 (26.0 per cent) never had alcohol. The rest 8.5 per cent (17) workers fell into the former alcohol consumer category. The reason why they gave up alcohol was not ascertained in the scheduled interview. Thirty per cent said that they had been consuming alcohol for more than 16 years, 46 per cent were relatively new entrants, having consumed alcohol for less than 5 years. Twenty-four per cent had been using alcohol for an intermediate period of 6-15 years. A few respondents refused to give details as to how long they had been consuming alcohol. Most of the respondents were reluctant to answer any query regarding alcohol consumption because during the course of this study a report was published in the newspaper that the health problems faced by the workers were due to the consumption of alcohol.

The number of persons addicted to smoking and alcohol is very high. Almost 65 per cent of the surveyed population was addicted to some tobacco products and alcohol. This percentage is substantially higher than any convenient standards. There were a number of reasons given for such high addiction among sewage workers. The principal reason was the nature of their work. The filth and unpleasant smell made them consume alcohol. Moreover, they thought that by consuming alcohol they could relax a bit after their obnoxious work. Some believed that alcohol acted as a germicide in the body so it protected them from any infection that might occur due to exposure. Most of them started the consumption of alcohol and bidi smoking only after joining sewer work.

The food habit of the 200 respondents was also interesting; only 6 per cent were vegetarians while 94 per cent ate both vegetarian as well as non vegetarian food. Most preferred wheat to rice. The calorific value or the nutritional value of their meal was not being investigated but the respondents who came to work from villages drank milk almost daily.

Age Group vs Body Mass Index

Table 15B: Age Group vs Body Mass Index			
Age Group	Body Mass Index (BMI)		
	Underweight (<20.7)	Normal (20.8-26.4)	Overweight (>26.5)
20-29 (N = 27)	16 (59.4)	09 (33.4)	02 (7.2)
30-39 (N = 90)	44 (48.4)	36 (39.4)	11 (12.0)
40-49 (N = 53)	24 (44.4)	26 (48.2)	04 (7.4)
50-59 (N = 28)	08 (28.6)	18 (64.3)	02 (7.1)
Figures in parentheses are in per cent			

According to Table 15B, approximately 50 per cent of the respondents across all age groups [expect 50-59 years] were found to be underweight when determined with the body mass index (BMI)37. But 59 per cent of respondents under the age of 30 had a BMI less than 20.7. It is encouraging to observe that only 9.5 per cent of the surveyed population had BMIs more than 26.5, which is considered as overweight. The high prevalence of an underweight population may be due to a lesser calorie intake than the amount required for the kind of rigorous manual work the respondents were performing.

F. Laboratory Findings

All the 200 workers were subjected to blood tests, for routine haemogram. The parameters tested in the complete haemogram includes haemoglobin, red blood cell (RBC) count, packed cell volume (PCV), mean corpuscular volume (MCV),

Table 16A: Haemogram							
Parameters (Normal Range)	Haemoglobin (130-180 g/l)	RBC ($4.5\text{-}6.5\times10^{12}$/l)	PCV (0.4-0.55)	MCV (78-99 fl)	MCH (27-32 pg)	MCHC (300-360)	RDW (11.0-15.0%)
< Normal	37 (18.5)	68 (34.2)	30 (15.1)	18 (9.6)	33 (16.6)	21 (11.2)	0 (0.0)
Normal	160 (80.0)	129 (64.8)	167 (83.9)	131 (70.1)	121 (60.8)	164 (87.7)	100 (50.3)
> Normal	3 (1.5)	2 (1.0)	2 (1.0)	38 (20.3)	45 (22.6)	2 (1.0)	99 (49.7)
Total	200	199	199	187	199	187	199
Figures in parenthesis are in percent							

mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin

concentration (MCHC), red cell differential width (RDW), white blood cell (WBC) count (also known as total leukocyte count, TLC), differential leukocyte count (DLC), platelet count and erythrocyte sedimentation rate (ESR). The blood samples were collected at the working site in the vaccutainers and sent to the laboratory. The fully automatic cell counter (Coulter make) was used to analyse all the above parameters. The results for all these parameters are computed in the Tables 16A & 16B.

Haemogram

Table 16B: Haemogram

Parameters (Normal Range)	WBC (4.0-11.0 x 109 /l)	Eosinophils (<6 per cent)	Platelets (150-450 x 109 /l)	ESR (<21 mm/Hr)
< Normal	1(0.5)	0(0.0)	43 (26.9)	0 (0.0)
Normal	182 (91.0)	64 (32.7)	116 (72.5)	173 (88.3)
> Normal	17(8.5)	132 (67.3)	1 (0.6)	23(11.7)
Total	200	196	160	196
Figures in parentheses are in per cent				

The hemoglobin concentration is normal in 160 subjects i.e. 80 per cent individuals have normal formation of hemoglobin from the bone marrow. 37 workers have less than normal hemoglobin while 3 of them have higher values than the normal levels. The possible reasons for the lower concentrations may be ascribed to malnutrition, decreased production from the bone marrow, or to increased destruction in the peripheral circulation. To reach a conclusive diagnosis, a battery of other investigations need to be performed and is beyond the scope of this report. The variations in the other parameters in the above table are secondary to the variations in the hemoglobin levels of the individuals.

Haemogram

Table 16 B shows the values of the WBC count for 200 workers. Seventeen persons had more than normal counts, indicating acute or chronic infectious disease states. Abnormally high (67.3 per cent of 196 workers) eosinophil counts indicated allergies, asthma, hay fever, eczema and parasitic infection. The correlation between high eosinophil counts and the workload is done later in the

report. Platelet count was possible only in 160 individuals due to clumping of platelets in the blood samples. High ESR values amongst 11.7% workers indicate some chronic infections, or autoimmune diseases.

[Presence of HBsAg (Australia Antigen) was tested in 50 blood samples by the card method (for qualitative detection of antibodies hepatitis B virus). HBsAg test is two-site immuno-assay for the detection of Hepatitis B surface antigen. None of the tests showed any positive reaction for the infection.]

Kidney Function Test

The biochemical tests for the assessment of the functioning of the kidneys were performed on 50 randomly selected individuals. Of them, 4 persons showed high creatinine values and 3 have high urea. This is indicative of a deterioration of

Table 17: Kidney Function Test

Parameters	Sodium	Potassium	Chloride	Urea	Creatinine
< Normal	1	1	0	0	0
Normal	49	44	50	47	46
> Normal	0	1	0	3	4
Total	50	46	50	50	50

normal kidney function, usually due to the decreased filtering of waste material by the kidneys. Waste material then starts accumulating in the blood of the affected individual.

Urine Routine Examination

Table 18 summarizes the reports of urine, routine and microscopic, examinations. Of 198 samples, 32 (16.2 per cent) have presence of protein and 15 (7.6 per cent) samples showed the presence of blood in their urine. The possible

Table 18: Urine Routine Examination

Parameters	Protein	Blood	Glucose	Leukocytes	Epithelial Cells	Crystals
Normal	166 (83.8)	183 (92.4)	186 (93.9)	183 (92.4)	177 (89.4)	133 (67.2)
Abnormal	32 (16.2)	15 (7.6)	12 (6.1)	15 (7.6)	21 (10.6)	65 (32.8)
Figures in parentheses are in per cent						

reasons for such abnormality include infection of the urinary tract, the presence

of kidney stones and malfunctioning kidneys. Although only 4 workers said they were diabetic but a laboratory examination of urine confirmed high sugar levels in 12 subjects. This reflects an undiagnosed diabetic status prevailing in these workers. The presence of leucocytes in the urine samples of 15 (7.6 per cent) individuals indicates active or recent infection of the urinary tract. The epithelial cells and crystals in urine samples are normal variables of the routine examination of urine and do not signify much of abnormality.

Pulmonary Function Test

Of 53 PFTs performed on sewage workers, 26 results (49.1 per cent) were normal. Sixteen (30.2 per cent) have shown mild restrictive changes in the recorded values for FCV, FEV1. Three workers were reported as having moderate restriction. The rest of the 8 workers equally (that is, 2 each) reported as having mild obstruction, moderate severe restriction, moderate severe obstruction and very severe obstruction.

Table 19: Pulmonary Function Test

PFT	Number	Per cent
Normal	26	49.1
Mild Restriction	16	30.2
Mild Obstruction	2	3.8
Moderate Restriction	3	5.7
Moderate Obstruction	0	0
Moderate Severe Restriction	2	3.8
Moderate Severe Obstruction	2	3.8
Very Severe Obstruction	2	3.8
Total	53	100

Of 35 chest X-rays conducted in randomly selected individuals in the cohort, 3 x-rays showed evidence of lung tuberculosis. Another 3 x-rays revealed old and healed tuberculosis patches. The X-ray examination of one individual indicated the presence of hypertensive heart changes. Five X-rays showed shadows in the lung area, indicative of infective lung diseases. The rest of the 23 X-rays was normal.

G. Statistical Analysis of Exposure-Outcome Assessment

In this study, a software analytical tool, (Epi Info 2000) developed by World Health Organisation (WHO) for epidemiological studies was used to find out statistical correlation between the frequency of hazard exposure and the

symptoms experienced by the exposed respondents of sewage workers. Various observations of the previous data tables are suggestive of adverse exposure-outcome relationship. To establish this relationship scientifically, the software Epi Info 2000 has been used. Chi square values and P-values for each outcome variable of both acute as well as chronic symptoms were calculated in relation to the frequency of exposure to hazardous work. The P-values less than or equal to 0.05 were suggestive of significant exposure-outcome correlation and were taken into consideration.

Acute Symptoms vs Work Load

Table 20: Acute Symptoms vs Work Load

				Frequency of Exposure (Per Month)				
	Symptom	Yes	No	0-2 (n=13) (6.5)	3-10 (n=69) (34.7)	>10 (n=118) (58.8)	Chi Sq	P value
a.	**Eye irritation**	159 (79.5)	41 (20.5)	6 (3.8)	60 (37.7)	93 (58.5)	11.26	0.0035
b.	**Upper respiratory tract irritation**	114 (57.0)	86 (43.0)	2 (1.8)	47 (41.2)	65 (57)	12.84	0.0016
c.	Loss of consciousness	24 (12.0)	176 (88.0)	1 (4.2)	5 (20.8)	18 (75.0)	2.89	0.235
d.	**Syncope**	41 (20.5)	159 (79.5)	0	11 (26.8)	30 (73.2)	5.99	0.0501
e.	Headache	68 (34.0)	132 (66.0)	2 (2.9)	24 (35.3)	42 (61.8)	2.16	0.339
f.	Nausea/Vomiting	70 (35.0)	130 (65.0)	3 (4.3)	29 (41.4)	38 (54.3)	2.72	0.257
g.	Difficulty in breathing	76 (38.0)	124 (62.0)	3 (3.9)	31 (40.8)	42 (55.3)	2.92	0.231
h.	Loss of body balance	16 (8.0)	183 (91.5)	0	3 (18.8)	13 (81.2)	3.84	0.146
i.	Metallic taste in mouth	54 (27.0)	146 (73.0)	1 (1.9)	23 (42.6)	30 (55.6)	4.01	0.134
j.	**Light headedness**	41 (20.5)	159 (79.5)	0	10 (24.4)	31 (75.6)	7.29	0.026
k.	Fatigue	34 (17.0)	166 (83.0)	0	9 (26.5)	25 (73.5)	4.89	0.086
l.	**Skin rash**	121 (60.5)	79 (39.5)	3 (2.5)	46 (38.0)	72 (59.5)	8.73	0.012
m.	**Cut injury**	183 (91.5)	17 (8.5)	7 (3.8)	65 (35.5)	111 (60.7)	25.35	0.00000313
n.	Loose motion	9 (4.5)	191 (95.5)	0	1(11.1)	8 (88.9)	3.53	0.17

Figures in parentheses are in per cent

Table 20 indicates some highly significant results. Eye Irritation and Upper Respiratory Tract (URT) Irritation have P-Values 0.0035 and 0.0016, respectively, when compared with frequency of underground sewer work done by the workers. This means that an increase in the number of times a worker enters a sewer manhole, the probability of experiencing eye irritation and URT irritation also increases. The probable reason of this significant correlation can be the exposure to irritant gases inside the sewer line. The tissues in the eyes and URT are sensitive enough to react immediately if exposure to such gases happens. Acute symptoms, such as syncope and light-headedness have shown significant correlation (P-values 0.0501 and 0.026) with the workload of the workers, which can be due to acute exposure to various gases that have the potential to cause adverse effects on nervous system. Heavy manual work in oxygen deficit (hypoxic) environments may also contribute significantly to such symptoms. Most of the manholes are confined spaces with oxygen concentration less than 19.5 percent. A significant correlation is also seen in acute cases of skin rash (P-Value 0.012), which is probably attributed to direct skin contact of the sewage. A very high correlation has been seen with cut/injury in underground sewer work (P-Value 0.00000313) as many sharp objects are encountered commonly inside the sewer line. Working in the underground sewer line with minimum protection is the common among the respondents.

Some other acute symptoms, such as headache, nausea/vomiting, breathing difficulties and metallic taste in the mouth were also experienced by many of the respondents but statistically no significant relationship can be established with the workload. The positive responses are definitely on the higher side but not significantly related to occupational exposures.

Chronic Symptoms vs Work Load

Table 21A : Chronic Symptoms vs Work Load								
				Frequency of Exposure (Per Month)				
	Symptoms	Yes	No	0-2 (n=13) (6.5)	3-10 (n=69) (34.7)	>10 (n=118) (58.8)	Chi Sq	P value
a.	Fatigue	31 (15.5)	169 (84.5)	1 (3.2)	7 (22.6)	23 (74.2)	3.55	0.169
b.	Tiredness	152 (76.0)	48 (24.0)	3 (2.0)	56 (36.8)	93 (61.2)	21.48	0.000021
c.	Body ache	83 (41.5)	117 (58.5)	2 (2.4)	29 (34.9)	52 (62.7)	3.98	0.136
d.	Headache	97 (48.5)	103 (51.5)	4 (4.1)	37(38.1)	56(57.7)	2.41	0.299
e.	Watering of eyes	73 (36.5)	127 (63.5)	0	25 (34.2)	48 (65.8)	8.36	0.015
f.	Burning of eyes	51 (25.5)	149 (74.5)	0	12 (23.5)	39 (76.5)	10.38	0.0055
g.	Nausea/ Vomiting	22 (11.0)	178 (89.0)	0	5 (22.7)	17 (77.3)	4	0.135
h.	Cough	145 (72.5)	55 (27.5)	7 (4.8)	52 (35.9)	86 (59.3)	2.56	0.277
i.	Cough with sputum	61 (30.5)	139 (69.5)	4 (6.6)	22 (36.1 per cent)	35 (57.3)	0.1	0.95
j.	Blood in sputum	2 (1.0)	198 (99.0)	0	0	2 (100)	1.4	0.495
k.	Wheezing	21 (10.5)	179 (89.5)	1 (4.8)	9 (42.8)	11 (52.4)	0.76	0.684
l.	Breathlessness	31 (15.5)	169 (84.5)	0	10 (32.3)	21 (67.7)	2.91	0.233
m.	Irritability	20 (10.0)	180 (90.0)	0	6 (30.0)	14 (70.0)	2.03	0.362
n.	Dizziness	34 (17.0)	166 (83.0)	0	11(32.4)	23 (67.6)	3.24	0.198
o.	Confusion	NA	NA					
p.	Sleep disturbances	17 (8.5)	183 (91.5)	0	5 (29.4)	12 (70.6)	1.77	0.412
q.	Skin irritation	83 (41.5)	117 (58.5)	1 (1.2)	30 (36.1)	52 (62.7)	6.5	0.037
r.	Skin roughness	72 (36.0)	128 (64.0)	0	26 (36.1)	46 (63.9)	7.85	0.019
s.	Skin rash	91 (45.5)	109 (54.5)	2 (2.2)	29 (31.9)	60 (65.9)	6.45	0.039
t.	Skin colour change	15 (7.5)	185 (92.5)	0	4 (26.7)	11 (73.3)	1.91	0.385
u.	Decreased hearing/loss	7 (3.5)	193 (96.5)	0	3 (42.9)	4 (57.1)	0.62	0.732
v.	Diarrhoea	9 (4.5)	191 (95.5)	0	2 (22.2)	7 (77.8)	1.59	0.452
w.	Low backache	54 (27.0)	146 (73.0)	1 (1.9)	20 (37.0)	33 (61.1)	2.65	0.265
Figures in parentheses are in per cent								

Some significant correlations are prominently seen with chronic symptoms of the sewage workers. P-value 0.000021 indicates very high significance of tiredness. But the influence of multiple factors, such as long distance travelling, malnutrition and other psychosocial factors cannot be ruled out. A large number of respondents experienced chronic body ache and headache but these symptoms were not found to be associated with the workload. The probable factors, which may contribute to such an outcome, may be environmental agents along with some personal habits.

The watering and burning of eyes have P-values 0.015 and 0.0055, respectively, which was also highly significant. This observation was consistent with the significant correlation of acute eye irritation calculated in the preceding table. The apparent reason of this significant correlation can be the continuous or repetitive exposure to irritating gases inside the sewer line.

A significant correlation is seen in chronic symptoms of skin irritation, skin roughness and skin rash, having P-values 0.0370, 0.019 and 0.039, respectively. This also supports the finding of the previous table of acute symptoms where a significant correlation of skin rashes with the workload has been established. The possible reason of such significant correlations with chronic skin ailments can be due to the continuous or repetitive exposure to the chemical and biological contaminants in the sewage.

A little less than three-quarters of the respondents had chronic cough and almost 30 per cent of the respondents had cough with sputum. However, these symptoms were not correlated with the frequency of underground work by the sewage workers.

Various other chronic symptoms were investigated but none signified any correlation with occupational exposure. A positive response for both acute and chronic diarrhoea is considerably low among the respondents. A significant numbers of respondents (27 per cent) reported persistent low backache but this is also statistically not significant with workload.

Chronic Symptoms vs Smoking

Table 21B : Chronic Symptoms vs Smoking					
Variables	Smoking			Chi square	p- value
	Current	Former	Never		
Eye Irritation (n = 159)	110	4	45	1.46	0.481
Upper Respiratory tract Irritation (n = 114)	79	4	31	1.73	0.629
Syncope (n = 41)	30	2	9	3.3	0.192
Lightheadedness (n = 41)	29	2	10	2.63	0.268
Tiredness (n = 152)	106	3	43	0.46	0.795
Watering of Eyes (n = 73)	49	3	21	2.61	0.271
Burning of Eyes (n = 51)	40	2	9	5.51	0.06
Cough (n = 145)	104	3	38	2.75	0.252
PFT (n = 27)	21	1	5	2.65	0.265
Chemosis (n = 70)	62	1	7	20.39	0.00003
Orodental Hygiene (n = 107)	85	2	20	6.68	0.035
Pyorrhoea (n = 66)	57	1	8	14.79	0.00061

As all these symptoms could well fit into an arguable cascade of causative agents, ranging from the environmental pollutants to the personal habits of the exposed workers, verification within the scope of study was imperative. The role of environmental pollutants (for example, suspended particulate matter, diesel exhaust, vehicular pollution, and volatile organic compounds), other than those in occupational exposure, cannot be accounted for here. However smoking could have many of the significant symptoms attributed to its armoury of pollutants. P-values were calculated for these symptoms with the smoking habits the workers.

The symptoms showing high statistical correlation with the frequency of underground work were also subject to statistical calculation with the smoking habit. Table 21B conclusively indicates that none of the symptoms (eye irritation, upper respiratory irritation, syncope, light-headedness, tiredness, watering of eyes,

burning of eyes etc. which have high statistical correlation with the frequency of underground work) correlates to smoking statistically. Interestingly the signs of chemosis, poor orodental hygiene as well as inflamed gums (pyorrhoea) can significantly be attributed to smoking. However, neither smoking nor the workload had any statistical confirmation to poor performance in the pulmonary function test.

Correlation with Eosinophils

Table 22 A : Correlation with Eosinophils

Variables		Eosinophils		Chi square	p- value
		Normal	> Normal		
Work Load (Frequency of going underground/ month)	**0-2**	**9**	**4**	**15.09**	**0.00052**
	3-10	**28**	**39**		
	>10	**27**	**89**		
Workplace	Residential	20	34	1.73	0.629
	Industrial	20	51		
	Commercial	15	25		
	Mixed	9	22		
Smoking	Current	44	89	0.03	0.853
	Former	2	2		
	Never	18	41		
Alcohol	Current	44	84	0.85	0.652
	Former	6	11		
	Never	14	37		
Chemosis	Present	24	45	0.095	0.757
	Not seen	40	87		
Orodental Hygiene	Poor	39	66	1.65	0.198
	Normal	25	66		

As is evident from the above table, an attempt was made to correlate the prevalence of a high eosinophil count with various confounding factors acting as the causative agent in sewage workers. Two categories of eosinophil count were made. The count 0-6 was considered as normal while the count above 6 was taken

as above normal, or high count. The relevant factors as per acquired data through the structured questionnaire from the sewage workers could be attributed to the distribution of workplace, their smoking habit, alcohol intake, orodental hygiene, chronic conjunctivitis (chemosis) and on the workload (that is, the frequency of going inside the sewer line/month). Chi square and p-value was calculated for each confounding variable to show the statistical significance. It is very clear from the table that the frequency of entering sewer lines had a grave impact on the prevalence of a high eosinophil count in the selected individuals. The p-value of 0.00052 indicates a high statistical significance — as the frequency of underground work increases, the eosinophil count increases. This is in spite of the fact that the total white cell counts were not affected by the sewer work (p- value 0.419). It is seen that only 17 workers (n = 200) have higher total white cell count than normal while 132 workers (n = 196) have high eosinophil count. The known causes of eosinophilia include asthma, hay fever, allergies, eczema and parasitic infections. Although the present study does not pin point specific causes of eosinophilia but high prevalence of eosinophilia is suggestive of allergic origin.

The mean eosinophil counts were also worked out with the frequency of underground work. It is seen that there is a linear increase in the eosinophil count with the frequency of underground work. The workers who entered the sewer line 3-10 times per month revealed an interesting phenomenon. Of the 67 workers in this group, 39 showed a maximum count of 12 eosinophils. However, the mean eosinophil in this group is 10.68. This indicates a highly skewed normal distribution curve to the right.

Distribution of Eosinophils

Table 22B : Distribution of Eosinophils

Work Load (Frequency of going underground/ month)	Mean Eosinophil count	Standard Deviation	Minimum Count	Maximum Count
0-2	5.6	8.35	1	35
3-10	10.68	3.54	2	12
>10	12.22	8.03	2	40

Note: The mean eosinophil in the normal group (that is, 0-6 eosinophil) is 4.046 (Std. deviation 1.577), in the eosinophilic group (7 or more than 7 eosinophil) is 14.75 (Std. deviation 7.624). The mean eosinophil for the total surveyed group (n = 196) stands at 11.26 with a Std. deviation of 8.075.

CHAPTER 7

Follow-up Survey

To take a fair estimate of the contemporary happenings at the surveyed stores, a revisit was done on these selected stores. The salient findings of the revisit are as follows:

- Three respondents of the studied population died in the course of one year.

Mangal Das, who was working with Karampura store, died in service at the age of 59. The person died because of a severe respiratory illness. The Pulmonary Function Test (PFT) conducted as part of the medical investigation of this study, found severe restriction and very severe obstruction. The PFT test was conducted on Mangal Das on April 01, 2004. The ESRwas reported to be 48 mm/hour where the normal range is less than 21mm/hour. Traces of protein were also reported in the urine sample. Both the tests were conducted on March 10, 2004.

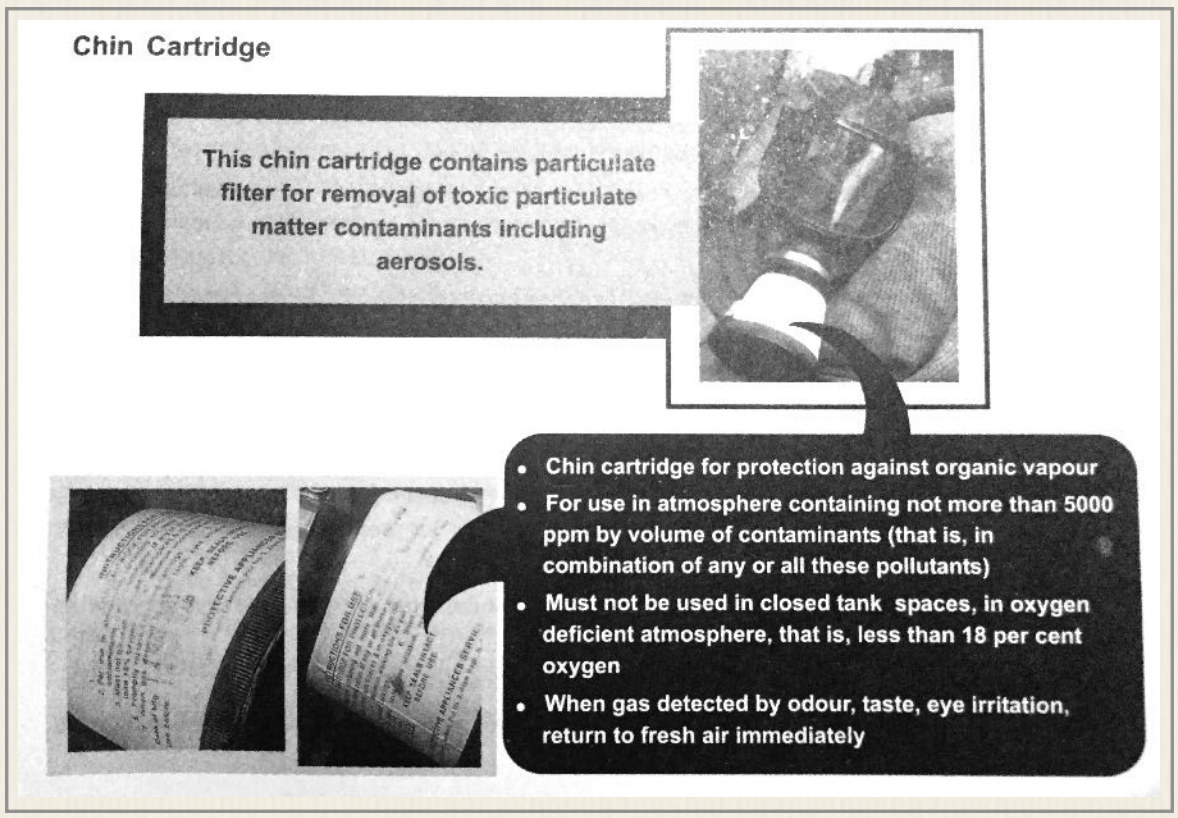
Nanak of DDA flats, Kalkaji store, expired at the age of 56, before retirement. According to his colleagues, he was intermittently absent from duty due to illness and died after a few months. According to the medical report conducted during the course of study, he was found to be hypertensive (high blood pressure 170/120). He was not aware of the high blood pressure and was not taking any medication. He was also found to have bilateral hand tremors. His haemoglobin level was also higher than the normal limit and traces of protein were found in urine sample. Both the tests were conducted on March 19, 2004.

Hari Krishan, a beldar with Kalkaji G block, died in an accident while cleaning a sewer line at Giri Nagar. According to his colleagues, he went down the drain without a safety belt and succumbed to the gases inside the manhole. The Junior Engineer entered the manhole to rescue him but he too died in the process. The survey questionnaire of 29-year-old Hari Krishan revealed that he used to go inside the manhole more than 10 times a month. He complained of many and frequent ailments — upper respiratory irritation, breathlessness, irritation, watering and burning of the eyes and rash, irritation and roughness of the skin. All the parameters of his haemogram report were excessively above the normal limits. His haemoglobin was 5.3 gm per cent (N=13.0-18.0), with a high eosinophilia of 21 per cent (N = <6 per cent). It could be because of such a low haemoglobin level that he succumbed to the asphyxiating gases present in the sewer. He left behind his wife and two children with no source of income for survival.

- Status of regularisation: Only 4-5 daily wagers were made permanent during this one year.
- According to the re-surveyed workers, none has been diagnosed for any serious or chronic disease other than common cold and gastro-intestinal diseases during the last 12 months. None was hospitalised during this period.
- The incidence of cuts and injuries was found to remain very high among the workers. Many of them had to take long-term medication and apply local dressings for the wounds to heal. The causes of such injuries were found to be the sharp broken objects present in the sewer line (similar to the study finding). A few injuries were also the result of the different equipment, such as water jet machine and khapchi, used in work. One worker's right leg was injured because a manhole cover fell on his leg. The authorities do not take any measures to prevent cuts and injuries. The protective foot-wear provided by the department does not prevent such injuries.
- Disproportionate distribution of equipment: The quantity of safety equipment at stores is all whimsical and are not supplied in adequate number

to meet the need of the workers. A store with 8-10 workers had a first aid box but one with 50-60 workers had none. Similarly, there may be 4 belts with 8 workers and 5 belts for 50 workers. And all the equipment is under the lock and key of the supervisor of the store. In his absence and in emergency situations these are not available for use. There is no protocol for the procurement of safety equipment from the main stores, the replacement of damaged equipment and the periodicity of availability of new equipment.

- DJB had provided new safety belts with double ropes for lifting and with the provision of thigh belts around 4 months back (Jan–Feb 2005). Ironically, none of the interviewed workers knew how to use them.
- The available safety and protective equipment is not appropriate to the type of exposure in the sewage work. The gloves are too heavy and hard, making it difficult to remove silt from the blocked line. Also these gloves do not provide any protection against injuries from sharp or broken objects. Gumboots are provided in lurk of safety footwear, but these gumboots don't provide protection against sharps and broken objects. Many a times, these gumboots hamper work as they get filled with sewage water. A few stores provide helmets with headlights. These battery-operated headlights do not work in the gaseous conditions of the sewer lines. An exceptional blunder on the part of DJB is the distribution of a cartridge-type breathing and face mask for underground work. The following specifications were found on the operating label on the cartridge.



CHAPTER 8

Recommendations

Long-term recommendations

A. Policy Level Interventions

1. Detailed and comprehensive guidelines on occupational safety and health as a policy document.
2. Induction programme for the new employees at the time of recruitment as well as at the time of intra-store transfers.
3. Formulation of job entry procedure and work permit (operational control procedure, OCP) for every job pertaining to sewer maintenance.
4. Pre-employment, periodic and specific medical surveillance programmes for all the workers.
5. Safety and health audits as well as accident investigation procedure.
6. Workplace exposure assessment programmes for toxic/harmful contaminants and documentation.
7. Back-tracking of problems, origin/source identification of blockades and appropriate technology to counter it.
8. Establishment of emergency preparedness and response team.
9. Departmental policy for inventory management, that is, regular procurement and dissemination of (safety and personal protective equipments, decontamination and washing facilities for employees at workplace, etc.)

10. Government policies to modify the current employment characteristics, regularise daily wagers, insurance facilities, better housing facilities for workers, free education to the children of sewer workers.
11. Allocation of resources in the form of finances and expertise for carrying out all the above steps.

B. Technology Interventions

1. Use of preventive and proactive maintenance of sewer lines with the use of advanced technology.
2. Use of chemical detectors with easy applicability for workplace assessment before entering confined space.
3. Use of mechanical screeners in sewer lines to prevent the entry of solid non-degradable materials.
4. Use of proper lighting systems for underground work.
5. Use of mechanical supports to replace bamboo khapchi, or mechanical means to prepare the khapchi.

C. Training and Education Programmes

1. Training, education and awareness about the identification of hazard, safety, health, emergency and first aid.
2. Provisions for refresher training modules at specific intervals according to the scheduled training calendar for the year.
3. Public awareness drives to reduce the blockage problem.
4. Proactive baseline data collection and availability of data for management decisions.

D. Welfare Programmes:

1. Availability of drinking, bathing and washing facility at the stores.
2. Availability of soap, oil, barrier creams, first-aid boxes at the stores.

E. Safety Provisions:

1. Supply of adequate and appropriate protective gear.
2. Supply of air respirators for deep sewer line work.
3. Arrangement for mobile decontamination facility for workers with proper washing and bathing facilities with soap.
4. Adoption of injury act prevention programme.

F. Health Interventions

1. Employees should be encouraged to go for treatment of unattended symptoms/illnesses to recognized medical centres.
2. Employees should be given the basic hands-on training in first aid and cardio-pulmonary resuscitation procedures. This should be made mandatory before new recruitments and inbuilt in the induction program.
3. Employees should be provided with first-aid boxes at each store. An inventory should be instituted to replace the contents before expiry date.
4. Employees should be provided accidental/dismemberment/permanent disability or loss insurance coverage and the sum assured must be according to the risk.
5. Medical benefits should be extended to the dependents of the workers.
6. Employees should be immunized against tetanus, hepatitis (A & B) and typhoid.

Short–term Recommendations

1. Clear-cut enumerated accountability and responsibility for accidents.
2. Effective work permit system/checklist before entering in the manhole.
3. Formation of safety committees with worker representatives and office-in-charge in each store.

References

1. Granick H: *Underneath New York*, New York, 1991, Fordham University Press.
2. Environment and Health, Park's Textbook of Preventive and Social Medicine, 516; 15th edition.
3. Friis, L. 2001. Health of municipal sewage workers. Studies of cancer incidence, biomarkers of carcinogenicity and genotoxicity, and self reported symptoms. Acta Universitatis Upsaliensis. *Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine* 1015. 67pp. Uppsala. ISBN 91-554-4980-8.
4. Jeffrey R: Brubacher, Sewer and Sanitation Personnel, Occupational, Industrial, and Environmental Toxicology, Mosby, 265
5. Mary O. Brophy, Hazards in sewage (waste) treatment plants, Vol. 3 - Pages 101.1-101.26 (Printed Version), Encyclopedia of Occupational Health.
6. OSHA: *Sewer system entry*, Publication No 1910.146 App E, Washington. DC, 1994, US Government Printing Office.
7. Guidotti TL: Occupational exposure to hydrogen sulfide in the sour gas industry: some unresolved issues, *Int Arch Occup Environ Health* 66:153, 1994.
8. Tvedt B et aI: Brain damage caused by hydrogen sulfide: a followup study of six patients, *Am J Ind Med* 20:91, 1991.
9. Glass DC: An assessment of the exposure of water reclamation workers to hydrogen sulfide, *Ann Occup Hyg* 34:509, 1990.

10. Zuskin E, Mustajbegovic J, Schachter EN: Respiratory function in sewage workers, *Am J Ind Med* 23:751, 1993.

11. Kraut A et aI: Neurotoxic effects of solvent exposure on sewage workers, *Arch Environ Health* 43:263, 1988.

12. Sewer collapse and toxic illness in sewer repairmen-Ohio, *MMWR Morb Mortal Wkly* Rep 30:89, 1981.

13. Lundholm M, Rylander R: Work related symptoms among sewage workers, *Br J Ind Med* 40:325, 1983. .

14. Laitinen S et al: Worker's exposure to airborne bacteria and endotoxins at industrial wastewater treatment plants, *Am Ind Hyg Assoc J* 55:1055, 1994.

15. Palchack RB et al: Airborne endotoxin associated with industrial scale production of protein products in gram negative bacteria, *Am Ind Hyg Assoc J* 49:420, 1988.

16. Castellan RM et al: Inhaled endotoxin and decreased spirometric values, *N Engl J Med* 317:605, 1987.

17. Morse DL et al: Occupational exposure to hexachlorocyclopentadiene. How safe is sewage? *JAMA* 241:2177, 1979.

18. Srikanth R, Khanam A, Rao V: Cadmium levels in the urine of male sewage sludge farmers of Hyberabad, India, *J Tox Environ Health* 43: I, 1994.

19. Friis L, Edling C, Hagnar L: Mortality and incidence of cancer among sewage workers: a retrospective study, *Br J Ind Med* 50:653, 1993.

20. Lafleur J, Vena JE: Retrospective cohort mortality study of cancer among sewage plant workers, *Am J Ind Med* 19:75, 1991.

21. Scarlett-Kranz JM et aI: Urinary mutagens in municipal sewage workers and water treatment workers, *Am J EpidemioI1*24:884, 1986.

22. Morgan RW et al: Fetal loss and work in a waste water treatment plant, *Am J Public Health* 74:499, 1984.

23. Rylander R et aI; Sewage worker's syndrome, *Lancet* 478, 1976.

24. Mattsby I, Rylander R: Clinical and immunological findings in workers exposed to sewage dust, *J Occup Med* 20:690, 1978.

25. Melbostatd E, Eduard W, Skogstad A: Exposure to bacterial aerosols and work related symptoms in sewage workers, *Am J lnd Med* 25:59, 1994.

26. Rylander R et at: Studies on humans exposed to airborne sewage sludge, *Schweiz Med Wochenschr* 107:182, 1977.

27. Clark CS et al: Sewage worker's syndrome, *Lancet* 1009, 1977.

28. Scarlett-Krantz JM et aI: Health among municipal sewage and water treatment workers, *Toxicol Ind Health* 3:311, 19…

29. Nethercott JR, Holnes DL: Health status of a group of sewage treatment workers in Toronto, Canada, *Am Ind Hyg Assoc J* 49:346, 1988.

30. Gad ER, Kay AB: Widespread immunoglobulin E-mediated hypersensitivity in the Sudan to the "green nimitti" midge, Cladotanytarsus lewisi (Diptera: Chironomidae), *J Allergy Clin Immunol* 66:190, 1980.

31. Reiffenstein RJ et aI: Toxicology of hydrogen sulfide, *Annu Rev Pharmacol Toxicol* 32:109, 1992.

32. Beauchamp RO et al: A critical review of the literature on hydrogen sulfide toxicity, *Crit Rev Toxicol* 13:25, 1984.

33. Arnold IM et al: Health implication of occupational exposures to hydrogen sulfide, *J Occup Med* 27:373, 1985.

34. McCunney RJ: Health effects of work at wastewater treatment plants: a review of the literature with guidelines for medical surveillance, *Am J Ind Med* 9:271, 1986.

35. Poole CJM, Shakespeare AT: Should sewage workers and carers for people with learning disabilities be vaccinated for hepatitis A? *BMJ* 306:1102, 1993.

36. Nethercott JR: Airborne irritant contact dermatitis due to sewage sludge, *J Occup Med* 23:771, 1981.

37. NHANES II Survey (USA 1976-1980)