STUDY, AWARENESS, AND POLICY ADVOCACY FOR THE PREVENTION OF OCCUPATIONAL EXPOSURE TO WELDING FUMES AMONG METAL FABRICATORS IN NEPAL

2022

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This research has been completed by Center for Public Health and Environmental Development (CEPHED) in collaboration with the Ministry of Labour, Employment and Social Security, Occupational Safety and Health Center (GoN, MoLESS, OSHC), Federation of Grill and Steel Fabricators, Nepal (FGSFN), and SMS Environment & Engineering Pvt. Ltd.

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MESSAGE

It is a matter of pleasure for me to write this message for the Center for Public Health and Environmental Development (CEPHED) which is publishing the research report entitled" **Study, Awareness and Policy Advocacy for the Prevention of Occupational Exposure to Welding Fumes Among Metal Fabricators in Nepal"** output of a collaborative project of CEPHED with the Occupational Safety and Health Center (OSHC), Government of Nepal, Federation of Grill and Steel Fabricators, Nepal (FGSFN), and SMS Environment & Engineering (SMSEE), Pvt. Ltd. The study covers the background, welding context of Nepal, welding fumes, types of welding, health of welding fumes exposure, risk factors of welding workers, and rationale of problems in the context of Nepal. The further report contains details of objectives, methodology, results and discussions, conclusions, recommendations, and expected impacts of the research study on society.

Realizing the extreme hazards of one of the 3D (Dirty, Dangerous, and Demanding) jobs associated with metal fabrications through ongoing welding in Nepal, the finding of this study of welding fumes exposure level, metal characteristics of captured welding fumes, and pulmonary function test (PFT) of the welding workers will be indeed very crucial and serve as the basis of formulating welding rod/electrodes quality standards as well as fixing the exposure limit of the welding fumes for Nepal. However, the report only contains data of Kathmandu Valley, for the clear picture of National scenario the extended study is must necessary to prepare National guidelines and norms in future.

In this regard, the Occupational Safety and Health Center (OSHC), Department of Labour and Occupational Safety (DOLS), Ministry of Labour, Employment and Social Security (MOLESS) will definitely take appropriate initiatives toward the adoption of welding fume exposure limits and enact quality standards of the welding rods/electrodes. Generating new data and evidence through this collaborative research study on the welding fumes, their metal characteristics, and associated health implications among the welders will be of great importance to the government of Nepal and the Occupational Safety and Health (OSH) sector as a whole.

OSH Center under the DOLOS, MOLESS has been actively working towards effective implementation of the Labour Act and Labour Regulations including all the provisions related to OSH for reducing occupational exposures including welding fumes.

Successful completion of this research and publications is evidence of the best examples of collaboration between NGO like CEPHED with our OSHC, SMS Environmental Engineering Pvt. Ltd., and FGFSN will fulfill the information gap related to welding fumes and associated workers' exposure and health implications. The welding workers' level of exposure has been known through this research which helps to envision adopting the regulatory and technical measures required to solve the problem to prevent the ongoing exposure to the welding fumes of the metal fabricators.

Finally, I would like to congratulate OSHC, CEPHED, SMSEE, and FGSFN, all the research team members, and entire teams involved in the completion of this research and preparation of this commendable research report which can be an important reference for those who are working in the field of Occupational Safety and Health and environment.

Er. Umesh Yadav
Center Chief

Developing World Outreach Initiative

American Industrial Hygiene Association, Northern California Section

San Francisco, California, USA

July 2022

Dear Colleagues: The Developing World Outreach Initiative sends its congratulations to the Center for Public Health and Environmental Development on the publication of its important report on the hazards of occupational exposure to welding fumes among metal fabricators in Nepal.

This research and resulting policy proposals are critical for protecting the vulnerable workforce of metal fabricators in Nepal by documenting the workplace exposure levels, adverse health effects to workers, and the preventative measures needed to maintain the workers' health.

CEPHED, and its study collaborators, are to be congratulated as well for undertaking this study in a scientific manner, yielding critical results for the protection of these workers – not only in Nepal but everywhere metal fabricators are exposed to welding fumes.

DWOI is pleased to have contributed to this worthy effort, and we wish the findings and recommendations receive the widest possible dissemination in Nepal and globally.

Best regards for your continued success!

Garrett D. Brown

Secretary-Treasurer, DWOI

California, USA.

ACKNOWLEDGEMENT

First of all, sincere thanks go to **The Takagi Fund for Citizen Science, Japan, and Developing World Outreach Initiative (DWOI), the USA** for providing financial and technical support for this study. We highly acknowledge the support, collaboration, cooperation, and coordination from the Occupational Safety and Health Center (OSHC), Department of Labour and Occupational Safey (DoLOS), Ministry of Labour, Employment and Social Security (MoLESS), Federation of Grill and Steel Fabricators Nepal (FGSFN), and its members and SMS Environment & Engineering Pvt. Ltd. as well as Asia Monitor Resource Center (AMRC).

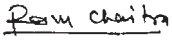
CEPHED highly acknowledges the regular support and cooperation from all welding workshops, engineering enterprises, Patan Industrial Area, Balaju Industrial Area, Bhaktpur Industrial Area, National Engineering, Structo Nepal, Everest Engineering Workshop, Sindhu Metal Workshop, Balaju Yantrasala, JP Steel and Engineering Pvt. Ltd., Valley Metal Engineering, Shree Krishna Metal Pvt. Ltd., Nepal Transformer and S & S Metal Workshops, their senior officials, managers as well as all the welding workers for providing their time, making information available, and most importantly providing an opportunity to visit their industries guided by technical personnel's and participating in the personal samplers of welding fumes and pulmonary function test (PFT), etc.

We express our gratitude to Mr. Umesh Yadav, Chief, OSHC; Mr. Dinesh Prasad Sah, MD, SMS Environment & Engineering Pvt. Ltd.; Mr. Mohan Katuwal, President, FGSFN; Mr. Satish Kumar Upadhyaya, Mr. Yaman Singh Rana, Mr. Ajay Kumar Gupta of OSHC, Mr. Bhola Shresha, Mr. Sunil Babu Khatri, Ms. Alisha Niroula, Ms. Archana Sah and Mr. Ujwal Sah, Mr. Bhanubhakata Lamichhane, Mr. Raju Rai, Mr. Suhash Thapa, Mr. Narayan Shrestha, Mr. Raju Lal Shrestha, Mr. Shiv Sunar, Mr. Sali Ram Subedi, Mr. Sudan Bista, etc in coordinating, supporting though making available equipment, laboratory and fieldwork efforts while collecting the welding fumes samples, PFT and questionnaire survey, data analysis ,report preparation and making this research study success.

Last but the least, CEPHED is grateful for the excellent cooperation, support, and supervision provided by the Kathmandu Metropolitan City, Social Development Department, and Social Welfare Council (SWC) for approving this important project to be carried out towards the protection of metal fabricators, welders, public health and preservation of the environmental pollution.

This document provides the latest information on welding fumes, their characteristics, and associated health and environmental implications among the welders and other who works at welding workshops and lives in the surrounding area from welding fumes. This also provides the sets of recommendations to address the related issues thus meeting the spirit of the government's positive and progressive promotion of Occupations Safety and Health related decisions, Labour Acts, Labour regulations, and other related policies toward the protection of public health, workers health, and environment.

It provides details information for government agencies, trade unions, and OSH Experts to envision required control measures as well as also serves as the basis of a larger study, adoption of a standard of welding rods/electrodes as well as fixing the welding fumes exposure limit to the Government of Nepal, Ministry of Labour, Employment and Social Security (MoLESS), Department of Labour and Occupational Safety (DOLOS) and Occupational Safety and Health Center (OSHC), etc.



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CONTENTS

1. BACKGROUND

The Federal Democratic Republic of Nepal is a landlocked sovereign state located in Asia. Nepal with an area of 147,181.48 km^2, lies within the latitude 26° 22'N to 30° 27' N and longitude 80° 04'E to 88° 12'E in south Asia. The Himalayan country borders China in the north and India in the south, east, and west. The average east to west length of the country is 885km and the north to south width is 193km. The altitude ranges from 60m in the south to 8848m, with the summit of Mount Everest, in the north within a short distance of only 160 km. The nearest point in Nepal from the sea is about 960 Km away. Nepal is among the least developed countries and 47 landlocked countries in the world. Nepal's population as of 1st July 2022 is 30,225,582 with a net increase of one person every minute[1].

With the increase in population, the demand for houses and other wood-based products has gone very high and become increasingly scarce commodities in the case of Nepal. Thus, people are forced to move the alternative fabricated products like metal fabrication. Additionally, the metal fabrication work has increasingly become diverse applications in many areas right from houses, and engineering to industry applications, etc. Thus providing a lot of employment opportunities to nonskilled,semi-skilled, and skilled manpower in this metal fabrication industries and workshops. **Metal fabrication work has been also known as a 3D (Dirty, Dangerous, and demanding) job and had been associated with different health and environmental risks.**

Welding and cutting processes pose several potential health hazards. Welding hazards pose an unusual combination of safety and health risks. By its nature, welding produces fumes and noise, gives off radiation, involves electricity or gases, and has the potential for burns, shock, fire, and explosions. The most common hazards involve exposure to radiation, heat, noise, fumes, gases, and ergonomics in metal fabrication work.

1.1 Welding Context of Nepal

As there are numerous health implications from the welding fumes that have been documented elsewhere (e.g.OSHA fact sheets), welders are unknowingly exposed to several toxic welding fumes in Nepal in absence of required awareness and regulatory frameworks (exposure limits and welding rod/ electrode quality standard). There were hardly any local data available in the public domain to assess the level of exposure and health damages from exposure to these welding fumes. Thus, this project supported by **Takagi Fund for Citizen Science, Japan, and Developing World Outreach Initiatives (DWOI), USA** is aimed at generating health and environment-based data that will be widely used for awareness-raising as well as policy advocacy for the required regulatory framework.

A mix of technical studies of personal exposure level and lung function tests of the workers coupled with the questionnaire survey related to socio-economic aspects within the Kathmandu Valley to know the welder`s perceptions about their health implications as well as environmental pollution were carried out.

Center for Public Health and Environmental Development (CEPHED) completed this research work in close coordination with the Occupational Safety and Health Center (OSHC), Department of Labour and Occupational Safety (DOLES), Ministry of Labour, Employment and Social Security (MoLESS), Federation of Grill and Steel Fabricators Nepal (FGSFN), and its members and SMS Environment & Engineering Pvt. Ltd.

Currently, about 11000 Metal Grill Fabricating industries and workshops from small to larger scale are registered and in operation throughout the country of Nepal, employing about 1,60,000 semi-skilled and skilled manpower and benefitting directly 15,00,000 depending family members (Mr. Mohan Katuwal, President, FGSFN 2022).

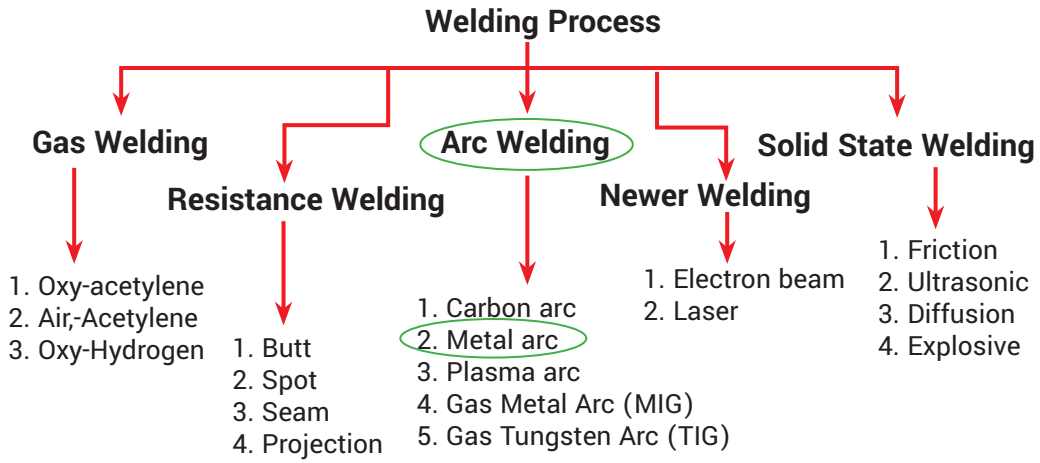
During our engagement with metal fabricators and welders on Polychlorinated Biphynile (PCB) issues, the toxic welding fumes (fumes that are generated by the manual metal arc or oxy-acetylene welding of iron, mild steel, or aluminum) coming from the welding rod/electrodes they used were other major health concerns among the workers. It does not only impact the workers' health but resulting great environmental pollution load to the surrounding area and causes damage to the community health too. Eye, Nose, and Throat (ENT) irritation and respiratory tract infection are the major health implications, and surrounding environmental pollution, etc. are the major problems. Prolonged exposure to welding fume may cause lung damage and various types of cancer, including lung, larynx, and urinary tract. Health effects from certain fumes may include metal fume fever, stomach ulcers, kidney damage, and nervous system damage. Prolonged exposure to manganese fume can cause Parkinson–like symptoms. Gases such as helium, argon, and carbon dioxide displace oxygen in the air and can lead to suffocation, particularly when welding in confined or enclosed spaces. Carbon monoxide gas can form, posing a serious asphyxiation hazard are the direct observable implications of using different kinds of welding rods[2].

These workers need to be protected from their ongoing occupational exposure to toxic fumes coming from welding rods. There is neither any safe exposure limit being adopted by the Government of Nepal nor any standards specification of the welding rod has been enacted. This research-based project aimed at generating new data on the personal exposure of the workers by measuring the toxic fumes by personal samplers as well as testing their respiratory vitality through the use of a Pulmonary Function Test (PFT) with the help of medical teams coupled with some health-related questionnaire survey with the metal workers to know their perception about the health and environmental impact of welding fumes. This gives a clear indication of the level of health damage, required to raise awareness among all metal welders/fabricators and do the policy advocacy for the improvement of their health through having exposure limits and standards of welding rods

The finding of the research work was first shared among all concerned stakeholders through organizing a workshop and then used for the policy advocacy for sector improvements to improve the health and wellbeing of the vulnerable welders in Nepal by adopting quality standards for welding rod/electrodes exposure limits of welding fumes.

1.2 Welding, Welding fumes, and types of welding

The chemicals in the fumes depend on the type of welding, the material being welded, the welding gas used, and the electrode or welding rod. The likely exposure of the welder to the various constituents of the welding fume depends on all of the above in addition to their location, other welding activities, ventilation, and the work practices of the welder. Other activities such as grinding and polishing, surface coatings, contaminants, and degreasing agents, can further complicate exposures.



Welding is a fabrication process whereby two or more parts are fused through heat, pressure, or both forming a join as the parts cool. Welding is usually used on metal and thermoplastics but can also be used on wood. The completed welded joint may be referred to as a weldment. Welding fumes contain a variety of metals, including aluminum, arsenic, beryllium, lead, and manganese. Argon, nitrogen, carbon dioxide, carbon monoxide, and hydrogen fluoride gases often are produced during welding. Welding fumes can cause serious health problems for workers if inhaled. Welding fumes are produced when metal is heated above its melting point, vaporizes, and condenses into fumes. Exposure to various gases can also occur during welding which may include various gases. The different types of welding used in metal fabrications:

Shielded Metal Arc Welding (SMAW)

Shielded Metal Arc Welding (also known as SMAW or stick welding) involves using a stick with an electric current to form an electric arc that joins the metals together. Shielded Metal Arc Welding is commonly used in industrial and steel fabrication.

Gas Tungsten Arc Welding (GTAW/TIG)

Gas Tungsten Arc Welding (GTAW) uses a tungsten electrode to complete the weld. This type of welding is used for complex projects like welding thick sections of stainless steel.

Gas Metal Arc Welding (GMAW/MIG)

Gas Metal Arc Welding is sometimes referred to as Metal Inert Gas (MIG). With this type of welding, a shielding gas along a wire electrode heats up and joins the two metals. GMAW is perhaps the most commonplace welding process for industrial projects.

Flux-cored Arc Welding (FCAW)

Flux core arc welding is an alternative to shield welding that offers greater speed and probability. Flux core arc welding is a semi-automatic or automatic arc welding process. FCAW requires a continuously-fed consumable tubular electrode containing a flux and a constant-voltage or, less commonly, a constant-current welding power supply[3].

Among these different types of welding fabrications, we have mainly focused on mild iron arc welding.

Arc Welding (Fusion Welding) is mainly adopted in Nepal:

As this study has been mostly focused on Arc Welding, the most prevalent welding type adopted in Nepal. In this type of welding process, welded metal is melted from the edges to be joined and allowed to solidify from the liquid state and usually below the recrystallization temperature without any applied deformation. Arc welding is the most extensively employed method of joining metal parts by fusion. In this welding, the arc column is generated between an anode, which is the positive pole of the power supply, and the cathode, the negative pole. When these two conductors of an electric circuit are brought together and separated for a small distance such that the current continues to flow through a path of ionized particles called plasma, an electric arc is formed. This ionized gas column acts as a high resistance conductor that enables more ions to flow from the anode to the cathode. Heat is generated as the ions strike the cathode. This heat is used for melting metal to be joined or melting the filler metal which is further used as the joining material of welding metal. The electrode is either consumable or non-consumable as per welding requirements. The temperature at the center of the arc is 6000 ^{0}C to 7000 ^{0}C.

1.3 Rationale of the Study

Previous research studies include a variety of welders, with or without personal protective equipment, in a variety of welding environments. More specifically, welders spending most of their work time welding were evaluated via pulmonary questionnaires and PFT testing. Welding exposure is a significant risk to welders. According to the research studies, welding exposures can be minimized by using respiratory protective equipment and appropriate environmental ventilation, smoking cessation can minimize the effects of welding exposures. Multiple articles highlighted an increase in respiratory symptoms and a reduction in PFT values. Each study found a high prevalence of chronic bronchitis and respiratory with a reduction of the peak expiratory meter (PEF) and significantly lower forced expiratory volume (FEV) and forced vital capacity (FVC). Again these studies support the hypothesis that welding fumes are related to a decline in pulmonary function.

In addition, research was consistent across the studies and validated the research hypothesis that welding fumes exposures are related to pulmonary decline. The majority of the studies were retrospective chart reviews with small to moderate sample sizes. This study is to provide further evidence supporting the hypothesis that welding fumes exposure is related to pulmonary decline and to clarify the risk of exposure to reduce the possible long-term effect of welding fumes. Questionnaire data are used differently in each article and can affect results depending on how the data are used in the study. Smoking complicates the interpretation and comparison of results. Smoking status often changes during workers' lifetimes and can become a compounding factor with exposure.

1.4 Occupational Hazards and their Risk for welders during welding

Welders are exposed to many hazards during their welding process. They are exposed to physical, chemical, ergonomic, and mechanical hazards. Lack of prevention and control measures to reduce the risk of hazards makes worse conditions of work for the welders. Lack of awareness of health hazards of welding hazards and personal protective equipment workers not realized their occupational health status. Welders can tllolerate and adapt to a level of exposure without deterioration of health and it can be said that below the Threshold Limit Value (TLV) is the safer workplace. ACGIH is research and epidemiological organization that published the TLV for the many hazards. Most of the countries directly adopted their TLV in their law but few of the countries

took reference TLV and published as it a Permissible Exposure Limit (PEL). The following hazards and their risk can be illustrated.

Electric shock: The welders face the most frequent serious and immediate risk causes of electric shock. Electric shock can cause serious injury or death. Electric shock occurs when welders accidentally touch open wires or open connections to an object that has a voltage between them. If the workers keep a raw wire in one hand, the electric current flows through the wires and welding machine in another hand it can lead to death and serious problems for welders. Therefore safety precautions should be taken by welders.

Fumes and Gases: It is the most unusual in welding practice that excessive contact with welding gases and gases may present a danger to the safety of welders. Welding fumes contain a seriously damaging large amount of compounds made from metal oxides such as ferrous oxide, manganese oxides, etc., welding materials or welding process, according to the OSHA given guidelines for that keep use sufficient ventilation and emission in the work environment to monitor toxic smoke and gases exposures, it depends on which materials used for the welding process. Welding is required adequate ventilation in the workplace to hold gases and gasses for the respiration cycle and general environment.

Flames and Fires: The welding process produces high temperatures which may be sufficient if proper safety procedures or personal protection devices are not used. While the welding process may lead temperature of 10,000 degrees Fahrenheit, the danger is not the welding process, danger when that contact with the object and spike to the explosion. This can go as far as 300 meters from the weld zone. Install fire alarm for security to prevent this condition and also saves human life.

Risk of Accident: Burns are the most common welding injury. They are caused by a lack of, or improper, personal protective equipment (PPE). Acute exposure to welding fumes can irritate the eyes, nose, and throat, nausea, and dizziness. Prolonged exposure could cause lung damage, kidney damage, stomach ulcers, nervous system damage, and cancers of the larynx, lung, and urinary tract. Electrical shock is one of the most common accidents welders face. It is a severe threat that can lead to serious injury or death. It occurs when a welder is placed into an electrical circuit by touching together two metal objects that have a voltage between them[4].

Ergonimical Hazards: Common ergonomic risk factor that arises during welding activities are awkward postures, forceful exertion, repetitive heavy work, static load, contact stress, and other external factors such as extreme temperature from direct sunlight. Welders have a high prevalence of musculoskeletal complaints, including back injuries, shoulder pain, tendonitis, reduced muscle strength, carpal tunnel syndrome, white finger, and knee joint diseases. Work postures especially welding overhead, vibration, and heavy lifting can all contribute to these disorders. Most of the ergonomic impact is a chronic effect where it only can be detected for a long time of exposure[5].

Radiation (during radiography of welding): Welding arcs give off radiation over a broad range of wavelengths - from200 nm (nanometres) to 1,400 nm (or 0.2 to 1.4 µm, micrometers). This includes ultraviolet (UV) radiation (200 to 400 nm), visible light (400 to 700 nm), and infrared (IR) radiation (700 to 1,400 nm). Certain types of UV radiation can produce an injury to the surface and mucous membrane (conjunctiva) of the eye called "arc eye," "welders' eye" or "arc flash." These names are common names for "conjunctivitis" - an inflammation of the mucous membrane of the front of the eye. The symptoms include:

- pain - ranging from a mild feeling of pressure in the eyes to intense pain in severe instances

- tearing and reddening of the eye and membranes around the eye
- sensation of "sand in the eye" or abnormal sensitivity to light
- inability to look at light sources (photophobia)[6]

Exposure to Radiofrequency radiation for longer durations of time causes the Calcium in the cell membranes to start leaking. This is a common result of EMF radiation in both animal and human bodies. The leakage and the vibrations can cause the cells in their bodies to start functioning abnormally. The results can be in the form of **Cell mutation instead of replication and the cells in the human body may stop functioning at all.** As a result, a variety of problems can be triggered. These include **Radiation sickness, Skin cancer, Brain tumors, and Neurogenerative disease[7].**

Use an EMF Meter to monitor the levels to measure electrical field, magnetic field, and radiofrequency fields), routing the cable and electrodes together or simply securing the cables and electrodes with a tie wrap or tape. The working position of the welders with electrode and cable should be in one side), avoid proximity by maintaining a safe distance, low-level power selection of EMF Blocking Gears like EMF shielding products such as clothings, and caps etc.

PPE: Personal Protective Equipment (PPE) greatly reduces the risk of injury and minimizes the effects of toxins. Personal protective equipment (PPE) is important for welders because there are hazards when welding, cutting, and brazing. These hazards can include exposure to metal fumes and UV radiation, burns, shocks, cuts, and broken toes. A welding helmet is one of the most important pieces of welding safety gear welders use. The most common welding injuries are eye injuries caused by particles, irritation, or UV radiation exposure, and they account for nearly one-quarter of all welding injuries. A welding jacket is standard for any welding safety gear A welder should never work without gloves A good pair of boots or foundry shoes is important for every welder[8].

Injuries and Insufficient practices and PPE: Injuries from welding are common because welding work welders will lead to various situations and physical exertion. In that major role play personal protective equipment (PPE) for welders to keep free from welding hazards. Such as one of the most common burns in welding accidents, the proper use of PPE gives the welders liberty and adequate protection from the welding hazards.

1.5 Health Impact of Welding Fume Exposures

Welding is a common industrial process as two percent of the working population in industrialized countries has been engaged in some sort of welding. Welding is also a hazardous process. Burn to the skin, flash burns to the eyes, and fire are some of the more immediate and acute hazards. Welding fumes result in both acute and more long-term chronic effects. Fumes are solid particle that originates from consumable welding rods, base metals, and any coatings present on the base metal. Despite advances in control technology, welders continue to be exposed to welding fumes and gases. The chemicals contained in these fumes and gases depend on several factors such as types of welding being performed, materials the electrode is made of, types of metal being welded, presence of coatings on the metals, time and duration of the welding works and ventilation status, etc.

According to OSHA, possible elements of welding fumes and related hazards include the following metals Zinc, Cadmium, Beryllium, Iron Oxide, Mercury, Lead, Fluorides, Chlorinated hydrogen solvents,

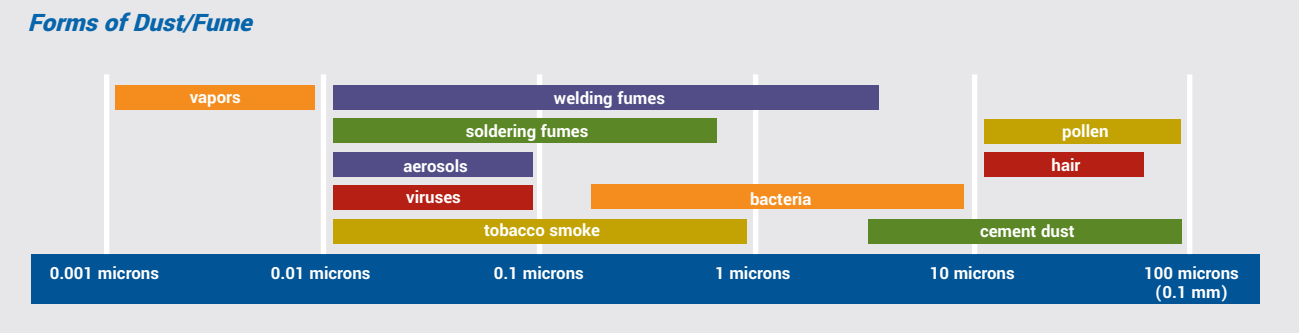
phosgene, Carbon monoxide, Ozone, Nitrogen oxide, etc., with short ENT irritations to long term health effects like cancer and reproductive failure. As a NIOSH literature review on welding and lung cancer revealed, welders have a 40 percent increased risk of developing occupational occupationally induced lung cancer. This fact is compounded by the continued introduction of the new welding process, techniques, and materials. As a result, welding will likely be a high priority for regulators and this or the industry in the coming years[9].

A study carried out on the Chronic effects of welding exposure on pulmonary function tests and respiratory symptoms have revealed that respiratory symptoms and chronic bronchitis were more prevalent in welding (p< o,o5). Welders who were smokers showed a higher frequency of chronic bronchitis than the control who smoked (p< 0,05). The study concludes that welders working in the condition of inadequate ventilation, have an increased risk of chronic bronchitis and impairment of pulmonary function. It seems that strong efforts should ne be made to persuade welders to stop smoking, better ventilation should be attained and welders should wear respiratory protective devices[10].

On welding operation, metals are converted to the molten state, and they evaporated due to the very high temperature, and this produced vapor is called fume. The production of this metal vapor is with oxidation reactions; therefore, metal oxides such as aluminum, chromium, copper, and cadmium are produced according to the metal nature of fumes. Medical investigations proved constituent compounds of fume have negative effects on health. However, the influence of fume on health is dependent upon several factors such as the amount of produced fume, special metal and gas presence near the electrode tip, type of metal in the welding operation, and constituent compounds of the electrode. Each company or factory is managed by different sectors and workers. Workers groups are more vulnerable because they are more evolved with special toxic and hazardous substances; unfortunately, workers don't have appropriate and adequate training to deal with the risks in many countries and developing country, especially in Nepal. As mentioned, fume threatens the health, and their impacts are categorized into short-term and long-term effects. As the name implies, short-term effects appear immediately, a few hours, and days after inhalation; these impacts include problems such as metal fume fever. On the other hand, long-term effects make a problem after several years, and lead to chronic disease, normally. Of course, workers can be safe from short-term effects by attention to the simple and basic rules. While these simple and basic rules don't guarantee the safety of the long-term effects of these toxic fumes and gases.

A fume with a special compound may create irreparable problems with very low concentration; while, another fume may have fewer impacts at high concentration. Therefore, awareness of different compounds is very important. For example, operation threshold and effectiveness of aluminum is 1 milligram per cubic meter in every 8 hours of work, **while this amount is 0.00005 milligram per cubic meter in every 8 hours of work for beryllium compound**.

Therefore, a fume with beryllium compound produces in welding is more dangerous than a fume with aluminum compound. This amount is called the threshold limit value in safety standards. The threshold limit value determines the allowable concentration of a compound for application and inhalation, and it is specified with exact investigations and analysis by experts. Therefore, exceeding this amount is associated with damaging effects. Produced fume in the welding process, composed of fine and respirable particles. These particles' diameter is about 0.2 – 0.3 microns; therefore, they can affect the human respiratory tract easily.



According to the investigations, the effective diameter of fume particles and welding ash is in the range of 0.0005 – 5000 micrometers. Therefore, tiny particles of pollutants increased their destructive power. It is concluded, that pollutant inhalation in welders is 4 times more than in other people according to the analysis and comparison between welders and others. Disadvantages of fine metal particles in fume consideration required different research because this is a very detailed topic. Briefly, some of the disadvantages can be noted; for example, an aluminum compound in fumes leads to respiratory tract irritation, copper compound leads to acute problems such as irritation to the eyes, nose, and throat, nausea and metal fume fever, manganese compound can cause problems such as metal fume fever and chronic problems in the central nervous system and zinc oxides may lead to metal fume fever too. Many other problems can occur due to inhaling these pollutants.

The hazardous substances in welding fumes created during welding are formed from several components: Basic and supplementary materials, inert gases, coating contamination, and ambient air. A pre-requisite for the formation of hazardous substances in certain physical or chemical processes. This includes evaporation, condensation, oxidation, decomposition, pyrolysis, and combustion. The type and quality of the hazardous substances in welding fumes depend on the welding process and the materials used [11].

Welding Fumes, Sources and Their Consequences		
Fume Type	**Source**	**Health Effect**
Aluminum	Aluminum components of some alloys, e.g., copper, zinc, steel, magnesium, brass, and fillers.	Respiratory irritant.
Beryllium	Beryllium is a hardening agent found in copper, magnesium, aluminum alloys, and electrical contacts.	**"Metal Fume Fever.**" A cancer-causing cell. Other long-term effects include damage to the lungs
Cadmium Oxides	Cadmium oxides are stainless steel and zinc alloys that contain cadmium as well as coated materials.	Respiratory irritation, sore throat, dry throat, chest pain, and shortness of breath. Chronic effects include renal failure and emphysema.
Chromium	Chromium is mostly stainless-steel and high-alloy materials, welding rods. Also used as a coating material.	Increased risk of lung cancer. Some individuals may develop skin irritation. Some forms are carcinogens.
Copper	Copper alloys such as Monel, brass, and bronze also include some welding rods.	Severe effects include eyes, nose, and throat irritation, , nausea, and "Metal Fume Fever."
Fluorides	Fluoride is a common electrode coating and flux material for both low- and high-alloy sheets of steel.	The severe effect is irritation of the eyes, nose, and throat. Chronic exposures can lead to bone and joint problems. Chronic effects include fluid retention in the lungs.
Iron Oxides	Iron oxides are major contaminants in all iron or steel welding processes.	**Siderosis** – a bad form of lung disease is caused by carcinogens deposited in the lungs. Severe symptoms include irritation of the nose and lungs. Tends to clear up when exposure stops.

Lead	Solder, brass, and bronze alloys, primer/ coating on steels.	Long-term effects on the nervous system, kidneys, digestive system, and mental capacity. It also causes lead poisoning.
Manganese	Manganese is used in most welding processes, especially high-tensile steels.	**"Metal Fume Fever."** Long-term outcomes may include problems with the central nervous system.
Molybdenum	Steel alloys, iron, stainless steel, nickel alloys.	Severe effects include eye, nose, and throat irritation, and shortness of breath.
Nickel	Stainless steel, Inconel, Monel, Hastelloy, and other high-alloys, welding rods, and coated steel.	The severe effect includes irritation of the eyes, nose, and throat. There is an increased risk of cancer in occupations other than welding. Associated with dermatitis and respiratory problems.
Vanadium	Vanadium is an alloy of some steel, iron, stainless and,nickel.	Irritation of eyes, skin, and respiratory tract. Chronic effects include bronchitis, retinitis, pneumonia, and pneumonia.
Zinc	Galvanized, painted metal.	Metal Fume Fever.
Source: Welding Fume Hazards Dangers, Risks and How to Reduce Them | WIC (weldinginfocenter.com)		

The effects are divided into three categories:

1) Respiratory and lung-damaging substances
2) Toxic (poisonous) hazardous substances
3) Carcinogen (carcinogenic) hazardous substances

1. Hazardous substances in welding fumes damage the lungs and respiratory system

If welders are exposed to a high concentration of these hazardous substances in welding fumes over a longer period, then this may lead to a strain on the respiratory system, specifically the lungs. Respiratory diseases such as bronchitis up to a permanent narrowing of the respiratory system (obstructive bronchitis) are the consequence. Furthermore, dust deposits can settle in the lungs. These may occur in the form of **siderosis (iron overload) when working with iron oxides**. The absorption of high concentrations of hazardous substances in welding fumes also triggers fibrogenic reactions (connective tissue proliferation) in the lungs. Substances affecting the lungs and their effect on the human body are e.g.

Iron oxides: Dust deposits in the lung (welders' lung or lung siderosis) / Siderosis (leads to joint problems, diabetes, congestive heart failure, or impotence)

Aluminum oxide: Aluminizes (aluminum dust lung, causes a change of the functional lung tissue into non-functional tissue)

Magnesium oxide: Fever, sweats, and tickles in the throat / Irritation of the eyes and nasal mucosa / impaired lung function

Titanium dioxide: Dust deposits in the lungs / Damage to liver, spleen, kidneys, heart, and brain / Weakening of the immune system

2. Toxicity of the welding fumes

Toxic substances in welding fumes have a very harmful health effect on the body once a certain concentration is reached. The concentration is decisive with regards to the effect: Whilst slight poisoning may lead to minor health problems, large concentrations of these hazardous substances in welding fumes may cause life-threatening poisoning or at worst be fatal. Depending on hazardous substances, the dangerous dose varies according to the hazardous substances. The toxic hazardous substances in welding fumes include

Manganese oxide: Irritant effect on the respiratory system /Pneumonia / Damages of the nervous system / Parkinson's disease

Zinc oxide: Zinc fever (Nano-particles in the lungs lead to cell necrosis)

Copper oxide: Nausea, diarrhea, pain in the eyes / Metal fume fever (malaise with symptoms similar to having the chills) / Damage to liver and kidneys
Nitrogen oxides: Irritation of the respiratory system and shortness of breath / potentially fatal pulmonary edema (lung dropsy)
Carbon monoxide: Prevents the oxygenation of the blood and thus leads to an undersupply of organs / Dizziness, fatigue, headaches, fainting, pulse and breathing increase in pulse rate and quicker breathing /Unconsciousness, respiratory paralysis, cardiac arrest
Carbon dioxide: Increased respiratory rate and volume / Dizziness, headache, shortness of breath, and unconsciousness.

3. Carcinogenicity of the welding fumes
Carcinogenic substances in welding fumes can cause malignant tumors in the body. Furthermore, these substances also have a toxic effect in many cases. In general, cancer risk depends on several factors such as genetic predisposition or environmental impact. Thus, there are no documented figures on the exact impact of hazardous substances. There is, however, proof that an increased dose of these hazardous substances in welding fumes increases the risk of cancer. **Scientists from the World Health Organization (WHO) have found an increased risk of lung cancer for welders.**

For carcinogenic substances, no threshold value is known below which there is no longer any risk. Thus, there is a need for minimization as per the Hazardous Substances Regulation. Examples of hazardous substances in welding fumes are:
Chrome (VI)-compounds: Irritation and chemical burns to the mucosa
Lead oxide: Nerve and kidney damage / gastrointestinal disorders / Nausea
Nickel oxide: Carcinogen in the respiratory organs [12]

1.6 Occupational Safety and Health Laws Labour Act 2017

Following the different provisions of over 30 Fundamental Rights enshrind into the Constitution of Nepal including that workers and /or labours in the like with the **International Labour Standard** such as the right to freedom (to form union associations), right to equality, rights against exploitations, rights against forced labour, right to employment, rights regarding labour, etc and others and include the compensation provision in case of failure of ensuring these fundamental rights by the perpetrator, an exclusive Labour Act 2017 and Labour Regulation 2019 with several provisions of Occupational Safety and Health (OSH) were enacted.

The Labour Act of Nepal provides directives on the areas of Occupational Safety and Health for the workers in Nepal. The Labour Act section 12 from Section 68 to Section 83 is related to OSH. The Labour Act remains applicable to all workplaces regardless of the number of employees at any given workplace. incorporated the insurance provisions including demands coverage of at least NPR seven hundred thousand for every worker as workplace injuries-related treatment cost. The other OSH-related provisions included in the Labour Act identify the preparation of Safety and Health Policy applicable to each workplace and such policy should be registered in respective Labor Offices. The Labour Act also requires the formation of a Safety Committee when 20 or more workers are engaged in any workplace. The Act also provides provisions for the formation of different OSH-related committees. The Labour Act has made the employers responsible and accountable for the duties towards the workers and directs the **employers for making appropriate safety and health arrangement, arrangements ensuring no adverse effect on the workers from the use, operation, storage, or transportation of chemical, physical, or biological materials**. It also

requires employers responsible for disseminating necessary notice, information, and training related to safety and health. The Labour Act has also made the employee and workers of developing responsibilities towards attaining safety and health at the workplace which include abstaining from doing any activities that are likely to affect the safety and health of any individual in the workplace, cooperating with the employer for proper implementation of the health and safety arrangements, to use the personal safety devices provided free of cost by the employer, etc.

The Act has delegated authorities to the workers on stopping work anytime, in case of the immediate threat of any injury or adverse health effect or damage to the equipment in the workplace. The Act also bars employees from any communicable diseases to prevent the spread of communicable diseases at the workplace until the treatment is completed. The compensation provision allowed by the Act identifies that all the expenses for the investigation and treatment of any work-related diseases should be provided by the employer and where such disease cannot be cured, the worker should be provided with compensation as prescribed.

Additionally, the Public Health Service Act 2018 was introduced by the Government of Nepal and it encompasses the health and safety issues for the workers involved in the health care service. Section 44 of this Act speaks about the safety of the health workers in risky zones and encourages them to adopt safety measures. The same section also requires the health workers to be insured by the employers. The Act also endorses the provision of risk allowance to the workers and in case of serious infection, injury, or death necessary compensation has also been recommended.

Thus despite having some general provision related to OSH in the world of workers in Nepal, no specific provision was made for the welding workers and hence some specific legal and policy framework related to welding jobs needs to be made.

2. OBJECTIVES OF STUDY

Objectives: Following objectives are intended to achieve to address the issues by promoting citizen science in Nepal;

a) Study of welder's exposure level to welding fumes and their lung function test.
b) Study of Workers' perception of their health and environmental impacts of welding fumes.
c) Raise awareness among the welding workers and their federations by sharing the research findings.
d) Advocate with the government to promulgate the Standards of Welding Rod/Electrode and personal exposure limits.

3. METHODOLOGY

The following methodology has been followed to achieve the objectives.

a) The measurement of personal exposure level using personal samplers (21 from 11 Welding and Engineering Workshops)
b) The Pulmonary Function Test (PFT) test among 88 Welding workers and 20 nonwelders (control) to check their lungs functions related implications.
c) The questionnaire survey with Metal Fabricators (108 against 100 targeted) to understand their awareness level and health as well as environmental implications from the metal fumes.

d) Result from analysis using the statistical package and report preparation, publications, and dissemination through organizing the workshop.
e) Policy advocacy with concerned government agencies for fixing the exposure limit and welding rod quality standard.

3.1 Preparation for a research study

Before starting the whole study and research work, a technical team of field surveyors comprising engineering, environment, and health sectors were oriented with the help of OSH and Laboratory Experts through organizing a "**Kickoff and Orientation Program"**. The team was trained, questionnaires were prepared and tested, equipment was procured, sampling sites were identified and the team of surveyors with expert backup was mobilized in the field.

Letters in the name of the major Industrial Areas (e.g. Patan, Blaju, and Bhaktpur) including the potential engineering workshops were written from OSHC, and coordination was made together with all potential workshops and samplings of welding fumes, PFT, and questionnaire survey was performed.

Welding fumes were collected from the different workshops in Kathmandu valley. Altogether 21 samples from different types scales of engineering workshops ranging from small to the larger industry from Kathmandu, Lalitpur, and Bhaktapur. The sample was taken from Patan Industrial Area (PIA), Balaju Industrial Area, Bhaktapur Industrial Area, and others from outside the industrial areas in the Kathmandu valley. From the Patan industrial area, 9 samples were taken. And 2 samples were taken from the Everest engineering workshop and the Sindhu Metal workshop., 2 samples were from Balaju Yantrasala from Balaju Industrial Area. The other samples were collected from Satungal (1 from JP Steel and Engineering Pvt. Ltd), 1 from Modern Valley Metal Engineering, Syuchatar), and 1 from Shree Krishna Metal Pvt. Ltd. The study was also done in Bhaktapur industrial area (Nepal Transformer), 3 samples were taken, 2 Samples from S & S Metal Workshop in Gwarko were also taken. **In total 21 samples were collected for personal exposure sampling as well as metal characterization (table). All participants in which personal samplers were installed were male.**




3.2 Personal Sampling for determination of exposure to welding fumes and toxic metals

A total of 21 welding fumes samples were collected from different working locations in Kathmandu Valley, Nepal. The collected samples were safely transported to the OSHC laboratory and determined the welding fumes concentration. The samples were collected with the help of SKC, US-made personal samplers. The sampler's flow rate was calibrated with the soap bubble method before using it. Pre weighted Cellulose Ester membrane filter was used for the collection of welding fumes. Calibrated four-digit balance was used for weighing the filter paper. The filter paper was desiccated for 24 hours before taking the initial weight. All the weighted filter paper was marked and stored safely for taking to the field.

Personal samples were mounted on the body of the welder and allowed them to perform their routine work. The flow rate of the sampler was fixed at 1.9 LPM and run for 8 hrs. The removal of the sampler from the worker's final flow rate was also noted to calculate the average flow rate. Collected samples were safely stored and transported to the OSHC laboratory. Samples were again desiccated for 24 hrs before taking the final weight of the filter paper. After taking the weight of the filter paper again samples were safely stored and transported to **NESS Private laboratory** for further analysis for the determination of heavy and toxic metals. Metals were determined by using the AAS. All the obtained values were normalized and calculated as the Time Weighted Average (TWA) values. The obtained TWA values were compared with the ACGIH TLV/TWA.

1.	**INSTRUMENT NAME**	**DIGITAL MASS BALANCE**
	BRAND	METTLER TOLEDO
	MODEL No.	AB54
	S/N	1117173906
	Specifications	Max. 51 g Min. 10 mg e = 1 mg d = 0.1 mg TDNR 265121329 50/60 Hz
2.	**INSTRUMENT NAME**	**Cellulose Nitrate Membrane FILTER PAPER**
	BRAND	Whatman® made in Germany
	MODEL No.	Cat. No. 7188002
	Specifications	0.8 µm 100 Circles- 25 mmφ
3.	**INSTRUMENT NAME**	**PERSONAL SAMPLER PUMP**
	BRAND	SKC Ltd.
	S/N	508619
	MODEL No.	EEx ia IIC T4
	Specifications	Flow range 0.2 to 5.0 litre/min Operating temp. 32 to 113 F (0 to 45 C) Weight 0.950 kg

S.N.	Parameters	Sampling Method	Analysis Method
1	Welding Fumes	Personal Sampler	Gravimetric Analysis
2	Metals (Fe, Mn, Zn, Cu, Ni, Cr)	Personal Sampler	Atomic Absorption Spectrometry, ISO, 9855:1993.
3	Lungs Function Test	Peak Flow Meter	Comparison of Measured value with the predicted value

The personal level exposure sampling and study were accomplished with the support of Technical Officers at the Occupational Safety and Health Center (OSHC) of the Ministry of Labour, Employment and Social Security (MoLESS) of the Government of Nepal (GoN), a collaborating partner of the project guided by OSH Expert Mr. Dinesh Prasad Sah from other collaborating project partner SMS Environment and Engineering Pvt. Ltd.

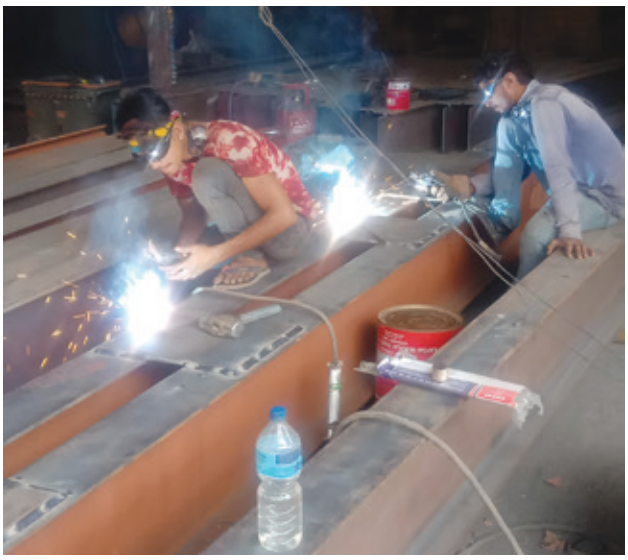
The samplers were installed in the selected welders by providing them some initial briefing and instructing them not to interfere with the instruments. The initial and final time of samplers installed were noted along with the adjustment of the break time. The researcher court time and again the samplers to check their proper functionality ensuring proper working of the instruments.

Table: Personal exposure measurement in Welding Workshops

Indu. No.	Sample Number	Name	Age	Name of Workshop	Address	Education	Yr. of Work	Day/ week	Hr./ day
1	1	Lal babu Sharma	30	National structure industries	PIA	8 class	10	7	12
1	2	Kapendra Tamang	30	National structure industries	PIA	12 class	8	6	8
1	3	Saroj Rasaili	22	National structure industries	PIA	6 class	1 1	6	8
2	4	Jitendra Chaudhary	24	Structo Nepal	PIA	10 class	8	6	10
2	5	Khagendra limbu	37	Structo Nepal	PIA	8 class	14	6	10
2	6	Dil Ram Subedi	50	Structo Nepal	PIA	6 class	25	7	8
3	7	Gyanendra Nakarmi	46	Powertech Nepal	PIA	10 Class	30	6	8
3	8	Bijay Sharma	19	National structure industries	PIA	5 class	4	6	12
3	9	Mukesh Kumar Yadav	25	National structure industries	PIA	11 class	4	6	10
4	10	Sun Bahadur Tamang	29	Everest Engineering	Nakhipot	Illiterate	12	6	8
5	11	Nurasha Ansariri	22	Sindhu Metal	Nakhipot	9 class	2	7	11
6	12	Janak ale	48	JP STEEL	Satungal	10 class	18	6	8
7	13	Pradip Bishwokarma	30	Shree Krishna metal Udhyog	Bauthali	5 class	10	6	10
8	14	Phurpa Dorje Lama	21	Modern valley metal	Syuchatar	5 class	6.5	6	10
9	15	Ram Sundar Budhathoki	59	Balaju Yantrasala	BIA	5 Class	20	6	8
9	16	Satya Narayan Shresthaha	62	Balaju Yantrasala	BIA	illiterate	40	6	8
10	17	Ganga Prasad Wagle	78	Nepal Transformer	Bhaktapur IA	Not studied	45	6	10
10	18	Saroj Kayesha	36	Nepal Transformer	Bhaktapur IA	5 class	16	6	10
10	19	Toran pun Magar	20	Nepal Transformer	Bhaktapur IA	11 class	1 .5	7	10
11	20	Suraj Shrestha	21	S.S METAL	Gowarko	10 CLASS	7	6	8
11	21	Narayan Malla	28	S.S METAL	Gowarko	12 CLASS	8	6	8

PIA= Patan Industrial Area, BIA=Balaju Industrial Area, Bhaktapur IA= Bhaktapur Industrial Area



4. RESULTS AND DISCUSSION

4.1 Personal Exposure to Welding fumes

A total of 21 personal samplings were collected from 11 different engineering welding workshops from Kathamndu, Lalitpur and Bhaktpur industrial area and outside and analyzed further for welding fumes concentration and metal characterizations.

Table: The exposure level of welding fumes

Sample No.	Sampling Locations	Welding Fumes Concentration (mg/m^3)	TLV, mg/m^3 by ACGIH	Ventilation Contidion
1	PIA	2.8	5	Cross Ventilation
2	PIA	2.8		Cross Ventilation
3	PIA	2.8		Cross Ventilation
4	PIA	7.2		Not sufficient, enclosed
5	PIA	8.4		Not Sufficient, enclosed
6	PIA	26.4		Not Sufficient, enclosed
7	PIA	4.8		Open

Sample No.	Sampling Locations	Welding Fumes Concentration (mg/m^3)	TLV, mg/m^3 by ACGIH	Ventilation Contidion
8	PIA	7.8		Not Sufficients , enclosed
9	PIA	10.8		Not Sufficients , enclosed
10	Nakhipot	3.8		Open
11	Nakhipot	9.0		Partially Open
12	Satungal	6.3		Not sufficient , enclosed
14	Bauthali	4.9		Open area
15	Syuchatar	3.1		Open area
17	BIA	4.9		Open area
18	BIA	3.1		Open Area
19	Bhaktapur IA	14.1		Not sufficient, enclosed
20	Bhaktapur IA	46.5		Not Sufficient, enclosed
21	Bhaktapur IA	11.6		Not sufficient, enclosed
22	Gowarko	5.0		Sufficient
23	Gowarko	4.3		Open area

From the above table, 52 % (11 of 21) of the fumes emitted exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Guideline Value of welding fume exposure of 5 mg/m^3. This indicates over 50% of the welding workers have a higher level of exposure to welding fumes that contains a very high level of multiple toxic fumes. Thus welders need to be protected from getting continuous exposure to these multiple toxic metals through envisioning the required regulatory framework of metal fumes exposure limits, welding rod/electrode standards, and required engineering control like fume eaters and administrative control measures like full PPEs.

Poor ventilation has a direct association with high exposure to welding fumes. As 10 out of 11 (91%) of the welding workshops showing higher welding fumes were having poor ventilation system and mostly enclosed types.

4.2 Welding fumes characterization

The welding fumes were studied to estimate the personal level of exposure and are also further sent for laboratory analysis for their metal characterizations contained in them. Acid reflux methods were used to digest the filter paper to extract the metals to be analyzed. The extracted metal liquid was then tested with the help of AAS (Atomic Absorption Spectroscopy). The results have been summarized as follows.

Table: Metal Characteristics of Welding Fumes

Sample No.	Fe, mg/m³	TLV, mg/m³	Mn, mg/m³	TLV, mg/m³	Cr, mg/m³	TLV, mg/m³	Ni, mg/m³	TLV, mg/m³	Cu, mg/m³	TLV, mg/m³	Zn, mg/m³	TLV, mg/m³
1	0.74	5	0.04	0.2	0.000	0.003	0.003	0.2	0.0025	0.2	0.007	2
2	0.46	5	0.04	0.2	0.000	0.003	0.011	0.2	0.0007	0.2	0.000	2
3	0.76	5	**0.58**	0.2	**0.328**	0.003	0.076	0.2	0.0616	0.2	0.047	2
4	1.89	5	**1.27**	0.2	0.000	0.003	0.000	0.2	0.0024	0.2	0.028	2
5	2.18	5	0.18	0.2	0.001	0.003	0.008	0.2	0.0401	0.2	0.057	2
6	**6.10**	5	0.77	0.2	0.000	0.003	0.003	0.2	0.0063	0.2	0.047	2
7	0.49	5	0.07	0.2	0.002	0.003	0.051	0.2	0.0069	0.2	0.063	2
8	0.13	5	0.06	0.2	0.000	0.003	0.000	0.2	0.0000	0.2	0.000	2
9	1.05	5	0.15	0.2	0.000	0.003	0.000	0.2	0.0081	0.2	0.005	2
10	0.63	5	0.06	0.2	0.000	0.003	0.000	0.2	0.0101	0.2	0.053	2
11	1.88	5	0.16	0.2	0.000	0.003	0.014	0.2	0.0045	0.2	0.021	2
12	0.28	5	0.05	0.2	0.000	0.003	0.008	0.2	0.0072	0.2	0.034	2
14	0.95	5	0.06	0.2	0.000	0.003	0.000	0.2	0.0039	0.2	0.000	2
15	0.33	5	0.01	0.2	0.000	0.003	0.000	0.2	0.0052	0.2	0.000	2
17	0.69	5	0.06	0.2	0.000	0.003	0.012	0.2	0.0000	0.2	0.004	2
18	0.37	5	0.02	0.2	0.000	0.003	0.019	0.2	0.0000	0.2	0.009	2
19	2.45	5	0.17	0.2	0.000	0.003	0.011	0.2	0.0000	0.2	0.018	2
20	**5.00**	5	**1.28**	0.2	0.000	0.003	0.021	0.2	0.0133	0.2	0.063	2
21	1.10	5	**0.25**	0.2	0.000	0.003	0.033	0.2	0.0038	0.2	0.039	2
22	0.78	5	0.04	0.2	0.000	0.003	0.016	0.2	0.0000	0.2	0.044	2
23	0.64	5	0.02	0.2	0.000	0.003	0.010	0.2	0.0000	0.2	0.002	2

Furthermore, metal characterization of welding fumes gives rise to the concern of high exposure to more dangerous chemicals like iron (Fe) beyond the TLV value of 5 mg/m³ may result in Serodosis, Manganese beyond the TLV Value of 0.2 mg/m³ may resulting reproductive failure and Chromium beyond the TLV value 0.003 mg/m³ may result into the irritation, chemical burns, and cancer respectively.

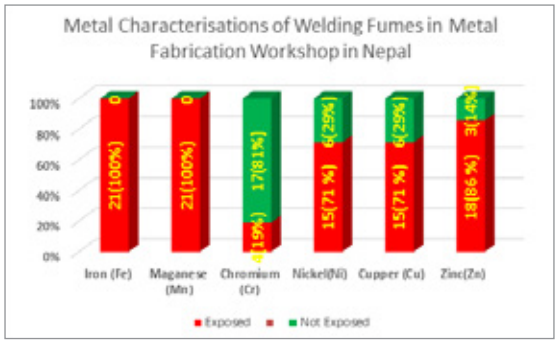


Table: Toxic Metals exceeding TLV Value in welding fumes.

Metals analyzed	Total Nu. Of Samples	Metal Founds in No. of	% of Total Samples	Value ranges (mg/m^3)	TLV Value (mg/m^3)	No. of Sample exceeding TLV Value
Iron (Fe)	21	21	100	0.13 to 6.1	5	2
Manganese (Mn)	21	21	100	0.01 to 1.28	0.2	4
Chromium(Cr)	21	4	19	0.000 to 0.328	0.003	1
Nickel(Ni)	21	15	71.42	0.00 to 0.033	0.2	0
Copper(Cu)	21	15	71.42	0.000 to 0.0616	0.2	0
Zinc(Zn)	21	18	85.71	0.006 to 0.063	2	0
Source: CEPHED, Laboratory Test Results,						

Welding workers are prone to exposure to multiple toxic chemicals while working in the workshop. 100 % of welding fumes samples contain Iron (Fe) ranged from **0.13 to 6.1 mg/m^3** and 100% of welding fumes samples contains Manganese(Mn) ranged from **0.01 to 1.28 mg/m^3**, 19% of samples contains Chromium ranged from **0.000 to 0.328 mg/m^3**, 71.43 % of samples contain Copper (Cu) ranged from **0.000 to 0.0616 mg/m^3** and 71.43 % of samples contain Nickel ranged from **00.00 to 0.033 mg/m^3** and 85.71% of samples contain Zinc ranged from **0.006 to 0.063 mg/m^3**.

Iron (Fe): Iron is the principal alloying in steel manufacture, During welding, these fumes arise from both the base metal and the electrode. The primary acute effects of exposure to iron oxides are irritation of nasal passages, through lungs. Long-term exposure may cause iron pigmentation of the lungs, a condition known as siderosis. Most authorities agree that these iron deposits in the lungs are not dangerous[9].

Manganese (Mn): Welding fumes are composed of metals and most fumes contain asmall percentage of manganese. There is a concern among workers, employers, and health professionals about potential neurological effects associated with exposure to manganese in welding fumes.

Chromium (Cr): Welding and Hexavalent Chromium Chromium is a component in stainless steel, nonferrous alloys, chromate coatings, and some welding consumables. Chromium is converted to its hexavalent state, Cr(VI), during the welding process. Cr(VI) fume ishighly toxic and can damage the eyes, skin, nose, throat, and lungs and cause cancer.

Copper (Cu): Acute effects include irritation of the eyes, nose, and throat, nausea, and "Metal Fume Fever."

Nickel (Ni): The fume from welding processes may contain compounds ofchromium, including hexavalent chromium, and nickel. The composition of the base metals, the welding materials used, and the welding processes affect the specific compounds and concentrations found in the welding fume. Examination of the world literature reveals several epidemiological studies which demonstrate a slight excess risk of respiratory tract cancer incidence among the general welding population exposed to even moderate levels of exposure[13].

Zinc: Used in large quantities in the manufacture of brass, galvanized metals, and various other alloys. Exposure to these fumes is known to cause metal fumes fever. Symptoms are similar to those of the common flu, fever (rarely exceeding 102°F.), chills, nausea, and aching of the head and body. These symptoms rarely more than 24 hours[9].

4.3 Study of respiratory illness through PFT (Pulmonary Function Test)

A total of 108 (88 welders and 20 controls) from Kathmandu, Lalitpur, and Bhaktapur participated in the study. The study showed that 100% of the welders started the job as an apprentice to experienced welders. They learned welding skills through hands-on apprenticeships.

Welding workers were selected from each workshop studied to capture the personal welding fume exposure as well as welding fume characterizations to see the linkage between the level of fumes and associated health and environmental conditions of the welding workshop and its overall impacts on the welding workers.

i) Comparison of PFT test value:

The PFT test was carried out to test the respiratory illness among the 88 exposed welding workers and analyzed by comparing it with the predicted value with the measured value. The Lung Check Peak Flow Meter (PFM) has a predicted value zone indicated as follows. According to the American

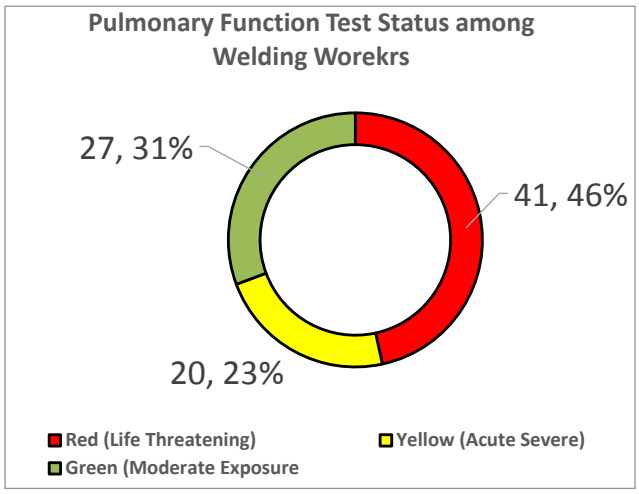
Lungs Association, the red band ranges from 60 to 250 L/min, the Yellow band ranges from 250 to 450 L/Min and the Green band ranges from 450 to 800 L/min according to EU /ATS.

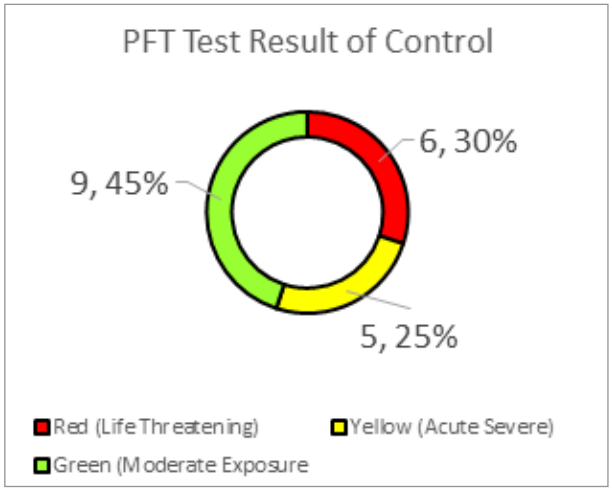
ii) Interpretation of PFT test value:

The decision about the severity of the respiratory illness was decided based on the complete falls within the range of predicted value (age and weight) basis which is green, within the range of either one value (upper or lower) with a yellow band and both out the range of predicted value were grouped into the red band.

Zones	Reading	Description
Green Zone	80 to 100 percent of the usual or personal best peak flow reading	A peak flow reading in the green zone indicates that the asthma is under good control.
Yellow Zone	50 to 79 percent of the usual or personal peak flow reading	Indicates caution. It may mean respiratory airways are narrowing and additional medication may be required.
Red Zone	Less than 50 percent of the usual or personal best peak flow readings	Indicates a medical emergency. Severe airway narrowing may occurr and immediate action needs to be taken. This would usually involve contacting a doctor or hospital

A total of 88 samples of exposed welding works data were analyzed and the chart has been created for pulmonary function test among welders in which red color indicates life-threatening 41(46%), yellow color indicates acute severe 20(23%), and green color indicates moderate exposure 27 (31%).





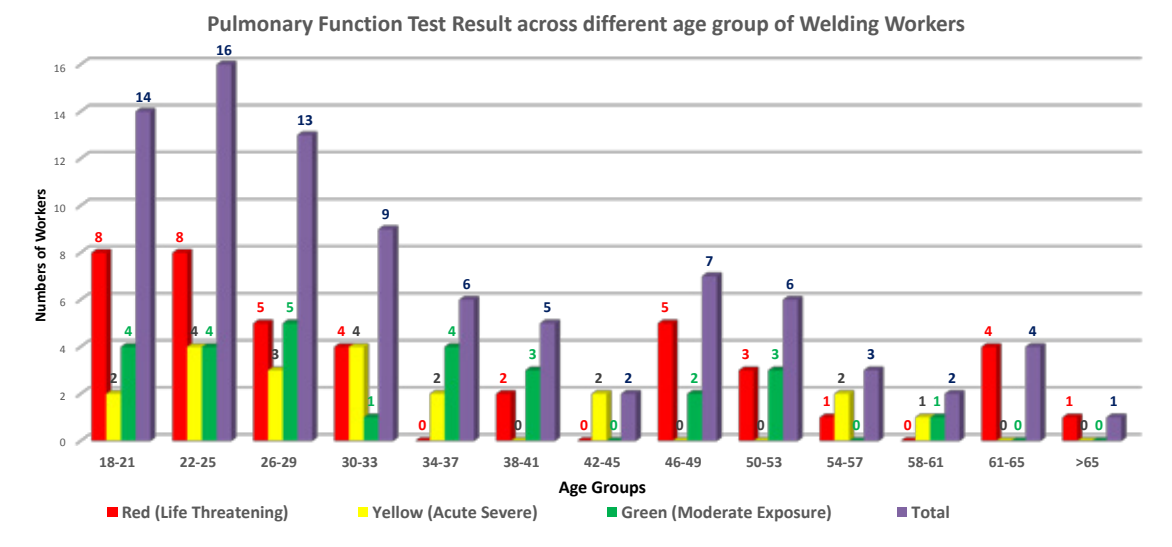
iii) Age group-wise PFT Test Status among the welding Workers.

The table and bar graph below indicated the respiratory illness status of the studied welding workers group in their different age groups.

Table: Age-wise PFT Test result interpretations

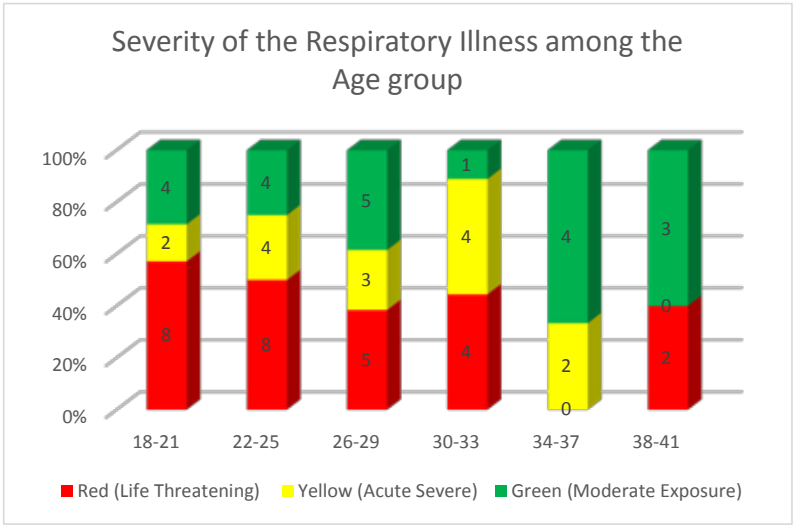
Health Status Vs Age Group	18-21	22-25	26-29	30-33	34-37	38-41	42-45	46-49	50-53	54-57	58-61	61-65	>65	Total	%age
Red (Life Threatening)	8	8	5	4	0	2	0	5	3	1	0	4	1	41	46.6
% age	19.5	19.5	12.2	9.8	0.0	4.9	0.0	12.2	7.3	2.4	0.0	9.8	2.4	100.0	
Yellow (Acute Severe)	2	4	3	4	2	0	2	0	0	2	1	0	0	20	22.7
% age	10	20	15	20	10	0	10	0	0	10	5	0	0	100	
Green (Moderate Exposure)	4	4	5	1	4	3	0	2	3	0	1	0	0	27	30.7
% age	14.8	14.8	18.5	3.7	14.8	11.1	0.0	7.4	11.1	0.0	3.7	0.0	0.0	100.0	
Total	14	16	13	9	6	5	2	7	6	3	2	4	1	88	100
% of Total	15.9	18.2	14.8	10.2	6.8	5.7	2.3	8.0	6.8	3.4	2.3	4.5	1.1	100.0	

According to the table the age group of 18-21 are 14 in numbers, among them (8- red zone), (2 – yellow zone), and (4 –green zone); The age group of 22-25 are 14 in numbers among them (8-red zone), (4-yellow zone) and (4 – green zone); The age group of 26-29 are 13 in number among them (5-red zone), (3- yellow zone) and (5-green zone); The age group of 30-33 are 9 in numbers among them (4 -red zone), (4- yellow zone) and (1- green zone); The age group of 34-37are 6 in numbers among them (2-yellow zone) and (4-green zone); The age groups of 38-41 are 5 in number among them (2 –red zone) and (3- green zone); The age groups of 42-45 are 2 in number among them (2-yellow zone); The age groups of 46-49 are 7 in numbers among them (5-red zone) and (2-green zone); The age groups of 50-53 are 6 in numbers among them (3- red zone) and (3-green zone); The age groups of 54-57 are 3 in numbers among them (1 – red zone) and (2- yellow zone); The age group of 58-61 are 2 in number among them (1-yellow zone) and (1- green zone); The age group of 61-65 are 4 in number among them (4-red zone) and, the age groups above 65 years are 1 in the red zone.



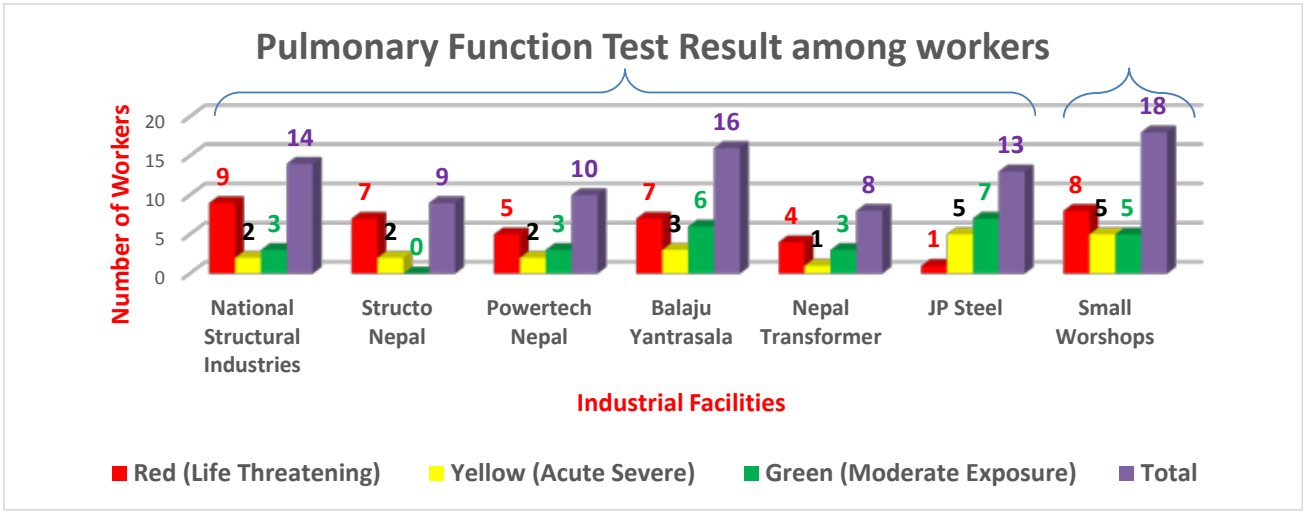
iv) Younger workers are more vulnerable

Furthermore, the respiratory illness severity has been prominent in young age groups (Fig) who will work relatively longer period is a shocking result. It means the younger the workers severe the health impact. It should be the reverse case otherwise. Therefore, medical surveillance is needed among the welding workers.



v) Industries-wise PFT Test Status among the welding workers.

The pulmonary function test results among workers according to industries wise, In Patan industrial area 3 industries we visited and studied in which National Structural Industries, the total number of a sample taken was 14, among them (**64%,** 9-red zone), (2-yellow zone) and (3-green zone); Structo Nepal's total number of a sample taken was 9, among them (**78%,** 7-red zone) and (2-yellow zone) and the last one is Powertech Nepal's total number of samples taken was 10, among them (**50%,** 5-red zone), (2-yellow zone) and (3-green zone).



In Balaju industrial area we visited and study carried out in one industry which is Balaju Yantrasala. In Balaju Yantrasala, 16 samples were taken among them (**44%,** 7- red zone), (3-yellow zone), and (6- green Zone).

Likewise, in Bhaktapur industrial area, we visited one industry which is Nepal transformer were selected and studied. The total number of samples taken was 8, among them (**50%,** 4- red zone), (1- yellow zone), and (3- green zone). **In the case of industrial areas and engineering workshops with**

long hours and heavy-duty, welding is ongoing, the exposure level is high among the metal fumes and that has coherence with their lungs functions test result with a higher percentage (44 to 78%) of workers lungs function has found to have deteriorated also directly linked to poor ventilation.

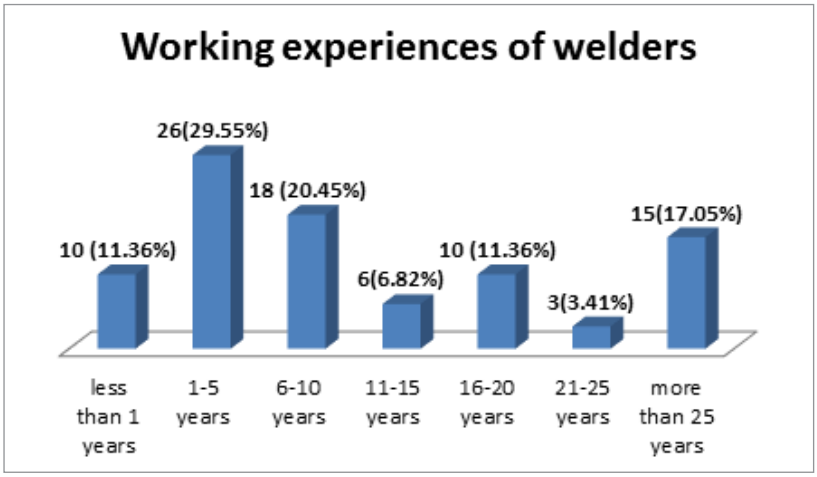
We also visited and studied other private industries which are JP steel in Naikap and the total number of samples was 13, among them (1-red zone), (5- yellow zone), and (7- green zone). **This is possible because of using of PPE provided by the enterprenures despite of having poor ventilation and hihger level of weldign fumes measured in this engineering workshop.** We also visited and studied were carried out in other four small grill workshops where the total number of samples collected was 18, among them (8- red zone), (5- yellow zone), and (5- green zone) were found. **Finally, altogether 88 welding workers were studied among which workers falls in the red zone (life-threatening) were 41 (47%), 20 (23%) in the yellow zone (acute severe), and 27 (30%) in the green zone (moderately exposure).**

4.4 Perception of welders about health and environmental impacts of welding

Health and Environment impact-related perceptions among the welders were observed with the help of a set of pre-tested questionnaires on different issues related to personal information, education, training, health, environment, work duration, smoking habits, protective gears used, ventilation, maintenance of hygiene, and sanitation, preventive measures available and adopted, etc., and analyzed to represent in a more meaningful manner.

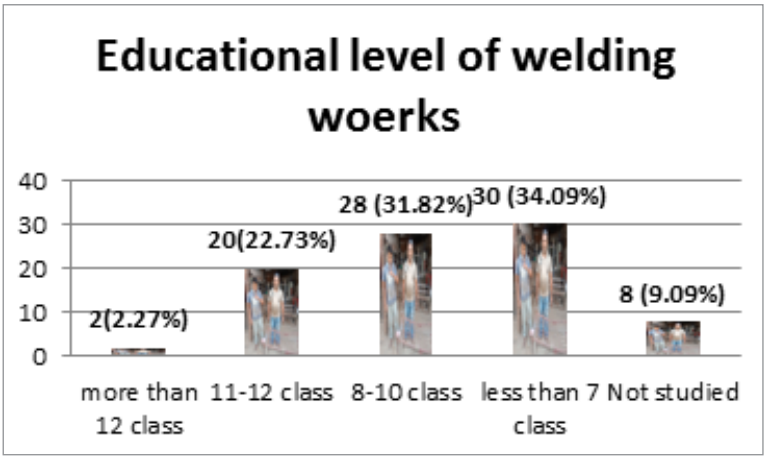
i) Duration of Work

Welding workers have worked a varied number of years in the welding workshops and exposed to toxic welding fumes. The workers who work with welding fumes for more than 25 years were 15 in number, more than 21 years are 3 in numbers, more than 16 years are 10 in numbers, more than 11 years are 6 in numbers, more than 6 years are 18 in numbers. The majority of the workers have fewer years of working experience. 26 in numbers workers have worked for (1-5) years are which is highest among all and less than the one-year working experience of workers were 10 in numbers.



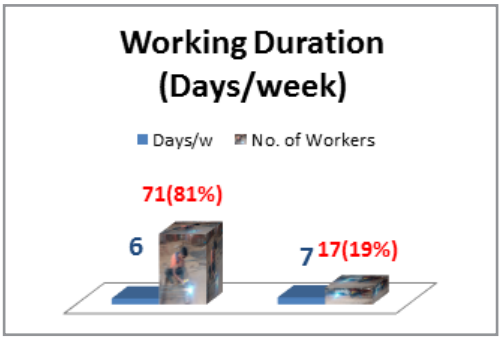
ii) Education level of welding workers

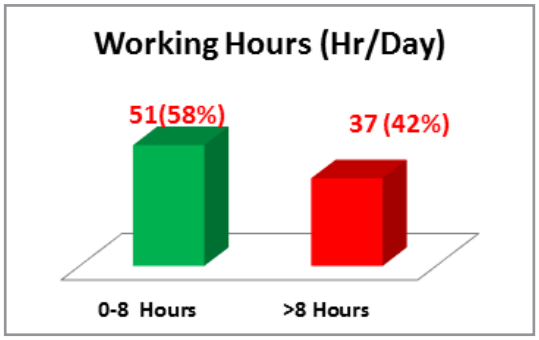
Poor education levels have been found among the welding workers which is one of the hindering factors to made aware of occupational safety and health issues among them. There were very few numbers of workers who studied more than 12 classes which were only 2 in number among a total of 88. The workers who studied (11-12) class were 20 in numbers, likewise, the worker who studied (8-10) were 28 in numbers, the workers who studied less than 7 class were 30 in numbers and the workers who has never attended the school were 8 in numbers.



iii) Working hours of welding workers

The number of workers who worked for 6 days in a week was 71 and 7 days in a week was 17, most of the workers work for 6 days in a week.



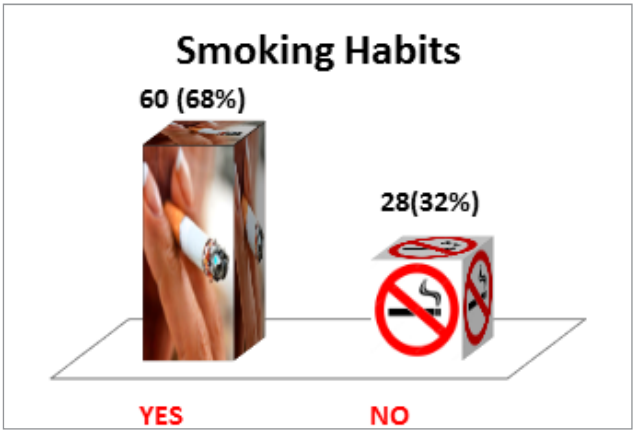


The workers who work for (0-8) hours were 51 (58%), the workers who worked for more than 8 hours were 37 (42%), and most of the workers work for more than 8 hours for money as overtime.

There are elongated hours of working of the welding workers that have provided the enabling environment for the longer exposure to the toxic welding fumes.

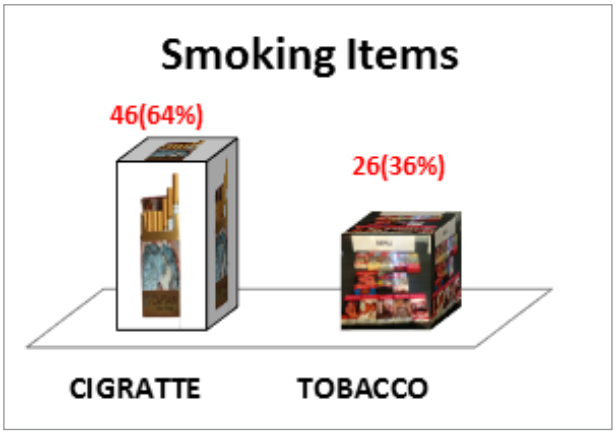
iv) Smoking habits among welding workers

There were more smoker workers than nonsmoker workers. 60 of 88 workers (68%) were smokers versus 28 of 88 (32%) are of non-smokers. The workers who were involved in smoking for less than a year were 3 in number, and workers involved in smoking for (1-5) years were 21. likewise involved in smoking for (6-10) years were 15. Similarly, workers involved in smoking for (11-15) were 5. From (16-20) were 4, from (21-25) were 5 and above 25 years were 7 in numbers respectively.



v) Types of Smoking habits among welding workers

Among the total number of workers who smoke daily, the workers who smoke cigarettes were 46 (64%) in number, and the workers who hew tobacco were 26 (36%) in number.



vi) Ventilations condition

The ventilation found in the study was natural and cross ventilation. None of the workshops has adopted forced ventilation. Poor ventilation has a direct association with high exposure to welding fumes. As 10 out of 11 (91%) of the welding workshops showing higher welding fumes were having poor ventilation system and mostly enclosed types.

vii) The practice of using PPEs (Personal Protective Equipments)

The welding engineering workshops and enterprises were claimed to be provided with all the PPEs to the workers but workers are not using them all; In all most all welding workshops, the workers were hardly seen using full PPEs. Most frequently they were seen using Gloves and Google. Few were found to be using Helmets, Goggles, or Gloves. Whereas even fewer were found to be using Helmets, Goggles, Gloves, Mask, or Dress. It is recommended that the enterprises need to provide all the PPEs at no cost as well as have the policy to use them properly all the time.

Table: Observed Personal Protective Equipment (PPE) uses in different workshops

Industries name	Equipment
National structures industries	Gloves, Goggles
Everest engineering	Gloves, Goggles
Power tech Nepal	Goggles
Structo Nepal	Helmet, Goggles, Gloves
Jp steel	Helmet, Goggles, Gloves, Mask
Balaju Yantrasala	Helmet, Goggles, Gloves, Mask
Sindhu metal	Goggles
Nepal transformer	Helmet, Goggles, Gloves, Mask, Dress
S.S. Metal	Gloves, Goggles
Modern valley Engineering Pvt. Ltd	Gloves, Goggles
Shree Krishna metal Udhyog	Gloves, Goggles

Viii) Welding rod/electrode types and characteristics

The wielding workers in Nepal were found mainly using two types of the rod which is Chinese and Indian rod. Mostly Indian and Chinese welding rods/electrodes were found to be used in almost all welding workshops in the studied area of Nepal, welding rods CHE 40 (E6013), MHS (E6013), and SUDO (E6013) were found to be used. All of them contain a Warning Message: Protect yourself and others. Read and understand this label. FUMES AND GASES can be dangerous to your health. ARC RAYS can injure eyes and burn skin. ELECTRIC SHOCK can kill.

A welding rod is a generic name used to refer to electrodes or filler metal that is used to join two other base metals when performing shielded metal arc welding (SMAW). Welding rods can either be consumable or non-consumable in their use. Consumable rods disintegrate or melt to form the bonding material that holds two metal pieces together. However, non-consumable rods simply provide enough catalytic reaction with the base metals to propagate their fusing in an oxygen-rich atmospheric environment. The length of any continuous weld bead is directly proportional to the length of the welding rod.

There are many materials and types of rods that have been used for welding. The fumes generated are based on the electrode they used for welding. There are many types of welding rods that have been practiced in Nepal.

5. CONCLUSION

From the above study, it has been broadly found the very poor level of awareness and policy redressal provision for the prevention of occupational exposure to welding fumes among the metal fabricators in Nepal. The level of welding fumes was quite high in more than 50% of the engineering workshops. 52 % (11 of 21) of reading from 11 welding workshops have exceeded the American Conference of Governmental Industrial Hygiene (ACGIH) guideline value (5 mg/m^3) indicates over 50% of the welding workers have a higher level of exposure to welding fumes that contains a very high level of multiple toxic metals. **In the case of industrial areas and larger engineering workshops with long hours and heavy-duty welding is ongoing, the exposure level is high among the metal fumes and that has coherence with their lungs functions test result with a higher percentage (44 to 78%) of workers lungs function has found to have deteriorated has also been associated with the poor ventilation system.** Furthermore, metal characterization of welding fumes gives rise to the concern of high exposure to more dangerous chemicals like iron (Fe) beyond the TLV value of 5 mg/m^3 may result in Serodosis, Manganese beyond the TLV Value of 0.2 mg/m^3 may result in reproductive failure and Chromium beyond the TLV value 0.003 mg/m^3 may resulting into the irritation, chemical burns, and cancer respectively.

Welding workers are prone to exposure to multiple toxic chemicals while working in the workshop. 100 % of welding fumes samples contain Iron (Fe) ranged from **0.13 to 6.1 mg/m^3** and 100% of welding fumes samples contains Manganese(Mn) ranged from **0.01 to 1.28 mg/m^3,** 19% of samples contains

Chromium ranged from **0.000 to 0.328 mg/m³**, 71.43 % of samples contain Copper (Cu) ranged from **0.000 to 0.0616 mg/m³** and 71.43 % of samples contain Nickel ranged from **00.00 to 0.033 mg/m³**and 85.71% of samples contain Zinc ranged from **0.006 to 0.063 mg/m³**.

The respiratory illness severity has been prominent in young age workers groups who will work relatively longer period is a shocking result. It means the younger the workers severe the health impact. It should be the reverse case otherwise. Therefore, medical surveillance is needed among the welding workers.

Most of the workers (81%) work for 6 days a week is more than the workers (19%) who work for 7 days a week. The 52% of the worker who worked for 8 hours in a day was more than the 48% of workers who works for more than 8 hours. The workers who smoke are more than the nonsmokers. Cigarette smokers are more than chewing tobacco. Many workers work for more than 1-5 years with welding fumes. 15 workers are working with welding fumes for more than 25 years. Most of the workers has only studied less than 7 class.

6. RECOMMENDATIONS

Following three level of recommendations has been made based on the finding of the research to improve the overall occupational safety and health condition of the welding workers.

6.1 Policy Level Recommendations

- Enactment of welding rod quality standards and their effective implementation and monitoring mechanism in place.
- Develop the Permissible Exposure Limits (PEL) of welding fumes and heavy metals. It can be done by the adoption of TLV of ACGIH and PEL of OSHA.
- Inclusions of special provisions of protection of welders' occupational exposure to welding fumes in the labour laws (Act, Regulation and policy, etc.). Make compulsory to it submit the periodic health surveillance report of all welders in DOLOS.
- Urgent and immediate needs to define and recognize welders' jobs as a hazardous job
- Introduce OSH-focused IEC materials for welders in the local language
- An insurance policy needs to be implemented to ensure all the workers as this work is dangerous of nature etc.

6.2 Industrial /Workshop Level Recommendations

- Maintain minimum OSH-related provisions (e.g. rest rooms, separate and safe toilet for men and females, clean and safe workplace), etc in every welding workshop.
- Adequate provision of engineering and administrative control measures all possible hazards in the work of welding.
- Provide a local exhaust ventilation system in all welding jobs. Welding-based industry must have the provision of cross ventilation.
- Work permits system introduction while working in a confined space.
- Barication between welders and nonwelders
- Regular OSH and awareness training for welders etc.
- Welders should be provided with the respirator to protect from welding fumes.

6.3 Workers Level Recommendations

- Try to work in cross ventilation areas or open areas.
- Keep the welding rod and cable together on any one side of the welder's position.
- Consumption of Balance diets
- Use of full PPEs mandatory
- Maintain personal hygiene along with quitting smoking behaviors
- Regular OSH training and awareness among welders.

7. EXPECTED IMPACT OF RESEARCH STUDY ON SOCIETY

The welding workers' level of exposure has been known that help to envision adopting the regulatory and technical measures required to solve the problem to prevent the ongoing exposure to the welding fumes of the metal fabricators.

The level of awareness among the metal fabricators has been raised through the awareness and capacity-building programs that will help the welders to prevent their exposure as well as the reduce environmental burden of these toxic fumes.

Health and environment-related implications are known that will help fabricators as well as communities to be prepared for all possible prevention and control measures to be taken to avoid further exposure.

Effective implementation of enacted standards and another regulatory mechanism in place will improve the health and environmental condition of the surroundings.

Welding workers will be protected from getting exposure to toxic fumes.

Research-based formulation of standards and exposure limit fixation will ensure effective implementation as well as provide a sustainable solution to the problems.

Fulfill the data gap in the public domains of welding fumes, its metals characterizations, and associated public health and environmental impacts

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नेपालमा मेटल फ्याब्रिकेटरहरू बीच वेल्डिङको धुवाँबाट हुने व्यावसायजन्य जोखिमको रोकथामको लागि अध्ययन, जनचेतना र नीतिगत पैरवी

परिचय

संघीय लोकतान्त्रिक गणतन्त्र नेपाल एसियामा अवस्थित भूपरिवेष्ठित सार्वभौमसत्ता सम्पन्न राज्य हो। नेपाल विश्वका अतिकम विकसित र ४७ भूपरिवेष्ठित राष्ट्रहरूमा पर्छ। नेपालको जनसंख्या १ जुलाई २०२२ को अनुसार ३०,२२५,५८२ हो। हालको जनसंख्या वृद्धि दर प्रत्येक मिनेटमा एकजना थपिदै गएको छ। जनसङ्ख्या वृद्धिसँगै घर र अन्य काठमा आधारित उत्पादनहरुको माग निकै बढेको छ र नेपालको सन्दर्भमा काठको उपलब्धता नियुन हुदै गएको कारण मानिसहरू धातुको निर्माण सामाग्रि जस्ता वैकल्पिक उत्पादनहरूको प्रयोग गर्न बाध्य छन्। धातु, निर्माण कार्य, घरहरू, र इन्जिनियरिङदेखि उद्योग इत्यादि धेरै क्षेत्रहरूमा बढ्दो रूपमा विविध प्रयोगहरू भएको छ।

वेल्डिङ र काट्ने प्रक्रियाहरूले धेरै सम्भावित स्वास्थ्य खतराहरू निम्त्याउँछ। वेल्डिङबाट सुरक्षा र स्वास्थ्य सम्बन्धि जोखिमहरूबिच असामान्य संयोग खडा गर्छ। यसको प्रकृति अनुसार, वेल्डिङले धुवाँ र आवाज उत्पन्न गर्छ, विकिरण उत्सर्जन गर्छ। वेल्डिङमा बिजुली वा ग्याँसको प्रयोग हुने भएकोले पोल्ने, झटका दिने, आगो र विस्फोटको सम्भावना हुन्छ। सबैभन्दा सामान्य खतराहरू विकिरण, गर्मी, ध्वनि, धुवाँ, ग्यास र इर्गोनोमिक्सको जोखिमहरु हुने गर्दछ।

वेल्डिङको धुँवाबाट हुने धेरै स्वास्थ्य असरहरू अन्यत्र अभिलेखित भएकाले (जस्तै OSHA का तथ्याङ्कहरू), वेल्डरहरूलाई आवश्यक सचेतना र नियामक संयन्त्र जस्तै एक्सपोजर सीमा र रडको गुणस्तरको मापदण्डको अभावमा नेपालमा कामदारहरु धेरै विषाक्त वेल्डिङ धुवाँको सम्पर्कमा आइरहेको छ। एक्सपोजर र स्वास्थ्य क्षतिको स्तर निर्धारण गर्न सार्वजनिक रुपमा कुनै पनि स्थानीय तथ्यांक उपलब्ध थिएन। तसर्थ, Takagi Fund for Citizen Science, Japan र Developing World Outreach Initiatives (DWOI) USA को आर्थिक सहयोगमायो परियोजना स्वास्थ्य र वातावरणमा आधारित तथ्यांक जुटाएर व्यापक रूपमा जनचेतना बढाउनुका साथै आवश्यक नियामक संयन्त्रहरुको लागि पैरवी गरिने रहेको छ।

कामदारहरूको वेल्डिङ धुँवामा व्यक्तिगत एक्सपोजर स्तर, फोक्सोको कार्य क्षमता परीक्षणको प्राविधिक अध्ययन लगायत काठमाडौं उपत्यका भित्र वेल्डिङमा कार्यरत कामदारहरुको सामाजिक, आर्थिक, स्वास्थय र वातावरणीय प्रदूषणको बारेमा धारणाहरू प्रश्नावली सर्वेक्षणको माध्यमबाटजान्ने प्रयास गरिएको थियो।

जनस्वास्थ्य तथा वातावरण प्रवर्द्धन केन्द्र (CEPHED) ले व्यवसायजन्य सुरक्षा तथा स्वास्थ्य केन्द्र (OSHC), श्रम रोजगार तथा सामाजिक सुरक्षा मन्त्रालय (MoLESS), ग्रिल एण्ड स्टिल फेब्रिकेटर्स महासंघ (FGSFN) र SMSEE इन्जिनियरिङ प्राईभेट लिमिटेडको संयुक्त प्रयासमा यो अध्ययन समपन्न गरिएको थियो।

हाल नेपालभर करिब ११००० मेटलफ्याब्रिकेटर कार्यशालाहरू दर्ता भई सञ्चालनमा रहेका छन्, जसबाट करिब १६०,००० रोजगारी सृजना भइरहेका छन् र करिब १५,००,००० आश्रित परिवारका सदस्यहरू लाभान्वित भईरहेको ग्रिल एण्ड स्टिल फेब्रिकेटर्स महासंघको तथ्याङक छ।

मेटल फ्याब्रिकेटर र वेल्डरहरूसँगको हाम्रो संलग्नताको क्रममा, तिनीहरूले प्रयोग गरेको वेल्डिङ रड/इलेक्ट्रोडहरूबाट आउने विषाक्त वेल्डिङ फ्युमहरू (धुवाँहरू) अर्को प्रमुख स्वास्थ्यको कारक तत्व रहेकोपाइएको थियो। यसले कामदारको स्वास्थ्यमा मात्र असर नगरी वरपरको क्षेत्रमा ठूलो वातावरणीय प्रदूषण निम्त्याउँछ र सामुदायिक स्वास्थ्यमा पनि क्षति पुर्‍याउँछ। आँखा, नाक, घाँटी (ENT) जलन र श्वासप्रश्वास संक्रमण प्रमुख स्वास्थ्यमा पर्ने प्रभावहरू हुन् र वरपरको वातावरणीय प्रदूषण प्रमुख समस्याहरू हुन्। वेल्डिङको धुवाँसंग लामो समयसम्म सम्पर्कमा रहँदा फोक्सोमा क्षति पुग्न सक्छ र फोक्सो,मुत्र नलिलगायत विभिन्न प्रकारका क्यान्सरहरु हुन सक्छ।केही धुवाँबाट हुने स्वास्थ्य प्रभावहरूमा, धातुको धूवाँको ज्वरो, पेटको अल्सर,मृगौलामा क्षति, र स्नायु प्रणालीको क्षतिहुनसक्छ। म्यांगनीजको धुवाँको लामो समयसम्म सम्पर्कमा रहँदा पार्किन्सन(क्षारे) रोग जस्ता लक्षणहरू हुन सक्छ। हेलियम, आर्गन, र कार्बन डाइअक्साइड जस्ता ग्यासहरूले हावामा अक्सिजनलाई विस्थापित गर्छ र निसासिने हुन सक्छ, विशेष गरी जब सीमित वा बन्द ठाउँहरूमा वेल्डिङ गर्दा कार्बन मोनोअक्साइड ग्यास बन्न सक्छ, र श्वासप्रश्वासमा खतरा उत्पन्न हुन सक्छन्।यि विभिन्न प्रकारका वेल्डिङ रडहरू प्रयोग गर्दा प्रत्यक्ष देख्न सकिने प्रभावहरू हुन्। यी कामदारहरूलाई वेल्डिङ रडबाट निस्कने विषाक्त धुवाँमा तिनीहरूलाई निरन्तर पेशागत जोखिमबाट जोगाउन आवश्यक छ। वास्तवमा, नेपाल सरकारले न त कुनै सुरक्षित एक्सपोजर सीमा अपनाएको छ, न त वेल्डिङ रडको कुनै मापदण्ड तोकिएको छ। यस अनुसन्धानमा आधारित परियोजनाले व्यक्तिगत नमूनाहरू(Personal Samplers)द्वारा विषाक्त धुवाँ नाप्दै कामदारहरूको व्यक्तिगत एक्सपोजरका नयाँ तंथ्याकसिर्जना गर्ने उद्देश्यका साथसाथै चिकित्सा टोलीहरूको सहयोगमा पल्मोनरी फंक्शन टेस्ट (PFT) को प्रयोग गरेर उनीहरूको फोक्सोको कार्य क्षमता परीक्षण गर्ने उद्देश्य पनि राखेको थियो। वेल्डिङको धुवाँको स्वास्थ्य र वातावरणीय प्रभावबारे कामदारहरूको धारणा जान्नको लागि उनीहरूसँग केही स्वास्थ्य-सम्बन्धित प्रश्नावली सर्वेक्षण गरिएको थियो। अध्ययनका परीणामहरु सर्वप्रथम एक कार्यसाला गोष्ठि मार्फत सबै सरोकारबालाहरु र मेटल वेल्डर/ फ्याब्रिकेटरहरूमा जानकारि गराइएको थियो। अध्ययनका परीणामहरुसचेतना जगाउन, आवश्यक एक्सपोजर सीमा र वेल्डिङ रडहरूको मापदण्डहरूको निर्धारण गरी उनीहरूको स्वास्थ्यको सुधारको लागि नीतिगतपैरवी गरिनेछ।

अध्ययनका उद्देश्यहरू

नेपालमा नागरिक विज्ञान (citizen science)को प्रवर्द्धन गरेर समस्याहरूलाई सम्बोधन गर्न निम्न उद्देश्यहरू हासिल गर्ने रहेको छ;

क) वेल्डिङको धुवाँमा वेल्डरको एक्सपोजर स्तर र तिनीहरूको फोक्सोको कार्यक्षमताको परीक्षण अध्ययन गर्ने।
ख) वेल्डिङको धुवाँले उनीहरूको स्वास्थ्य र वातावरणीय प्रभावहरूको बारेमा कामदारहरूको धारणाको अध्ययन गर्ने।
ग) वेल्डिङ कामदारहरू र तिनीहरूका महासंघहरूमा अनुसन्धानका निष्कर्षहरू साझा गरी चेतना जगाउने।
घ) वेल्डिङ रड/इलेक्ट्रोड र व्यक्तिगत एक्सपोजर सीमाको मापदण्डहरू जारी गर्न सरकारसँग पैरवि गर्ने।

अध्ययन क्षेत्र

काठमाडौं, ललितपुर र भक्तपुरबाट विभिन्न ११वेल्डिङ कार्यशालाहरु बाट २१ वटा वेल्डिङको धुवाँ नमुनाहरु संकलन गरिएको थियो । पाटन औद्योगिक क्षेत्र, बालाजु औद्योगिक क्षेत्र, भक्तपुर औद्योगिक क्षेत्र र काठमाडौं उपत्यकाका अन्य इन्जिनियरिङ कार्यशालाबाट नमूना लिइएको थियो । पाटन औद्योगिक क्षेत्रबाट ९ वटा नमुना संकलन गरिएको थियो । एभरेष्ट इन्जिनियरिङ वर्कसप र सिन्धु मेटल वर्कसपबाट २ वटा नमूना लिइएको थियो । बालाजु औद्योगिक क्षेत्रबाट २ वटा नमूना सङ्कलन गरेका थियौं जुन बालाजु यन्त्रशालाको हो । अन्य नमूना सतुङ्गलबाट (१ जेपी स्टिल एण्ड इन्जिनियरिङ प्रालि), १ वटा मोर्डन भ्याली मेटल इन्जिनियरिङ, स्युचाटारबाट र १वटा श्रीकृष्ण मेटल प्रालिबाट संकलन गरिएको थियो । भक्तपुर औद्योगिक क्षेत्र (नेपाल ट्रान्सफर्मर) बाट ३ वटा नमूना लिइएको थियो । साथै ग्वार्कोमा रहेको (S&S मेटल वर्कसप) मा २ वटा मात्रै नमूना लिइएको थियो।अन्तत समग्रमा २१ नमुनाहरु संकलन गरिएको थियो।

अधय्यन विधि

१) अनुसन्धानमा परिमाणात्मक एवं गुणात्मक तथ्याकं संकलन विधि लागू गरिएको थियो।

२) काठमाडौं उपत्यकाका (काठमाडौं, ललितपुर, भक्तपुर) का विभिन्न वेल्डिङ कार्यशालाबाट तथ्यांक संकलन गरिएको थियो।

३) प्रश्नावली बनाइ सर्वेक्षण गरिएको थियो। प्रश्नावलीमा : उमेर, लिङ्ग, वैवाहिक स्थिति, शिक्षा, आयु, रोजगारीको अवधि, एक्सपोजर र अध्ययन सहभागीहरूको स्वास्थ्य अवस्था,धुम्रपानको स्थिति,बचावटका उपायहरु, इत्यादि समावेश गरिएको थियो ।

४) मेटल फ्याब्रिकेटर्स (८८) जना र कन्ट्रोल (२०) गरी कुल १०८ जनासँग प्रश्नावली सर्वेक्षण गरिएको थियो।

५) व्यक्तिगत नमूनाहरू(personal sampler) प्रयोग गरेर व्यक्तिगत एक्सपोजर स्तरको मापन (११ कार्यशालाका २१ जनामा) गरिएको थियो। साथै, सङ्कलन गरिएको धुवाँको नमुनाहरुमा धातुहरुको बारेमा पनि परिक्षण गरिएको थियो।

६) ८८ वेल्डिङ कामदारहरू बीचको पल्मनरि फनस्न टेस्ट (PFT) परीक्षणबाट तिनीहरूको फोक्सोको कार्यक्षमता परिक्षण गरिएको थियो।

७) तथ्याङ्कीय प्याकेजको प्रयोग गरी नतिजा विश्लेषण गरि प्रतिवेदन तयार पारिएको थियो।

८) अनुसन्धान मुलक प्रतिवेदन सबै सरोकारवाला विच एक जनचेतना तथा क्षमता अभिवृद्दि कार्यशाला गोष्ठि मार्फत सार्वजनिक गरिएको थियो।

परीणाम

नेपालमा मेटल फ्याब्रिकेटरहरू बीच वेल्डिङको धुवाँबाट हुने व्यावसायिक जोखिमलाई रोक्नको लागि जनचेतना र नीतिगत समाधानको प्रावधानको स्थिति अत्यन्तै कमजोर रहेको अवस्थामा गरिएको यो अध्यनबाट वेल्डिङ कामदारहरू कार्यशालामा काम गर्दा धेरै विषाक्त रसायनहरूको जोखिममा सहेको पाईएको थियो ।

वेल्डिङ धुवाँको मापन परीणाम

सि. न.	नमुनाहरु लिएको स्थान	वेल्डिङको धुवाको एकाग्रता (mg/m^3)	टिएलभि mg/m^3 by ACGIH	भेन्टिलेसनको सुविधा
१	पिआइए	२.८	५	क्रस भेन्टिलेसन
२	पिआइए	२.८		क्रस भेन्टिलेसन
३	पिआइए	२.८		क्रस भेन्टिलेसन
४	पिआइए	७.२		अपर्याप्त
५	पिआइए	८.४		अपर्याप्त
६	पिआइए	२६.४		अपर्याप्त
७	पिआइए	४.८		खुला
८	पिआइए	७.८		अपर्याप्त
९	पिआइए	१०.८		अपर्याप्त
१०	नखिपोट	३.८		खुला
११	नखिपोट	९.०		आधा खुल्ला
१२	संतुङगल	६.३		अपर्याप्त
१४	बउथलि	४९		खूल्ला ठाउँ
१५	स्युचाटार	३.१		खूल्ला ठाउँ
१७	बिआइए	४९		खूल्ला ठाउँ

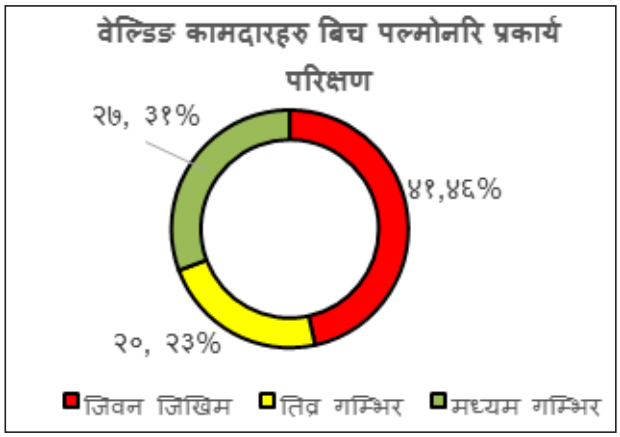
१८	बिआइए	३.१		खूल्ला ठाउँ
१९	भक्तपुर	१४.१		अपर्याप्त
२०	भक्तपुर	४६.५		अपर्याप्त
२१	भक्तपुर	११.६		अपर्याप्त
२२	ग्वार्को	५.०		पर्याप्त
२३	ग्वार्को	४.३		खूल्ला ठाउँ

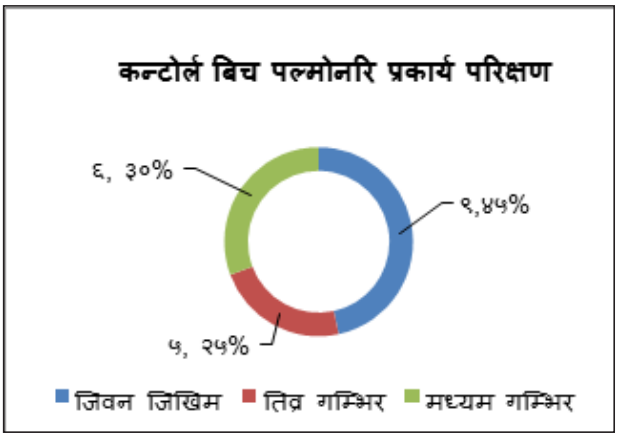
अध्ययनबाट, ५०% भन्दा बढी इन्जिनियरिङ कार्यशालाहरूमा वेल्डिङको धुवाँको स्तर निकै उच्च थियो। ५२% (२१ मध्ये ११) ११ वेल्डिङ कार्यशालाहरूबाट पढाइको अमेरिकी सम्मेलन सरकारी औद्योगिक स्वच्छता (ACGIH) दिशानिर्देश मापदण्ड (५ mg/m^3) नाघेको थियो। अर्थात ५०% भन्दा बढी वेल्डिङ कामदारहरूले वेल्डिङको धुवाँको उच्च स्तरको जोखिममा रहेका छन् भन्ने प्रष्ट हुन्छ।

त्यस्तै गरी, धुवाँमा धातुको विशेलेषण गर्दा फलाम, म्यांगनीज, क्रोमियम, निकेल, तामा र जिंक जस्ता धातुहरूको उच्च स्तर देखाएको छ।

नमुना संख्या	फलाम, mg/m^3	TLV, mg/m^3	म्यांगनिज, mg/m^3	TLV, mg/m^3	क्रोमियम, mg/m^3	TLV, mg/m^3	निकेल, mg/m^3	TLV, mg/m^3	कप्पर, mg/m^3	TLV, mg/m^3	जिंक, mg/m^3	TLV, mg/m^3
१	०.७४	५	०.०४	०.२	०.०००	०.००३	०.००३	०.२	०.००२५	०.२	०.०००७	२
२	०.४६	५	०.०४	०.२	०.०००	०.००३	०.०११	०.२	०.०००७	०.२	०.०००	२
३	०.७६	५	०.५८	०.२	०.३२८	०.००३	०.०७६	०.२	०.०६१६	०.२	०.०४७	२
४	१.८९	५	१.२७	०.२	०.०००	०.००३	०.०००	०.२	०.००२४	०.२	०.०२८	२
५	२.१८	५	०.१८	०.२	०.००१	०.००३	०.००८	०.२	०.०४०१	०.२	०.०५७	२
६	६.१०	५	०.७७	०.२	०.०००	०.००३	०.००३	०.२	०.००६३	०.२	०.०४७	२
७	०.४९	५	०.०७	०.२	०.००२	०.००३	०.०५१	०.२	०.००६९	०.२	०.०६३	२
८	०.१३	५	०.०६	०.२	०.०००	०.००३	०.०००	०.२	०.००००	०.२	०.०००	२
९	१.०५	५	०.१५	०.२	०.०००	०.००३	०.०००	०.२	०.००८१	०.२	०.००५	२
१०	०.६३	५	०.०६	०.२	०.०००	०.००३	०.०००	०.२	०.०१०१	०.२	०.०५३	२
११	१.८८	५	०.१६	०.२	०.०००	०.००३	०.०१४	०.२	०.००४५	०.२	०.०२१	२
१२	०.२८	५	०.०५	०.२	०.०००	०.००३	०.००८	०.२	०.००७२	०.२	०.०३४	२
१४	०.९५	५	०.०६	०.२	०.०००	०.००३	०.०००	०.२	०.००३९	०.२	०.०००	२
१५	०.३३	५	०.०१	०.२	०.०००	०.००३	०.०००	०.२	०.००५२	०.२	०.०००	२
१७	०.६९	५	०.०६	०.२	०.०००	०.००३	०.०१२	०.२	०.००००	०.२	०.००४	२
१८	०.३७	५	०.०२	०.२	०.०००	०.००३	०.०१९	०.२	०.००००	०.२	०.००९	२
१९	२.४५	५	०.१७	०.२	०.०००	०.००३	०.०११	०.२	०.००००	०.२	०.०१८	२
२०	५.००	५	१.२८	०.२	०.०००	०.००३	०.०२१	०.२	०.०१३३	०.२	०.०६३	२
२१	१.१०	५	०.२५	०.२	०.०००	०.००३	०.०३३	०.२	०.००३८	०.२	०.०३९	२
२२	०.७८	५	०.०४	०.२	०.०००	०.००३	०.०१६	०.२	०.००००	०.२	०.०४४	२
२३	०.६४	५	०.०२	०.२	०.०००	०.००३	०.०१०	०.२	०.००००	०.२	०.००२	२

१००% वेल्डिङको धुवाँ नमूनाहरूमा धेरै उच्च स्तरको फलाम र म्यांगनीज पाइएको थियो, १९% नमूनाहरूमा क्रोमियम पाइएको थियो, ७१.४२% नमूनाहरूमा तामा र निकेल र ८५.७१% नमूनाहरूमा जिंक पाइएको थियो। यसबाट कार्यशालामा काम गर्दा वेल्डिङ मजदुरहरू धेरै विषाक्त रसायनहरूको सम्पर्कमा आउने खतरा रहेको प्रमाणित भयो।

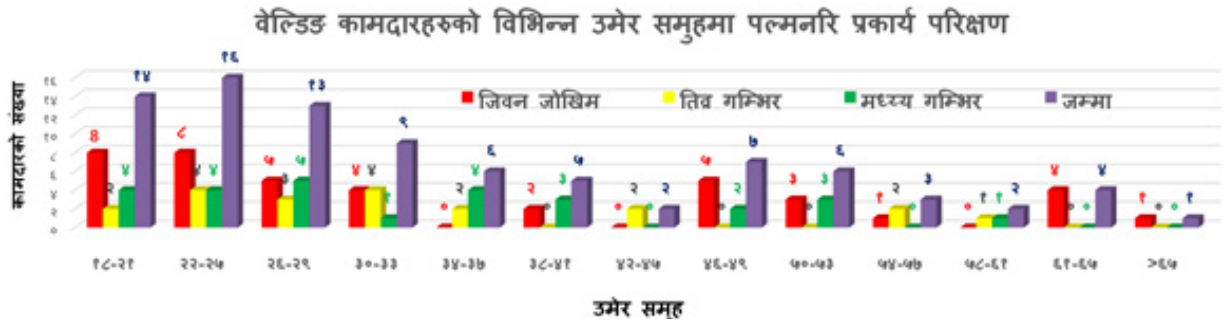




कुल ८८ वेल्डरहरू र २० कन्टोर्ल गरी जम्मा १०८ जना बीच पल्मोनरी फंक्शन टेस्ट (PFT) परीक्षण नमूनाहरू विश्लेषण गरिएको थियो र चार्ट तयार गरिएको थियो जसमा रातो रङले जीवन जोखिम(Life threatening) (४१.४६%), पहेँलो रङले तीव्र गम्भीर(Acute severe) (२०.२३%), र हरियो रङलाई मध्यम जोखिम(moderate exposure) (२७.३१%) को संकेत गर्दछ।

युवा कामदारहरू बढी जोखिममा छन्

यसबाहेक, श्वासप्रश्वास रोगको जोखिम युवाहरूमा प्रमुख रहेको छ। यसको अर्थ सबैभन्दा सानो उमेरका कामदारहरूको स्वास्थ्यमा गम्भीर असर परेको छ। यो अन्यथा उल्टो कुरा हुनुपर्छ। त्यसैले, चिकित्साको निगरानीमा रहिरहन वेल्डिंग कामदारहरू बीच आवश्यक छ। चित्रमा उल्लेख भए अनुसार जति कम उमेर उनीहरु नै सबैभन्दा बढी जोखिममा रहेको ग्राफले देखाइएको छ।



निष्कर्ष

अध्ययनबाट, नेपालमा मेटल फ्याब्रिकेटर्समा वेल्डिङको धुवाँको व्यवसायजन्य जोखिमलाई रोक्नको लागि चेतना र नीतिगत समाधानको व्यवस्थाको अत्यन्तै कमजोर स्तरको रहेको पाइयो । ५०% भन्दा बढी इन्जिनियरिङ कार्यशालाहरूमा वेल्डिङको धुवाँको स्तर निकै उच्च थियो। ११ वेल्डिङ कार्यशालाहरूबाट पढाइको २१ वेल्डिङ धुवाँको नमूनाहरु मध्ये ५२% (२१ मध्ये ११), ACGIH दिशानिर्देश मापदण्ड (५ mg/m^3) नाघेको छ भने ५०% भन्दा बढी वेल्डिङ कामदारहरू वेल्डिङको धुवाँको उच्च स्तरको जोखिममा छन्। जसमा धेरै विषाक्त धातुहरू छन्। औद्योगिक क्षेत्रहरू र ठूला ईन्जिनियरिङ् कार्यशालाहरूमा लामो समयर हेवी-ड्युटी वेल्डिंगको कार्य चलिरहेका छन्।धुँवामा पाईने धातुहरुको एक्सपोजर स्तर उच्च छ । वेल्डिङ वर्कशपहरुमा कार्यरत कामदारहरुको फोक्सोको कार्य परीक्षणको नतिजा हेर्दा उच्च प्रतिशत (४४ देखि ७८%) कामदारहरूको फोक्सोको कार्य बिग्रिएको पाइयो। यसबाहेक, वेल्डिङको धुँवाको धातु विशेषताले ५ mg/m3 को TLV मापदण्ड भन्दा बढि फलाम (Fe) जस्ता खतरनाक रसायनहरूको उच्च जोखिमको चिन्तालाई जन्म दिन्छ, जसबाट सिडरोसिस जस्तो रोग लाग्न सक्छ, ०.२ mg/m^3 को TLV मापदण्ड भन्दा बढि म्यांगनीजले प्रजनन क्षमता विफल हुन सक्छ। र TLV मापदण्ड ०.००३ mg/m^3 भन्दा परको क्रोमियमले क्रमशः जलन, रासायनिक जलन र क्यान्सर सम्म हुन सक्छ।

वेल्डिङ कामदारहरू कार्यशालामा काम गर्दा धेरै विषाक्त रसायनहरूको जोखिममा हुन्छन्। १००% वेल्डिङ धुवाँको नमूनाहरूमा ०.१३ देखि ६.१ mg/m^3 सम्मको फलाम (Fe) पाइएको थियो र १००% वेल्डिंग धुवाँको नमूनाहरूमा ०.०१ देखि १.२८ mg/m^3 सम्मको म्याङ्गनीज (Mn) पाईएको थियो, १९% नमूनाहरूमा ०.३२८ mg/m^3 क्रोमियम (Cr) सम्म पाईएको थियो। ७१.४३% नमूनाहरूमा ०.००० देखि ०.०६१६ mg/m^3 सम्मको कपर (Cu) र ७१.४३% नमूनाहरूमा ००.०० देखि ०.०३३ mg/m^3 सम्मको निकेल पाईएको थियो र ८५.६३% नमूनाहरूमा ०.००६ देखि ०.०६३ mg/m^3 सम्म जिंक (Zn) पाईएको थियो जसबाट कामदारहरु विभिन्न रोगको सिकार हुनसक्ने सम्भावना निकै बढी रहेको पाइयो ।

श्वासप्रश्वाससम्बन्धी रोगको गम्भीरता युवा उमेरका कामदार समूहहरूमा मुख्य रुपमा देखिएको छ।जसले अपेक्षाकृत लामो समयसम्म काम गर्नेछन्। यसको मतलब वेल्डिङमा काम गर्ने जवान कामदारहरूको स्वास्थ्यमा गम्भीर असर परिरहेको छ। यो अन्यथा उल्टो हुनुपर्छ। तसर्थ, वेल्डिंग कामदारहरूमा चिकित्सकिय निगरानीको बिल्कुल आवश्यक छ।

माथिको अध्ययनबाट धेरैजसो कामदार (८१%) ले हप्तामा ६ दिन काम गर्द थियो । हप्तामा ७ दिन काम गर्ने १९% थियो । दिनमा ८ घण्टा काम गर्ने कामदारको संख्या ५८% थियो ८ घण्टाभन्दा बढी काम गर्ने कामदार ४२% थियो । धुम्रपान नगर्ने (३२%) भन्दा धूम्रपान गर्ने कामदार (६८%) हरु बढी थियो । चुरोट पिउनेहरु (६४%) खैनी चपाउने भन्दा (३६%) धेरै थियो । १-५ वर्ष भन्दा बढी वेल्डिङको धुँवामा काम धेरै कामदारहरू थियो। १५ जना कामदार २५ वर्षभन्दा बढी समयदेखि वेल्डिङको धुवाँमा काम गरिरहेका थिए । अधिकांश कामदारको शैक्षिक अवस्था कम मात्र पढेका थियो ।

सिफारिस

वेल्डिङ कामदारहरूको समग्र व्यवसायजन्य सुरक्षा र स्वास्थ्य अवस्था सुधार गर्न अनुसन्धानको निष्कर्षका आधारमा निम्न तीन तहका सिफारिसहरू गरिएको छ।

१)नितिगत सिफारिसहरू

क) वेल्डिङ रडको गुणस्तर मापदण्डहरू लागू गर्ने र तिनको प्रभावकारी कार्यान्वयन र अनुगमन गर्ने संयन्त्र कायम गर्नुपर्छ।

ख) वेल्डिङ धुँवा र यसमा पाईने खतरनाक धातुहरूको अनुमतियोग्य एक्सपोजर सीमाहरू (Permissible Exposure Limit) विकास गर्नुपर्ने । यो ACGIH को TLV र OSHA को PEL लाई अपनाएर गर्न सकिन्छ।

ग) श्रम कानून(ऐन, नियमावलि र नीति, आदि) मा वेल्डरहरूको पेशागत जोखिमलाई वेल्डिङको धुवाँको सुरक्षा सम्बन्धि विशेष प्रावधानहरूको समावेश गर्नुपर्छ।श्रम तथा व्यवसायजन्य सुरक्षा विभागमा (DOLOS)मा सबै वेल्डरहरूको आवधिक स्वास्थ्य निगरानी रिपोर्ट पेश गर्न अनिवार्य बनाउनु पर्छ।

घ) वेल्डरहरूको कामलाई जोखिमपूर्ण कामको रूपमा परिभाषित र पहिचान गर्न जरुरी र तत्काल आवश्यक छ।

ङ) स्थानीय भाषामा वेल्डरहरूका लागि व्यवसायजन्य सुरक्षा र स्वास्थ्य (OSH) –केन्द्रित शिक्षा र जनचेतना मुलक सुचना सामाग्रिहरु (IEC) सामग्रीहरूको व्यवस्था गर्नुपर्छ।

च) वेल्डिङको काम प्रकृतिको खतरनाक आदि हुने भएकाले सबै श्रमिकहरुको स्वास्थय जिवन सुनिश्चित गर्न जिवनबीमा नीति लागू गर्न आवश्यक छ आदि।

२)औद्योगिक / कार्यशाला स्तर सिफारिसहरू

क) प्रत्येक वेल्डिङ कार्यशालामा न्यूनतम व्यवसायजन्य सुरक्षा र स्वास्थ्य (OSH)सगँसम्बन्धित प्रावधानहरू (जस्तै विश्राम कोठा, पुरुष र महिलाका लागि छुट्टै र सुरक्षित शौचालय, सफा र सुरक्षित कार्यस्थल) आदिको व्यवस्था मिलाउनु पर्दछ।

ख) इन्जिनियरिङ् र प्रशासनिक नियन्त्रणको पर्याप्त प्रावधानले वेल्डिङको काममा सबै सम्भावित खतराहरूको समाधान गर्नुपर्दछ।

ग) सबै वेल्डिङ कार्यहरूमा स्थानीय धुँवाको निकास भेन्टिलेसन प्रणाली प्रदान गर्नुपर्दछ। वेल्डिङमा आधारित उद्योगमा क्रस भेन्टिलेसनको व्यवस्था हुनुपर्दछ ।

घ) सीमित र बन्द ठाउँमा काम गर्दा कार्य अनुमति प्रणाली लागुगर्नुपर्दछ।

ङ) वेल्डर र ननवेल्डरहरू बीच ब्यारिकेशन(अलग अलग व्यवस्था) हुनुपर्दछ।

च) नियमित व्यवसायजन्य सुरक्षा र स्वास्थ्य (OSH) र वेल्डरहरूका लागि सचेतना प्रशिक्षण तालिम आदि।

छ) वेल्डरहरूलाई वेल्डिंगको धुवाँबाट जोगाउने किसिमका रेस्पिरेटर प्रदान गरिनु पर्छ।

३) श्रमिक स्तर सिफारिसहरू

क) क्रस भेन्टिलेसन क्षेत्र वा खुला ठाउँहरूमा काम गर्ने व्यवस्था गर्नुपर्दछ।

ख) वेल्डिङ रड र केबललाई एकै छेउमा सँगै राख्नुपर्दछ।

ग) सन्तुलित आहारको उपभोग गर्नुपर्दछ।

घ) पूर्ण व्यक्तिगत सुरक्षा सामाग्रिहरु (PPEs) को अनिवार्य प्रयोग गर्नुपर्दछ।

ङ) धुम्रपान गर्ने बानी त्याग्नका साथै व्यक्तिगत सरसफाइमा ध्यान दिनुपर्दछ।

च) वेल्डरहरू बीच नियमित व्यवसायजन्य सुरक्षा र स्वास्थ्य (OSH) सम्बन्धि तालिम र जनचेतना बढाउनु पर्दछ आदि।

Center for Public Health and Environmental Development (CEPHED) is an environmental NGO established in the year 2004, by a group of activists and experienced people from the medical, environmental, and public health sectors. CEPHED's focus is to serve Nepalese people and communities in the field of public health and the environment. CEPHED has adopted the vision of connecting people to science and technology for healthy leaving and environmental safety and providing access to new scientific knowledge, technology and safety measures from the environment and public health sectors through research, coordination, capacity building, and policy dialogue.

CEPHED has been engaged mainly in research, awareness raising, capacity building, and policy development especially in the areas of chemical management, pesticides, obsolete pesticides, healthcare waste, persistent organic pollutants (POPs), heavy metals like mercury, lead, and cadmium, toxic children toys, lead in paints, lead in household and school dust, lead in artificial jewelry, lead in lipsticks, mercury in cosmetic-skin whitening creams, mercury in a hospital environment, mercury in aquatic animals (fish), mercury in CFLs, lead in noodles, lead in kajal (eye product), lead and mercury in Sindoor, pesticides in vegetables as well as mercury in human bodies (dentists, nurses, fishermen, and women of childbearing age, workers of metal plating workshops and Ayurvedic medicine industries') and also working on Occupational and Environmental Health and Safety (OEHS) issues. CEPHED has contributed to successful policy influences like Lead paint standards, cosmetic standards, highly hazardous pesticides, ban of mercury-based equipment, banning of mercury dental amalgam, banning of import, sale, distribution, and uses of all form of asbestos in Nepal etc.,

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Occupational Safety and Health Center (OSHC): In view of the need to develop the promotion and protection of safe working conditions in industrial establishments as a complete basic aspect of industrial business, then His Majesty of Government with technical support from ILO established the Occupational Safety and Health Project (OSHP) in the year 2052 B.S. (1995 A.D. According to the decision of the Government of Nepal, Council of Ministers dated 2075/3/32 B.S., the OSHP was named "Occupational Safety and Health Center (OSHC)", and the permanent organization structure has been approved since 2075 Shravan 1 (17 July, 2018). Its objective is to implement related Laws, Rules & Regulations, Codes of practice, Guidelines and Standards for the promotion of occupational safety and health at the workplace; regular and systematic workplace inspection and monitoring of legal provisions of workplace reform; the proper mechanism for the flow of necessary information and also server as a resource center for necessary training and training for all parties concerned for the protection and promotion of health and safety of workers at the workplace.

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SMS Environment and Engineering Pvt. Ltd. (SMSEE) is a private consulting service company established in the year 2014 AD. It has been carrying out consulting and scientific services mainly in the core areas of Occupational Safety and Health (OSH), Environment, and Energy Efficiency. The company also owns a well-equipped laboratory that specializes in environmental, energy, and occupational safety and health monitoring and analysis. The company has been providing its expert consulting and research services to government agencies, NGOs, INGOs, municipalities, industries, hospitals, hydropower, construction projects, etc. in formulating standards, assessment of safety measures, monitoring environmental parameters, and energy auditing, training, and many more. SMSEE aims to assist all the sectors of industries and business corporations to enhance their productivity, and quality of products, improve the working conditions, assist in complying with the promulgated OSH and environmental standards, and thereby improve the quality of life of the people.

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The Federation of Grill and Steel Fabricators, Nepal (FGSFN) is an umbrella organization of 11,000 metal fabricators operating across the country founded in 2069. At present, the network of the federation has been expanded to 67 districts of the country. With the aim of establishing the grill business as an orderly and dignified profession by promoting the protection of the rights and interests of the grill and steel enterprises who have been providing services by doing all the work related to metal fabrication of grill materials, gates, ladders, railings, trusses, shutters, poles, turbines, and metal fabrication, etc. The Federation in cooperation with various organizations produces skilled manpower required in the grill industry, providing various types of training related to insurance, occupational safety, and health. Uses of PCB-contaminated transformer oils have been eliminated jointly with CEPHED by showcasing the safer alternative of dry welding machines thus protecting the welders' health and environment. Currently also collaborated for this welding fumes study. In the same way, the Federation also publishes the price list of grills and other goods, carries out a physical examination of workers, administers vaccination, blood donation, industrial visits, reports the problems of grill business to various agencies of the government, and get it solved, bring illegal businesses under the legal scope, etc. The federation has been also working towards ensuring jobs, instructing and encouraging workers to use safety equipment - gloves, glasses, helmets, aprons, shoes, safety belts, etc. In this way, according to the demand of the time, the federation is moving forward with the goal of making effective plans for the bright future of the grill and steel enterprises.

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