GB-EPA

REPORT ON

ASSESSING INDOOR AIR QUALITY DUE TO FUEL WOOD BURNING AND ASSOCIATED CARDIO-VASCULAR AND RESPIRATORY DISEASES IN THE BUFFER ZONE OF CENTRAL KARAKORAM AND DEOSAI NATIONAL PARK

Report developed by: Gilgit-Baltistan Environmental Protection Agency (GBEPA) and WWF–Pakistan, Gilgit-Baltistan

The report on assessing Indoor Air Quality due to fuel wood burning and Associated Cardio-vascular and Respiratory Diseases in the Buffer Zone of Central Karakoram and Deosai National Park was prepared by the technical assistance of Gilgit-Baltistan Environmental Protection Agency (GBEPA) and funded by WWF Pakistan, under the framework of the "***Improvement of central Karakorum National Park Management System as model for mountain ecosystems in Northern Pakistan"*** Project, funded by the Government of Italy and UNDP-Pakistan.

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Abbreviations and Acronyms

AD	Animal Dung
AR	Agricultural Remains
ARI	Acute Respiratory Infection
ASHRAE	American Society of Heating Refrigeration and Air Conditioning Engineers
BZ	Buffer Zone
CFM	Cubic Feet per Minute
CKNP	Central Karakorum National Park
CO	Carbon Monoxide
CO2	Carbon Dioxide
COHb	Carboxyhemoglobin
COPD	Chronic Obstructive Pulmonary Disease
CZ	Core Zone
DNP	Deosai National Park
EC	Electricity
GB	Gilgit-Baltistan
GB-EPA	Gilgit-Baltistan Environmental Protection Agency
IAP	Indoor Air Pollutant
IEQ	Indoor Environmental Quality
NEQS	National Environmental Quality Standards
PM	Particulate Matter
R&D	Research and Development
SBS	Sick Building Syndrome
UNDP	United Nations Development Program
SUPARCO	Space and Upper Atmosphere Research Commission
WHO	World Health Organization
WWF	World Wildlife Fund for Nature

Executive Summary

Human gets exposed to toxic pollutants through inhalation and ingestion; long lasting bioaccumulation and toxicity of these pollutants have demonstrated a great threat for human health and environment. These toxic pollutants get their path in air through burning of fossil fuel, wood, coal, animal dung and agricultural remains. The toxicity of these pollutants to human depends on duration, concentration and route of exposure. Due to free radical formation, these pollutants accumulate in human body and cause various chronic disorders. Prolonged exposure can lead to chronic respiratory infections, asthma, eye stinging, hypertension and heart diseases. In mountainous area like Gilgit Baltistan (GB), due to prolong winters, impoverished conditions and lack of access to modern energy sources, the local populace residing in high altitude areas is highly dependent on animal dung, agricultural remains and wood to meet their daily energy needs.

This study (a causal research study) was conducted to assess the indoor air quality and to estimate potential health burden in two high altitude buffer zone villages of Central Karakoram National Park (CKNP) and one village of Deosai National Park (DNP). A total of 15 households (5 from each village) were selected to assess Indoor Air Pollutants (IAP). Twenty four hours data of Particulate Matter (PM2.5), temperature, humidity and eight hours data of CO was monitored along with ventilation rate (CO_2).

The average concentration of PM2.5 was almost 100 times higher than the National Environmental Quality Standards (NEQS) and World Health Organization (WHO, 2005) guidelines. About 66% of the samples were found beyond the National Environmental Quality Standards for CO on 8 hours average. Among the samples 60% were under-ventilation not fulfilling the ASHRAE standards **(American Society of Heating Refrigeration and Air Conditioning Engineers)** for living rooms. The air quality in homes using electricity and LPG for cooking and heating in separate kitchens with proper ventilation was within the limits of health based standards. High concentrations of PM2.5 and CO were recorded in homes using animal dung and wood, especially during cooking hours.

Health impact assessment indicated an increased level of disease burden during winters. According to the respondents, prevalence of respiratory and cardio-vascular diseases during winters were in order of Cough > Wheezy, Bronchitis > Heart Diseases, Chest Tightness and Shortness of breath (asthma).

This study intends to draw attention of Policy Makers towards a grave public health issue. Effective and efficient energy solutions exist, which need to be practically implemented in marginalized high-altitude communities. Provision of improved stoves and modern energy sources (LPG, Electricity etc.) along with better insulation/construction practices will decrease the risk of exposure to indoor air pollutants and uplift the economic conditions by reducing the expenditure on health and energy demand. Household efficient energy programs will lift families out of poverty and accelerate development progress.

1. Background

To meet the energy demands on daily basis, more than one half of the global population and around 95% of poor countries worldwide rely on coal, solid fuels and biomass fuels (wood, agricultural residue, dung). These fuels are used for heating and cooking on traditional stoves or open fires which generates high level of pollutants including carbon monoxide and particulate matter. These Indoor Air Pollutants (IAP) causes enormous health threats to human beings globally. Women, young children and elderly people are more susceptible to IAP as women are mostly responsible for activities like cooking and heating; children and elderly people spent most of the time indoor (Duflo et al., 2008).

Solid fuel is among the top most environmental factors causing fatal diseases; it is ranked fourth among overall excess deaths after waterborne diseases, malnutrition and unsafe sexual activities (Bruce et al., 2006). Number of research studies have been conducted which concludes that IAP may cause chronic effects on human health, their long term exposure in early ages may cause chocking of lungs and influences productivity in life later (Almond., 2006).

1.1. Fuel Types, Traditional Cooking Stoves and Air Pollution Levels

On daily basis approximately three billion people put their lives at risk by using solid fuels which is "The world's single greatest environmental health risk". According to WHO more than 3 billion people with low income level and development stand at the bottom of energy ladder depending on locally available fuel sources, neither efficient nor clean (Holdren et al., 2000). Major portion of this population resides in Africa and Asia; about 95% population in Chad and Afghanistan rely on these fuels, followed by Ghana, India and China.

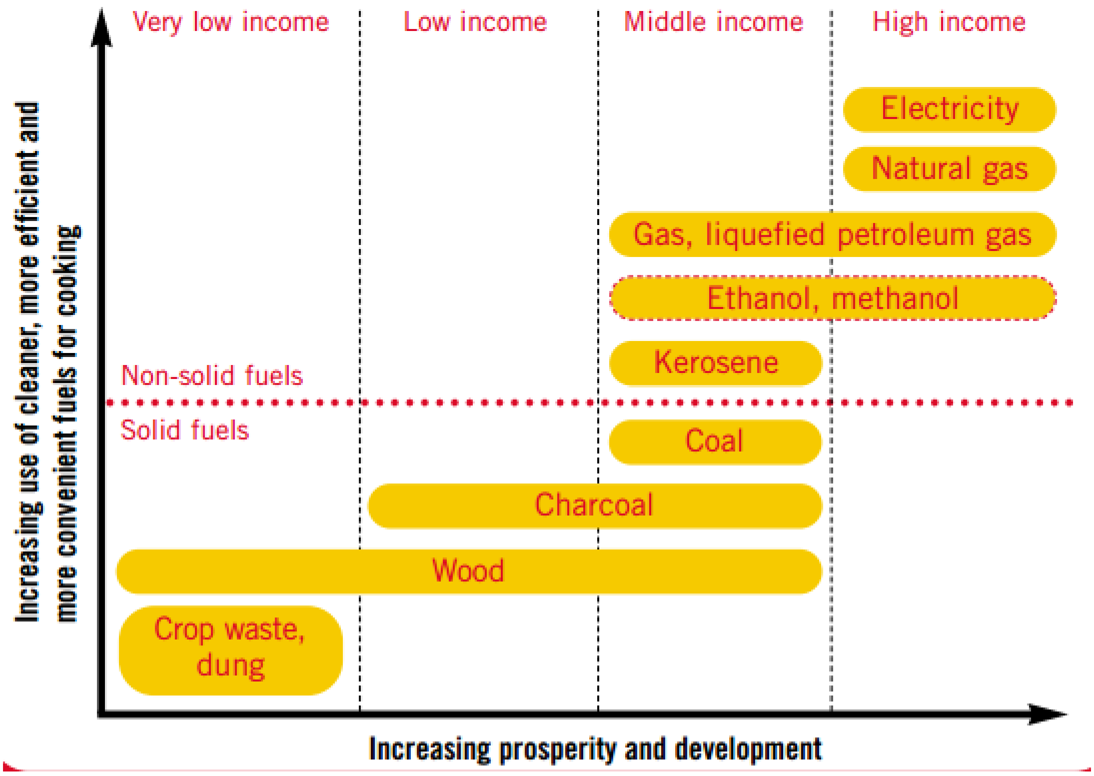

Figure 1: **The energy ladder: household energy and development inextricably linked.**

Source: Rehfuess, E., and World Health Organization, 2006.

Exposure of IAP to the populace at lower level of the energy ladder is 10 times more than permissible limits of NEQS for 24 hours. According to a study conducted by Holdren et al., in 2000, in India the concentration of PM10 for average 24 hours exceeds 2000µg/m^{3}in households using solid fuels. Dasgupta et al. in 2004, found an average 600 µg/m^{3}in Bangladesh. Ezzati, Saleh and Kammen conducted a real time study for two consecutive years i.e.2000 and 2001 in rural Kenya, they found peak concentration of 50,000µg/m^3 in cooking area, which concluded that in developing countries children, women and old age people gathered near stoves are mostly exposed to dangerous levels of pollutants.

A study conducted by SUPARCO in Azad Jammu and Kashmir 2010; in Muzaffarabad measured value of PM2.5 ranged from 16µg/m^3 -128µg/m^3, in Mirpur the values varied from 25µg/m^3-120µg/m^3. Stone et al. 2009 in Lahore reported annual average concentration of PM2.5 of 194±94µg/m^3. Similarly Raja et al.2009 measured a highest value of 476µg/m^{3}in Lahore. Qadir and Zaidi, 2006 in Faisalabad measured Total Suspended Particles (TSP) on working days which ranged between467µg/m^3-600µg/m^{3}with an average of 550µg/m^3.

The Global Health Community recognized that there is lack of information or no information at all in some parts of the world about the exposure level and harmful effects of burning low quality solid fuels.

2. Introduction

Indoor Environmental Quality (IEQ) is "the quality of a building's environment in relation to the health and well-being of those who occupy space within it" (Karapetsis et al., 2016). Highly complex indoor environment and individuals residing in buildings are prone to different levels of contaminants released in the form of gases and particles. The main sources of indoor air pollutants are combustion, construction, cleaning products, microbial growth and tobacco smoke. Long-term exposure to these pollutants reduces longevity due to lung cancer, respiratory and cardio-vascular diseases. Increase in cardiovascular and respiratory diseases, exacerbation of asthma and other related health impacts are due to short-term exposure (over hours or days) to high levels of air pollution.

Many efforts during last three decades have been made to save human health from harmful effects of outdoor pollutants. A large number of air monitoring stations have been installed in different sensitive and critical areas. These equipment provides information on outdoor pollutants to which populace is exposed. Contrary to this, people spend 80-90% of their time in indoor ambiences, the quality of which is very important factor influencing the health.

Energy plays vital role to meet the basic needs of mankind such as lighting, cooking, heating and boiling water. Energy, a prerequisite for good health, is being largely ignored worldwide. According to an estimate by World Health Organization (WHO 2006), 1.5 million deaths (mostly children and mothers) per year and millions suffer by chronic respiratory diseases, are attributed to poor indoor air quality.

WHO reviewed the epidemiological studies conducted to investigate the impacts of indoor air pollution on human health. According to this review, children under the age of five year are at more risk of pneumonia and other severe infectious diseases due to inhalation of indoor polluted air. Exposure of women to indoor pollution is three times more and likely to suffer from chronic bronchitis, obstructive pulmonary disease and emphysema.

Approximately 3,96,000 deaths in Sub-Saharan Africa and about 4,83,000 deaths in South East Asia have been reported due to indoor air pollution from burning of biomass fuels during 2002. High reliance on coal and biomass in China resulted in chronic respiratory diseases among adults, and took 4, 66,000 lives in Western Pacific in 2002. The majority of victims of indoor air pollution is poor urban dwellers and rural communities, and will leave devastating effects if ignored (Zhang and Smith., 2007).

2.1. Indoor Air Quality and Health Diseases

Among various pollutants particulate matter and carbon monoxide being the smallest airborne particles poses negative impacts on human health and contributing towards acute respiratory infections and cardio-vascular diseases.

2.1.1. Acute Respiratory Diseases

Irritation and inflammation in the lungs are due to the prolong exposure to air pollutants which cause malfunctioning of the lungs/respiratory system. Poor air quality adversely impacts the human health especially in pregnant women, children and/or those who are already suffering from any lung or heart disease (Brown et al., 2008).Exposed to higher concentration of indoor air pollutants for longer period, can cause chest tightness, shortness of breath, coughing, headaches and throat irritation in healthy people as well (Klara et al., 2012).

2.1.2. Chronic Respiratory Diseases

Air pollution and asthma are interlinked; it's a condition which causes swelling of airways, production of more mucus causing difficulty in breathing. Repeated exposure to higher level of air pollutants can cause severe respiratory infections like cold, pneumonia or bronchitis, increase hospitalization rates due to asthma. Chronic exposure to higher level of air pollution aggravates inflammation of lungs characterized by obstructed air flow and its persistence leads to Chronic Obstructive Pulmonary Diseases (COPDs). It is mostly caused by smoking and exacerbated by indoor and outdoor air pollution as well (WHO 2005).

2.1.3. Lung Cancer

Lung cancer is notably caused by smoking, while the risk of this disease is increased by occupational and environmental exposure. In 2013, WHO (International Agency for Research on Cancer) concludes that air pollution especially outdoor is a known carcinogen, which is described as abnormal or uncontrolled cells in lungs, which resultantly impairs the lungs function leading to development of tumors. The growth of tumor can destroy tissues of lungs and other organs, and spreads to other body parts (Delfino et al., 2008).

2.1.4. Heart Disease and Stroke

Exposure to outdoor or indoor air pollution increases the risk of stroke and heart disease. According to research conducted by USEPA and the American Heart Association, they found that long-term exposure to air pollution is directly linked to plaque buildup which cause narrowing or blockage of arteries; healthy individuals exposed to air pollution specifically particulate matter and nitrogen oxides for prolonged time had accelerated cases of atherosclerosis, to the extent that in some individuals, risk for heart attack increased. Researchers found that the higher the exposure level, the faster atherosclerosis progresses. This relationship proved by different scientists and published their results in Lancet research journal during August 2016, which states that factors like worsen inflammation and premature blood vessels and accumulation of calcium in coronary artery; all are caused by long-term exposure to pollutants.

2.2. Indoor Air Pollutants and Associated Risks

2.2.1. Particulate Matter (PM)

Particulate Matter is not a single compound but the mass concentration of all particles smaller than 2.5µg and 10µg in diameter in ambient air. High level of PM 2.5 and PM 10 leads to coronary obstruction, respiratory infections, asthma and excess mortality including cardio vascular diseases, especially in women and children (Bonvalot et al., 2016). PM is mostly used indicator of indoor air pollution and health hazard. These particles easily penetrate into blood stream and lungs and have highest health damaging potential (Chen et al., 2015).

2.2.2. Carbon monoxide

Incomplete combustion of fuels emits carbon monoxide, which is colorless, odorless and toxic gas. Solid fuels used for cooking and heating inside homes are major source of indoor CO pollution. Exposure to high concentrations of carbon monoxide can be fatal. Carbon monoxide is absorbed through the lungs and spreads through the alveolar capillary membrane. Once absorbed, it passes through the erythrocyte membrane and enters the erythrocyte matrix, forming carboxyhemoglobin (COHb) with hemoglobin; carbon monoxide has a 200-fold higher affinity for hemoglobin than oxygen (Tiwary and Colls, 2009). This binding reduces the ability of the blood to carry oxygen and interferes with the release of oxygen from the tissues; the resulting loss of oxygen delivery can interfere with cellular respiration and cause tissue hypoxia. The health effects of carbon monoxide are generally thought to be related to the level of carboxyhemoglobin in the blood. In addition, to increased daily mortality, the health effects of carbon monoxide include early onset of cardio-vascular disease, behavioral disorders, decreased performance in young healthy men, birth weight loss, and sudden infant death syndrome (Saksena et al., 1992). The severity of the CO poisoning depends on the concentration of the exposed individual, the time of exposure and the general potential health condition. The acute effects of carbon monoxide poisoning are particularly acute in organs that require large amounts of oxygen, the brain and heart. Prolonged or chronic exposure to carbon monoxide can lead to symptoms that are easily misdiagnosed, such as headache, fatigue, dizziness and nausea (Jones, 2002).

3. Contextual Analysis

In Gilgit-Baltistan the impacts of indoor air quality and processes/effects on human health is yet to be established. Exposure to certain chemicals and materials through air is one of the major environmental health issue in various parts of GB. Indoor ambient environment, being contaminated with a variety of chemicals poses serious environmental health threats, both for communities and the overall environment of the region.

In GB, harsh climatic conditions such as prolong winters at high altitude valleys, as well as lack of access to energy sources like, LPG, electricity, biogas and fossil fuel along with geographical and socio-economic conditions compel the local populace to consume wood and animal dung as a major source of energy. During prolonged winters, i.e. from October till March, large quantity of wood and animal dung is used for cooking and heating purposes. At higher elevations this practice remains throughout the year.

Built structures with inadequate ventilation for energy conservation measures are one of the main causes of poor indoor air quality. Concentration of pollutants from building materials and heating system can be reduced through design interventions i.e. proper ventilation. In rural areas of GB, constructions are based on traditional design practices in a way to conserve energy for longer periods, which reduces proper ventilation and sustain pollutants. ***Bukhari*** is a wood burning traditional system widely used for heating and cooking purposes across GB. The existing design and construction practices of houses in GB and the poor design and manufacturing of Bukhari and its flawed installation inside the building contributes to annual deaths from carbon monoxide poisoning and ARI (Acute Respiratory Infections) in aged and new-born.

4. Scope of Study and Objectives

This study intends to draw attention towards an ignored public health concern, which will help in provision of improved fuel efficient and environment friendly alternatives for energy, resultantly improving women's health and reduce child mortality. Beside health improvement, economically effective household energy programs will uplift economic conditions of the community and accelerate development progress.

An immediate action is required to adopt specific strategies using a framework to combat prevalent risk factors in environment. Given the geographical location and available resources; wise-use of existing resources is needed to tackle prevailing environmental risk in the region.

In order to design appropriate strategies, policies and mitigation measures to reduce the health risk due to poor indoor air quality and to understand spatial and temporal scales of the change, a baseline study on indoor air quality and related cardio-vascular diseases was carried out.

4.1 Objectives

Keeping in view the gravity of situation, GB-EPA has carried a joint venture with WWF-P and UNDP, aiming to study the indoor air quality of rural areas and assess their impacts on human health. The co-operation is based on the development of an improved regional knowledge, information and research gap analysis. The main objectives of the study are:

1. To determine the level of indoor air quality in three villages of the project sites;

2. To examine impacts of indoor air quality on health of mountain communities in Gilgit-Baltistan.

5. Methodology

A causal research study was designed to assess the indoor air quality and related diseases. Over all 15 samples were collected by adopting simple random sampling method from three buffer zone villages of CKNP and DNP i.e. Astak District Skardu (Sample 1-5), Hoper District Nagar (Sample 6-10) and Sher Quli District Astore (Sample 11-15); five houses were selected from each village.

On the basis of identified sampling locations a data acquisition plan was developed to obtain representative data on the required environmental parameters (annex-I). A total of three criteria indoor air pollutants, including Particulate Matter (PM2.5), Carbon monoxide (CO) and Carbon Dioxide (CO_2) along with temperature and humidity were examined on-site by using portable environmental monitoring equipment.

Monitoring equipment were placed in main living area, where community spend their most of the time, at a distance of 1m from doors, windows and cooking /heating sources. The data was collected between 8thOctober and 5thNovember 2019. TSI Dust Track Aerosol Monitor Model 8520 USA was acquired to collect and log real time data in µg/m^3 for PM2.5.To monitor temperature, humidity and CO_2in ppm, Telaire® 7001i and HOBO Data Logger (Edinburgh Instruments Ltd, Livingston, UK) were used to log real time data. CO levels were measured and recorded for 8-hour period by using Testo 317-3,CO Monitor.

Equipment	Parameters	Working Principle
DustTrak Aerosol Monitor - 8520(USA)	Particulate Matter PM2.5	Laser Photometry
TELAIRE, 7001, CO_2 Monitor (Mexico)	Carbon dioxide(CO_2), Ventilation	Non-Dispersive Infrared (NDIR) Spectroscopy
Testo 317-3,CO Monitor (Germany)	Carbon Monoxide (CO)	Biomimetic Sensor Technology
HOBO Data Logger U12-013 (Australia)	Temperature, Relative Humidity	Electric resistance

5.1 Survey based data

A questionnaire was developed to collect contextual data on fuel type, household, inhabitant activities and related health impacts. The questionnaire was divided in two sections comprising 25 items, the first section investigated general information about fuel type and consumption patterns while the second section assessed different diseases related to the indoor air pollutants(annexure-II).

5.2 Guidelines

National Environmental Quality Standards of Pakistan for ambient air quality recommends 35µg/m^3 and 15µg/m^3 for PM2.5 for 24 hours and 1 hour standard values respectively. The average 8 hours standard limits for CO is 5mg/m^3. American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) indicate the level of CO_2 concentration above 1000ppm as poor ventilation. There are no WHO and NEQS for CO_2 concentration.

5.3. Study Area

GB contains one of the most spectacular landscapes of the world. The three mightiest and geologically active mountain ranges in the world–the Hindu Kush-Karakoram-Himalaya (HKH) confluence in the area. Towards the west of GB lies the eastern Hindu Kush, towards the north and east stands the Karakoram Range; and the western Himalaya stands in GB's southern parts.

GB is spread over an area of 72,971 square km, nearly half of which contains mountain peaks, glaciers, lakes and highlands. There are 14 mountain peaks above 8,000 m (known as 'eight thousanders) in the world, of which five (05) are found in GB. More than 50 peaks above 7,000 m stands within a radius of 500 km in the region. A vast glacial area spread over 15,000 square km comprises of at least 5,000 big and small glaciers, including three of the world's longest outside the polar region (Biafo, Baltoro and Batura). There are nearly 3,000 big and small glacial lakes; out of which at least 36 are considered to be unsafe and at the verge of an outburst in different parts of the region. Although, the three major mountain ranges in GB considerably differ from one another, one common feature is the complexity of their topography. A crucial feature of GB is that its mountain ecology and socio-economic systems are strongly inter-dependent. Any imbalance on either side can jeopardize this delicate relationship between man and the nature.

The study was conducted in the buffer zone of Central Karakoram and Deosai National Parks. These park areas mainly consist of two main zones, Core zone and Buffer zone. The Core Zone (CZ) aims at preserving a unique ecosystem, and is populated by important species, where long-term conservation and preservation has to be ensured. Whereas, Buffer Zone (BZ) is important to maintain a harmonic interaction between nature conservation and the use of the natural renewable resources through a sustainable way. This promotes the conservation of landscapes, traditional forms of land use, together with social and cultural features.

These natural parks are the highly glaciated areas in the world and extremely sensitive to climate change. The volume of ice in a glacier, its surface area, thickness and its length is determined by the balance between input (snow and ice) and outputs (melting and calving). These factors are regulated by temperature, humidity, wind speed and slope.

Three buffer zone villages; Sher Quli from DNP and; Hoper and Astak from CKNP were selected to conduct the study. The communities of these areas are highly dependent on natural resources in mountainous terrain and are vulnerable to the changing climatic patterns which have effects on its built environment, lives, livelihood and economy. Communities are totally dependent on solid fuels including wood, coal and animal dung for energy due to harsh climatic conditions.

Central Karakoram National Park (CKNP)

The CKNP covering an area of 10,557.73 km^{2}one of the largest protected area in Pakistan and highest National Park in the world, spreads over five administrative districts of GB. It was declared as the National Park in 1993 to protect and manage fragile mountain ecosystem, associated biodiversity and other natural resources. It is characterized by extremes of altitudes that range from 2,000 ma.s.l to over 8,000 ma.s.l, including K2, the second highest peak in the world.

Deosai National Park (DNP)

The DNP covering an area of about 3000 km^2 and its elevations range from 3,500 to 5,200 ma.s.l, with about 60% of the area between 4,000-4,500 m. Mean daily temperatures range from -20 °C to 12 °C. It was declared as the National Park in 1993 by government of Gilgit-Baltistan in collaboration with WWF-P for protection and conservation of Himalayan Brown Bear and its habitat.

DNP and CKNP are typical highland ecosystems, which is characterized by low atmospheric pressure, cold, aridity, low oxygen and carbon dioxide levels, intense isolation, rapid radiation, and high ultraviolet radiation. The park is covered by snow most of the year (October- May, depending on weather).

Figure 2: Map of Gilgit-Baltistan

6. Results & Discussion

A total of 15 samples were collected from three villages Astak (n=5), Sher Quli (n=5) and Hoper (n=5). An integrated approach for heating and cooking (i.e. use of agricultural remains, animal dung, wood/woody shrubs, gas and electricity) was observed in all selected houses, though the ratio of wood and animal dung was higher than all other sources. Table 1 provides summary of different energy sources used in the study area.

Table 1: Source of Energy used

Sources	All (n)	Astak	Sher Quli	Hoper
Coal	-	-	-	-
Animal Dung	11	3	4	4
Wood	9	2	4	3
Agricultural Remains	3	1	0	2
Gas	4	2	1	1
Electricity	2	1	-	1

6.1. PM 2.5

This study characterizes the concentration of major indoor pollutants in ambient air, where open or inefficient combustion takes place. It was difficult to examine the pollutants by nature with a single fuel type, as all the sampled houses were using different type of sources at a time.

The mean concentrations of PM2.5 recorded for continuous monitoring of 24 hours were160.435µg/m³, 60.924µg/m³ and 124.836µg/m³ for Sher Quli, Astak and Hoper respectively. Among the samples tested40% (n=2) from Astak, 60% (n=3) from Hoper and 80% (n=4) from Sher Quli were found beyond the NEQS as depicted in Figure No.3.

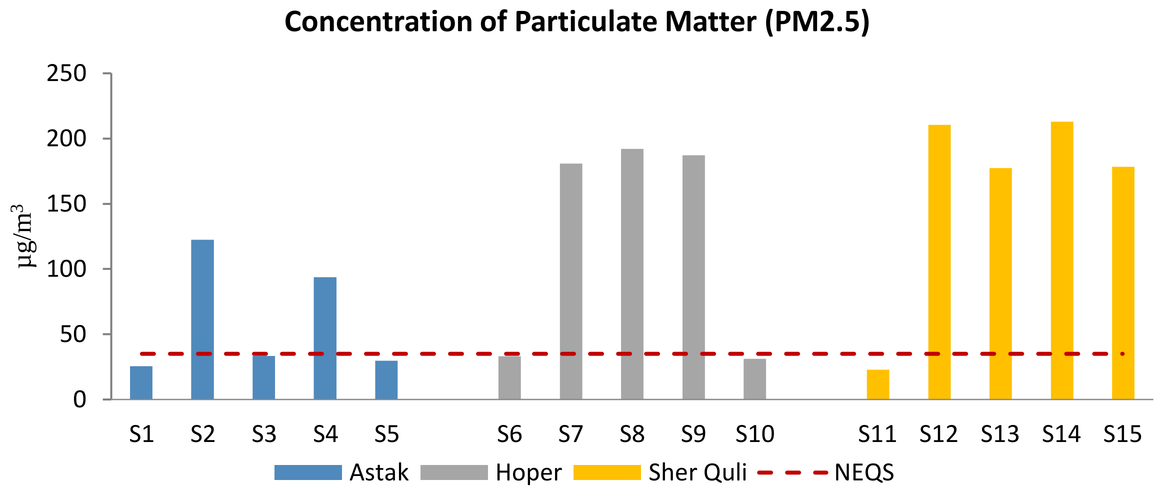

Figure 3: Average (24 hours) concentration of PM 2.5

The samples using electricity and gas as a main source of energy and having separate kitchen with proper ventilation, showed an average value of 28.4µg/m³ for 24 hours monitoring, where as wood and dung burning samples, the average concentration of PM2.5 for 24 hours was 158.8µg/m³, which showed much higher concentration of PM 2.5 than households using electricity and gas.

The concentration of PM2.5 during cooking time was also recorded. This monitoring was carried out to better reflect the exposure of women and children, spending most of the time indoor.

Following figure illustrates 24 hour average concentration of PM2.5. The peak values of PM2.5 represents active smoking within homes, a clear increase in concentration can be seen during the hours of cooking i.e. 8pm to 12pm and then again during breakfast time i.e. 7am to 11am; the level then decrease once the occupants go for sleep in night and for work during day time.

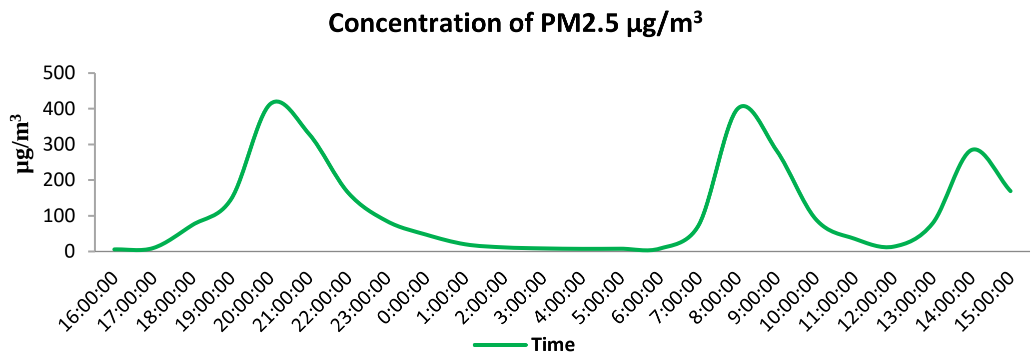

Figure 4: One hour average concentration of PM2.5 for 24 hours

6.2. Carbon Monoxide (CO)

The real time concentration of CO in ppm was monitored at each identified location for 8 hours. The results indicated a minimum concentration 4.4 ppm of CO at sampling site S1; whereas it was found highest 13.72 ppm at sample site S12. The average values of 60% (n=3) samples from Astak, 60% (n=3) samples from Hoper and 80% (n=4) samples from Sher Quli were beyond NEQS.

Averages for the CO concentration are given in annex-III of the report while the results of averages at each location are plotted in Figure No.5.

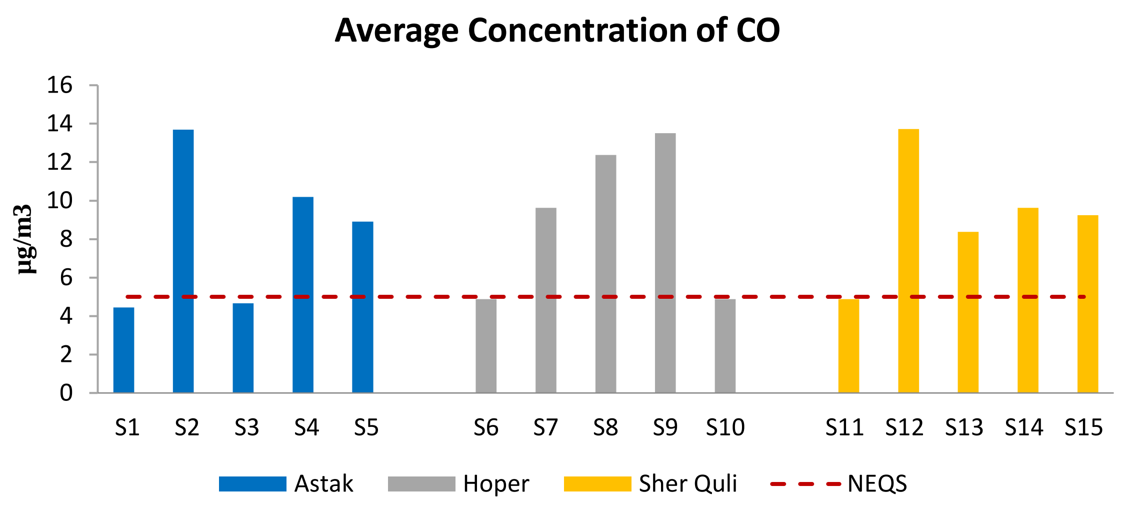

Figure 5: CO concentration at each location

6.4. Carbon Dioxide (CO_2)

A good indicator of proper ventilation is the level of CO_2 present in a space. Carbon dioxide is a normal by-product of respiration, combustion and other processes. Elevated levels of CO_2 may indicate that additional ventilation is required. ASHRAE Standard 62 recommends an indoor level not to exceed above 700 ppm, and for outdoor ambient air the standard is about 300 to 400 ppm (TSI 2013).

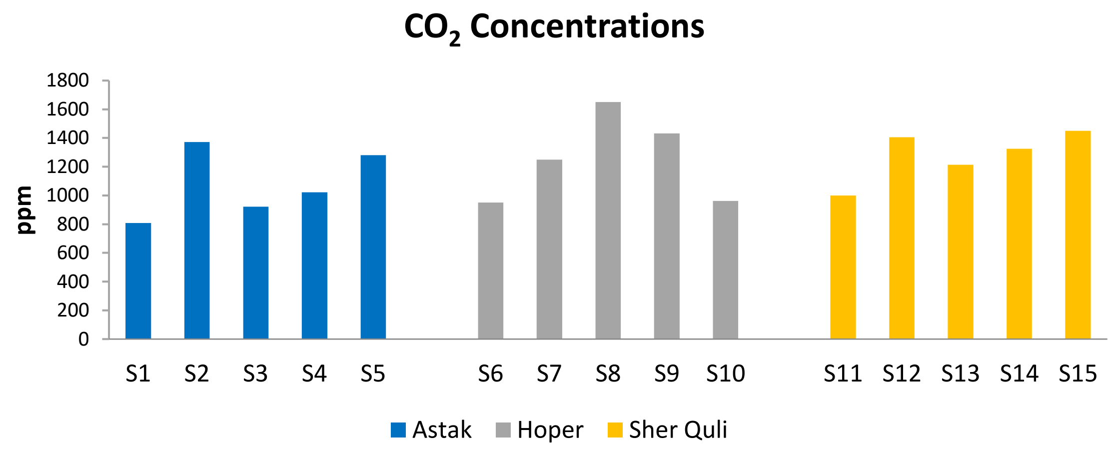

Figure 6: Average concentrations of CO_2

The results indicate an average concentration of1080.6ppm, 1248.8ppm and 1278.6ppm at Astak, Hoper and Sher Quli. The minimum CO_2 was 809ppm measured at sampling siteS1 and highest of 1650ppm at sampling site S8.Averages for the CO_2 concentration are given in annex-III of the report while the results of average at each location are plotted in Figure No. 6.

6.5. Temperature

A certain level of temperature (20-26⁰C) is needed for acceptable level of comfort and occupational activity (ISO 1984). According to recent studies, reduction in mental work capacity can be observed above 24⁰C.Temperature is one of the basic IAQ measurements that has a direct impact on perceived comfort and, in turn, concentration and productivity (Molina, C., et al 1989). According to ASHRAE Standard 55, the recommended temperature ranges perceived as "comfortable" are 22.8 to 26.1°C in the summer and 20.0 to 23.6°C in winter(TSI, 2013).

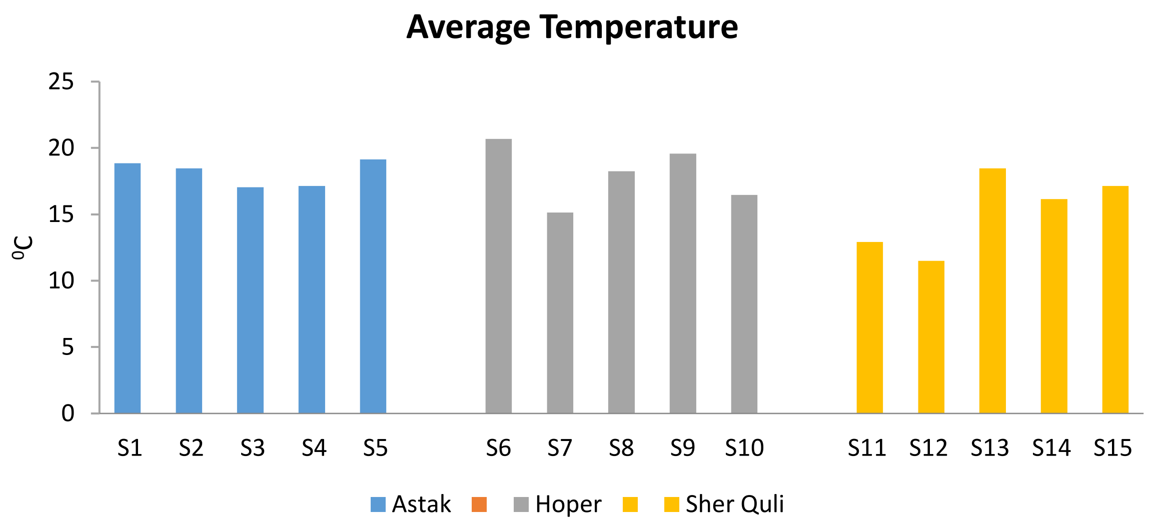

Figure 7: Average temperature of each location for 24 hours monitoring

The real time indoor temperature was monitored at each location for 24 hours. The results indicate an average temperature of 17.2⁰C and ranged between 15.1⁰C-19.9⁰C. Average temperature is given in annex-III of the report while the results at each location are plotted in Figure No.7.

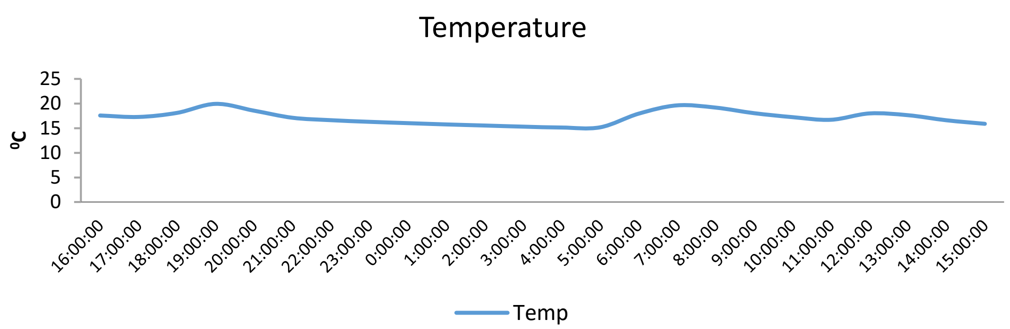

Figure 8: Average temperature of all location

Above figure illustrates 24 hour average temperature over the time. The peak values of temperature represents heating activities within homes, a clear increase in temperature can be seen during the hours of cooking i.e. 8pm to 12 pm and then again during breakfast time i.e. 7am to 11am.

6.6. Humidity

High level of humidification above 70% may produce secondary pollutant at high temperature, which cause uncomfortable environment and pose serious health threats. Especially during winters high level of humidity leads to structural damages and low level of humidity less than 20% leads to drying of mucous membranes and skin. Direct effect of low and high levels of humidity is neglect able, but indirect effects could play role in SBS. According to ASHRAE Standard 55, indoor humidity levels should be maintained between 30 percent and 65 percent for optimum comfort (TSI, 2013).

Average humidity recoded was 47%, the minimum humidity recorded was 38% and maximum was 53%. Average values for the humidity are given in annex-III of the report while the results of average at each location are plotted in Figure No.9.

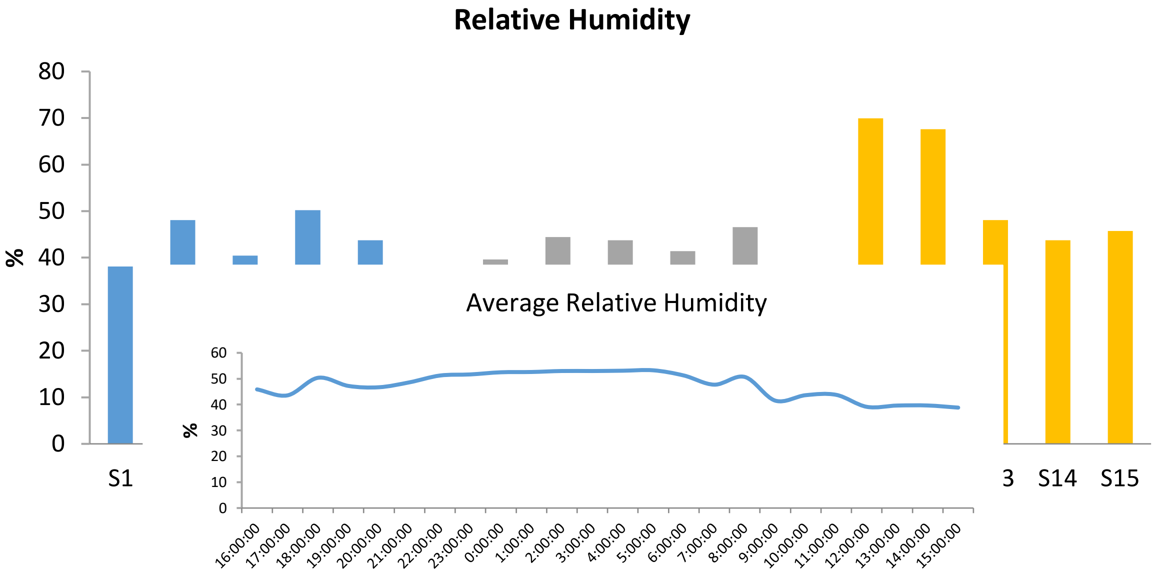

Figure 9: Average relative humidity

An inverse relation was found between temperature and relative humidity. The level of relative humidity was found minimum during heating and cooking hours when temperature reaches its peak. The average level of relative humidity has been plotted in figure No.10.

Figure 10: Average % of relative humidity for 24 hours monitoring

6.7. Ventilation

Under-ventilation and energy saving practices are the main causes of poor indoor air quality and Sick Building Syndrome (SBS), especially in many of the under developed and developing countries, where primary source of energy is biomass. Proper ventilation can reduce the concentration of pollutants produced due to indoor activities like cooking and heating, and decrease the level of health risk to the residents. Although the most significant mitigation to reduce such indoor pollutants is source control. According to ASHRAE standard 62-1989 "ventilation for Acceptable Indoor Air Quality" in living rooms must be 30 CFM/person and in Kitchen it should be 15CFM/person to extract and dilute biomass-effluents. As most of populace in study area use a common room for cooking and living therefore, in this study 20CFM/person has been considered as proper ventilation and above 30CFM/person has been considered as over ventilation. Among the samples tested 40% of samples from Astak, 60% of samples from Hoper and 80% of samples from Sher Quli were found under-ventilated. Average ventilation in sampled houses is shown in Figure No.11.

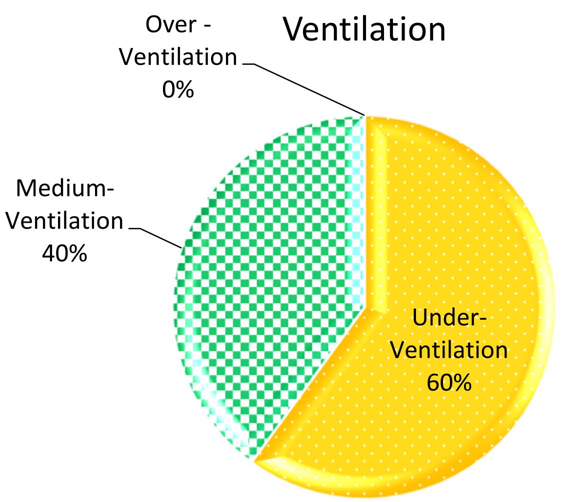

Figure 11: Average ventilation

7. Health Risk Assessment of Indoor Air Quality

According to the World Health Organization (WHO) poor indoor air quality is 8th most significant risk factor, responsible for 2.7 percent of total global burden of diseases (WHO 2005). In developing countries indoor air pollution is considered as an important risk factor for respiratory health. Substantial proportion of time is being spent indoor by most of the populace, thus exposed to elevated levels of indoor air pollution. Indoor air quality is influenced by both macro and micro environmental determinants. Macro-environmental determinants include socio-economic and demographic factors while micro-environmental determinants consist of housing characteristics i.e. fuel for cooking, heating and tobacco smoke (Rumchev et al., 2017). Use of solid fuel in developing countries for cooking is one of the most important and widespread source of indoor air pollution. Solid fuel is being used as primary source of energy by 52% of the world's population as compared to 16% in Eastern and Central Europe. Solid fuel include burning of wood, animal dung, agricultural remains and coal, releasing complex mixture of chemicals and gases such as NOx, SOx, Particulate Matter (PM), organic compounds and free radicals.

Despite of harsh climatic conditions and high dependency on solid fuel for domestic purposes (i.e. cooking and heating) limited number of studies on indoor air quality and health risk assessment have been conducted in Gilgit-Baltistan. The main objective of this section is to assess impacts of housing characteristics and environmental factors on prevalence of indoor air quality related diseases. This study is first of its own kind conducted in Gilgit-Baltistan and will provide data for future studies.

Based on USEPA methods there are three main ways to intake dose include oral ingestion, inhalation and dermal contact.

For determining Health Risk Assessment of Ambient Air Pollution following developed methods of USEPA can be used:

$$ADD_{ing} = \frac{C \times IRing \times F \times EF \times ED \times CF}{BW \times AT}$$

$$ADD_{inh} = \frac{C \times IRing \times F \times EF \times ED}{PEF \times BW \times AT}$$

$$ADD_{der} = \frac{C \times CF \times SA \times AF \times ABS \times F \times EF \times ED}{BW \times AT}$$

Where, ADDing, ADDinh and ADDder are the adsorbed dose of exposure to air pollutants via oral, ingestion, inhalation, and dermal contact respectively.

Whereas:

- *C is concentration of pollutant*
- *ABS is absorption factor*
- *AF is adherence factor*
- *ED is exposure duration*
- *CF is conversion factor*
- *EF is exposure frequency*
- *F is fraction of time spent*
- *PEF is particle emission factor*
- *SA is exposed skin surface*
- *IRing and IRinh is ingestion and inhalation rate*

(Mohsenibandpi,A. et al.,2018)

7.1. Methodology

A total of 15 households (05 from each village) were selected for interview. Data on health status, demography and housing characteristics was collected by field survey through pre-designed questionnaire. The questionnaire was divided into two sections, first part was about demography including gender, household size and income, housing characteristics with particular emphasis on fuel type, cooking and indoor smoking. Second section was designed to investigate health status of the correspondents including experience of wheeze, cough and breathlessness.

Chronic Daily In-take

Health Risk from indoor air quality through inhalation was assessed for children and adults separately by deriving following formulas from USEPA developed methods;

Air pollutants take different pathways to enter human body which are during inhalation, skin contact and oral ingestion. In comparison to oral intake all the other pathways are considered insignificant. The Cinh (mg kg-1 day-1) of air pollutants through inhalation was calculated by Eq. (1)

$$Cinh = \frac{Cp \times In}{Bw} \text{ ....I}$$

Where "Cp" is the concentration of pollutant in air. "In" (m^3 day^{-1}) is the daily average inhalation rate (assumed to be 7.6 m^3/day for children and 20 m^3/day for Adults) (US EPA), and Bw (kg) is the average body weights (assumed to be 72 kg for adult and 32.7 kg for child) (Jan et al., 2010; khan et al., 2013).

Health risk indexes (HRI)

Estimation of chronic health risks, HRI was calculated by using Eq. (II).

$$HRI = \frac{Cinh}{Rf} \text{ ....II}$$

Where Rf is reference dose (in this study NEQS for ambient air quality were considered as reference dose) and HRI values above 1 were considered to have negative health impacts.

7.2. Results and Discussions

7.2.1. Demography

According to the respondents 54% of the households earn less than 20,000 Pak Rupees per month. Numbers of households comprising three children were more than 54%, only 23% of the households had one child and 27% reported more than three children. Majority of the mothers 92% were illiterate and only 8% had primary education. Among fathers 14% had primary education and 13% had secondary education. Most of the populace 85% spends 18 hours indoor during winters which reduce to 12 hours in summers. Mothers and Children spend most of their time indoor as compared to adult males. According to the correspondents 90% of the population in study area relies on solid fuel for cooking and heating. About 45% of the communities used solid fuel throughout the year and remaining 65% use integrated approach i.e. uses LPG, Electricity and solid fuel. On an average each household spends 45,000 rupees annually for energy. Primary source of energy for 96% of the populace in study area was animal dung followed by > wood>electricity and >gas.

Table 2: Demographic Data

Household (n=15)	n (%)
Family Income	
<20000	53.33%
>20000	46.66%
Mothers Education	
Illiterate	93.33%
Primary	6.66%
Secondary	-
High	-
Fathers Education	
Illiterate	73.33%
Primary	13.33%
Secondary	13.33%
High	-
Indoor Time	
Winters	16-18 Hrs
Summers	12-14 Hrs
Annual Expenditure on Fuel	
Winters	30,000-60,000
Summers	10,000-20,000

7.2.2. Impact of Housing Characteristics on Indoor Air Quality

Results showed that the households relying on biomass as primary source of energy were significantly exposed to the high concentration (158.85mg/m^3) of Particulate Matter (PM) and CO level (15ppm) as compared to (28.44mg/m^3) and (6ppm) for those using LPG and electricity as primary source of energy. It was also observed that the households cooking in living room or spending most of time in kitchen were at higher risk as compared to those who had a separate kitchen with proper ventilation. Children who spend most of time with mothers while cooking were significantly exposed to the indoor air pollutants as compared to the other members of family.

Table 3: Housing Characteristics

House Characteristics	n
Number of Rooms	
<3	9
>3	6
Smoking at House	
Yes	5
No	10
Fuel Type	
Integrated (Wood+AD+Gas+EC)	15
Type of Stove	
Improved stove	
Conventional stove	12
Open chamber cooking	3
Separate Kitchen	
Yes	4
No	11

7.2.3. Health Status

Almost all respondents reported at least one respiratory symptom especially during winter season when high amount of solid fuel is being used for heating and cooking. The common respiratory symptom were in order of Cough (24%)>Wheeze(20%)>Bronchitis(18%) > Heart Diseases and Chest Tightness (11%) > Shortness of breath (12%).

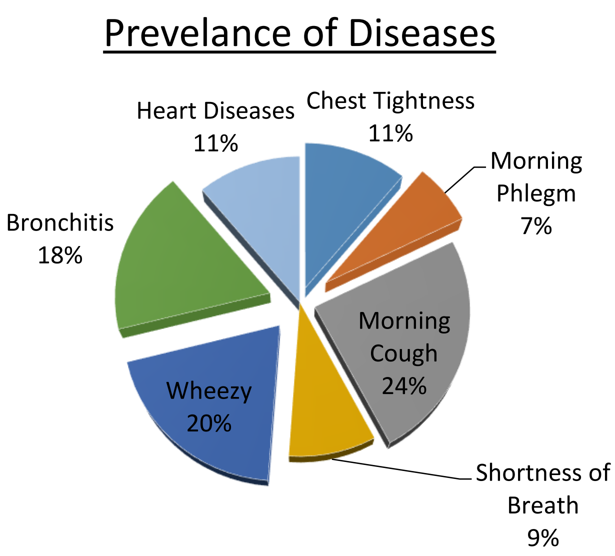

Figure 12: Health Status

7.3. Health Risk Assessment

7.3.1. Chronic Daily Intakes (CDI)

Chronic Daily Intake (CDI) values of pollutants through inhalation in selected locations of Gilgit Baltistan are summarized in Table No: 4 The CDI values of pollutants were detected in the order of CO> PM2.5 through inhalation. The highest CDI value of PM2.5 was detected at Sher Quli which was 44.5 mg/(kg.day). The mean CDI values of CO ranged between 0.49 to 0.56 mg / (kg.day) in adults and 0.41 to 0.46mg/(kg.day) in children. The mean CDI value of PM2.5 ranged from 16.92 to 44.5 mg/(kg.day) in adults and 14.1 to 37.2 mg/(kg.day) in children. The highest CDI values of CO in adults and children were detected in Hoper.

Table 4: Chronic Daily Inhalation in mg/kg.day

Parameter	Individuals	Astak	Sher Quli	Hoper
		n=5	n=5	n=5
PM 2.5	Adults	16.923	44.565	34.676
	Children	14.159	37.287	29.013
CO	Adults	2.482	2.548	2.803
	Children	2.077	2.132	2.345

7.3.2. Health Risk Index (HRI)

The Health Risk Index (HRI) values for each selected pollutant is plotted in Table No.5: Among the samples tested HRI values for PM2.5 showed health risk for both adults and children in Sher Quli while in Hoper and Astak no health risk was found both for PM2.5 and CO.

Table 5: Health Risk Index

Parameter	Individuals	Astak	Sher Quli	Hoper
		n=5	n=5	n=5
PM 2.5	Adults	0.483	1.273	0.990
	Children	0.404	1.065	0.828
CO	Adults	0.496	0.509	0.560
	Children	0.415	0.426	0.469

Conclusion and Recommendation

Indoor air pollution in GB especially during winters is a major public health hazard. Fuel type, open chamber fires and poorly functioning stoves are the main sources of indoor air pollution. Traditional energy saving practices with poor ventilation further aggravates the situation by trapping indoor air pollutants for longer time. In addition, economic level of household also play vital role in selection of cleaner energy sources. Marginalized communities of GB are highly dependent on wood, animal dung and agricultural remains as a primary source of energy which is neither efficient nor clean.

The results indicate high level of IAP and personal exposure with poor ventilation from cooking and heating with conventional fuel types in poorly functioning stoves. High level of respiratory diseases was also observed during winter season. It can be deduced from the prevalence of these diseases and level of IAP that poor indoor air quality may be one reason of respiratory illness during winter. Health impacts of air quality are multi-layered problems; finding and solving one issue may not get to the root cause. Many parameters may be contributing to an overall problem which also needs to be considered.

This study concludes high level of exposure to indoor air pollutants and high burden of diseases that needs to be addressed on priority basis to protect the public health from indoor air pollutants. To protect public health, it is essential to centralize all available resources, regulatory power and scientific knowledge. In order to better understand indoor air quality and related health effects, further studies are needed to be focused on the following:

- Annual data collection on number of people exposed to IAP at home.
- Understanding the behavior of inhabitants and estimating time spent at home by sensitive receptors i.e. children, mothers and older people.
- Development of methodologies to evaluate health problems attributable to IAP.
- Studies to reduce indoor air pollutants in order to improve health of future generations.
- Sensitization and awareness to public about health impacts of IAP.
- Development and provision of energy efficient and environment friendly alternatives to conventional stoves.
- Provision of modern energy sources i.e. electricity and hydal power.

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ANNEX-I

Activity	Sub-Activities	Months 2019				
		Aug	Sep	Oct	Nov	Dec
Identifying problem, introduction of topic, literature review and theoretical frame work	• *Identifying the broad problem area and setting research objectives* • *Literature review* • *Setting theoretical frame work*	√				
Developing Methodology	• *Organizing Equipment* • *Development of Questionnaire*		√			
Data collection	• *Deosai* – • *Sher Quli*			√		
	• *CKNP* – • *Hoper*			√		
	• *CKNP* – • *Astak*				√	
Testing the data					√	
Analysis, concluding and finalizing research						√
Submission of Draft Report						√

ANNEX-II

QUESTIONNAIRE

Date______________________ **Time**______________________

*Village*______________ *Number of Households*____________________

DEMOGRAPHIC

1. Name of respondent____
2. Age of respondent____
3. Gender____
4. Marital Status____
5. Level of education____
6. Household size____
7. Number of Children <12 Years____
8. Number of Adults> 12 Years____
9. Monthly Income____
10. Annual Expenditure on Health____
11. Type of Fuel used/consumed
    a) Primary___________________
    b) Secondary_________________
12. Annual expenditure on fuel____
13. Expenditure on fuel during summers_____________________________________
14. Expenditure on fuel during winters_____________________________________
15. Number of Hours spent indoor
    a) Summer___________________
    b) Winters___________________

HEALTH STATUS

16. Did you or any of your family member have experienced any of following symptoms during any specific season;
    a. Chest Tightness b. Morning Phlegm
    c. Morning Cough d. Shortness of Breath
    If yes to the above then specify
    i. Age___________________ ii. Gender___________________
    iii. Specific to any season_________________
17. Do you or any member of your family chest sound wheezy or whistling while doing or after physical movement
    a. Yes b. No
18. Do any of your family member been diagnosed for bronchitis
    a. Yes b. No
    If yes to above then specify
    a. Age_____________ b. Gender__________
19. Do you or any of your family member ever suffered or died from any kind of heart diseases
    a. Yes b. No
    If yes to above then mention
    a. Gender__________ b. Age______________

c. Season__________

20. Do any of your family member snore at night

a. Yes b. No

If yes to above then specify

a. Age_____________ b. Gender_________

21. What is the frequency of opening your house to outside air in winter___________

22. Is there anybody who smoke in your home

a. Yes b. No

23. Number of rooms in house_________

24. Separate Kitchen

a. Yes b. No

25. Windows in Kitchen

a. Yes b. No

ANNEX-III

Sher Quli

Site No: 1

Date:	**8/10/19**
Time:	***11:00 AM***
Altitude:	***3246m***
E'074^{0}22	***N'35^{0}55, 23.1***

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	2	11	4.8	5	8
PM 2.5	µg/m^3	1.16	60.4	22.8	35	24
Temp	^{0}C	10.5	15.9	12.9	-	-
R.H	%	58.7	77.7	69.9	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHRAE	*Ventilation
CO_2	Ppm	1000	470	530	20	30	Normal ventilation

*Calculated through ventilation calculator ASHRAE standard 62-1989 "ventilation for acceptable indoor air quality"

Site No: 2

Date:	**9/10/19**
Time:	***12:00 AM***
Altitude:	***3452m***
E'075^{0}741.3	***N'35^{0}20, 2.8***

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	6	22	13.7	5	8
PM 2.5	µg/m^3	8.3	1034	210	35	24
Temp	^{0}C	9.1	14.5	11.4	-	-
R.H	%	56.4	75.4	67.6	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHRAE	Ventilation
CO_2	Ppm	1405	4012	866	12	30	*Under ventilation/ Poor air Quality*

Site No: 3

Date:	**10/10/19**
=Time:	***09:00 AM***
Altitude:	***3246m***
E'074^{0}22	***N'35^{0}55, 23.1***

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	1	15	8.3	5	8
PM 2.5	µg/m^3	1.89	1027	177.2	35	24
Temp	^{0}C	16.1	21.3	18.4	-	-
R.H	%	39.1	53.3	48.08	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHRAE	Ventilation

CO_2	Ppm	1213	480	733	14	30	*Under ventilation/ Poor air Quality*

Site No: 4

Date:	**11/10/19**
Time:	***09:00 AM***
Altitude:	***3246m***
E'074⁰22	***N'35⁰56, 24.1***

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	3	18	9.6	5	8
PM 2.5	$\mu g/m^3$	10	1036	213	35	24
Temp	^0C	13.8	19.05	16.1	-	-
R.H	%	34.8	49.07	43.7	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHRAE	Ventilation
CO_2	Ppm	1325	505	820	13	30	*Under ventilation/ Poor air Quality*

Site No: 5

Date:	**12/10/19**
Time:	***10:00 AM***
Altitude:	***3246m***
E'074⁰22	***N'35⁰55, 23.1***

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	2	18	9.2	5	8
PM 2.5	$\mu g/m^3$	0.43	983	178	35	24
Temp	^0C	14.8	20.04	17.1	-	-
R.H	%	36.8	51.04	45.7	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1450	460	990	10	30	*Under ventilation/ Poor air Quality*

Table 6. Data Collected FAP PPHI Chilum Astore

Diseases	Year 2018							Year 2019						
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Oct
ARI	54	35	34	61	40	28	68	33	27	47	55	52	10
Hypertension	9	3	10	5	4	8	5	7	8	8	18	15	2
Eye infections	3	0	2	0	1	4	7	7	8	0	11	5	2
Asthma	2	1	0	0	2	9	0	0	2	0	0	2	0
Pulmonary infection	1	0	0	0	3	0	0	0	0	1	1	0	3
Total	**69**	**39**	**46**	**66**	**50**	**49**	**80**	**47**	**45**	**56**	**85**	**74**	**17**

[1]A substantial difference between prevalence of disease during summers and winters can be seen in the table given. Furthermore incidence of diseases during winters can be attributed to poor indoor air quality as microbial activities become dormant during this season.

Astak

Site No: 1

Date:3/Nov/2019

Time: 9:00 am

Altitude: 2503

E'075^{0}01'47.6 N'35^{0}40'50.0

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	1	9	4.6	5	8
PM 2.5	$\mu g/m^3$	3.1	70.5	25.6	35	24
Temp	^0C	14.1	26.1	18.8	-	-
R.H	%	19.3	52.94	38.13	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	809	440	369	28		Normal ventilation

Site No: 2

Date:4/Nov/2019

Time: 9:00 am

Altitude:2533

E'075^{0}01'52.1 N'35^{0}01'52.1

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	4	21	13.1	5	8
PM 2.5	$\mu g/m^3$	5.7	361.06	122.3	35	24
Temp	^0C	16.1	21.3	18.4	-	-
R.H	%	39.1	53.3	48.08	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1372	430	942	6.1		*Under ventilation/ Poor air Quality*

Site No: 3

Date:5/Nov/2019

Time: 9:00 am

Altitude: 2554

E'07^{0}02'34.2 N'35^{0}42'49.7

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	1	10	4	5	8
PM 2.5	$\mu g/m^3$	2.4	81.9	33.2	35	24
Temp	^0C	14.7	19.9	17.03	-	-
R.H	%	21.6	54.3	40.4	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	921	475	446	21.32		Normal ventilation

Site No: 4

Date:6/Nov/2019

Time: 9:00 am

Altitude: 2635

E'075^{0}0245.6 N35^{0}43'27.3

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	2	16	10.1	5	8
PM 2.5	$\mu g/m^3$	2.4	320.1	93.6	35	24
Temp	^0C	14.8	20.02	17.1	-	-
R.H	%	41.2	55.5	50.2	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1021	485	536	19	30	Normal ventilation

Site No: 5

Date:7/Nov/2019

Time: 9:00 am

Altitude: 2641

E'075^{0}02'48.4 N' 35^{0}44' 35.2

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	3	15	8.5	5	8
PM 2.5	$\mu g/m^3$	2.5	81.2	29.6	35	24
Temp	^0C	16.8	22.03	19.1	-	-
R.H	%	34.8	49.06	43.7	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1280	445	835	13.32	30	*Under ventilation/ Poor air Quality*

Table 5. Data Collected FAP PPHI AstakRoundu

Diseases	Year 2018			Year 2019									
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct
ARI	637	0	54	96	61	46	31	100	30	35	37	35	60
Hypertension	415	22	58	32	41	16	18	39	40	25	19	12	85
Eye infections	--	--	--	--	--	--	--	--	--	--	--	--	--
Asthama	64	0	1	2	5	5	8	20	0	3	6	8	3
Pulmonary infection	8	0	0	0	1	0	0	3	0	2	0	0	2
Total	**112**	**22**	**113**	**130**	**108**	**67**	**57**	**162**	**70**	**65**	**62**	**55**	**150**

Hoper

Site No: 1

Date:28/Oct/2019

Time: 10:00 am

Altitude: 2811

E'074^{0}45'48.6 N'36^{0}11'043

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	2	9	4..8	5	8
PM 2.5	µg/m^3	3.1	82.3	33.1	35	24
Temp	^{0}C	18.4	23.5	20.6	-	-
R.H	%	35.4	49.7	44.4	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	950	538	412	24.3	30	Normal ventilation

Site No: 2

Date:29/Oct/2019

Time: 10:00 am

Altitude: 2809

E'074^{0}45'47.9 N'36^{0}13'03.1

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	5	19	9.6	5	8
PM 2.5	µg/m^3	5.32	989.9	180.6	35	24
Temp	^{0}C	12.8	18.03	15.1	-	-
R.H	%	35.4	49.7	44.4	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1250	540	710	12.5	30	*Under ventilation/ Poor air Quality*

Site No: 3

Date:30/Oct/2019

Time: 10:00 am

Altitude: 2803

E'074^{0}45'47.4 N'36^{0}13'04.5

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	5	22	12.3	5	8
PM 2.5	µg/m^3	10.3	993.1	191.9	35	24
Temp	^{0}C	15.9	21.1	18.2	-	-
R.H	%	34.7	49.04	43.7	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1650	535	1115	8	30	*Under ventilation/ Poor air Quality*

Site No: 4

Date:31/Oct/2019

Time: 10:00am

Altitude: 2771

E'074^{0}46'04.2 N' 36^{0}13'10.9

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	7	21	13.5	5	8
PM 2.5	µg/m^3	6.9	901.6	187.2	35	24
Temp	^{0}C	17.3	22.4	19.5	-	-
R.H	%	32.4	46.7	41.4	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	1432	590	842	10.9	30	*Under ventilation/ Poor air Quality*

Site No: 5

Date:1/Nov/2019

Time: 10:00 am

Altitude: 2783

E'074^{0}46'07.8 N' 36^{0}13'08.8

Parameter	Unit	Min	Max	Avg	NEQs	Hours
CO	mg/m^3	1	11	4.8	5	8
PM 2.5	µg/m^3	2.1	81.4	31.1	35	24
Temp	^{0}C	14.1	19.3	16.4	-	-
R.H	%	37.6	51	46.5	-	-

Parameter	Unit	Inside	Outside	Difference	CFM/person	ASHR	Ventilation
CO_2	Ppm	962	545	417	25.2	30	Normal ventilation

Table 6. Data Collected FAP PPHI Hoper Nagar

Diseases	Year 2018				Year 2019								
	Sep	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**
ARI	25	22	15	18	17	63	--	40	45	32	38	20	21
Hypertension	10	11	--	--	--	08	--	10	--	20	08	--	--
Eye infections	10	12	--	--	--	04	--	06	--	08	08	--	06
Asthama	04	--	--	--	02	10	--	0	10	10	05	08	0
Pulmonary infection	-	--	--	--	--	--	--	0	--	--	--	--	0
Total	**49**	**45**	**15**	**18**	**19**	**85**	**--**	**56**	**55**	**70**	**59**	**28**	**27**

ANNEX-IV

PM2.5 and CO levels recorded at Astak Skardu

Site 1						Site 2					
Date	Time	PM2.5	CO (ppm)	Tem	RH	Date	Time	PM2.5	CO (ppm)	Tem	RH
2-Nov-19	16:00:00	3.132	2	14.102	40.231	3-Nov-19	16:00:00	5.777	4	19.415	45.922
2-Nov-19	17:00:00	4.123		15.423	43.321	3-Nov-19	17:00:00	5.786		19.01	43.382
2-Nov-19	18:00:00	4.132		16.231	39.955	3-Nov-19	18:00:00	19.908		19.674	52.464
2-Nov-19	19:00:00	18.254	6	20.432	23.432	3-Nov-19	19:00:00	186.657	14	21.365	50.465
2-Nov-19	20:00:00	56.023	8	21.342	25.431	3-Nov-19	20:00:00	291.028	18	19.747	49.557
2-Nov-19	21:00:00	60.394		18.01	33.401	3-Nov-19	21:00:00	361.069		18.368	50.293
2-Nov-19	22:00:00	30.435		19.698	43.357	3-Nov-19	22:00:00	202.768		17.677	51.487
3-Nov-19	23:00:00	16.134		19.008	41.417	4-Nov-19	23:00:00	122.101		17.367	52.238
3-Nov-19	0:00:00	14.231		18.771	44.715	4-Nov-19	0:00:00	67.996		17.081	52.532
3-Nov-19	1:00:00	9.126		18.39	47.265	4-Nov-19	1:00:00	45.321		16.818	52.127
3-Nov-19	2:00:00	8.451		18.01	48.065	4-Nov-19	2:00:00	37.982		16.603	52.522
3-Nov-19	3:00:00	4.112		17.605	48.577	4-Nov-19	3:00:00	31.062		16.364	52.396
3-Nov-19	4:00:00	5.192		17.32	49.321	4-Nov-19	4:00:00	30.043		16.197	52.371
3-Nov-19	5:00:00	4.173		16.963	50.394	4-Nov-19	5:00:00	28.026		16.316	52.359
3-Nov-19	6:00:00	4.156		16.82	52.047	4-Nov-19	6:00:00	43.272		19.771	50.521
3-Nov-19	7:00:00	19.402	5	20.865	34.231	4-Nov-19	7:00:00	186.046	17	21.174	49.754
3-Nov-19	8:00:00	62.176	10	22.896	38.785	4-Nov-19	8:00:00	334.378	21	20.175	53.385
3-Nov-19	9:00:00	70.508		21.843	36.939	4-Nov-19	9:00:00	204.174		19.605	40.433
3-Nov-19	10:00:00	51.304	7	18.224	39.365	4-Nov-19	10:00:00	121.883	6	19.034	43.575
3-Nov-19	11:00:00	43.013		17.677	40.53	4-Nov-19	11:00:00	30.301		18.415	42.835
3-Nov-19	12:00:00	6.431	3	26.182	19.324	4-Nov-19	12:00:00	28.008	5	18.868	42.225
3-Nov-19	13:00:00	4.138	3	21.003	21.435	4-Nov-19	13:00:00	304.038	20	19.0356	41.435
3-Nov-19	14:00:00	60.168		18.052	25.432	4-Nov-19	14:00:00	179.976		18.0132	40.512
3-Nov-19	15:00:00	56.106		17.402	28.301	4-Nov-19	15:00:00	69.004		17.112	39.142

Site 3						Site 4					
Date	Time	PM2.5	CO (ppm)	Tem	RH	Date	Time	PM2.5	CO (ppm)	Tem	RH
4-Nov-19	16:00:00	2.431	2	17.985	42.541	5-Nov-19	16:00:00	2.431	2	18.075	48.054
4-Nov-19	17:00:00	2.802		17.58	45.631	5-Nov-19	17:00:00	2.802		17.67	45.514

4-Nov-19	18:00:00	2.811		18.244	42.265	5-Nov-19	18:00:00	2.811		18.334	54.596
4-Nov-19	19:00:00	16.933	2	19.935	25.742	5-Nov-19	19:00:00	16.933	13	20.025	52.597
4-Nov-19	20:00:00	45.702	4	18.317	27.741	5-Nov-19	20:00:00	145.702	15	18.407	51.689
4-Nov-19	21:00:00	50.073		16.938	35.711	5-Nov-19	21:00:00	250.073		17.028	52.425
4-Nov-19	22:00:00	70.114		16.247	45.667	5-Nov-19	22:00:00	320.114		16.337	53.619
5-Nov-19	23:00:00	60.813		15.937	43.727	6-Nov-19	23:00:00	161.813		16.027	54.37
5-Nov-19	0:00:00	54.91		15.651	47.025	6-Nov-19	0:00:00	96.91		15.741	54.664
5-Nov-19	1:00:00	42.805		15.388	49.575	6-Nov-19	1:00:00	42.805		15.478	54.259
5-Nov-19	2:00:00	20.13		15.173	50.375	6-Nov-19	2:00:00	20.13		15.263	54.654
5-Nov-19	3:00:00	12.791		14.934	50.887	6-Nov-19	3:00:00	12.791		15.024	54.528
5-Nov-19	4:00:00	5.871		14.767	51.631	6-Nov-19	4:00:00	5.871		14.857	54.503
5-Nov-19	5:00:00	4.852		14.886	52.704	6-Nov-19	5:00:00	4.852		14.976	54.491
5-Nov-19	6:00:00	2.835		18.341	54.357	6-Nov-19	6:00:00	2.835		18.431	52.653
5-Nov-19	7:00:00	18.081	3	19.744	36.541	6-Nov-19	7:00:00	18.081	14	19.834	51.886
5-Nov-19	8:00:00	45.855	8	18.745	41.095	6-Nov-19	8:00:00	150.855	16	18.835	55.517
5-Nov-19	9:00:00	79.187		18.175	39.249	6-Nov-19	9:00:00	299.187		18.265	42.565
5-Nov-19	10:00:00	81.983	10	17.604	41.675	6-Nov-19	10:00:00	168.983	5	17.694	45.707
5-Nov-19	11:00:00	51.692		16.985	42.84	6-Nov-19	11:00:00	96.692		17.075	44.967
5-Nov-19	12:00:00	5.11	2	17.438	21.634	6-Nov-19	12:00:00	5.11	2	17.528	44.357
5-Nov-19	13:00:00	2.817	1	17.6056	23.745	6-Nov-19	13:00:00	2.817	14	17.6956	43.567
5-Nov-19	14:00:00	70.847		16.5832	27.742	6-Nov-19	14:00:00	270.847		16.6732	42.644
5-Nov-19	15:00:00	46.785		15.682	30.611	6-Nov-19	15:00:00	146.785		15.772	41.274

Site 5					
Date	**Time**	**PM2.5**	**CO (ppm)**	**Temp**	**RH**
6-Nov-19	16:00:00	5.461	3	20.085	41.601
6-Nov-19	17:00:00	4.19		19.68	39.061
6-Nov-19	18:00:00	18.529		20.344	48.143
6-Nov-19	19:00:00	72.064	14	22.035	46.144
6-Nov-19	20:00:00	64.384	9	20.417	45.236
6-Nov-19	21:00:00	51.004		19.038	45.972
6-Nov-19	22:00:00	30.704		18.347	47.166
7-Nov-19	23:00:00	21.068		18.037	47.917
7-Nov-19	0:00:00	13.237		17.751	48.211
7-Nov-19	1:00:00	3.001		17.488	47.806
7-Nov-19	2:00:00	3.571		17.273	48.201
7-Nov-19	3:00:00	2.534		17.034	48.075

7-Nov-19	4:00:00	3.575		16.867	48.05
7-Nov-19	5:00:00	4.054		16.986	48.038
7-Nov-19	6:00:00	3.516		20.441	46.2
7-Nov-19	7:00:00	72.069	15	21.844	45.433
7-Nov-19	8:00:00	81.268	16	20.845	49.064
7-Nov-19	9:00:00	54.94		20.275	36.112
7-Nov-19	10:00:00	11.973	5	19.704	39.254
7-Nov-19	11:00:00	15.066		19.085	38.514
7-Nov-19	12:00:00	10.068	3	19.538	37.904
7-Nov-19	13:00:00	66.296	9	19.7056	37.114
7-Nov-19	14:00:00	53.217		18.6832	36.191
7-Nov-19	15:00:00	46.745		17.782	34.821

PM2.5 and CO levels recorded at Hoper Nagar

Site 1						Site 2					
Date	Time	PM2.5	CO (ppm)	Tem	RH	Date	Time	PM2.5	CO (ppm)	Tem	RH
26-Oct-19	16:00:00	3.123	2	21.632	37.447	27-Oct-19	16:00:00	5.321	6	16.081	42.246
26-Oct-19	17:00:00	12.102		21.227	34.907	27-Oct-19	17:00:00	7.243		15.676	39.706
26-Oct-19	18:00:00	57.001		21.891	43.989	27-Oct-19	18:00:00	16.222		16.34	48.788
26-Oct-19	19:00:00	61.321	10	23.582	41.99	27-Oct-19	19:00:00	173.12	11	18.031	46.789
26-Oct-19	20:00:00	72.102	11	21.964	41.082	27-Oct-19	20:00:00	224.12	15	16.413	45.881
26-Oct-19	21:00:00	82.311		20.585	41.818	27-Oct-19	21:00:00	978.12		15.034	46.617
26-Oct-19	22:00:00	59.234		19.894	43.012	27-Oct-19	22:00:00	360.12		14.343	47.811
26-Oct-19	23:00:00	47.331		19.584	43.763	27-Oct-19	23:00:00	142.12		14.033	48.562
27-Oct-19	0:00:00	12.111		19.298	44.057	28-Oct-19	0:00:00	100.12		13.747	48.856
27-Oct-19	1:00:00	8.101		19.035	43.652	28-Oct-19	1:00:00	41.12		13.484	48.451
27-Oct-19	2:00:00	6.321		18.82	44.047	28-Oct-19	2:00:00	14.222		13.269	48.846
27-Oct-19	3:00:00	5.14		18.581	43.921	28-Oct-19	3:00:00	10.12		13.03	48.72
27-Oct-19	4:00:00	4.12		18.414	43.896	28-Oct-19	4:00:00	9.102		12.863	48.695
27-Oct-19	5:00:00	6.302		18.533	43.884	28-Oct-19	5:00:00	8.12		12.982	48.683
27-Oct-19	6:00:00	5.111		21.988	42.046	28-Oct-19	6:00:00	10.12		16.437	46.845
27-Oct-19	7:00:00	59.322	7	23.391	41.279	28-Oct-19	7:00:00	9.12	5	17.84	46.078
27-Oct-19	8:00:00	64.001	8	22.392	44.91	28-Oct-19	8:00:00	123.98	8	16.841	49.709
27-Oct-19	9:00:00	51.31		21.822	31.958	28-Oct-19	9:00:00	989.98		16.271	36.757
27-Oct-19	10:00:00	14.122	5	21.251	35.1	28-Oct-19	10:00:00	276.98	19	15.7	39.899
27-Oct-19	11:00:00	13.331		20.632	34.36	28-Oct-19	11:00:00	43.12		15.081	39.159
27-Oct-19	12:00:00	7.103	2	21.085	33.75	28-Oct-19	12:00:00	17.12	7	15.534	38.549
27-Oct-19	13:00:00	39.114	5	21.2526	32.96	28-Oct-19	13:00:00	11.12	6	15.7016	37.759
27-Oct-19	14:00:00	60.223		20.2302	32.037	28-Oct-19	14:00:00	113.98		14.6792	36.836
27-Oct-19	15:00:00	43.101		19.329	30.667	28-Oct-19	15:00:00	651.98		13.778	35.466

Site 3						Site 4					
Date	Time	PM2.5	CO (ppm)	Temp	RH	Date	Time	PM2.5	CO (ppm)	Tem	RH
28-Oct-19	16:00:00	10.363	6	19.201	41.579	29-Oct-19	16:00:00	6.909	7	20.522	39.269
28-Oct-19	17:00:00	19.342		18.796	39.039	29-Oct-19	17:00:00	15.888		20.117	36.729
28-Oct-19	18:00:00	176.24		19.46	48.121	29-Oct-19	18:00:00	172.03		20.781	45.811
28-Oct-19	19:00:00	227.24	13	21.151	46.122	29-Oct-19	19:00:00	323.12	15	22.472	43.812

28-Oct-19	20:00:00	981.24	17	19.533	45.214	29-Oct-19	20:00:00	877.12	16	20.854	42.904
28-Oct-19	21:00:00	363.24		18.154	45.95	29-Oct-19	21:00:00	399.56		19.475	43.64
28-Oct-19	22:00:00	145.24		17.463	47.144	29-Oct-19	22:00:00	241.12		18.784	44.834
28-Oct-19	23:00:00	103.24		17.153	47.895	29-Oct-19	23:00:00	89.04		18.474	45.585
29-Oct-19	0:00:00	44.24		16.867	48.189	30-Oct-19	0:00:00	35.32		18.188	45.879
29-Oct-19	1:00:00	17.24		16.604	47.784	30-Oct-19	1:00:00	13.12		17.925	45.474
29-Oct-19	2:00:00	13.24		16.389	48.179	30-Oct-19	2:00:00	9.707		17.71	45.869
29-Oct-19	3:00:00	12.24		16.15	48.053	30-Oct-19	3:00:00	8.867		17.471	45.743
29-Oct-19	4:00:00	11.24		15.983	48.028	30-Oct-19	4:00:00	7.767		17.304	45.718
29-Oct-19	5:00:00	13.24		16.102	48.016	30-Oct-19	5:00:00	9.861		17.423	45.706
29-Oct-19	6:00:00	12.24		19.557	46.178	30-Oct-19	6:00:00	8.504		20.878	43.868
29-Oct-19	7:00:00	127.1	19	20.96	45.411	30-Oct-19	7:00:00	137.026	16	22.281	43.101
29-Oct-19	8:00:00	993.1	22	19.961	49.042	30-Oct-19	8:00:00	901.612	21	21.282	46.732
29-Oct-19	9:00:00	280.1		19.391	36.09	30-Oct-19	9:00:00	234.71		20.712	33.78
29-Oct-19	10:00:00	46.24	6	18.82	39.232	30-Oct-19	10:00:00	53.112	7	20.141	36.922
29-Oct-19	11:00:00	20.24		18.201	38.492	30-Oct-19	11:00:00	16.786		19.522	36.182
29-Oct-19	12:00:00	14.24	5	18.654	37.882	30-Oct-19	12:00:00	10.123	9	19.975	35.572
29-Oct-19	13:00:00	117.1	11	18.8216	37.092	30-Oct-19	13:00:00	112.026	17	20.1426	34.782
29-Oct-19	14:00:00	655.1		17.7992	36.169	30-Oct-19	14:00:00	612.341		19.1202	33.859
29-Oct-19	15:00:00	204.1		16.898	34.799	30-Oct-19	15:00:00	199.026		18.219	32.489

Site 5					
Date	**Time**	**PM2.5**	**CO (ppm)**	**Tem**	**RH**
30-Oct-19	16:00:00	2.221	3	17.402	44.389
30-Oct-19	17:00:00	2.441		16.997	41.849
30-Oct-19	18:00:00	9.209		17.661	50.931
30-Oct-19	19:00:00	76.351	11	19.352	48.932
30-Oct-19	20:00:00	80.441	13	17.734	48.024
30-Oct-19	21:00:00	81.441		16.355	48.76
30-Oct-19	22:00:00	51.881		15.664	49.954
30-Oct-19	23:00:00	45.441		15.354	50.705
31-Oct-19	0:00:00	31.361		15.068	50.999
31-Oct-19	1:00:00	9.641		14.805	50.594
31-Oct-19	2:00:00	5.441		14.59	50.989
31-Oct-19	3:00:00	3.028		14.351	50.863
31-Oct-19	4:00:00	2.188		14.184	50.838
31-Oct-19	5:00:00	4.088		14.303	50.826
31-Oct-19	6:00:00	4.182		17.758	48.988

31-Oct-19	7:00:00	2.825	1	19.161	48.221
31-Oct-19	8:00:00	41.347	2	18.162	51.852
31-Oct-19	9:00:00	55.933		17.592	38.9
31-Oct-19	10:00:00	49.031	7	17.021	42.042
31-Oct-19	11:00:00	29.433		16.402	41.302
31-Oct-19	12:00:00	12.107	4	16.855	40.692
31-Oct-19	13:00:00	4.444	5	17.0226	39.902
31-Oct-19	14:00:00	70.347		16.0002	38.979
31-Oct-19	15:00:00	73.662		15.099	37.609

PM2.5 and CO levels recorded at Sher Quli

Site 1						Site 2					
Date	**Time**	**PM2.5**	**CO (ppm)**	**Tem**	**RH**	**Date**	**Time**	**PM2.5**	**CO (ppm)**	**Tem**	**RH**
8-Oct-19	16:00:00	2.233	3	12.89611	68.03	9-Oct-19	16:00:00	13.343	6	11.46411	65.688
8-Oct-19	17:00:00	3.212		12.46111	61.635	9-Oct-19	17:00:00	22.322		11.02911	59.293
8-Oct-19	18:00:00	3.312		14.26611	65.901	9-Oct-19	18:00:00	229.624		12.83411	63.559
8-Oct-19	19:00:00	49.331	13	15.72389	69.824	9-Oct-19	19:00:00	280.662	17	14.29189	67.482
8-Oct-19	20:00:00	60.004	16	14.64889	69.046	9-Oct-19	20:00:00	1034.008	21	13.21689	66.704
8-Oct-19	21:00:00	52.401		13.78611	71.263	9-Oct-19	21:00:00	416.802		12.35411	68.921
8-Oct-19	22:00:00	45.32		13.37722	74.439	9-Oct-19	22:00:00	192.64		11.94522	72.097
8-Oct-19	23:00:00	21.142		13.08778	75.558	9-Oct-19	23:00:00	110.284		11.65578	73.216
9-Oct-19	0:00:00	9.33		12.92	76.806	10-Oct-19	0:00:00	43.66		11.488	74.464
9-Oct-19	1:00:00	4.164		12.72722	77.348	10-Oct-19	1:00:00	12.328		11.29522	75.006
9-Oct-19	2:00:00	3.164		12.55778	77.174	10-Oct-19	2:00:00	10.328		11.12578	74.832
9-Oct-19	3:00:00	2.164		12.46111	77.347	10-Oct-19	3:00:00	9.328		11.02911	75.005
9-Oct-19	4:00:00	2.164		12.26778	77.639	10-Oct-19	4:00:00	8.328		10.83578	75.297
9-Oct-19	5:00:00	2.164		12.07389	77.763	10-Oct-19	5:00:00	10.328		10.64189	75.421
9-Oct-19	6:00:00	1.164		12.195	71.269	10-Oct-19	6:00:00	9.328		10.763	68.927
9-Oct-19	7:00:00	54.132	13	14.38889	66.639	10-Oct-19	7:00:00	145.264	15	12.95689	64.297
9-Oct-19	8:00:00	60.432	15	15.95278	64.475	10-Oct-19	8:00:00	1011.864	21	14.52078	62.133
9-Oct-19	9:00:00	40.107		11.41889	68.93	10-Oct-19	9:00:00	298.214		9.986889	66.588
9-Oct-19	10:00:00	12.114	7	10.61389	65.022	10-Oct-19	10:00:00	69.228	8	9.181889	62.68
9-Oct-19	11:00:00	6.308		10.59	68.889	10-Oct-19	11:00:00	43.616		9.158	66.547
9-Oct-19	12:00:00	10.154	4	13.28111	58.745	10-Oct-19	12:00:00	13.308	6	11.84911	56.403
9-Oct-19	13:00:00	36.044	11	12.17111	64.687	10-Oct-19	13:00:00	167.088	15	10.73911	62.345
9-Oct-19	14:00:00	45.11		12.07389	65.918	10-Oct-19	14:00:00	647.22		10.64189	63.576

9-Oct-19	15:00:00	23.42		12.38889	64.376	10-Oct-19	15:00:00	254.84		10.95689	62.034

	Site 3						Site 4					
	Date	Time	PM2.5	CO (ppm)	Tem	RH	Date	Time	PM2.5	CO (ppm)	Tem	RH
10-Oct-19	4-Nov-19	16:00:00	4.304	2	19.415	45.922	11-Oct-19	16:00:00	15.774	7	17.101	41.61
10-Oct-19	4-Nov-19	17:00:00	6.911		19.01	43.382	11-Oct-19	17:00:00	24.753		16.696	39.07
10-Oct-19	4-Nov-19	18:00:00	15.89		19.674	52.464	11-Oct-19	18:00:00	232.055		17.36	48.152
10-Oct-19	4-Nov-19	19:00:00	223.192	13	21.365	50.465	11-Oct-19	19:00:00	283.093	16	19.051	46.153
10-Oct-19	4-Nov-19	20:00:00	274.23	14	19.747	49.557	11-Oct-19	20:00:00	1036.439	23	17.433	45.245
10-Oct-19	4-Nov-19	21:00:00	1027.576		18.368	50.293	11-Oct-19	21:00:00	419.233		16.054	45.981
10-Oct-19	4-Nov-19	22:00:00	410.37		17.677	51.487	11-Oct-19	22:00:00	195.071		15.363	47.175
10-Oct-19	5-Nov-19	23:00:00	186.208		17.367	52.238	11-Oct-19	23:00:00	112.715		15.053	47.926
11-Oct-19	5-Nov-19	0:00:00	103.852		17.081	52.532	12-Oct-19	0:00:00	46.091		14.767	48.22
11-Oct-19	5-Nov-19	1:00:00	37.228		16.818	52.127	12-Oct-19	1:00:00	14.759		14.504	47.815
11-Oct-19	5-Nov-19	2:00:00	5.896		16.603	52.522	12-Oct-19	2:00:00	12.759		14.289	48.21
11-Oct-19	5-Nov-19	3:00:00	3.896		16.364	52.396	12-Oct-19	3:00:00	11.759		14.05	48.084
11-Oct-19	5-Nov-19	4:00:00	2.896		16.197	52.371	12-Oct-19	4:00:00	10.759		13.883	48.059
11-Oct-19	5-Nov-19	5:00:00	1.896		16.316	52.359	12-Oct-19	5:00:00	12.759		14.002	48.047
11-Oct-19	5-Nov-19	6:00:00	3.896		19.771	50.521	12-Oct-19	6:00:00	11.759		17.457	46.209
11-Oct-19	5-Nov-19	7:00:00	2.896	1	21.174	49.754	12-Oct-19	7:00:00	147.695	11	18.86	45.442
11-Oct-19	5-Nov-19	8:00:00	138.832	11	20.175	53.385	12-Oct-19	8:00:00	1014.295	21	17.861	49.073
11-Oct-19	5-Nov-19	9:00:00	1005.432		19.605	40.433	12-Oct-19	9:00:00	300.645		17.291	36.121
11-Oct-19	5-Nov-19	10:00:00	291.782	15	19.034	43.575	12-Oct-19	10:00:00	71.659	3	16.72	39.263
11-Oct-19	5-Nov-19	11:00:00	62.796		18.415	42.835	12-Oct-19	11:00:00	46.047		16.101	38.523
11-Oct-19	5-Nov-19	12:00:00	37.184	7	18.868	42.225	12-Oct-19	12:00:00	15.739	5	16.554	37.913
11-Oct-19	5-Nov-19	13:00:00	6.876	4	19.0356	41.435	12-Oct-19	13:00:00	169.519	8	16.7216	37.123
11-Oct-19	5-Nov-19	14:00:00	160.656		18.0132	40.512	12-Oct-19	14:00:00	649.651		15.6992	36.2
11-Oct-19	5-Nov-19	15:00:00	240.401		17.112	39.142	12-Oct-19	15:00:00	257.271		14.798	34.83

Site 5					
Date	Time	PM2.5	CO (ppm)	Tem	RH
12-Oct-19	16:00:00	4.45	4	18.091	43.581
12-Oct-19	17:00:00	13.429		17.686	41.041
12-Oct-19	18:00:00	151.625		18.35	50.123
12-Oct-19	19:00:00	202.663	8	20.041	48.124
12-Oct-19	20:00:00	956.009	17	18.423	47.216

12-Oct-19	21:00:00	338.803		17.044	47.952
12-Oct-19	22:00:00	114.641		16.353	49.146
12-Oct-19	23:00:00	32.285		16.043	49.897
13-Oct-19	0:00:00	34.771		15.757	50.191
13-Oct-19	1:00:00	3.439		15.494	49.786
13-Oct-19	2:00:00	1.439		15.279	50.181
13-Oct-19	3:00:00	0.439		15.04	50.055
13-Oct-19	4:00:00	2.439		14.873	50.03
13-Oct-19	5:00:00	1.439		14.992	50.018
13-Oct-19	6:00:00	0.439		18.447	48.18
13-Oct-19	7:00:00	117.374	11	19.85	47.413
13-Oct-19	8:00:00	983.974	18	18.851	51.044
13-Oct-19	9:00:00	270.324		18.281	38.092
13-Oct-19	10:00:00	41.338	2	17.71	41.234
13-Oct-19	11:00:00	15.726		17.091	40.494
13-Oct-19	12:00:00	12.616	3	17.544	39.884
13-Oct-19	13:00:00	138.087	11	17.7116	39.094
13-Oct-19	14:00:00	618.219		16.6892	38.171
13-Oct-19	15:00:00	225.839		15.788	36.801

ANNEX-V

Air Quality at Sher Quli, District Astore

Indoor Air Quality at Hoper, District Nagar

Indoor Air Quality at Astak, District Skardu