ISSN No:-2456-2165

Environmental, Social & Occupational Health & Safety (ESOHS) Risk and Impact Assessment of 2x660 MW Supercritical Coal Fired Power Plant Jamshoro

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Abstract:- The current study intends to analyze and assess the environmental, Social & Occupational Health & Safety (ESOHS) Risk and Impact Assessment of 2x660MW Supercritical Coal Fire Power Plant Jamshoro. The ESOHS risk and impact assessment has been conducted noticing and ensuring the international standards and guidelines, including the International and National standers. International Finance Corporation (IFC) Performance Standards and the World Bank Environmental, Health, and Safety Guidelines and Sindh Environment protection agency, Pakistan environment protection agency and other international good practices (OSHA, ISO) The study has assessed the environment of the 2x660MW power plant in Jamshoro, including air pollution, noise pollution, thermal pollution, solid waste management, and wastewater to minimize the project's impact on the environment. The AQMS FPI station which is an air quality management system has been utilized to identify the values related to air assessment, whereas, for noise pollution, the data has been collected to identify the impact of noise pollution using the Noise meter model UT353/UT353BT Mini Sound Level Meters. Noted and observed values for environmental pollution and their assessment has been done using the Leopold scoring criteria scale to assess the impact of these factors. Additionally, Social assessment of the power plant has been conducted through both online (i.e., Google Form) and paper-based survey methods at different locations of the coal-fired power plant. In the social assessment, 139 workers participated in the survey, either individually or in groups, with 96 workers residing in ZEPL accommodation and 43 workers in the E-block accommodation. Moreover, during the construction phase of the 2*660MW coal-fired power plant in Jamshoro, a comprehensive Occupational Risk Assessment has been conducted to ensure the health and safety of workers. The assessment covered various areas such as Work at Height, Fire Safety, Heat Management, Confined Space, and others. A 5x5 Risk Matrix has been used to evaluate the severity and likelihood of identified risks, enabling effective safety measures and protocols to be implemented. Based on the assessements to finded gap of imolimantion and suggect sutable recommondations for the 2x660MW coal-fired power plant in Jamshoro have been provided. to mitigation all assess risk and impacte of power plant during construection.

Keywords:- *Environmental, Social, Occupational health and safety, 2*660MW Coal-Fired Power plant, Jamshoro, Risk and impact assessments, IFC, World Bank environmental, health, and safety guidelines.*

I. INTRODUCTION

The environmental aspects of ESOHS initiatives have been the purpose of minimizing the negative influence of construction activities on the environment. This has involved proper waste management practices to eliminate pollution and contamination, implementing measures to conserve natural resources, and adopting sustainable construction techniques by adhering to ESOHS guidelines.[6] These construction companies could contribute to environmental preservation and eliminate their carbon footprints. [35]

ESOHS prioritizes the workers' welfare; it could promote a healthy work environment supporting their physical and mental well-being. This includes providing adequate rest of the regions, cleaning drinking water, and sanitary facilities on the construction sites. [1] In addition, the ESOHS program has been emphasized involving a measure to preserve workplace discrimination that promotes diversity and inclusion and would ensure equal opportunity for all employees. ESOHS practices have contributed to employee satisfaction, morale, and job performance by fostering a significant and inclusive work culture.

Occupational health and safety are a crucial role of the ESOHS in the construction industry. It includes determining and mitigating workplace hazards, delivering appropriate training and personal prospect equipment to their work, and implementing safety protocols. [36] Regular inceptions, risk assessment, and the incident reporting system are oriented to maintain a safe working environment. ESOHS has been measured, involving emergency preparedness plans, and effectively handling accidents or unforeseen events.

Particularly in Pakistan, from an environmental perspective, implementing ESOHS measures ensures that construction activities adhere to sustainable practices, reducing pollution and minimizing harm to ecosystems. Socially, ESOHS initiatives prioritize the well-being of workers by providing safe and inclusive work environments, promoting equal opportunities, and supporting their physical and mental health. Occupational health and safety practices are crucial in Pakistan to prevent accidents, injuries, and

occupational diseases, ensuring the safety and protection of construction workers. By embracing ESOHS practices, construction companies in Pakistan can create a sustainable and safe work environment that benefits workers and the wider community.

The 2x660MW Supercritical Coal Fire Power Plant Jamshoro is a significant project undertaken by the Government of Pakistan to address the country's electricity deficit. The project is in Jamshoro, in the Sindh Province of Pakistan. The China Machinery Engineering Corporation (CMEC) will construct the power plant. It will have a capacity of 1320 MW, which will be generated by two units, each having a capacity of 660 MW. [29] The project is expected to cost around $2 billion, and the construction will be completed by 2023.

The construction and operation of a power plant of this magnitude will significantly impact the environment, the social conditions of the surrounding communities, and the occupational health and safety of the workers involved. To assess the potential risks and impacts associated with constructing and operating the 2x660MW Supercritical Coal Fire Power Plant Jamshoro, an Environmental, Social, and Occupational Health and Safety (ESOHS) risk and impact assessment is required. [32]

An ESOHS risk and impact assessment is a process that identifies and evaluates the potential risks and impacts associated with a project or activity on the environment, social conditions, and occupational health and safety). [10] It also identifies measures to mitigate these risks and impacts and ensures the project complies with relevant regulatory requirements and international standards.

The ESOHS risk and impact assessment for the 2x660MW Supercritical Coal Fire Power Plant Jamshoro will focus on the following key areas:

- Environmental impacts: Power plant operation and construction work significantly impacts on the environment such as use of land, biodiversity, greenhouse emissions, and water and air quality. [25] The assessment will identify and evaluate these impacts and propose mitigation measures.
- Social impacts: The construction and operation of the power plant may have social impacts on the surrounding communities, including population displacement, changes in land use patterns, and impacts on local livelihoods. [14] The assessment will identify and evaluate these impacts and propose mitigation measures.
- Impact of occupational safety and health: Power plant operations and construction can give rise to risks related to worker`s safety and health [17]. The assessment will identify and evaluate these risks and propose mitigation measures.

The ESOHS risk and impact assessment will be conducted by international standards and guidelines, including the International Finance Corporation (IFC) Performance Standards and the World Bank Environmental, Health, and Safety Guidelines. The assessment will also comply with relevant national and local regulatory requirements.

II. CONSTRUCTION WORK

The construction crew has been demonstrated with the many workers that have been predicted, and the living region for the Chinese workers could be set up with the adjustment to the consultants' sites with all the requirements, which include the dining hall, washing facilities and the regeneration facilities and the washroom facilities. The temporary accommodation has been addressed with the domestic workers along with the enhancement of the quality that has been delivered with the E-Block and F-block regions of the project's sites. The two layers of the boundary walls have been constructed across the living region towards restricting the intellectual of construction workers and the local community.

A. Environmental, Social, Occupational Health and Safety:

The environmental, social, and occupational health and safety management systems have been demonstrated as part of the Constructor's commitments in the ES OHS policy. The ES-OHS-MS has been computed with the following managed that would be considered with the plans that would be addressing the construction for the where of the potential influence that could be the influence of its ES OHS through the projections.

The construction of the environmental management and would be able to access the monitoring plans. The new plans would consider the construction of occupational health and safety management. The study has considered the working accommodation that would be considered with the plans. The study also demonstrated the emergency preparedness and responsiveness of the plan, which would be considered with the sub-constructors and the supply chain management plans. The study also accessed the Hazardous material and the waste management plans. The ES-OHS-MS has been linked with the plans and underlying SOPs that would be submitted towards the JPCL, and it would be accessed with the final review for the total approval.

B. Aims

This Environmental, Social, and Occupational Health and Safety (ESOHS) risk and impact assessment aims to identify and evaluate the potential risks and impacts associated with constructing of the 2x660MW Supercritical Coal Fire Power Plant Jamshoro in Pakistan. The assessment will also propose measures to mitigate these risks and impacts and ensure compliance with relevant regulatory requirements, national and international standards.

C. Objectives

- Assessment of Environmental, Social and OH&S Risks and Impacts during the Construction of 2x660 MW CFPP Jamshoro.
- To Find the Gap and provide Recommendation than can decrease Environmental Social and OH&S risk and impacts of construction Activities of project.

D. Study Questions

- How to identify and evaluate the potential environmental impacts of the construction of the power plant containing factors such as land use, air quality, thermal pollution, wastewater, Noise pollution and land?
- How to identify and evaluate the potential social impacts of the construction and operation of the power plant, including changes in land use patterns, and impacts on local livelihoods?
- How to identify and evaluate the potential occupational health and safety risks of the construction and operation of the power plant?
- How to ensure that the ESOHS risk and impact assessment is conducted in accordance with international standards and guidelines, International Standards?
- What is the implementation process towards the findings of the ESOHS risk and impact assessment to all relevant stakeholders, including the project sponsors, government authorities, local communities, and civil society organizations?

III. METHOLDOGY

A. Natonal ans International Standards

International finance cooperation is an international body and provides the framework to commit and use approach of sustainability within the business context. This framework also provides the risk assessment or management framework for the industry or business considering the environment and social factors to achieve the sustainable goals and reduce the impact of climate [21]. IFC standards requires the business or client to apply the performance standards to achieve sustainable goals by managing social and environmental impacts and risks to accomplish the development opportunities [25]. The IFC framework provides the eight performance standards for development project as,

- "Management and Assessment of Social and Environmental Impacts and associated risks".
- "Working and Labor conditions"
- "Resource Efficiency and Pollution Prevention"
- "Community Health, Safety, and Security"
- "Land Acquisition and Involuntary Resettlement"
- "Biodiversity Conservation and Sustainable Management of Living Natural Resources"
- "Indigenous Peoples"
- "Cultural Heritage".

These indicated performance standards are designed to maintain the environmental and social aspects of the development and achieve the sustainable development goals.

B. Environmental Assessement

The 2*660MW coal-fired power plant in Jamshoro, a comprehensive environmental assessment is crucial. It should address air pollution, noise pollution, thermal pollution, solid waste management, and wastewater to minimize the project's impact on the environment.[31]

C. Methods and Tools

In this study, we aim to evaluate the environmental impact of a 2x660MW Supercritical Coal Fire Power Plant in Jamshoro. Specifically, it assesses the effects on air quality, noise levels, soil conditions, solid waste generation, and wastewater discharge. To conduct this assessment, we will employ the Leopold matrix, a qualitative method developed by Luna Leopold and a team of collaborators for the USGS in 1971. The Leopold matrix serves as a valuable tool to identify and quantify the potential environmental consequences of proposed projects on the surrounding ecosystem. By utilizing this method, we can assign numerical weightings to each factor and gain a comprehensive understanding of the overall environmental impact of the power plant project in Jamshoro. [12]

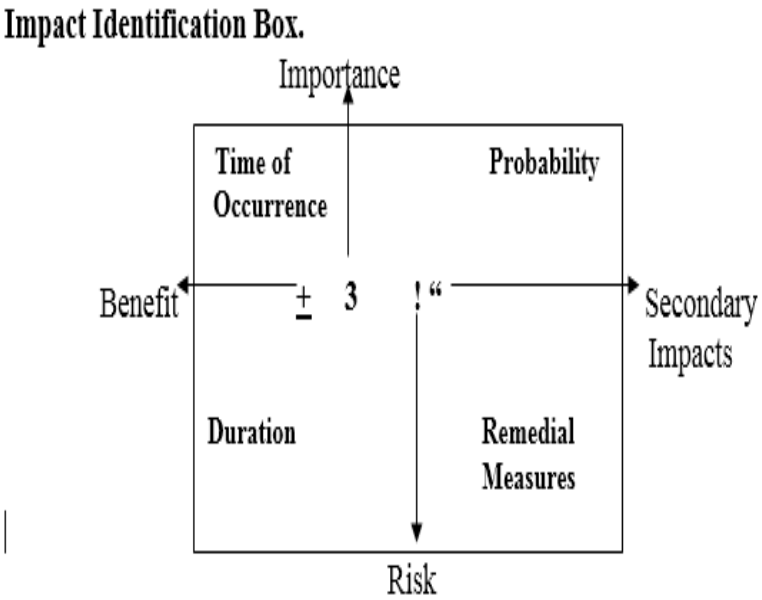


Fig. 1: Leopold Matrix

ISSN No:-2456-2165

Table 1: Leopold matrix scaling

Characteristics	Sy	Effect	Characteristics	Sy	Effect
Importance	5	Highly	Duration	L	Long
	4				
	3	Moderate		S	Short
	2				
	1	least		F	Permanent
	0	No Effect		?	Not Know
	?	Not Know	Benefit	+	Certain
Probability	C	Certain		-	Probable
	P	probable		?	Not Know
	U	Unlikely	Remedial Measures	Y	Planned
Time of Occurrence	D	Delayed		N	Not planned
	L	Long Term		?	Not Know
	?	Not Know	Risk	!	Potential Hazard
			Secondary Impact	*	Will give rise to
				“	Is a result of

D. AQMS.

It is system or method which is used to analyses quality of air through controlled approach. AQMS stations are a broad methodology to observe, assess, air quality in a specific region. The key aspect of this is to maintain and provide safety to public health and the environment through reducing the concentration of pollutants and sustaining air quality within acceptable standards. AQMS management is implemented by environmental, NGOs, governments, and industries to address the growing concerns regarding air pollution.[26] AQMS management system involves components such as,

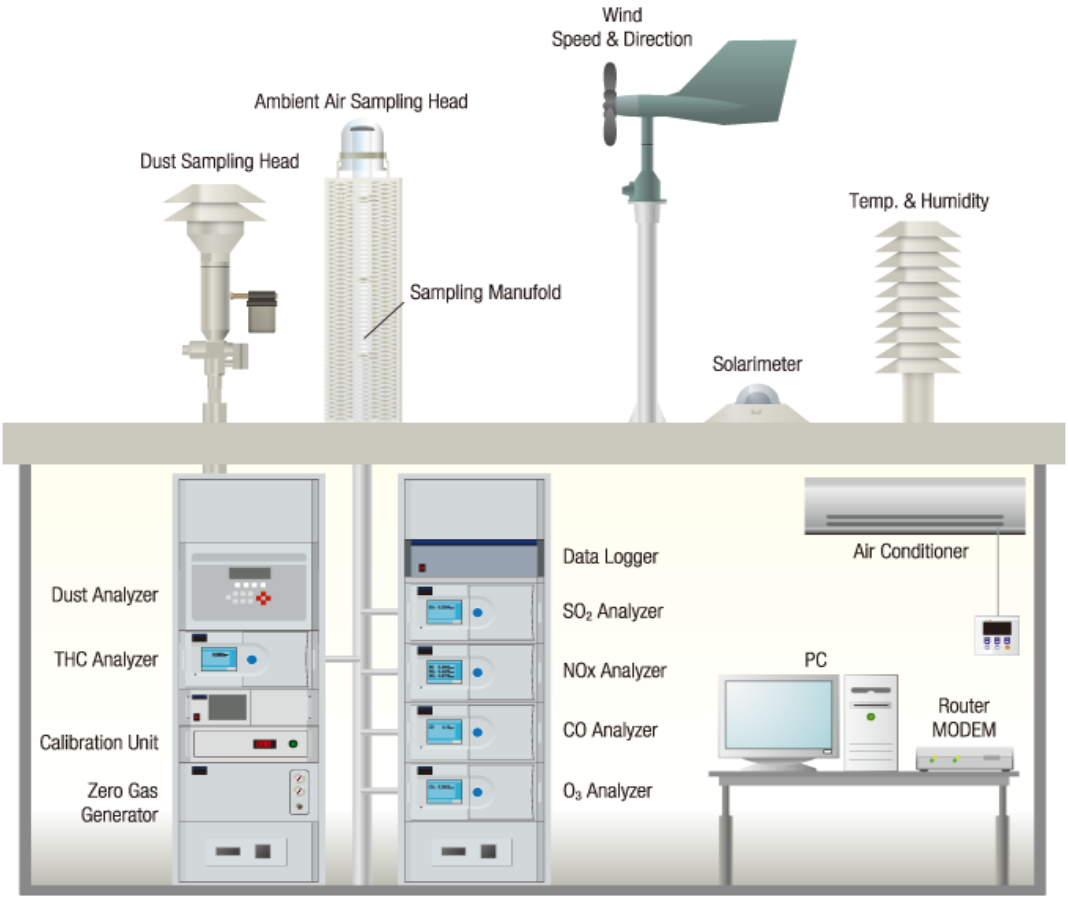


Fig. 2: AQMS Station

ISSN No:-2456-2165

E. Air Quality Monitoring Stations

AQMS management system is placed in specific areas to measure the various air pollutants concentrations. These specified locations uninterruptedly collect data on pollutants including particulate matter (PM10, PM2.5), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and others. Modern AQMS use internet-based communication systems for easy access to real-time air quality data. The study by [18] revealed that the study has been exploring the air population, health and social emissions of the specific matter in PM The management system provides data collection and analyzes it using air quality models and algorithms. AQMS models can help to identify the sources of pollution, predict future pollution levels, and simulate the impacts of different control measures. Similarly, the study of Wang [2] With the help of data collected, air quality indices are calculated to provide the public with easily understandable information concerning the current air quality status. Governments set air quality standards that define the maximum allowable concentrations of various pollutants. Moreover, AQMS management system works to guarantee compliance with these standards (IFC) by implementing regulations and policies on emissions from industrial facilities, transportation, and other pollution sources. [4].

F. Air pollution Assessment

Using the AQMS model, the air pollution assessment has been done for two different stations. One up stream and 2 downstream winds, the data for these two stations have been collected from the Air quality monitoring station. At 2x660MW Supercritical Coal Fire Power Plant Jamshoro, these to specified stations are located, the downstream wind is located near the office area and upstream wind is located at chimney side. The models which are deployed or used at both these stations is AQMS Focused Photonics Inc. (FPI), it is company headquarter in China that focusses on the manufacturing and development of advanced analytical instruments, predominantly in the environmental monitoring and air quality management field [27]. It is considered a leading company for producing high-quality gas analyzers and monitoring systems used in various industries, including environmental protection, industrial safety, and process control in the world. The current study has used this model to assess the Air pollution [7].

Table 2: Data For Downwind Steam Near Office Area

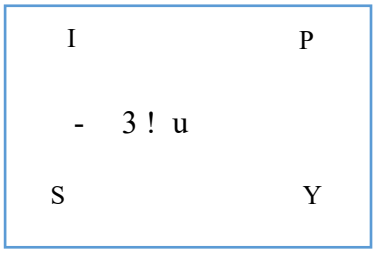
Parameter	Average24 hours ($\mu g/Nm^3$)	WBG IT-1 Standard ($\mu g/Nm^3$ 24-hour)	SEQS Standard ($\mu g/Nm^3$ 24-hour)
SO_2	56.0	125	120
NO	19.3	-	40
NO_2	59.0	120	80
C0	2.92	10	-
PM_{-10}	157.0	150	150
$PM_{-2.5}$	81.5	75	75

Table 3: DATA FOR UP STEAM NEAR CHIMNEY AREA

Parameter	Average24 hours ($\mu g/Nm^3$)	WBG IT-1 Standard ($\mu g/Nm^3$ 24-hour)	SEQS Standard ($\mu g/Nm^3$ 24-hour)
SO2	54.4	125	120
NO	17.9	-	40
NO2	49.3	120	80
CO	3	10	-
PM-10	158.2	150	150
PM-2.5	81.9	75	75

➢ *Leopold Criteria for Air Pollution Assessment*

For both the locations as prescribed in table 1 and 2 the calculated values through the AQMS FPI for 24 hours are shown and in unit of milligrams per cubic meter. The standard value which is acceptable for all the parameters in WBG IT-1 Standard is 10-125$\mu g/Nm^3$, whereas in the SEQS, the allowable in the range for all parameters as 40-120 $\mu g/Nm^3$. The calculated values are less than the standard values and meet the criteria of international standards. Now, to check the impact of all these parameters including SO2, NO, NO2, C0, PM-10, PM-2.5, the Leopold matrix has been directed to observe the calculated values.



The above impact identification box has been made with the help of calculated values of the selected parameters for the current study. In which the scale of Leopold has been employed and the quotes have been shown in the matrix in which,

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- I= relating to the time of occurrence of these parameters, it is immediate
- P = denotes probable which is the probability
- S = shows short term which is duration of parameters
- Y = shows planned which is remedial measures
- - shows the probable in terms of benefit concerning selected parameters on the air pollution.
- 3 shows the moderate which indicates importance and parameters effects on air pollution.
- u = is a result of, it is secondary impact of the parameters.
- ! = Risk, for the parameters, it is potential hazard.

G. Noise Pollution Assessment

To meet the desired objective of the study, the other aspect of the environmental assessment as Nosie pollution has been carried out and for that the calculation of the Nosie pollution at the different location has been demonstrated for the 2x660MW Supercritical Coal Fire Power Plant Jamshoro. Noise pollution is essential to consider as it has impacts on the population including workers or citizen, and impacts their health, well-being. Most noteworthy here to discuss is environmental, and social impacts of the noise pollution. By increasing popularity of environmental notion, the study has considered to assess the noise pollution and its impacts that leads to sustainable approaches. To assess the impact of noise pollution, data has been collected to gauge the impact of the noise population at different specified locations at 2x660MW Supercritical Coal Fire Power Plant Jamshoro.

➢ *Data Collection for the Noise Pollution*

The data has been collected to identify the impact of noise pollution using the Noise meter model UT353/UT353BT Mini Sound Level Meters. Moreover, different has been set to measure the noise pollution including Office Area, Chemical building, Admin building, service building, coal handling building, and others as mentioned in the below table 3. The data has been collected for one month and that process is divided into weeks as 1,2,3, and 4. For the noise pollution, the data has been collected in the daytime and the collection of data has not been carried out in the nighttime that can varies the values. The noise is measured in decibels (dB) and that represents the relative sound intensity or noise generated and the collected data is measured in dB. To check the collected values, the standards for allowed noise pollution has been followed to ensure meeting of the standard criteria that are shown in the table 2. The table 2 shows the Standers table in which different bodies are chosen to match the collected data for noise pollution including SEQS (The Sindh Environmental Quality Standards), world bank IFC and OSHA.

The standard values are given for different locations including residential, industrial, working environment, and vehicles. Likewise, both day and night values for noise pollution are given in the standers as shown in table 2. For instance, from table 1. for a coal handling building, noise pollution in first week was collected at 67.1, likewise, in week 2 as 65.7, 69. 9 for week 3, and 68.6 for week 4. It makes an average at 68.6. Now to compare this value calculated with the standards for Nosie pollution at the industrial areas it is 75 dB in daytime and 65 dB nighttime in SEQS standard. So, the coal handling building lies in the standard values. The same is true for all the locations and meets the requirements of the specified standards except the Turbine, Boiler, ESP locations, these three locations have exceeded the limit by specified by the standard bodies and is highlighted in the table.

Table 4: Nosie pollution data collection at different specified location at 2x660mw supercritical coal fire power plant jamshoro

Locations	Week 1	Week 2	Week 3	Week 4	Average Month
Office Area	58.3	55.6	66.4	62.2	60.6
Turbine	91.3	88.7	94.6	85.8	90.1
Boiler	87.4	82.9	81.3	79.9	82.9
Chemical Building	70.8	68.6	76.5	72.8	69.2
Admin Building	52.0	63.5	69.8	55.5	60.2
Service Building	53.3	54.5	60.3	64.6	58.2
Coal Handling Building	67.1	65.7	69.9	71.8	68.6
ESP	87.5	78.5	81.8	80.5	82.1
FGD	63.8	61.8	64.4	66.2	64.1
Worker Accommodation	54.2	53.8	51.7	49.4	52.2

Table 5: Standards values for noise pollution

	SEQS	World Bank	OSHA	IFC
Residential	Day=55 / Night=45	Day=55 / Night=45		Day=55 / Night=45
Industrial	Day=75 / Night=65	Day=70 / Night=70		Day=70 / Night=70
Working Envi.	-	-	90	85
Vehicles	85	-	-	-

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➢ *Leopold Matrix for Nosie Pollution*

To measure the impact of Noise pollution at the specified locations, the Leopold matrix is used as,

D	C
- 4! *	
L	N

- D = shows the delayed which is time of occurrence
- C = probability of certain effect
- L = shows the long-term duration of the Noise pollution
- N = remedial measures which are not planned
- ? shows the benefits of Nosie pollution which is not known.
- 4 = shows the importance and can highly effect
- ! shows the risk, for the Nosie pollution, it is potential hazard.
- *Shows the secondary impact and Nosie pollution will rise to.

H. Soil Pollution

Soil pollution is one of the essential parameters to consider. If not consider the soil pollution, it contaminates the soil and it can take time to recover that soil in natural form. The identification and presence of contaminated soil during the construction projects has been a problem as it requires proper classifying and identifying the contaminated and that involves costs to ensure complaint management and safety of contaminated materials [28]. Soil is contaminated when the percentage or concentration of pollutants is higher than the natural soil. It is due to activities that commenced on the site and have impacts on the soil. Additionally, the power plants have generated improper handling and disposal of coal ash and other solid wastes that could result in the soil and water contain mated, with a similar study revealed by [8] highlighted.

➢ *New Power Plant Assessment of Soil Pollution*

Soil pollution caused by workers' improper waste disposal practices during the construction activities of a 2x660 MW coal-fired power plant in Jamshoro. The study aims to identify the specific pollutants introduced into the soil and the potential environmental consequences. The observations made during the assessment reveal that workers have been contaminating the soil by throwing of various chemicals, oils, and grease, leading to soil pollution in the vicinity of the power plant construction site.

- Paint Thinner and Paint: Workers were observed disposing of paint thinner and paint residues onto the soil. These substances contain volatile organic compounds (VOCs) that can leach into the soil and groundwater, posing a risk to both environmental and human health.
- Used Oil and Grease: Lack of proper waste management resulted in workers discarding used oil and grease directly onto the soil. These oils can contain heavy metals and other harmful contaminants that can persist in the soil and cause long-term pollution.
- Glue and Chemicals: Improper disposal of glue and various chemicals used during construction activities further exacerbated soil pollution. These chemicals can alter soil properties, hinder microbial activity, and affect nutrient availability for plants.

➢ *Environmental impact by these pollutions*

- Soil Degradation: The pollutants can disrupt the natural soil structure and decrease its fertility, leading to a decline in agricultural productivity and vegetation growth.
- Groundwater Contamination: Leaching of VOCs and chemical residues into the soil can contaminate groundwater, potentially affecting drinking water sources and aquatic ecosystems.
- Air Pollution: Volatile substances like paint thinner and VOCs can evaporate into the air, contributing to air pollution and potentially causing respiratory issues in nearby communities.
- Ecosystem Disruption: Soil pollution can harm soil-dwelling organisms, disrupting the ecological balance and reducing biodiversity in the area.

➢ *Leopold Matrix for Soil Pollution*

D	C
-3 !	
L	Y

- D is delayed which is occurrence time of soil pollution
- C = probability of certain effect
- L = shows the long term duration of the soil pollution
- Y = remedial measures which are planned for new power plant
- ? shows the benefits of soil pollution which is not known
- 3 = shows the importance and can highly effect
- ! shows the risk, for the soil pollution, it is potential hazard
- *shows the secondary impact and soil pollution will rise to.

I. Solid Waste Management Assessment

This section provides the assessment of the constructed plant and intends to assess the waste collected or generated at the site construction. This assessment supports identifying the waste management system at the power plant. Solid waste management is the process or procedure that support to collect, dispose the harmful solids that can impact the environment. In addition, this management system provides collecting, treating, and disposing of the solid material which are no longer in use or has served its purpose. solid-waste management, the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Considering the current

ISSN No:-2456-2165

research, the plant construction and installation of equipment will generate considerable amount of hazardous and non-hazardous waste. Based on initial assessment it was determined that approximately 3200 kg is required for storage of waste generated. During the assessment it was found that there are two types of solid waste that can be generated at the site of construction which needs to be carefully planned to progress the newly constructed plant 2x660MW Supercritical Coal Fire Power Plant Jamshoro. Including non-hazardous and hazardous solid waste.

➢ *Non-Hazardous Waste*

Solid (non-hazardous) wastes generally include any garbage, refuse. Examples of such waste include domestic trash and garbage; inert construction / demolition materials; refuse, such as metal scrap and empty containers. During the assessment, it was noticed that the construction company has hired 3rd party contractor, which is Waste Management Solutions, it deals with nonhazardous waste. The collection for collecting the solid waste are working site, office, and living areas. The procedure of the waste collection and steps that can be taken are discussed below.

➢ *Procedure for Solid Waste Management*

The following procedure is followed at the site construction of the newly plant while collecting and disposing the solid waste materials to make the progress of the plant effective and free from the environmental impact and consider the health and safety concerns to avoid any hazardous situation at the construction of the newly plant.

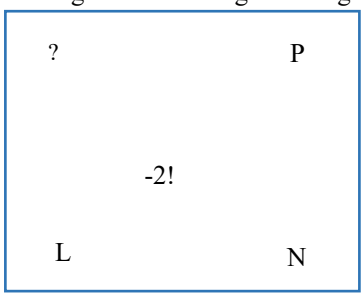
- ***Waste Collection****:* Waste collection areas (waste storage containers or waste bins) regular waste collection, transportation for domestic waste (except metal, wood and other construction or engineering waste material).
- ***Waste Segregation:*** This process involves dividing the waste into wet and dry, wet solid waste includes organic waste, whereas, dry comprises metals, wood, glass, or any material related. Hazardous and non-hazardous waste will be segregated at the point of generation. To carefully separate the waste, appropriate containers should be implemented.
- ***Waste Storage and Handling:*** Temporary storage area will be inspected by the Project Owner to identify any underground utilities. EPC Contractor will also inform Owner, if any underground utility identified during the survey for required mitigation measures. All waste shall be temporarily stored at a dedicated temporary Waste Yard.
- ***Waste Transportation:*** Waste transportation involves the movement of the waste material through appropriate vehicles from the collecting place to final disposal.
- ***Waste disposal:*** The collection, treatment, transport, and sorting of waste and its tipping and storage under or above the ground is termed as waste disposal. Collected waste disposal to the Waste Disposal Landfill Site at Looni kot. The operation including its recycling, recovery, and re-use should be implemented to reduce the waste amount and quantity that can impact the environment and health and social life of people.

➢ *Hazardous Solid Waste*

Hazardous waste shares the properties of a hazardous material (e.g. ignitability, corrosively, reactivity, or toxicity), or other physical, chemical, or biological characteristics that can pose a potential risk to human health or the environment. The study has observed that all hazardous waste has been collected and stored to the hazardous waste storage yard. However, it was found that only the collection of solid waste material has been done at the site construction of the new plant, disposal of solid material has not been performed yet, and that can harm the environment, health of the workers, soil contaminated, and related health and safety issues.

➢ *Leopold Matrix for hazardous Solid Waste*

Non-hazardous solid waste is being adequately managed by a third-party contractor with SEPA approval. Matrix is only made of hazardous waste The assessment specifically applies to hazardous materials, which are not disposed of on the first day of the project but are instead stored in a designated storage yard. However, it is essential to recognize that storing hazardous materials in the same storage yard can potentially lead to environmental pollution. Proper containment measures and stringent management practices should be implemented to prevent any adverse impact on the environment and surrounding areas. Exposure to hazardous waste can pose significant risks to human health. Toxic chemicals can enter the human body through ingestion, inhalation, or direct contact. Depending on the specific substances involved, the health effects can range from respiratory problems and skin disorders to more severe conditions, including cancer and organ damage.



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- 2 shows the moderate which indicates importance and parameters effects on air pollution.
- *shows the secondary impact and non-hazardous waste will rise to.
- ! = Risk, for the parameters, it is potential hazard.

J. Thermal Pollution

During the construction phase of a 2*660MW coal-fired power plant, thermal pollution can occur due to the utilization of air compressors for instrument air supply and boiler cleaning. These air compressors produce heat during their operation, which is dissipated using a Closed-Circuit Water (CCW) pump system. The CCW pump system is designed to provide cooling to various components and equipment involved in the construction process, ensuring proper functioning, and preventing overheating.

In this process, the CCW pump draws in fresh water from the retention basin of the plant, where the water temperature is maintained at 35.8 degrees Celsius and uses it as a heat sink for the air compressors. As the air compressor heat is transferred to the water, it converts the fresh water into hot water. However, during the construction phase, the cooling tower of the plant is not operational, so the hot water from the CCW pump is discharged back into the retention basin at a higher temperature, reaching 43 degrees Celsius. The temperature difference of 8 degrees Celsius results in the release into the environment [5]. The heat discharge in environment, we can use the formula Q = m * c * ΔT,

where:
Q = Heat transfer (in joules)
m = Mass of the fluid (in kilograms)
c = Specific heat capacity of the fluid (in J/(kg·°C))
ΔT = Change in temperature (in degrees Celsius)

$$m = 60{,}000\,kg$$
$$t1 = 35.8°C$$
$$t2 = 43°C$$
$$c = 4.18\,J/(g \cdot °C) = 4180\,J/(kg \cdot °C)$$
$$\Delta T = t2 - t1$$
$$\Delta T = 43°C - 35.8°C$$
$$\Delta T = 7.2°C$$
$$Q = m * c * \Delta T$$
$$Q = 60{,}000\,kg * 4180\,J/(kg \cdot °C) * 7.2°C$$
$$Q = 1{,}805{,}760{,}000\,Joules$$
$$Q = 1{,}805{,}760{,}000\,J / 1{,}000{,}000 = 1805.76\,MJ$$

So, the heat transfer is approximately 1805.76 megajoules (MJ).

This discharge of hot water and waste heat 1805.76 MJ into the environment can lead to thermal pollution in the surrounding ecosystem. The elevated water temperatures can harm aquatic life, disrupt the ecological balance, and negatively impact the overall health of the environment during the construction phase of the power plant. It is essential to monitor and manage this thermal pollution to minimize its adverse effects on the ecosystem and ensure responsible construction practices. Once the plant enters its operational phase, the cooling tower will be active, and the CCW system will operate on a closed circuit, reducing the impact on the environment by reusing the water for cooling purposes.

➢ *Leopold Matrix for Thermal Pollution*

D	P
- 3 !	
L	Y

- D is delayed which is occurrence time of soil pollution
- P = denotes probable which is the probability
- L = shows the long term duration of the thermal pollution
- Y = remedial measures which are planned for new power plant
- - = shows the benefits of thermal pollution effect are negatives
- 3 = shows the moderate important and can effect
- ! shows the risk, for the thermal pollution, it is potential hazard
- *Shows the secondary impact and thermal pollution will rise too.

K. Wastewater Assessment

Wastewater from the construction of a 2x660 MW coal-fired power plant in Jamshoro refers to the used water generated during various activities and processes related to the construction and operation of the power plant. This wastewater may contain various pollutants and contaminants depending on the sources and processes involved.

➢ *Domestic Wastewater*

Domestic wastewater at the construction site of the coal-fired power plant in Jamshoro is the used water generated from residential sources within the plant premises. This includes water used in offices, restrooms, kitchens, and other facilities used by workers and staff involved in the construction and operation of the power plant. The domestic wastewater generated during the construction of the coal-fired power plant should be collected through a well-designed sewage collection system. This system may consist of a network of pipelines, drains, and treatment units designed to transport the wastewater to a central point where it is discharged. In this time chemical department to ready for operation, the domestic wastewater is not processed or treated on-site but is instead discharged into the local municipal sewage system.

It's essential to ensure that the domestic wastewater discharge complies with local regulations and standards to avoid any adverse impact on the environment and public health.

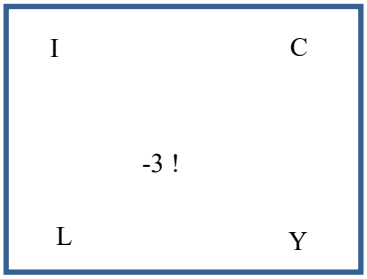
➢ *Industrial Wastewater*

Industrial wastewater at the construction site of the coal-fired power plant refers to the water used in industrial processes and activities. This can include water used for cooking, cleaning, boiler testing, chemical dosing, and other industrial operations necessary for the functioning of the power plant. At the time of assessment, the plant has been

testing auxiliary boiler The auxiliary boiler is used to provide additional steam or hot water during start-up or periods of increased demand. at the chemical department of the power plant, hydrochloric acid HCl [29] is dosed into the industrial wastewater to control its PH. Issue is that to make matters worse, after the dosing of HCl, the industrial wastewater is being discharged directly into the river without any further treatment or testing. This irresponsible practice can severely harm aquatic life, degrade water quality, and have far-reaching consequences for the surrounding ecosystems.

Chemicals with Improper Chemical Dosing and Discharge: However, it's concerning that the chemical dosing process is not being properly managed. Improper dosing of HCl can lead to fluctuations in pH, which may cause corrosion issues and affect the efficiency of downstream treatment processes [30]. Additionally, if the chemical dosing is not done correctly, it could lead to an uncontrolled release of acidic wastewater into the environment, posing serious environmental hazards.

➢ *Leopold Matrix for wastewater*



The above identification matrix has been made to identify the impact of wastewater creating. In which the quotes have been denoted within the matrix setting that is made with the help of Leopold scoring criteria. In which,

- I = immediately which is occurrence time of wastewater pollution
- C = denotes certain which is the probability
- L = shows the long-term duration of the wastewater pollution
- Y = remedial measures which are planned for new power plant
- - = shows the negative impact cerate
- 3 = shows the moderate important and can affect
- ! shows the risk, for the wastewater, it is potential hazard.
- *Shows the secondary impact and impact will rise too.

IV. SOCIAL IMPACT ASSESSMENT

A social assessment is a crucial and comprehensive process that involves identifying, analyzing, and assessing the social impacts of a specific project. It aims to evaluate the potential positive and negative consequences that the project may have on the affected communities and individuals. In this context, we will be conducting a social assessment for a 2x660 MW coal-fired power plant [11].

The primary focus of this social assessment is to thoroughly evaluate various aspects that can influence the local communities, workers, and the environment within the vicinity of the power plant. To gather comprehensive data and insights, the researcher employed both online and paper-based survey methods. The choice of survey methods is aimed at ensuring accessibility and understanding among the diverse groups of individuals involved. The social assessment survey involved various categories, enabling a comprehensive understanding of the project's social impact, including grievances, education Facilities, resettlement, worker Facilities, hiring Local Personnel, agriculture Training, health Care Facilities.

A. Survey Locations

To obtain a comprehensive understanding of the project's social impact, the survey will be conducted at multiple locations to assess the impact of activities conducted by the Power plant on the social aspect of society including.

- Inside the Project Area:
- Outside the Project Area
- Inside the Colony
- Labor Worker Accommodation

B. Survey Method

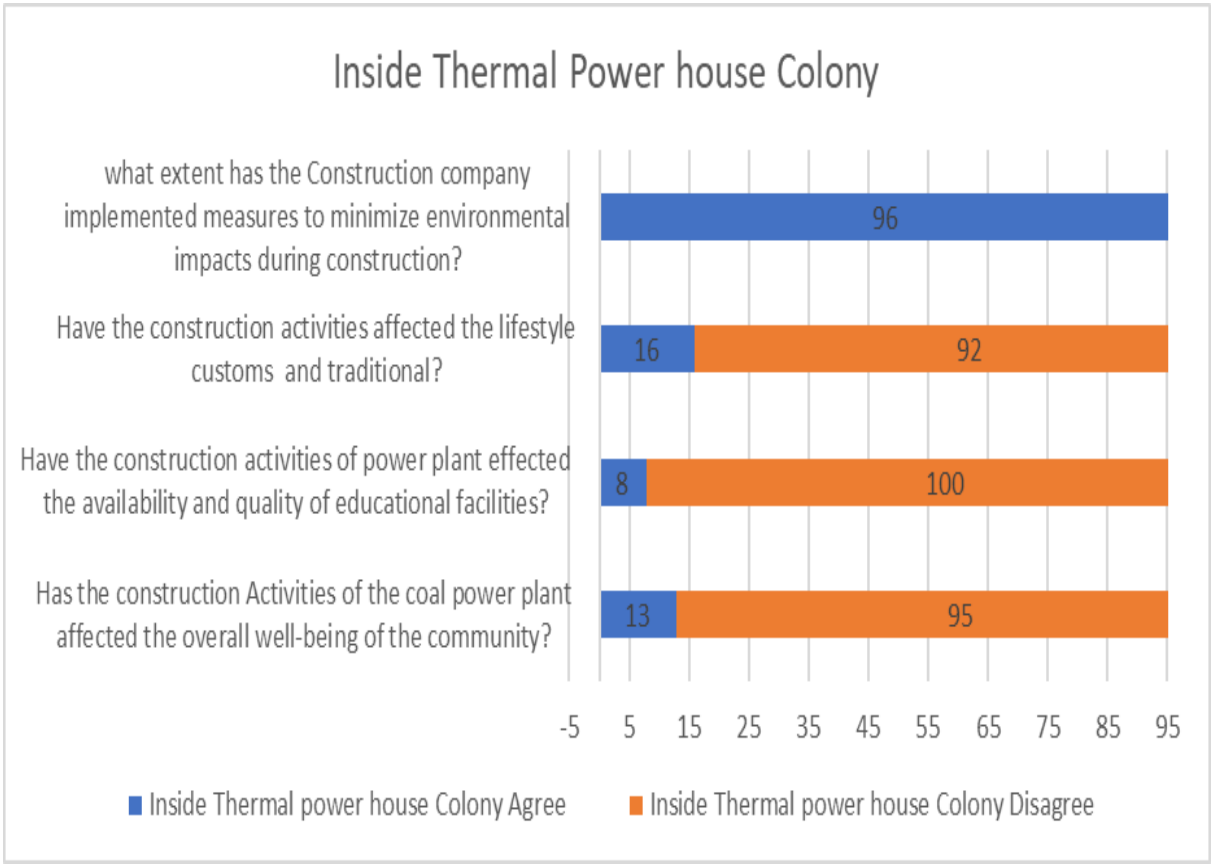
To ensure that all sections of the community are adequately represented, the social assessment survey will be conducted using two distinct approaches:

- Online Surveys: The online survey method has been employed for the communities residing in the colony, outside the project area, and inside the project area. This approach will leverage technology, allowing respondents to participate conveniently using online platforms such as Google Forms.
- Paper-Based Surveys: Recognizing that labor workers may not be well-versed in digital technologies; paper-based surveys will be administered at their accommodation sites. This will ensure that even those who are not familiar with mobile phones or digital interfaces can participate and provide valuable feedback.

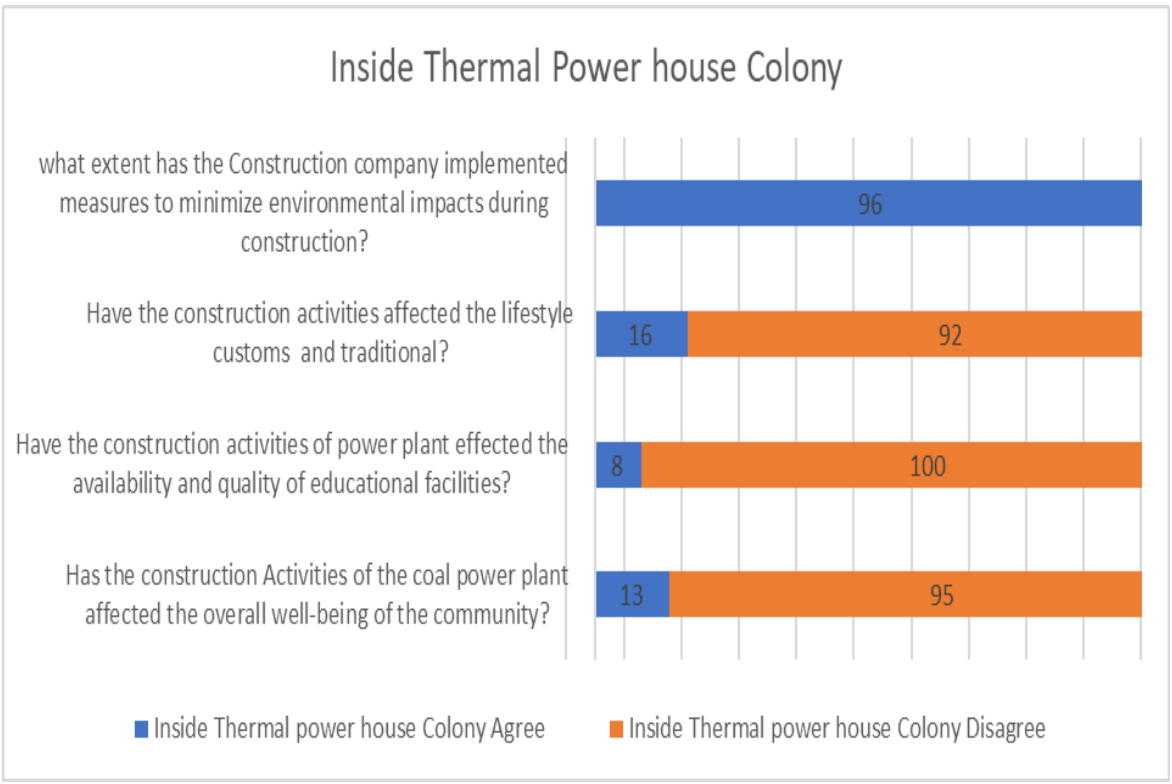
C. Data Collection

The questionnaires have been made for both survey designs including paper and online means. For the online survey, 19 questions have been established to know the response from the workers regarding the social impact of the 2x660MW coal-fired power plant. Whereas, for the paper-based survey, the workers residing in the ZEPL and E-block worker accommodations, both integral parts of the power plant construction site. A total of 139 workers participated in the survey, either individually or in groups, with 96 workers residing in ZEPL accommodation and 43 workers in the E-block accommodation.

➢ *Inside thermal powerhouse colony*

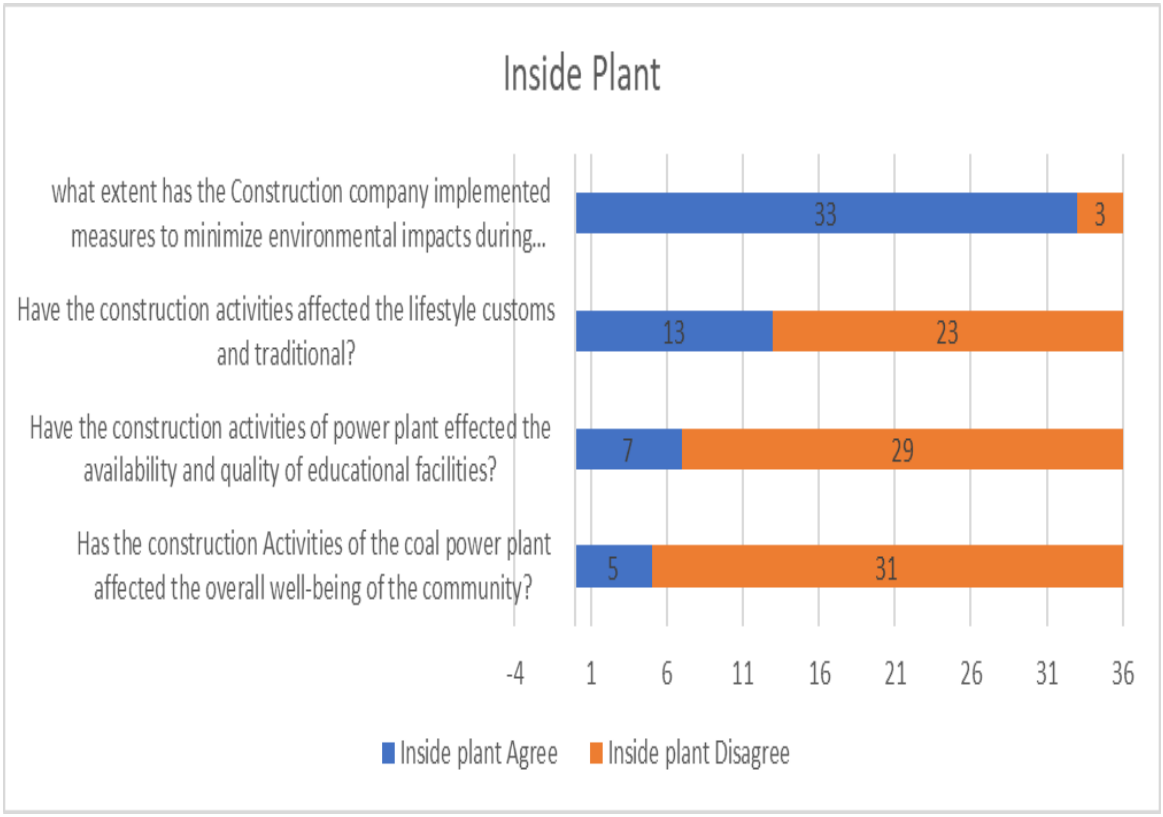


Graph 1: Inside thermal Powerhouse Colony

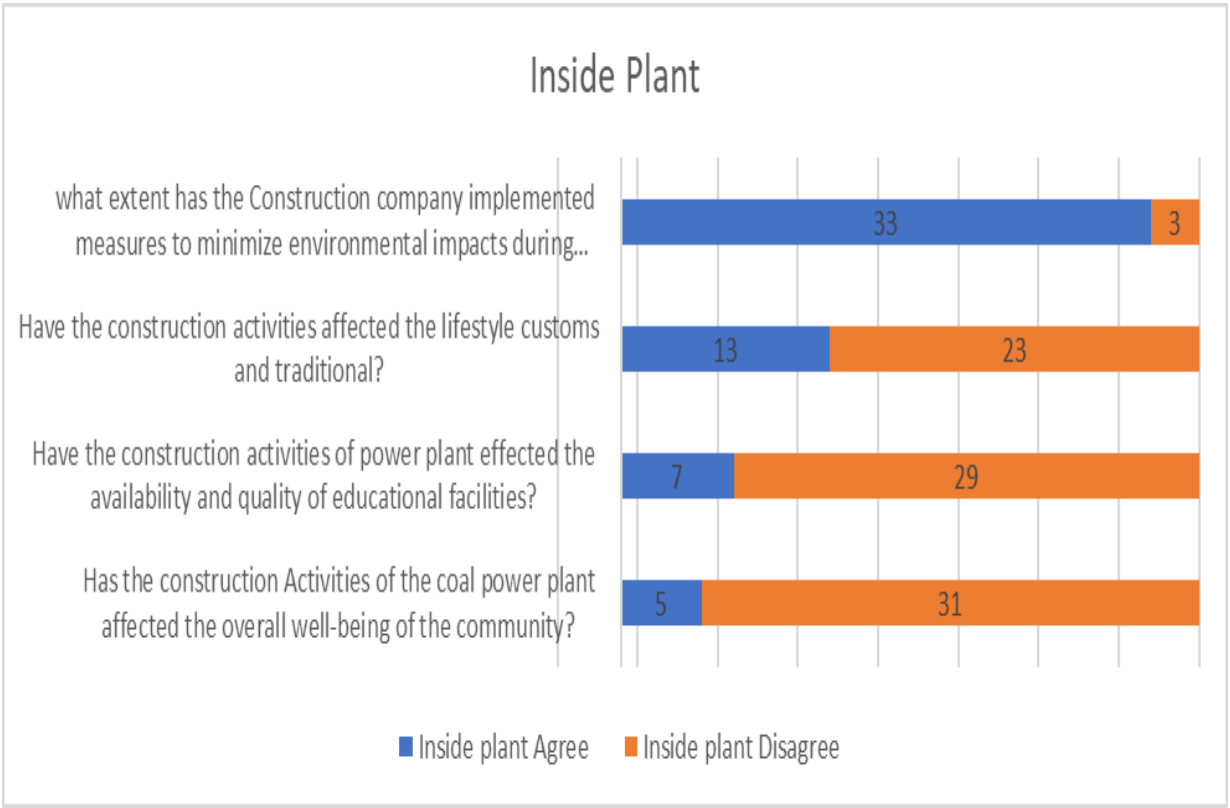


Graph 2: Inside thermal Powerhouse Colony

➢ *Inside plant*

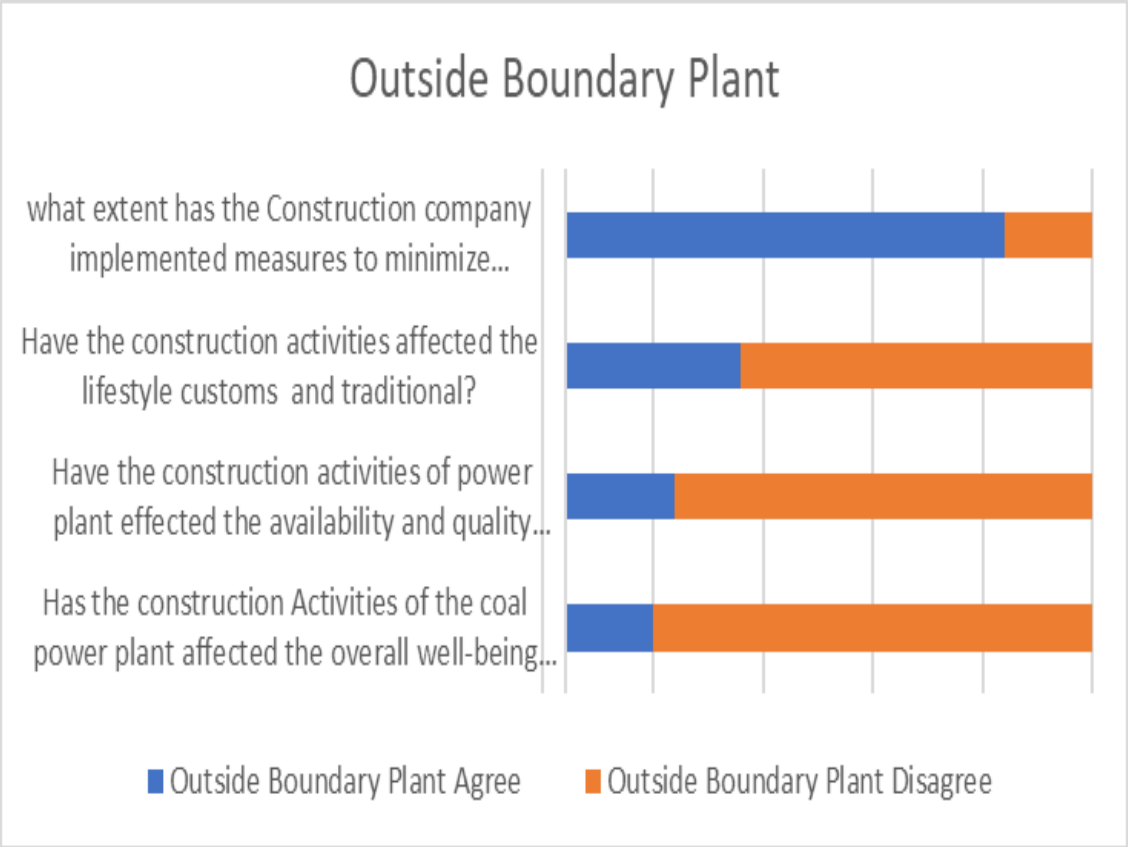


Graph 3: Inside Plant

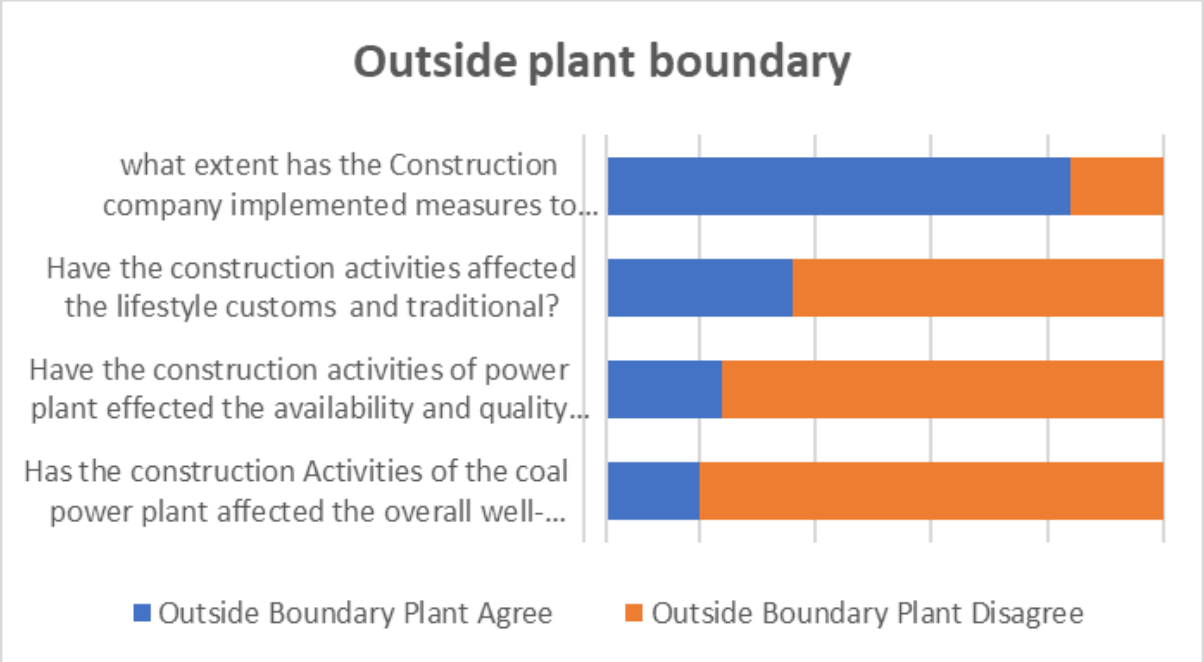


Graph 4: Inside plant

➢ *Outside Boundary plant*

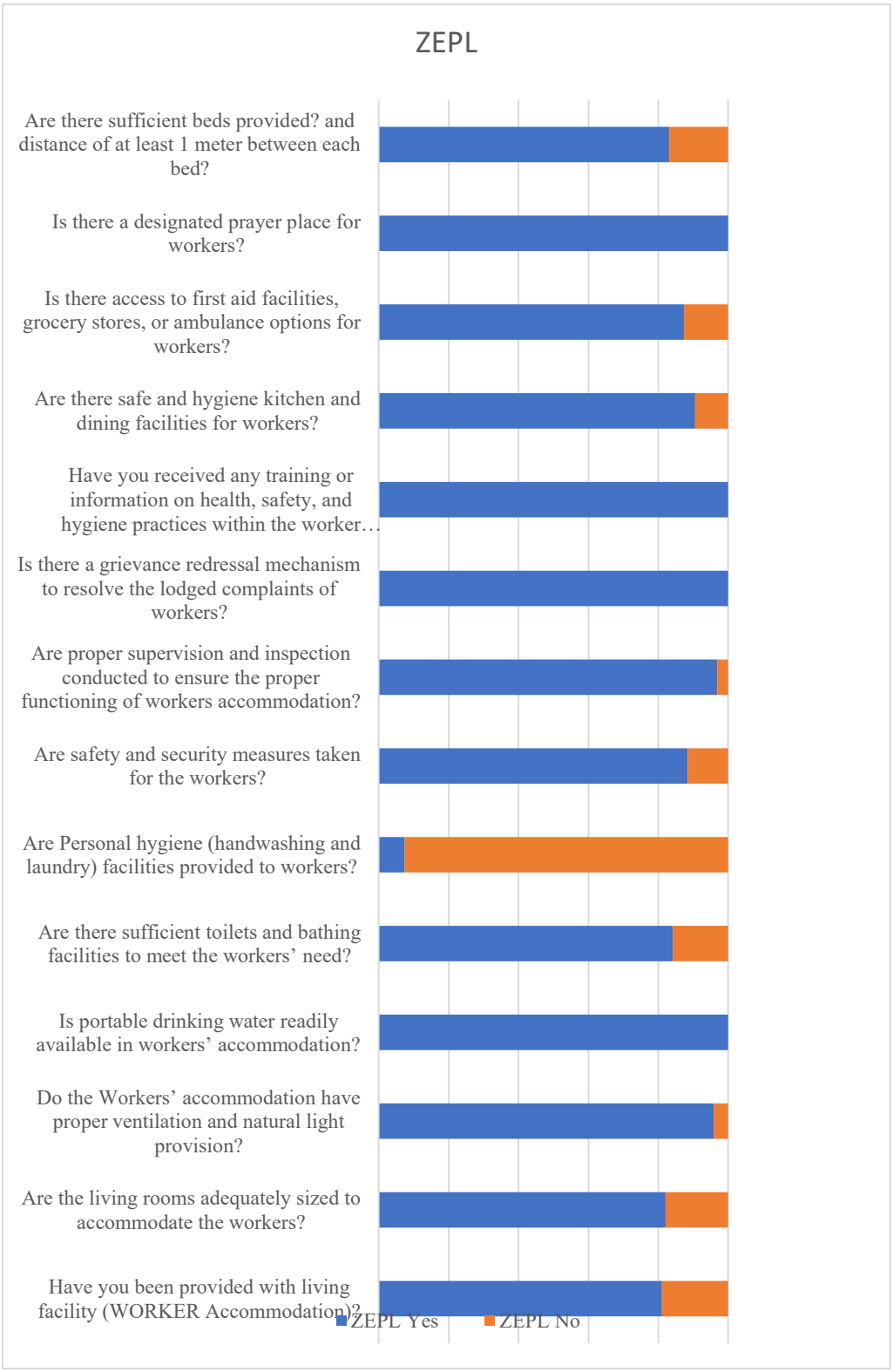


Graph 5: Outside Plant Boundary



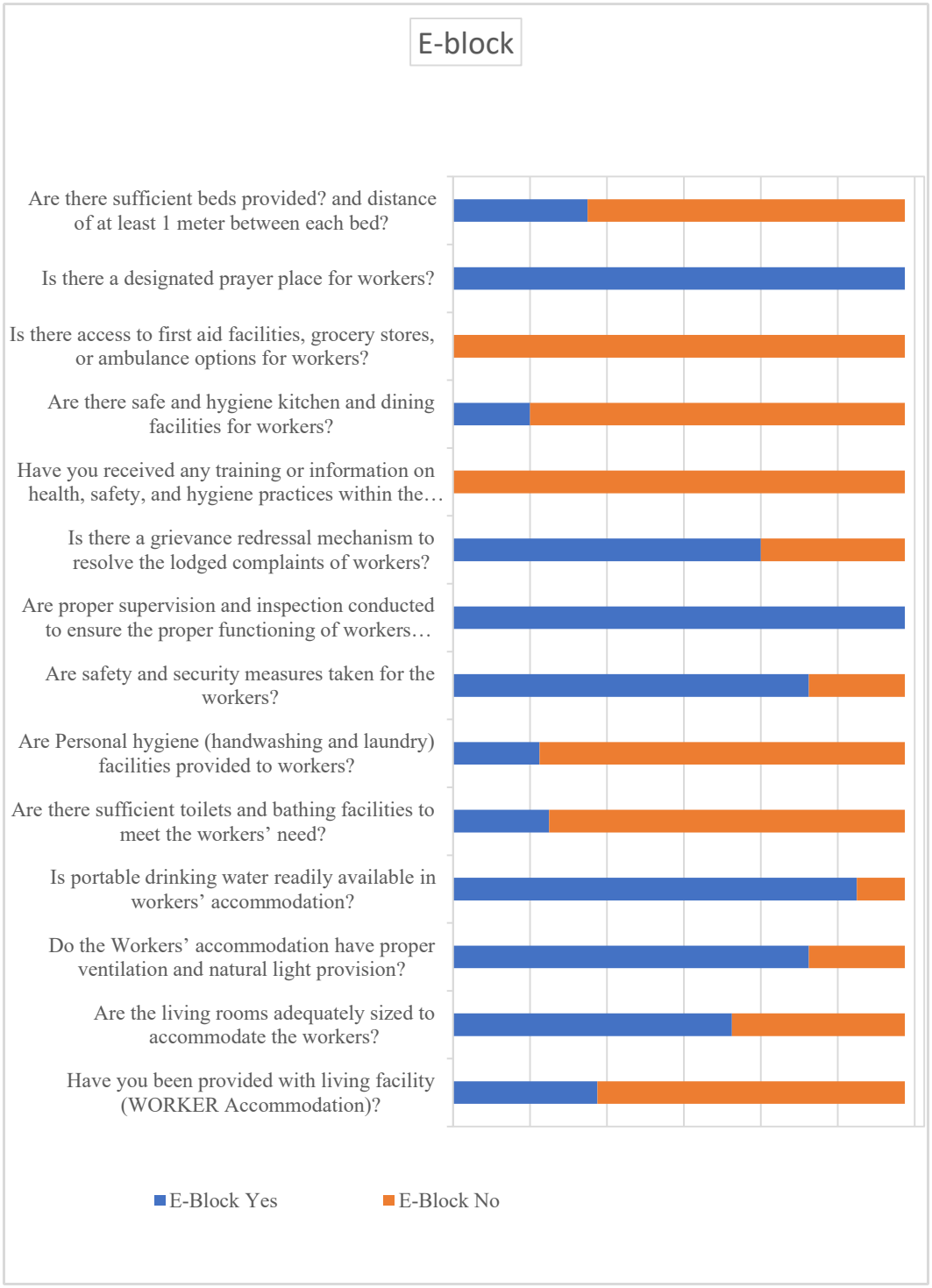
Graph 6: Outside Plant Boundary

➢ *ZEPL woker accomodation*



Graph 7: ZEPAL Worker Accommodation

➢ *E-block worker accommodation.*



Graph 8: E Block worker Accommodation

ISSN No:-2456-2165

V. OCCUPATIONAL HEATH AND SAFETY RISK ASSESSMENT

Occupational Risk Assessment for Health and Safety at 2x660MW Coal Fire Power Plant in Jamshoro. During the construction phase of the power plant a comprehensive Occupational Risk Assessment was conducted to ensure the health and safety of workers. The assessment covered various areas such as Work at Height, Fire Safety, Heat Management, Confined Space, Electrical and Chemical Safety, Traffic Management, Vehicle and Equipment Safety, Ergonomics, Housekeeping, Hand and Power Tool Safety, Loading and Unloading, Lifting Activities, Personal Protective Equipment (PPEs), Stress Management, and Excavation. [22] A 5X5 Risk Matrix was used to evaluate the severity and likelihood of identified risks, enabling effective safety measures and protocols to be implemented. The goal is to create a safe working environment for all employees involved in the power plant construction. [41]

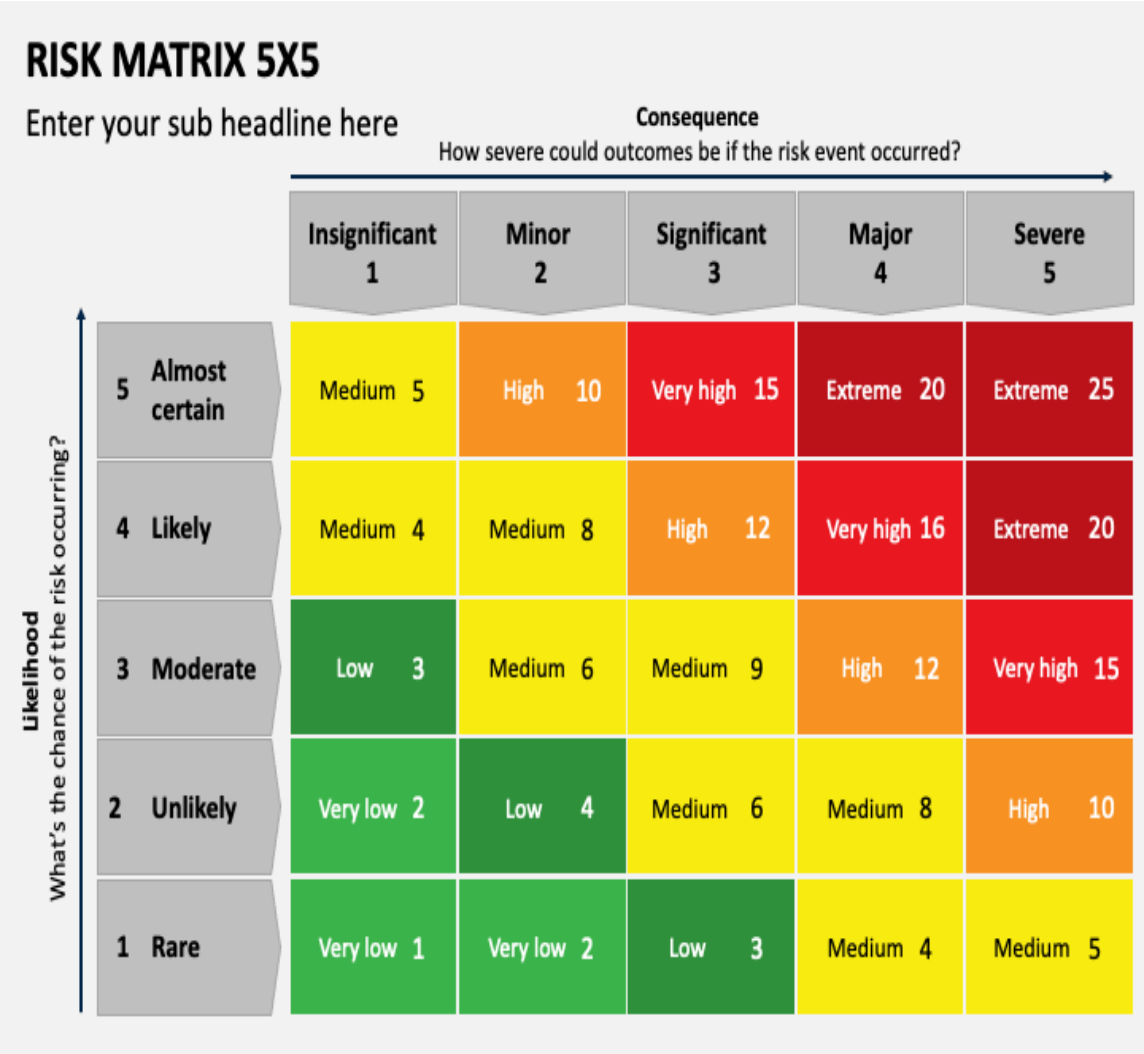


Fig. 3: Risk Matrix 5X5 for Occupational health and saftey

A. Risk Assessment Resukts

Table 6: Summary of Risk Assessment

Work at Height	Electrical safety	Fire Safety	Safety
Confined Space	Heat Management	Traffic Management	Vehicle and equipment safety
Housekeeping	Hand and Power tools	Loading and unloading	Lifting Activities
(PPEs)	Excavation	Stress management	Ergonomic

Above table shows that the Workplace risks were assessed across various categories, with high-risk areas including work at height, electrical safety, fire safety, chemical safety, confined space, vehicle, and equipment safety, loading and unloading, and lifting activities. Medium-risk areas encompassed heat management, traffic management, hand and power tools, personal protective equipment (PPEs), stress management, and ergonomic

concerns. Low-risk areas included excavation. A focus on safety training, regular inspections, and fostering a strong safety culture can help mitigate these risks and create a safer work environment.

VI. ENVIRONMENTAL ASSESSMENT GAP WITH STANDERS

A. Air Pollution

The air pollution against Stander has not met international and national standards for PM-10 and PM-2.5 parameters. The exceedance from the established limits for PM-10 and PM-2.5. All other parameters, including SO2, NO, NO2, and CO, met both international and national standards. However, for PM-10 and PM-2.5, the measured concentrations exceed the specified limits by 5 to 7%.

B. Noise Pollution

Through results it is found that the noise pollution generated through the boiler, turbine, and electrostatic precipitator (ESP) exceeded the limits set by national and international standards. However, the noise levels in other areas such as the office area, chemical building, admin building, service building, and coal handling building are within acceptable standards.

C. Solid Waste Management

The study has observed that all hazardous waste has been collected and stored in the hazardous waste storage yard. However, it was found that only the collection of solid waste material has been done at the site construction of the new plant, disposal of solid material has not been performed yet, and that can harm the environment, health of the workers, soil contaminated, and related health and safety issues.

D. Soil Pollution

The assessment reveals that workers have been contaminating the soil by disposing of various chemicals, oils, and greases, leading to soil pollution in the vicinity of the power plant construction site. Paint Thinner and Paint substances contain volatile organic compounds (VOCs) that can leach into the soil and groundwater, posing a risk to both environmental and human health. These oils can contain heavy metals and other harmful contaminants that can persist in the soil and cause long-term pollution. Glue and Chemicals: Improper disposal These chemicals can alter soil properties, hinder microbial activity, and affect nutrient availability for plants.

E. Thermal Pollution

CCW systems in operations normally has various elements involved in it such as heat exchanges, cooling towers, pumps, and linked elements. Concerning the observed things, it was found that the cooling towers provided a means for heat transfer and dissipation, while the circulating water absorbed heat from the equipment [30]. This cooling water is circulated through the system that allows the transfer of heat from the components to the surrounding environment. There are various causes of thermal pollution within the operational setting of power plant. Including the inefficient operation or design of CCW systems, if these systems are not optimized for heat fail or dissipation to adequately regulate the temperature of the cooling water, hot water can be discharged into natural water bodies that can result in thermal pollution. Moreover, operational activities that involve energy conversion, including power plants can generate waste heat as a byproduct. If the waste heat is not efficiently used or dissipated by CCW systems, it can contribute to thermal pollution [31].

Noticing the above discussion based on the CCW, it was estimated that water temperature of the system was 35.8º C and the output was seen and observed at 43º C. The difference was 7.2º C which is low in the case of the construction phase of the power plant, however, in the case of operations phase, it is higher.

F. Wastewater Assessment

The auxiliary boiler is used to provide additional steam or hot water during start-up or periods of increased demand. at the chemical department of the power plant, hydrochloric acid (HCl) is dosed into the industrial wastewater to control its PH. Issue is that to make matters worse, after the dosing of HCl, the industrial wastewater is being discharged directly into the river without any further treatment or testing. This irresponsible practice can severely harm aquatic life, degrade water quality, and have far-reaching consequences for the surrounding ecosystems.

VII. SOCIAL ASSESSMENT GAP STANDERS

A. Worker Accommodation

The survey results revealed several gaps between the current living and working accommodation and international standards. Inadequate space and overcrowding were noted, compromising workers' comfort and privacy. Some accommodations lacked proper ventilation and natural light, impacting the overall health of the living environment. Access to clean drinking water was not always readily available. [24]. Additionally, the survey highlighted issues with sanitary facilities, safety measures, and irregular maintenance. Workers' complaints were not always promptly addressed due to the absence of an effective grievance redressed mechanism. Health and hygiene training was lacking in some cases, as were properly equipped kitchen and dining facilities. Overall, addressing these gaps is crucial to ensure that accommodation aligns with international standards and provide a safe, healthy, and supportive environment for workers. [9]

B. Inside colony, inside plant, and outside boundary

The survey data reveals significant gaps between the construction activities of the coal power plant and international standards for social aspects. Several crucial areas were found lacking, including the absence of education and healthcare facilities for local communities, limited efforts to preserve cultural heritage, and insufficient community participation in decision-making processes. Additionally, the company's failure to prioritize local hiring and provide comprehensive training programs for the community raised concerns. Furthermore, the overall impact of the construction activities negatively affected the community's well-being. Addressing these gaps and adhering to international standards is essential to ensure

sustainable and socially responsible development practices that prioritize the welfare and empowerment of the local communities.

VIII. OCCUPATIONAL HEALTH AND SAFETY

Workers at the site are facing significant safety risks due to the lack of proper work at height training. Safety harness belts remain uninspected, with some lacking shock absorbers and featuring single huck belts. Furthermore, falling object hazards pose a serious threat, as work on scaffolding platforms proceeds without adequate barricades. Access ladders are missing on certain platforms, while others have untight planks and absent mid and top rails. Scaffolding lacks necessary inspections and inception tags, further compromising worker safety. Additionally, the edges of boiler structure platforms remain unprotected, lacking vital toe boards. Urgent action is required to address these critical safety concerns and protect the well-being of all workers involved.

The site's electrical safety measures are gravely inadequate and pose serious risks to workers and equipment. There is no evidence of pre-work safety inspections for electrical equipment, and power cables exhibit numerous joint issues, including exposed insulation and breaks. Welding machines and distribution boards lack proper grounding, increasing the likelihood of electrical accidents. Moreover, workers are seen operating high-voltage panels without proper barricades, putting them in danger. Many NTDC area workers lack essential PPE like hand gloves and safety shoes, while warning signs are absent in crucial areas. Electrical distribution boards are in poor condition, and cable management is haphazard at the boiler and turbine sites. Urgent action is imperative to address these critical safety lapses and safeguard the well-being of personnel and equipment.

Workers have not received proper training for these tasks, increasing the risk of accidents and injuries. Additionally, workers are using motorbikes to operate or tow hand trolleys, which is unsafe and poses a danger to both workers and others in the area. Moving a heavy load panel up to a height of 17 meters without proper equipment or safety measures is extremely hazardous. Moreover, structure parts are being uplifted without any barricades, putting workers at risk of falling objects and potential accidents. Insulation materials are being loaded with damaged ropes, further compromising worker safety.

IX. CONCLUSION AND RECOMMENDATION

The study conducted environmental, Social & Occupational Health & Safety (ESOHS) risk and impact assessment of the potential environmental, social, and occupational health and safety risks associated with the construction and operation of the 2x660MW Supercritical Coal Fire Power Plant in Jamshoro. The study highlighted the major findings of the assessment, including identified risks and potential impacts on the environment, surrounding communities, and workers' health and safety. The study has provided recommendations for the stakeholders to improve the environmental, social, and occupational health and safety of the 2*660MW coal-fired power plant.

A. Recommendations

- Dust Control Measures: Implement dust control measures during construction activities to reduce particulate matter emissions [16]. This may include water spraying, covering stockpiles of materials, and limiting heavy machinery use in windy conditions [13].
- Emission Reduction Technologies: Use low-emission construction equipment and vehicles, where feasible. Employ technologies like diesel particulate filters and selective catalytic reduction systems to reduce gaseous emissions.
- Noise Assessment and Monitoring: Conduct a comprehensive noise assessment to determine the exact source and intensity of noise pollution from the boiler, turbine, and ESP. Continuous noise monitoring should be established to track progress and ensure compliance with standards.
- Immediately initiate emergency response and containment measures to prevent any further harm to the environment and workers. Secure the hazardous waste storage yard and implement measures to contain any potential leaks or spills.
- Develop a hazardous waste disposal plan that outlines proper procedures for handling, transporting, and disposing of hazardous waste. This plan should comply with all relevant local, national, and international regulations and guidelines.
- Engage certified waste management experts and environmental consultants to assess the hazardous waste and recommend appropriate disposal methods based on the waste characteristics.
- Provide workers involved in hazardous waste handling with appropriate safety equipment and thorough training on handling, containment, and disposal procedures. Ensure that they have access to personal protective equipment (PPE) to protect themselves from potential hazards.
- Establish a systematic waste management plan on-site, including designated collection areas for different types of waste (e.g., chemicals, oils, paints). Provide clear signage and instructions to guide workers in proper waste disposal.
- Instead of discharging the hot water from the CCW pump directly into the retention basin, a temporary cooling system can be set up to cool the water before it is released back into the environment. This can help reduce the temperature difference and limit the thermal impact on the ecosystem.
- Implement water recycling and reuse strategies wherever possible. By reusing the water from the CCW system, the amount of hot water discharged into the environment can be minimized, reducing the overall thermal pollution.
- Improve Supervision and Inspection: Increase the frequency of supervision and inspection to maintain accommodation standards and address any issues promptly.

- Establish Grievance Redressal Mechanism: Set up a system for workers to voice their concerns and complaints, ensuring their grievances are heard and addressed effectively.
- Provide Health, Safety, and Hygiene Training: Conduct regular training sessions on health, safety, and hygiene practices to promote a healthy living environment for workers.
- Ensure that all workers have access to essential personal protective equipment (PPE) like hand gloves and safety shoes when working with electrical equipment.
- Place warning signs in crucial areas where high-voltage panels are operated without proper barricades.
- This section will introduce the construction phase and highlight its positive terms in ESOHS consideration. [20] revealed that in the construction phase, the workers might have been facing numerous occupational health and safety risks involved in the exposure towards the accident, strings and poor economics. Organize and manage cables effectively at boiler and turbine sites to reduce electrical hazards.

By implementing these recommendations, the site can significantly improve safety standards, reduce the risk of accidents and injuries, and create a safer working environment for all workers involved. Regular inspections, proper training, and the use of appropriate personal protective equipment will be crucial in safeguarding worker well-being and preventing potential hazards.

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