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ENVIRONMENTAL HEALTH AND SAFETY ISSUES ASSOCIATED WITH INDUSTRIAL ACTIVITY IN INDUSTRIAL ESTATE LAHORE

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ABSTRACT: The relationship between achieving an ecological future, economic growth, and human well-being has a long and varied philosophical history. Environmental health and safety (EHS) refers to the recognition, accurate assessment, and prevention of various health risks at work as well as the preservation of employees' productivity. On the other hand, ergonomics combines all of these issues to enhance the competency and well-being of workers. For this particular study project, an industrial estate was chosen, and it was further separated into three subzones for monitoring and assessment purposes. Instead of focusing on specific concerns, Industrial Estate was created to address the difficulties associated with industrialization as a whole. The utilization of two major data gathering techniques was employed. A specific checklist for EHS procedures and a review of the site area from an EHS perspective. To address the general situation of the industrial region, the appropriate measures of the various operations were also taken into consideration. Reviewing complaints and accident reports, conducting interviews, and other techniques are examples of further data collecting approaches. The majority of the results were in conformity with national norms of PEQs and international standards of the World Health Organization (WHO), according to a comparison of monitoring reports for ambient air quality and water quality. The PEQS-defined limit for PM10 was being exceeded. The graphs show how the air and water quality are currently in each location of the industrial site. The industrial estate's key problem zones have also been highlighted by the risk assessment matrix. However, a number of considerations suggested that improving the way EHS procedures were implemented was necessary for EHS compliance with corporate SOPs.

Key words: Occupational hazard and monitoring; environmental health and safety; industrial safety; risk assessment; water quality; and ambient air quality.

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INTRODUCTION

The state of occupational health and safety is worse in developing nations like Pakistan for a variety of reasons, including a higher percentage of uneducated workers and a lack of adequate medical facilities. Additionally, we lack trustworthy information on disasters, fatalities, and injuries at work. Because of insufficient EHS measures, there are significant financial losses as a result of occupational accidents and diseases. Different methods, such as the EFD software used for EHS in companies, helped to determine the area's degree of pollution (Valipour *et al.*, 2012). Software's like PERT and CPM usually helped to apply time, management of costs in a less time (Yafaia *et al*., 2014).

Worksite health and wellness programs are made for the wellbeing of the workers in the industries (Babu *et al.*, 2014). The study tends to identify flaws in operational efficiency of EHS practices in industrial sector and how to overcome on these deficiencies. Furthermore, the long and short term effects of these deficiencies are to be assessed to minimize their effects. The research deals with hazards those are not controlled on work site, causing incidents, accidents or environment issues leading to health and safety problems. Improper equipments also put many life's in danger and it can be painful (Yakubua *et al*., 2012). Occupational calamity in the Malaysia alone includes 66 death 4 cases of long-lasting disability and 50 cases of non-permanent incapacity (DOSH, 2011). Medium companies usually have high rate of accidents and mainly chemical industries have more accidents (Khrais *et al*., 2013). Commonly accepted safety management system methods are defined in consensus standards such as OHSAS 18001:2007 (British Standards Institute, 2007) and the Voluntary Protection Program (VPP) of OSHA's (Hogstedt and Pieris, 2013). Some human presentation development tools commonly used comprise of directing pre- and post-task briefings, carrying out peer-checking, and using self-checking methods such as "take-aminute," STAR (Stop-Think-Act-Review), for workers who do not trust they have the proper knowledge to make choices (Wachter and Yorio, 2013). (Aksom and Hadikusumo, 2008) observed that safety managing system practices counting incident inquiries, jobsite examinations, and safety inducements reduced incident rates and the number of unsafe acts (Vinodkumar and Bhasi, 2011) people found expressively differing insights of the relation between safety management systems and safety performance in OHSAS 18001-certified establishments versus those that were not licensed. This restricted research only measured observations of safety management systems to effect behavior and did not reflect objective, measurable performance data, such as Days Away Restricted or Transferred (DART) case rates (Vance, 2006; Raines, 2011).

The goals and objectives that will be attained by the adopted occupational health and safety management system are laid out in a strong health and safety strategy. The human resources, environmental, and quality management systems all function in a similar way to the health and safety management system (Hughes and Ferrett, 2011). Different epidemiological issues and many health impacts related to air pollution were observed. Increases in mortality rate related to cardiovascular issues were also monitored (Al-Wahaibi and Zeka, 2015). Stress and fatigue also participate in the absenteeism rate of workers (Duggirala *et al*., 2016). The most adverse effects on the human health contain an important decrease in life expectancy of the workers (Sana *et al*., 2013).

Critical incidents also occur within different workplaces and these are termed as psychological traumatic events (DeFraia, 2015). Different companies work with the industries to maintain the working conditions of an industry (Health and Safety Executives, 2013). Human errors as well as the electrochemical errors produce consequences and the failure in safety maintenance questions the ability to stop the accidents (Al Kazimi., 2015). Operation managers play their role in the safety culture and safety informing considered as one of the best predictor of the industry's safety culture (Wu *et al*., 2010).

To maintain the work place safety, Occupational Health and Safety Assessment Series 18001-certified companies are on the top of the list. They maintain the occupational safety (Mohammad fam *et al*., 2017)

MATERIALS AND METHODS

Site Selection: Board of Management of Industrial Estate (the "Industrial Estate") was built by Punjab Industrial Estate for a single purpose that is to promote and facilitate industrialization within the region and to deal with the issues concerning industrialization as a whole instead of individual problems. There are over 400 active units operating nearby. It is precisely located at 31.295105 N 74.176873 E on Raiwand Road, 45 kilometres from the heart of Lahore. This location was chosen for this specific study project, and it was further separated into three subzones for monitoring and assessment purposes.

Fig-1: Study Area "BOMSIE"

EHS Operational Efficiency Assessment Methods: There are mainly two methods for the collection of data, desk study regarding Environmental Health & Safety practices and by surveying the site area from EHS view point. Other methods may also include web audit reviews, review of complaints of accidental reports and checklists/interviews. Different documents, manuals, and material safety data sheet related to the site facilities, EHSQ policy and procedures of the company were obtained. A detailed study was carried out to understand the important features of BOMSIE, Raiwand road Lahore Policy and Procedures related to EHSQ before commencement of visit to the field, so that a detailed evaluation of compliance can be made. The people living near the 2 to 3 km radius of the emissions area, they are considered the most suitable for the questionnaires based study (Mehraj *et al*., 2013).

Ambient Air Monitoring: At selected monitoring sites, ambient air quality monitoring was carried out to measure the concentration of priority pollutants (Carbon monoxide, Nitrogen dioxide, Sulphur Dioxide, Particulate Matter). The HORRIBA APNA 360 Monitor was used for the monitoring. Additionally, GPS coordinates were gathered and reported in the study's section above. All of the field-recorded ambient air gas readings. The Fine Dust Sampler IPM-FDS 2.5/10 micron was used to detect particulate matter (PM10) in the field.

Ground Water Analysis: Samples of the ground water were taken at predetermined sampling locations. United States Environmental Protection Agency (USEPA) sample guidelines from 2001 were followed during the sampling. The sample points' GIS coordinate.

Drinking Water Analysis: Samples of the drinking water were taken from known RO facilities. The sample was done in compliance with the Sampling Rules 2001 of the United States Environmental Protection Agency (USEPA).

RESULTS AND DISCUSSION

Generalized Aspect and Impact: The findings of EHS practices and their long & short term impact are briefly summarized in Table-1.

Table-1: EHS Assessment findings.

Observations	Control measures	Consequences	Immediate and longer term actions
		1.0 Environment Hazard	
Noisy Area	Immediate	Workers working in high noisy turbine hall.	Provide ear plug / ear muff (Personal Protective Equipment's).
Consequences	Long Term	Deafness / headache	Training of workers and Arrangements to reduce the noise. (Administrative and Engineering Control to be improved).
Housekeeping	Immediate	Poor housekeeping Observed on site.	Good housekeeping on site
Consequences	Long Term	Un hygienic condition, Bacteria.	Good practice of housekeeping on Daily bases.
Waste Material	Immediate	Waste material like thermal insulation was found on site. Remove the thermal insulation material.	Remove the thermal insulation Material.
Consequences	Long Term	Damage of skin, eye and lungs.	Waste storage should be provided.
		2.0 Chemical Hazard	
Storage of Chemicals	Immediate	Chemical substance like hypochlorite present at workplace.	Remove these chemicals from workplace
Consequences	Long Term	Ill health.	Should be the suitable store area for these chemicals.
		3.0 Scaffolding Hazard	
Fall Hazard	Immediate	Workers working at scaffolding without full body harness.	Wear full body harness.
Consequences	Long Term	Major injury.	Management make sure availability of all personal protective equipment.
Scaffold Tag	Immediate	Work in progress on scaffolding without safety apparatus.	Avoid working on incomplete scaffolding

Consequences	Long Term	Chance of collapse may be it is incomplete.	All scaffolding must be inspected by a competent person
		4.0 Fire Hazard	
Hot Work	Immediate	During hot work cotton rags were found near welding.	Housekeeping
Consequences	Long Term	Chance of fire.	Management should make sure compliance of hot work procedure
Fire Hydrant	Immediate	Fire hydrant was block by wood Container.	Remove the container.
Consequences	Long Term	No access to fire hydrant in case of fire	Fire hydrant must always clear of obstructions.
Deliberate Ignition	Immediate	Work place has been targeted by deliberate ignition.	Strictly sign boards should be displayed
Consequence	Long Term	Causes huge damage when deliberate ignition unattended.	Make prohibited area, information and instruction should provide to workers.
		5.0 Electrical hazard	
Electrical Fire	Immediate	Electrical fire occurred in workplace due to damage or heating up of cables.	Insulate the cables which causes dangerous occurrence.
Consequences	Long term	Electrical fire develop in workplace and cause major injuries or loss	Remove the damage equipment or cables and suitable equipment must be provided
Electrical Burns	Immediate	Electricity causes skin burn or damage due to the damage cables and damage socket or electric spark.	Suitable personal protective equipment must be provided; gloves or clothing should be provided.
Consequences	Long Term	A person working in electrical area may have electrical burns.	Remove the cables or socket which causes electric burn. Ensure proper earthing.
Electric shock	Immediate	During work miss handling and unsuitable usage of damage equipment in workplace.	Remove the damage equipment.
Consequences	Long Term	Severe electric shock	Routinely inspection and provide training.
Arcing	Immediate	Loose connections and loose equipment were found at work place causes severe arcing.	Make sure that connections and equipment are in suitable condition
Consequences	Long Term	Produce glare due to ozone.	Remove the loose connections equipment and provide sustainable system to work.
		6.0 Mechanical Hazard	
Lifting Operation	Immediate	There was no barricading and sign posted during load lifting by crane.	Area should be barricaded and sign posted.
Consequences	Long Term	Chance of passing pedestrians under load.	Employees should be given briefing about importance of area barricading during load lifting operation.
Rotational Energy	Immediate	Coupling shaft of driving motor and pump has no guard cover	Provide guard cover over shaft
Consequences	Long Term	Chance of entrapment	Check all the pumps in power plant to ensure guard cover over rotating parts.
System Leakage	Immediate	Hot water leakage from seal of pump.	Turn off the pump and take stand by pump into service.
Consequences	Long Term	Injury due to splash of hot water.	Check the seals of all pumps.
		7.0 Confined space	
Lightning	Immediate	There is no adequate light due to	Light should be provided in the confined

		confined area.	area to perform work.
Consequences	Long Term	Chance of falling.	Lightning system must be provided such as emergency lights, normal tube lights must provide.
Hazardous substances/gases	Immediate	No gas test available, Hazardous substances or gases will be there in confined area.	Personal protective equipment used and respirators.
Consequences	Long Term	Chance of inhalation and causes sudden death.	Remove the hazardous substance or substitute.

Risk Assessment Matrix: A risk assessment was conducted based on observational data that assisted in identifying the site's potential hazards. The risk's likelihood and severity are often improved. For risk assessment, existing controls were also taken into account, and necessary measures were suggested. The likelihood of a danger and the severity of the hazard when it does occur are two risk criteria that are often evaluated to determine the risk value. In order to address the inadequacies of a precise risk score computation and reduce decision-making inconsistency, a fuzzy methodology is provided in this research that allows experts to utilize linguistic variables for assessing two aspects that are the parameters of the matrix method. Risk characterization was done according to the following keys:

Table-2: Probability and severity of risks.

Magnitude/ Severity of Risk		Probability of Occurrence	
5	Extensive (Life loss)	1	Highly Unlikely (Automatic Zone)
4	Major (Irreversible Damage)	2	Unlikely (Occasional Exposure)
3	Medium (Reversible Damage)	3	Possible (Intermittent Exposure)
2	Minor (Infrastructure/ Economical)	4	Likely (Regular Exposure)
1	Negligible	5	Highly Likely (Susceptible zone)

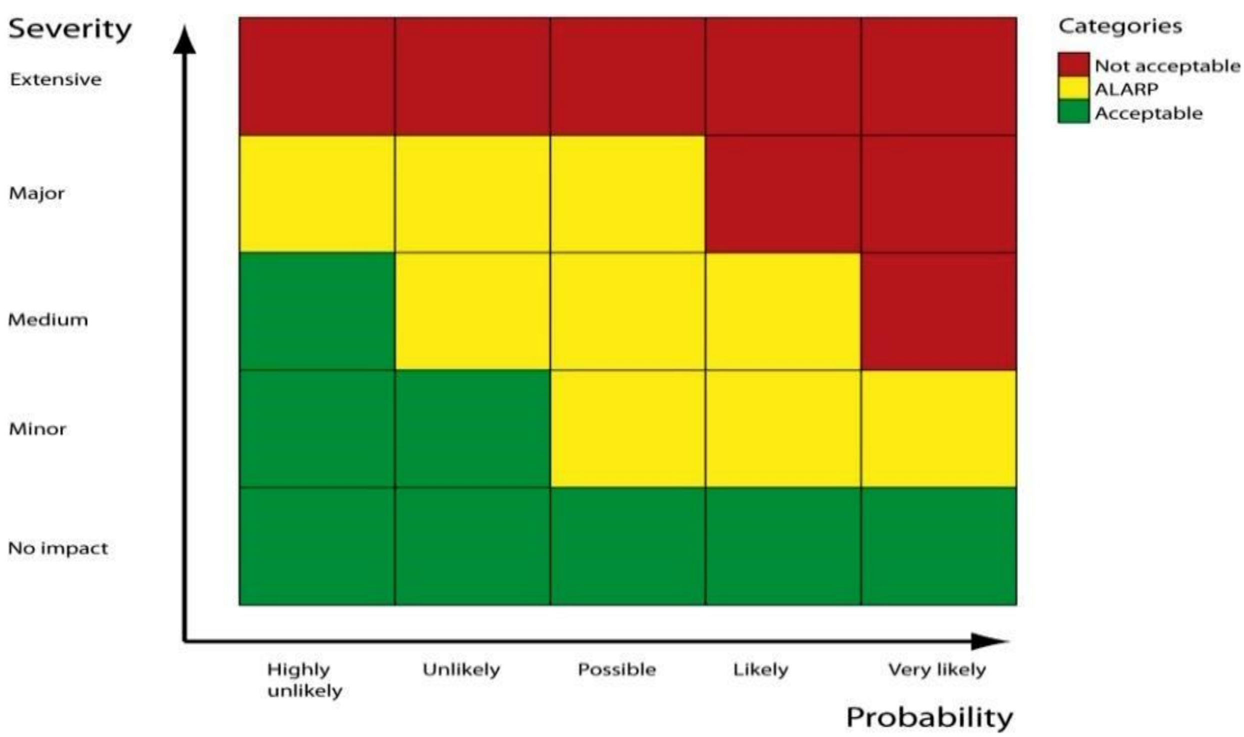


Fig-2: Risk Assessment Matrix

Risk Assessment describes the Probability of risk as well as the severity or impact of risk on environment.

Table-3: Risk characterization

Haawazards	Magnitude of hazard	Probability of occurrence	Risk characterization
Environment	**3**	**4**	**12**
Chemical	**2**	**2**	**4**
Scaffolding	**5**	**4**	**20**
Fire	**4**	**4**	**16**
Electrical	**4**	**3**	**12**
Mechanical	**4**	**3**	**12**
Confined Space	**3**	**2**	**6**

According to risk assessment matrix major non compliances and hazards were identified in the category of scaffolding and fire hazards. Potential non compliances that could lead to a potential hazard were identified in electrical, mechanical and environmental domains. Minor risks that had a low probability of occurrence were identified in confined work space and chemical section. This matrix can apply in any department of the industry (Gul and Guneri, 2016). Making judgments based on the information gathered in the preceding rounds of risk assessment as well as taking into consideration social and cultural norms, economic realities, and political issues are all part of risk management (Finizio and Villa, 2002).

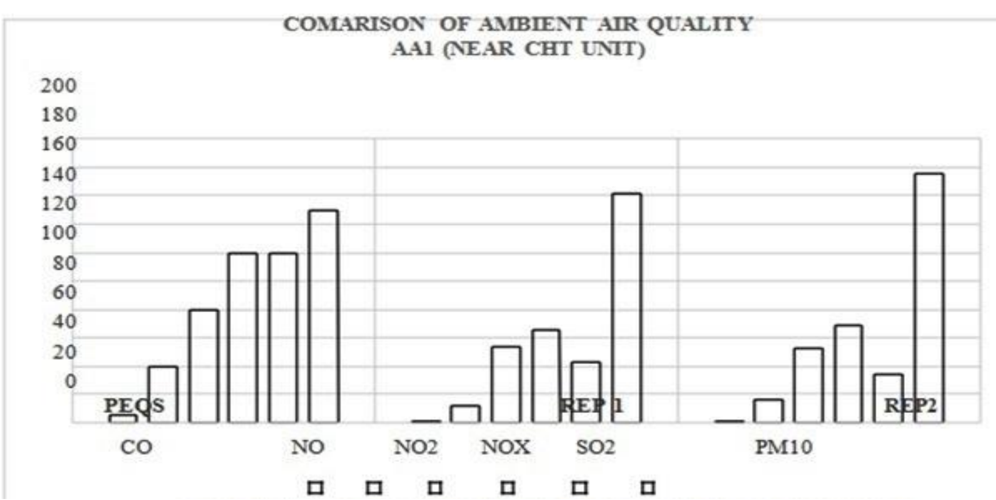
Table- 4: Site 1 Correlation of Ambient air quality AA1 near CHT Unit

Correlations

		CO	NO2	SO2	NO	PM
CO	Pearson Correlation	1	-.605	.676	.858	.881
	Sig. (2-tailed)		.587	.528	.343	.313
NO2	Pearson Correlation	-.605	1	.179	-.110	-.157
	Sig. (2-tailed)	.587		.885	.930	.900
SO2	Pearson Correlation	.676	.179	1	.958	.944
	Sig. (2-tailed)	.528	.885		.184	.215
NO	Pearson Correlation	.858	-.110	.958	1	.999*
	Sig. (2-tailed)	.343	.930	.184		.030
PM	Pearson Correlation	.881	-.157	.944	.999*	1
	Sig. (2-tailed)	.313	.900	.215	.030	

*.Correlation is significant at the 0.05 level (2-tailed).

The air quality characteristics are put to the Pearson correlation model. This demonstrates the relationship between several air quality metrics and whether or not they influence one another. All the metrics show a strong positive association with one another. The NO and PM variables showed the highest connection (p=.030, p <0.05). While NO and NO2 showed the smallest link (p=.930, p <0.05).



Graph-1: Site 1 Comparison of Ambient air quality AA1 near CHT unit

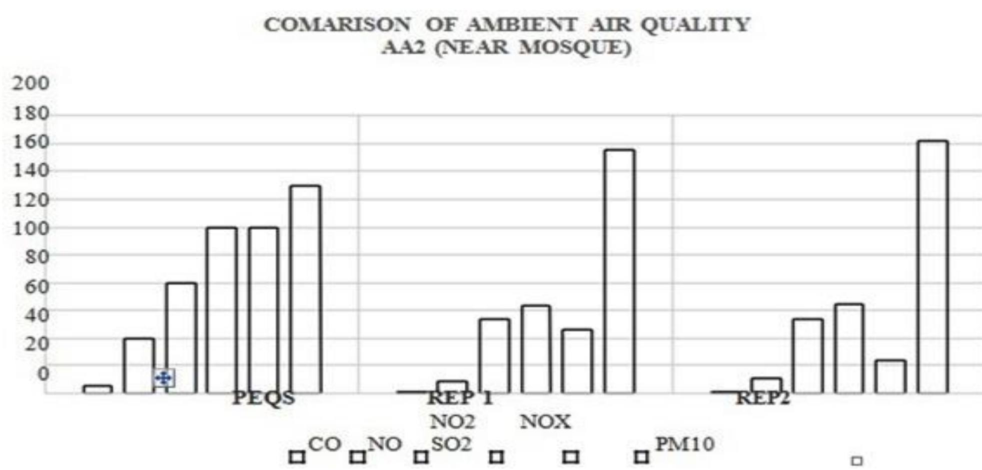
Table-5: Site 2 Correlation of Ambient air quality AA2 near Mosque

Correlations

		CO	NO2	SO2	NO	PM
CO	Pearson Correlation	1	-.605	.676	.858	.881
	Sig. (2-tailed)		.587	.528	.343	.313
NO2	Pearson Correlation	-.605	1	.179	-.110	-.157
	Sig. (2-tailed)	.587		.885	.930	.900
SO2	Pearson Correlation	.676	.179	1	.958	.944
	Sig. (2-tailed)	.528	.885		.184	.215
NO	Pearson Correlation	.858	-.110	.958	1	.999*
	Sig. (2-tailed)	.343	.930	.184		.030
PM	Pearson Correlation	.881	-.157	.944	.999*	1
	Sig. (2-tailed)	.313	.900	.215	.030	

*. Correlation is significant at the 0.05 level (2-tailed).

The air quality characteristics are put to the Pearson correlation model. This demonstrates the relationship between several air quality metrics and whether or not they influence one another. All the metrics show a strong positive association with one another. The highest significant value was observed between NO and PM ($p=.030$, $p<0.05$). While the weakest significant value was observed between NO and NO2 ($p=.930$, $p<0.05$).



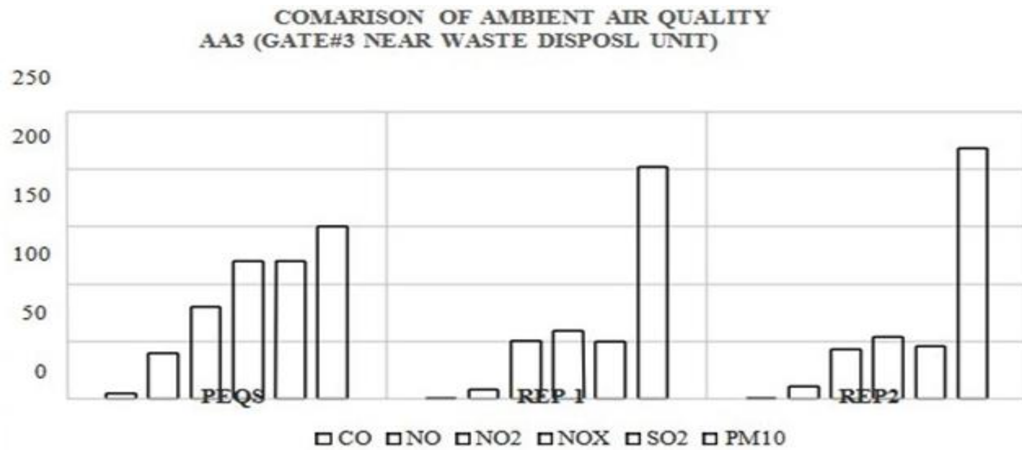
Graph-2. Site 2 Comparison of Ambient air quality AA2 near Mosque

Table-6: Site 3 Correlation of Ambient air quality AA3 near waste disposal unit

Correlations

aaw		CO	NO2	SO2	NO	PM
CO	Pearson Correlation	1	.844	.468	-.765	.693
	Sig. (2-tailed)		.360	.690	.445	.512
NO2	Pearson Correlation	.844	1	.869	-.991	.199
	Sig. (2-tailed)	.360		.330	.085	.872
SO2	Pearson Correlation	.468	.869	1	-.927	-.312
	Sig. (2-tailed)	.690	.330		.245	.798
NO	Pearson Correlation	-.765	-.991	-.927	1	-.067
	Sig. (2-tailed)	.445	.085	.245		.958
PM	Pearson Correlation	.693	.199	-.312	-.067	1
	Sig. (2-tailed)	.512	.872	.798	.958	

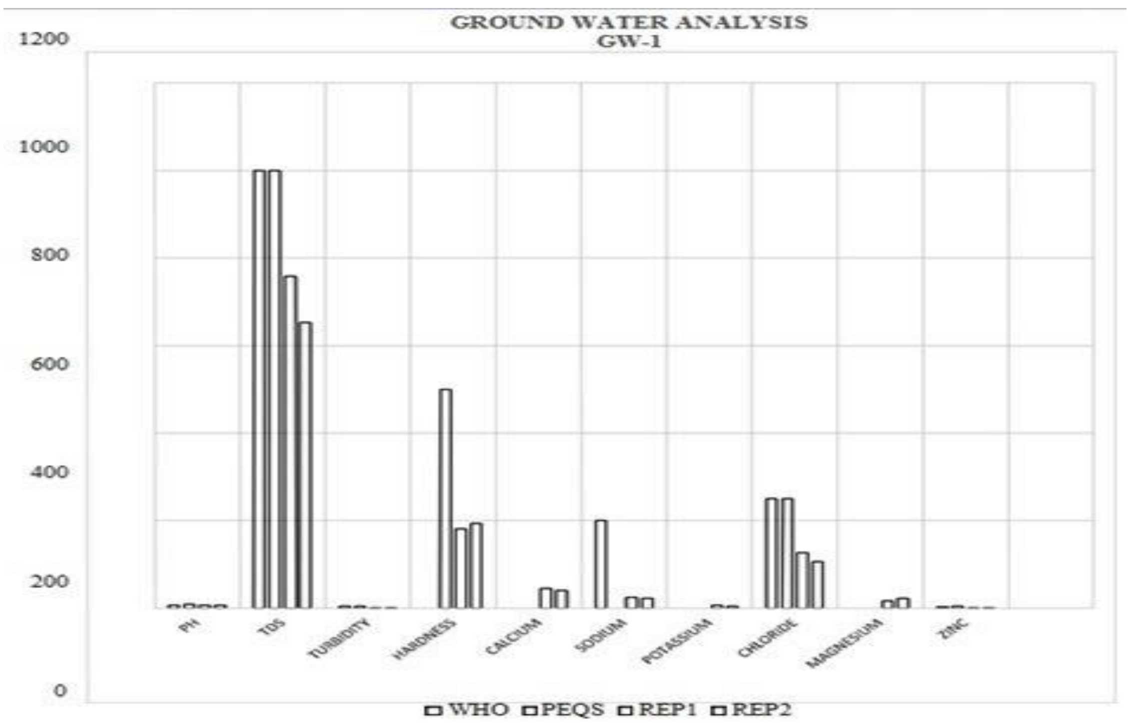
On the parameters of air quality, the Pearson correlation model is used. This demonstrates the relationship between several air quality metrics, showing whether or not they influence one another. All the metrics exhibit a significant positive connection. The strongest significance was observed between NO and NO2 ($p=.085$, $p<0.05$). While the weakest was observed between PM and NO ($p=.958$, $p<0.05$).



Graph-3. Site 3 Comparison of Ambient air quality AA3 near waste disposal unit

Table-7: Ground water Analysis Site Name: Gw-1(Water Storage Tank)

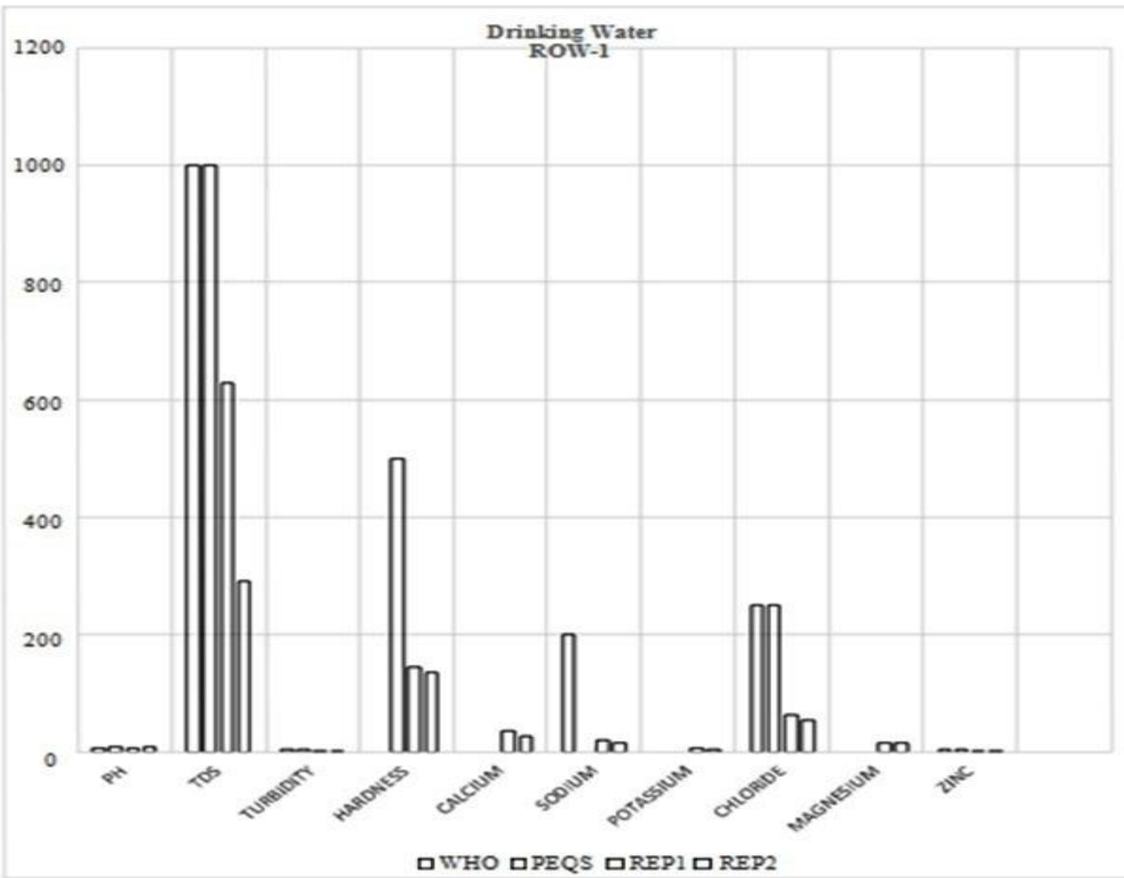
PARAMETERS	UNITS	WHO	PEQS	Summer Report	Winter Report
PH	-	-	6.5-8.5	6.98	7.14
TDS	Mg/l	1000	1000	758	652.4
TURBIDITY	NTU	5	5	0.9	1.2
HARDNESS	Mg/l	-	500	181	194
CALCIUM	Mg/l	-	-	44.6	40.4
SODIUM	Mg/l	200	-	24.8	23.1
POTASSIUM	Mg/l	-	-	6.4	4.6
CHLORIDE	Mg/l	250	250	127	106
MAGNESIUM	Mg/l	-	-	17.1	22.8
ZINC	Mg/l	3.0	5.0	0.89	0.78



Graph-4: Ground water Analysis

Table-8: Drinking Water Analysis Site Name: Row-1.

PARAMETERS	UNITS	WHO	PEQS	Report
PH	-	-	6.5-8.5	7.12
TDS	Mg/l	1000	1000	628
TURBIDITY	NTU	5	5	0.3
HARDNESS	Mg/l	-	500	145
CALCIUM	Mg/l	-	-	34.5
SODIUM	Mg/l	200	-	19.6
POTASSIUM	Mg/l	-	-	5.4
CHLORIDE	Mg/l	250	250	62.6
MAGNESIUM	Mg/l	-	-	14.4
ZINC	Mg/l	3.0	5.0	0.27



Graph-5: Drinking water Analysis

Table 9: Water Quality Index of Drinking Water Quality.

Parameter	Obtained values at the Site (ci)	Weight assigned (WI)	Relative Weight Wi = WI ∑n=1 WI	Quality Rating Scale q=ci/si*100	PEQS Standards (si)	Sub- Index SI (wi x qi)
pH 25 ^{o}C	7.12	4	0.235294118	109.5384615	6.5-8.5	438.1538462
Total Dissolved Solids (TDS)	628	5	0.235294118	62.8	1000	314
Chloride (Cl)	62.6	3	0.176471	25.04	250	75.12

Zinc	0.27	1	0.058824	5.4	5	5.4
Magnesium	14.4	2	0.117647	2880	0.5	5760
Total hardness	145	2	0.117647059	29	500	58

∑WI= 17
∑ wi= 0.941176471 WQI= 6650.673846

Table- 10: Water Quality Classification Based on WQI Values (Boateng et al.2016).

Sr. No	Type of water	Range
1	Excellent	<50
2	Good	50-100
3	Poor	100.1- 200
4	Very Poor	200.1-300
5	Unsuitable	>300

By calculating the SIi, the water quality index for drinking water quality is determined. The observed area's water quality index value was 6650.673846. Boateng *et al*. (2016) created a table of several classifications in which he created five sets of water quality, starting with excellent and progressing through decent, bad, extremely poor, and inappropriate. The water is unfit for drinking since the WQI was over the threshold of 300.

Conclusion: A project site's environmental health and safety is a crucial indication of the environment's and people's working health. Pakistan's largest industrial region is an industrial estate. This location was chosen for monitoring and assessment purposes. The analysis of the monitoring report for ambient air and water quality revealed that most findings were in line with PEQs and WHO national and worldwide standards. Numerous elements, in addition to monitoring, alert that the SOPs need to be maintained since they are not in line with the environment. Most of the outcomes were in line with the worldwide criteria of the WHO and the national norms of PEQs, according to the comparison of ambient air quality and water quality. PM^{10} was observed to be at elevated level in both summer and winters. It was the only factors that were exceeding the PEQS limit. The results were a comparative depiction of biannual monitoring (summer & winter season monitoring). However, a number of variables suggested that organizational SOP compliance with EHS was not up to par and that EHS policies needed to be implemented more effectively. Many of the section depict high risk and probability of occurrence and these factors must be eliminated to maximum possible extent. Also there is a great need of increasing awareness & acceptability about EHS practices specifically to the workers and generally to common public.

The relationship between achieving an ecological future, economic growth, and human well-being has a long and varied philosophical history. Occupational health and safety (OHS) refers to the recognition, accurate assessment, and prevention of various health risks at work as well as the preservation of employees' working capacities. On the other side, ergonomics combines all these issues to enhance employee competency and well-being while also boosting an organization's output rate by creating a productive workplace. Due to many circumstances, including a higher proportion of uneducated workers and inadequate medical facilities, the situation with regard to occupational health and safety is worse in Pakistan and other developing countries. Additionally, we lack trustworthy information on disasters, fatalities, and injuries at work. Because of insufficient EHS measures, there are significant financial losses as a result of occupational accidents and diseases. Both the water quality and the air quality met PEQs and WHO national and international criteria, respectively. The findings showed a comparison of biannual monitoring (summer & winter season monitoring). However, a number of variables suggested that organizational SOP compliance with EHS was not up to par and that EHS policies needed to be implemented more effectively. Many of the sections show significant danger and chance of occurrence, and it is important to remove these elements as much as feasible. Additionally, there is a critical need to raise understanding and acceptability of EHS procedures, particularly among employees and the general public.

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