ENVIRONMENTAL POLLUTION AT CONSTRUCTION SITES AND COUNTER MEASURES TO REDUCE THE POLLUTION AT SITE

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ABSTRACT
Objective: This paper aims to identify the types of environmental pollutions at construction sites along with their causes in the construction industry of Sindh.
Research Method: Quantitative method was adopted in this research. A detailed literature review of various papers was conducted to find out the various types and the respective causes of environmental pollution at the construction sites.
Findings: The study identified the noise, dust, air, and land pollution are the most occurring pollutions at the construction sites.
Originality: The study identifies the Importance Index of the types of environmental pollution at the construction sites of Pakistan. The method of research applied in this study is expected to provide the severity of the various causes of the identified environmental pollutions at the construction sites.
Keywords: Environmental Pollution, Construction Site, Construction Industry of Pakistan.

1. INTRODUCTION

The construction industry is complex in its nature because it comprises large numbers of parties as owners (clients), contractors, consultants, stakeholders, and regulators. This industry plays a major role in the development and achievement of society's goals (Enshassi et al., 2009). The construction industry of Pakistan like other countries also plays a vital role in the economic growth, it accounts for 2.53% of GDP (Gross Domestic Product). It employs 7.61% of the employed Pakistani Labor Force, the investment in the private sector has increased by 20.6% during FY2019-2020 and the 90% of total investment came from the private sector (BOI, 2019). The construction of new buildings, roads, and mega structures has a direct impact on the development of the nation and local communities, particularly in urban areas. Construction sites are found both within urban and rural areas, often in the proximity of homes. In the life cycle of a construction project, there are several activities that impact the built environment and human beings nearby, these construction activities include construction, demolition, and renovation.

Every industry has an impact on the environment, but construction is considered the main source of pollution. The construction and operation of buildings have a significant direct and indirect impact on the environment (Zolfagharian et al., 2012). Furthermore, the number of construction projects is growing day by day, and environmental contamination issues on construction sites are becoming more prevalent. The construction waste damages not only the water, air, and soil of the surroundings but the people residing nearby too (Shuai-ping, 2018). Thus, through this work, the various types of environmental pollution which occurs at the construction sites will be identified along with the most severe causes of that identified pollutions. The environmental pollution in Pakistan's construction sites particularly Sindh province will be extensively studied in this research.

2. LITERATURE REVIEW

2.1 INTRODUCTION

Pollution is the addition of any substance in any state whether it is solid, liquid or gas, or any form of energy whether it is heat, sound, or radioactivity to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. The major kinds of pollution, usually classified by environment, are air pollution, water pollution, land pollution, noise pollution, light pollution, and plastic pollution. Every kind of pollution can have negative effects on the environment and wildlife and often impacts health and wellbeing (*Pollution*, n.d.). The building industry is responsible for using a high volume of natural resources and generation a great amount of pollution because of energy consumption during extraction and transportation of raw materials (Morel et al., 2001). The pollutants that are generated continuously at construction sites, however, can not only contaminate the environment of the local community but also cause serious health problems and property loss for the residents (Wong-McSweeney et al., 2016).

Kaul (2021) mentioned that the pollution due to construction contributes a major portion of the total pollution count whereas most of the people don't even realize it and thinks that it doesn't affect the built environment or the peoples and other living things in the project's vicinity. Construction Pollution is mainly the pollution which is generated at the construction sites and can be in form of air noise, water, or the soil, depending upon the nature of the project (Kaul, 2021). Different researchers have pointed out various types of pollution at the construction sites which are shown in the Table 1.

Table 1: Various types of pollution at the construction sites

S. No	Type of Pollution	(Fernández et al., 2009)	(Xing et al., 2018)	(Khahro et al., 2016)	(Azarov et al., 2018)	(Zolfagharian et al., 2012)	(Hongwei, 2018)	(Yao et al., 2020)	(Siddiqi et al., 2002)	(G. Zhang, 2015)	(Hong et al., 2021)
1	Noise Pollution	*		*		*	*	*	*	*	*
2	Dust Pollution		*	*	*	*	*	*	*	*	*
3	Water Pollution			*			*	*	*	*	
4	Land Pollution			*		*		*	*	*	*
5	Air Pollution					*	*		*	*	*

2.2 TYPES OF POLLUTION

The major identified types of pollution from the existing studies are explained below along with their causes.

2.2.1 DUST POLLUTION

Dust can be defined as the dry dirt in the form of powder that covers the surfaces inside or outside of the buildings, or a very small dry piece of soil, sand, or other similar substances (Cambridge, 2022). Most of the construction projects are located in a densely populated area; hence they face this type of pollution (Li et al., 2010). Construction dust includes a number of different types of dusts that are commonly

generated on construction sites. Dir does not cause nuisance only but can also be seriously damaging to health, sometimes with long-term implications. Wooden dust along with this dry dirt can also be found at the sites which are produced by the grilling and drilling of the wood during construction. Kaul (2021) referred dust pollution as any material that was used in building for its construction gets amalgamated as particulate matter in the air during the demolition of building and they all will have long term effects on the lungs. There are numerous causes of the generation of dust pollution as different researchers have illuminated are shown below in Table 2.

Table 2: Causes of Dust Pollution

S.No	Cause	(C. Zhang, 2012)	(Zolfagharian et al., 2012)	(Shuai-ping, 2018)	(G. Zhang, 2015)	(Kaul, 2021)	(Xing et al., 2018)	(Jabbour et al., 2017)	(Dong et al., 2019)
1	Excavation	*					*		
2	Piling	*							
3	Site Clearance	*			*	*			
4	Backfilling	*							
5	Land Leveling	*		*	*		*		
6	Transportation of Material	*		*	*		*		
7	Other transportation vehicles	*		*	*		*		
8	Concrete Mixer				*				
9	Carpentry Sawdust				*				
10	Construction & Demolition			*	*	*			*
11	Drilling						*	*	
12	Material Storage						*		*
13	Other Construction activities like concrete blocks and bricks cutting, mortar making, sand blasting, grinding, crushing, etc.		*		*			*	

2.2.2 NOISE POLLUTION

Noise pollution can be defined as any disturbing or unwanted noise that interferes or harms or wildlife, although noise constantly surrounds us, noise pollution generally receives less attention than water quality and air quality issues because it cannot be seen, tested, or smelled, beside it also have effects on the environmental quality (Jain et al., 2016). Noise pollution is commonly generated inside many industrial facilities and some other workplaces, but it also comes from highway, railway and airplane traffic and also from outdoor construction activities (Nathanson et al., 2022). This type of pollution is so omnipresent in our society that we can't even fail to notice it, from streets to the airport it is noticed everywhere. According to a report shared by World Health Organization around 16000 premature deaths and 1.6 million healthy life years are lost across western Europe each year because of the environmental noise pollution (Environment Agency, 2021).

Noise is among the main pollution factors during construction and transportation vehicles as well as the construction machines which includes piling machine, excavator, concrete mixers, and transport vehicles used in the process of

construction are all major noise sources as during actual construction many sets of the equipment operate simultaneously leading to overlap of various sound sources with rising noise level (Zhang, 2012). The major causes of the noise pollution at construction sites are given below which are extracted from the existing literature as shown in the table 3.

Table 3: Causes of Noise Pollution at the construction site

S. No	Cause	*(C. Zhang, 2012)*	*(Zolfagharian et al., 2012)*	*(G. Zhang, 2015)*	*(Shuai-ping, 2018)*
1	Operation of Heavy Construction Machines	*			*
2	Extraction of raw material	*	*		
3	Transportation of Material	*	*		
4	Transport Vehicles	*	*		
5	Excavation	*	*		*
6	Concrete Pouring				*
7	Scaffolding and Framework's installation and handling			*	

2.2.3 LAND POLLUTION

The land pollution can be understood as the contamination of land and soil because of the decomposition of waste materials, both liquid and solid, on the land that affects the soil and ground water adversely (Kinhal, 2018). In various construction projects there are many activities which includes excavation of earth, construction of road, laying of pipeline, transportation of material, and construction of buildings, there will be certain amount of construction materials such as sand, lime, concrete, scrap, earth, etc. along with garbage and waste produced by the construction workers during the excavation of project and also daily life (Zhang, 2012). The land pollution is generally classified as the pollution generated by municipal solid waste and construction waste or debris and hazardous waste (Nathanson, 2017). Waste production is natural outcome of material composition however poor handling of materials, poor site control, lack of training, lousy stock control and damage to materials during delivery are some of the leading causes of excessive waste generation and inefficiency in construction projects (Maham, 2021). Kirch (2008) also studied that the accumulation of the solid and liquid waste products not only contaminate the groundwater but it contaminates the soil or land as well. The various causes of land pollution at construction sites, as studied by the various researchers are shown below in the table 4.

2.2.4 Air Pollution

According to World Health Organization, Air Pollution is the contamination of the indoor and outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Shireesha (2021) refers the air pollution to the release of pollutants into the air which are detrimental to the human health and the planet as whole. Whereas Kinhal (2018) refers the air pollution as a man made emission that are released into the atmosphere and poor air quality at the global level has caused approximately 4.2 million premature deaths in 2016 along with contributing into the warming of planet. Kinhal (2018) stated that the air pollution caused due to the land pollution is one of the main reasons for the lungs and breathing problems. There are a lot of machines that are being used at the

construction sites. Most of them run on diesel, as the combustion engines emit the huge amount of CO_2, SO_2 and CO into the air causing pollution. Kaul (2021) states that the emissions from the heavy duty machinery like excavator, crane, dozers, and concrete mixer trailers are worse than usual vehicles as they have no proper emission control system and thus are bigger concern to the environment. There are various causes of the air pollution generated at the construction sites as different researchers have pointed out which are given below in table 5.

Table 4: Causes of Land Pollution at the construction site

S. No	Cause	(C. Zhang, 2012)	(Zolfagharian et al., 2012)	(Shuai-ping, 2018)	(G. Zhang, 2015)	*(Dong et al., 2019)*	(Kirch, 2008)	(Nathanson, 2017)
1	Excavation	*					*	
2	Transportation of Material	*	*				*	
3	Construction Waste	*		*	*	*	*	*
4	Demolition			*		*		*
5	Extraction		*					
6	Domestic Waste including leachate from garbage			*				*

Table 5: Causes of the air pollution at construction site

S. No	Cause	(Zhang, 2012)	(Zolfagharian et al., 2012)	(Kaul, 2021)	(Dong et al., 2019)
1	Excavation	*	*		
2	Piling	*			
3	Site Clearance	*		*	
4	Backfilling	*			
5	Land leveling	*			
6	Material Transportation	*	*		
7	Emission from transportation and equipment	*		*	*
8	Material extraction		*		
9	Transport Vehicle	*		*	
10	C&D Waste				*

2.2.5 Water Pollution

Water is the one of the key natural resources utilized for drinking and other developmental purposes, it pollutes when harmful substances like chemicals or microorganisms contaminate a stream, river, lake, ocean, aquifer, or other body of water degrading water quality and rendering it toxic to humans or the environment (Denchak, 2022). Another researcher Joshi et al., (2022) describes it according to civil engineering as the water pollutes when the quality of water is harmful to the environment and human health due to unwanted materials entering into the water bodies, the contaminants like cement, paint, glues, sand, heavy metals, oils, and other toxic chemicals enter water bodies due to runoff. On the other hand, Kinhal (2018)

states that the toxic waste material and liquids that are discarded on land contaminate water through the sewage system and sludges and the contamination of soil seeps down and causes pollution in the groundwater and also destroys the water table. The wastewater produced in the process of construction mainly includes construction wastewater and domestic wastewater. Zhang (2012) utters that cooling water in operation of construction machines and equipment, washing water and wastewater caused by the washing of construction materials, maintenance of concrete and hydrostatic test of equipment in which there is certain amount of greasy dirt and sediment pollutes the site, not only these but domestic wastewater also which contains a large amount of bacteria and pathogens. Pumping or throwing the toxic waste from construction site into the nearby waterbodies harms the aquatic life as well as pollutes the water (Kaul, 2021). The numerous causes of the water pollution that are extracted from the existing literature are shown below in the table 6.

Table 6: Causes of Water Pollution at construction sites

S. No	Cause	(Zhang, 2012)	(Zhang, 2015)	(Shuai-ping, 2018)	(Dong et al., 2019)
1	Wastewater form construction activities like piling, cleaning of well, mortar or concrete stirring, maintaining hydrostatic properties of concrete, and curing.	*		*	*
2	Domestic Wastewater	*		*	
3	Wastewater from machines like generators or other equipment's cooling	*			
4	Wastewater from washing materials, walls, sites, wellpoint dewatering, sludge generated by pilling.	*	*		
5	Cleaning of vehicles				*
6	Temporary water leakage leading sewage overflow	*	*	*	
7	Waste slurry leading to blocked drains		*	*	

3. METHODOLOGY

The quantitative method of research has been adopted in this research study. The collection of data was done through questionnaire survey from the field experts who are currently engaged in the construction industry of Pakistan. The questionnaire survey is based on the identification of types of environmental pollution and their causes. The participants were asked about the level of occurrence of different types of the pollutions on the construction sites and the severity of their causes by using a 5 point Likert Scale. In this research the Likert Scale that has been used, has 5 points i.e., 1 for never, 2 for rarely, 3 for sometimes, 4 for often and 5 for always which shows the occurrence of the type of pollution. Besides, for the severity of the causes, the scale was used as 5 points i.e., 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. The responses of the participants have been recorded as well as analyzed statically. In this study, the occurrence and severity of each type and cause has been determined by adapting the formulae given below:

$$Severity\ Index = \frac{\sum_{5}^{1} a(\frac{n}{N}) \times 100}{5}$$

Where a is the constant expressing the weight assigned to each response, n is the number of each answer and N is the total number of respondents.

4. RESULTS AND DISCUSSIONS

The collected data from the experts during questionnaire survey was analyzed statically by the forementioned formulae and respectively ranked. Besides, the severity of each cause of the respective type of pollution was also ranked according to the severity index of each cause. The total number of respondents who filled the questionnaire was 152 and among them 70% had working experience more than 5 years working in different type of building construction projects with clients and contractors. The occurrence of different types of the pollution at construction sites is shown in Table 7.

Table 7: Occurrence of types of pollution

S. No	Type of Pollution	F. I	Rank
1	Dust	58.6%	1st
2	Noise	51.8%	2nd
3	Land	51.5%	3rd
4	Air	50.2%	4th
5	Water	47.0%	5th

Table 7 depicts that dust is reported as the most common pollution type occurring at the construction sites. This is followed by the noise pollution. This is true because not days most of the works are carried through different types of equipment which cause noise. Beside these, manual works also such as demolition activities by hammering and machine work such as drilling cause huge noise. It is imperative to make necessary arrangement for controlling the pollution occurring at construction projects for health and safety of the workers, neighbours and other associated stakeholders. The Severity of various causes of these identified types of pollution was also assessed as shown below in the table 8.

Table 8: Severity of different causes of the pollution

S. No	Type of Pollution	Cause	S. I	Rank
1	Dust	1. Excavation or drilling	84.60%	1st
		2. C&D Activities	84.30%	2nd
		3. Site Clearance	79.60%	3rd
		4. Land Leveling	78.70%	4th
		5. Transportation	78.00%	5th
2	Noise	1. Operation of construction machines	82.50%	1st
		2. Transportation	78.40%	2nd
		3. Extraction of Materials	78.00%	3rd
		4. Material Transportation	77.80%	4th
		5. Scaffolding and Framework	74.9%	5th
		6. Excavation	74.7%	6th
3	Land	1. C&D Waste	81.8%	1st
		2. Domestic Waste	80.9%	2nd
		3. Excavation	79.2%	3rd
		4. Erosion and sedimentation	77.6%	4th
		5. Transportation of materials	74.6%	5th
4	Air	1. C&D Activities	82.1%	1st
		2. Emission from transportation and different construction equipment	81.1%	2nd
		3. Transportation	79.1%	3rd
		4. Excavation and land leveling	78.2%	4th
		5. Wastewater contamination	74.2%	5th
5	Water	1. Domestic Wastewater	78.8%	1st

		2. Erosion and sedimentation on sites	78.0%	2nd
		3. Temporary water leakage during construction	77.4%	3rd
		4. Wastewater from construction activities	77.0%	4th
		5. Water overflow from machines for cooling purposes	76.3%	5th
		6. Infrastructure Curing	74.9%	6th

From table 8, it can be perceived that the major cause of dust pollution on the construction projects is excavation or drilling. This is true as excavation is not carried out in controlled environment. Further, excavated material is left unattended unless it is required for use or the place where excavated material is dumped is to be used for work. Operation of construction machines are reported as the very significant cause of noise pollution. Construction activities use several machines from the starting of the work such as excavators, drilling machines which cause heavy noise. In the category of land pollution, C& D waste is reported as the major cause. This happens due to poor waste management planning. In Pakistan, construction waste is very common a serious issue (Ali et al. 2019, Ahmed et al. 2021) and there is dire need of effective waste management (Akhund et al. 2019). C&D waste is also major cause of air pollution and is placed at 1st rank by the respondents. In the category of waste pollution, domestic wastewater is the most significant cause which needs serious attention.

5. CONCLUSIONS

This research study was aimed to identify the most occurring environmental pollution's types at construction sites and their respective causes in the construction industry of Pakistan's province Sindh. The study was achieved by conducting the questionnaire surveys. 152 respondents from the construction industry workers having more than 5 years experience participated in this survey. The research study shows that the Dust, Noise, Land, Air, and Water Pollution are the common types of pollutions occurring on construction sites. The study also reported significant causes of these pollution types where the excavation and drilling activities were reported major cause of dust pollution. The operation of the construction machines and equipment are severe reason for noise pollution. Land and air pollution is caused majorly due to construction and demolition activities and emissions from the transportation vehicles while the water pollution is resulted from the domestic wastewater or sewage water or waste slurry.

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