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Original Article

Monitoring of Environment and Human Health Impact Assessment of Paint Industry

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Abstract *- The present study is conducted on monitoring the environment and the impacts on human health associated with the paint industry. It is done to investigate the proposed area's environmental parameters and the health status of the people working at the site and in the vicinity. The paint industry is important from various perspectives because the paint is commonly used as a protection or decorative material for different objects and surfaces. Quality parameters of groundwater, wastewater, ambient air, and noise are studied, and results are discussed. National Environmental Quality standards are used to check if these parameters fall within the range of NEQS. TDS, TSS, COD, BOD, sulfates, phenolic compounds, and* PM_{10} *are high, and the noise level slightly exceeds the defined limits. Respiratory problems, asthma, heart problems, coughing, nausea, and dizziness are the main health problems within the industry. Environmental monitoring shows the atmospheric conditions of the industry and health problems are also related to some of the parameters high in wastewater or groundwater.*

Keywords *- Ambient Air Monitoring, Groundwater, Human Health Impacts, NEQS, Noise, Wastewater.*

1. Introduction

The word 'paint' covers various product types, including varnishes, lacquers, stains, coatings, primers, and other coverings. Paint is a formulated mixture of resins, pigments, fillers, solvents, and other additives.[1] Paints exist in solid, liquid, or gaseous suspension forms.[2] Numerous industries discharge the waste of the paint industry into the environment without treatment, which leads to adverse effects on the environment.[3] The paint industry is one of the rapidly developing divisions in the economy of Pakistan. A tough competition is found between all paint-developing firms. Paint has a huge structure capable of becoming liquefied when used for local and industrial purposes. Paint can be classified as water and oil-based paints.[4] Water-derived paints are composite mixes of organic and inorganic pigments, dyestuffs, cellulose-based extenders, and non-cellulose-based thickeners. Paint derived from oil is composed of mixtures of natural or synthetic oils. There is a shift in water-derived paints from the earlier use of oil-derived paints for structures. The usage of oil-derived paints for structures and local aims is quickly shifting to water-derived paints in these modern times.[5,6] The paint developing sectors use nearly 300 varieties of natural ingredients to manufacture diverse categories of paints. Nearby, 15% of natural ingredients in this sector are petroleum-derived.[7] The main natural ingredients of the paint industry are zinc oxide, titanium oxide, lithopone, turpentine, mineral, and resins, including vegetable-based resins, gums, and pigments. A further addition to painting for coloring, strengthening films, increasing value, and developing resistance against weather are metals and oxides of metals.[8]

Products of paints combine many chemicals like additives, pigments, binders, extenders, and solvents involving xylene, alcohols, glycol ethers, ketones, esters, and toluene.[9,10] The wastewater produced from the paint industry is generally through washing actions of reactors, mixers, blenders, filling lines, packing machines, and floor.[11] Wastewater from paint industries has produced significant concern in the science community as it comprises high masses of carbon-based noxious organic constituents, including oils, preservative agents, and solvents.[12-15] Due to the high concentrations of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), and suspended solids, action is required to decrease the pollutant load from the wastewater before its use.[16] Paint sludge released from different automotive is classified as hazardous waste because of organic and inorganic contaminants.[17]

The monitoring of air depends upon several atmospheric pollutants. In line with results in most other countries, the main pollutants recorded in the air at the monitoring stations are Carbon monoxide (CO), Sulphur dioxide (SO_2), Particulate matter (PM_{10}), and Nitrogen dioxide (NO_2).[18] These monitoring attempts are vital if air quality management efforts are to be improved.

Discharges of contaminants, for instance, Methyl iso-butyl ketone (MIBT), toluene, Methyl ethyl ketone(MEK), etc., from paint manufacturing industries are renowned for causing respiratory diseases, skin irritation, liver damage, and in extreme concentrations, they are thought to be as cancer-causing.[19] Adults may also experience fatigue, high blood pressure, and brain and kidney disturbances, while chronic exposures cause different types of ulcers and cancers.[20] In Nigeria, in the vicinity of the paint industry, fruits and vegetables were observed to have high metal content.[21]

The present study was conducted owing to the greater incidence of environmental and human health hazards in the paint industry. However, there is a shortage of available data signifying the adverse effects of the paint industry not only on the environment but also on the health of workers associated with this industry. The purpose of this research was to analyze the environmental quality (air, noise, drinking water, and wastewater) of the study area and to assess the health impacts faced by the workers within the vicinity of the paint industry.

2. Materials and Methods

2.1. Study Area

The current study was carried out in a paint industry which was at Chiniot road adjacent to and East of M3 Motorway at M-3 Industrialized City, Chak Jhumra Tehsil, District Faisalabad, Punjab (Figure 1). It covers an area of about 899,329 square feet. The nearest villages to the current study area were Bharoki Sahianwala and Chak 157-RB. Bharoki Sahianwala was almost 3 km east of the study area, and chak 157- RB was approximately 3.1 km away in the northeast of the study area. River Chenab was approximately 30km from the study area, while distributaries of the Jhung branch and Rakh branches were passing from the nearby areas of the current study area.

2.2. Sampling

The facts on the environmental monitoring and health impacts of the paint industry were reconnoitered with the support of the interviews, published literature, surveys, questionnaires, lab analysis, and observations. [28]

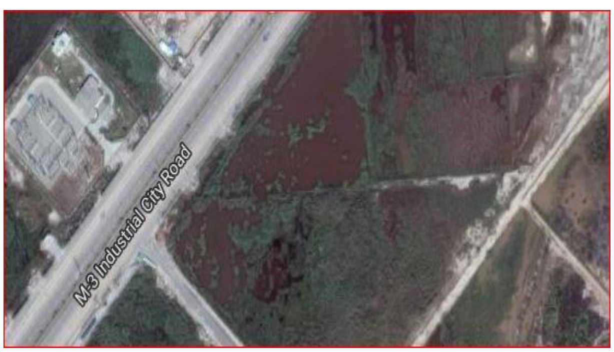

Fig. 1 Map of the Study Area

2.2.1. Environmental Monitoring

The monitoring Environment was done by examining and analyzing wastewater quality parameters and comparing them with NEQS. Wastewater, groundwater, parameters of air quality, and noise analysis were done. The air quality and noise analysis were done with the help of Horiba Air Pollution Monitor and Sound Level Monitor instruments. The findings were then matched with NEQS and the BASIC standards.

2.2.2. Human Health Impacts

Human Health Impacts of the paint industry on the workers and nearby community were determined with the help of interviews.

2.3. Questionnaires and interviews

The questionnaires were completed by the native residents close to the industry and the laborers in the paint industry. 50 questionnaires were distributed among people. Some of them were filled by laborers, and the leftover was filled by the native people close to the industry. The interviews were conducted based on designed questionnaires. Different questions were asked in the interviews regarding the impacts of the paint industry on the individual's health.

2.4. Material and Instruments

Environmental monitoring, including ambient air, wastewater, groundwater analysis, and noise monitoring, was done with the help of different instruments. The materials that were used in this study comprised gloves, spatula, bottles, filter paper, and plastic bags, while the instruments used were UV-VIS Spectrophotometer PHARO-300, COD Vials, BOD Incubator, EUTECH Bench PH Meter (PC 510), HACH Digital Titrator, Noise Meter, Horiba Analyzers, Turbidity Meter, Desiccators, Weighing Balance, Muffle Furnace and Oven.

2.5. Statistical Analysis

2.5.1. Water Quality Index

Water Quality Index is the most effective tool to convey facts on the quality of water and also converts the large data into a single value which facilitates an easy understanding of the facts.[23] Water Quality Index (WQI) is a significant parameter for determining water quality and its aptness for drinking. To estimate the WQI, 8 physiochemical parameters of drinking water were considered. Relative weight (wi) was assigned to them according to their impacts on health and comparative significance in defining water quality. The chemical parameters, for instance, TDS, Nitrate, and Nitrite having the main impacts on water quality, were assigned the weight of 5. In contrast, 1 was assigned to parameters having less impact like Zinc (Table 1,2). Further parameters, for instance, chloride, pH, and Manganese, were given the number between 2 and 4 lying on their significance in water. The water quality index (WQI) was computed to determine whether the water samples were suitable for drinking. The following water quality index equation was used in a research study.[24] The water quality index was evaluated with some water parameters labeled pollution indicators. Water Quality Index (WQI) was computed in the following way.

In the first step, relative weight from 1 to 5 was given to parameters according to their importance in water quality. After that, the relative weight of parameters was computed by equation.

$$W_i = w_i / \sum_{i=1}^{n} wi \quad \text{...(1)}$$

Where W_i is relative weight, w_i is the weight assigned to each parameter, and n is the number of parameters.

After this, a quality rating scale (q_i) was assigned to each parameter by dividing the concentration of each parameter by the standard value given by NEQS of that parameter, and then the outcome was multiplied by 100.

$$q_i = (C_i / S_i) \times 100 \quad \text{..(2)}$$

Where C_i is the concentration in milligram per milliliters of each parameter in the water sample, and S_i is the standard defined as per NEQs for each parameter. For determining the Water Quality Index (WQI), SI was determined for each parameter by the following equation.

$$SI_i = W_i \times q_i \quad \text{.. (3)}$$

In the equation mentioned earlier, SIi is the sub-index of ith parameter, and the quality rating relies on the ith parameter's concentration.

The final equation to calculate WQI was as follows;

$$WQI = \sum SI_i \quad \text{..(4)}$$

Thus, the WQI of both groundwater samples was determined to check if the water was suitable for drinking.

2.5.2. Pearson Correlation

Different parameters, including carbon monoxide, nitrogen oxides, sulphur dioxide, and particulate matter, were monitored in ambient air monitoring. The noise was also monitored. The statistical analysis tool, e.g., Pearson Correlation, was used to find out the relationship between various air pollutants of ambient air monitoring and noise with air pollutants. Pearson Correlation analysis tool was applied using the Statistical Package for Social Sciences (SPSS). The significance level was 0.01, against which results were reported.

2.5.3. Regression

Two types of regression analysis were applied to the questionnaire data. The multinomial regression analysis was applied to the nominal data obtained from the questionnaires. The binary logistic regression analysis was applied to the binary data. The variables were set according to the nominal and binary data, and then the regression was applied. The significance level was 0.005.

3. Results and Discussion

The paint industry is considered one of the major public-health issues causing industry in Pakistan. For the study, sample collection of the groundwater and wastewater was done. These include testing parameters like pH, COD, BOD, TDS, TSS, arsenic, turbidity, chloride, fluoride, boron, barium, sulphates, copper, lead, nitrate, nitrite, etc. To assess the quality of air, ambient air monitoring was done, and the noise level at the proposed site was monitored.

The groundwater sample showed exceeded values of TDS (Table 3). TSS, COD, and BOD values were high in the wastewater sample (Table 4). The high level in TSS, COD, and BOD could be a consequence of the occurrence of inorganic particulate matters such as pigments, extenders, additives, thickener, pure acrylic, styrene-acrylic binders, and cellulose present in the paint. High COD, BOD, and TSS values were also found in a research study on ‘effluent coming from paint industries.’ High BOD level is due to the breakdown of organic compounds such as thickener and acrylic compounds by the micro-organisms. People exposed to water with high concentrations of TSS and TDS are at risk of cancer.[25]

The present study also showed a high value of Particulate Matter (PM_{10}), as shown in Table 5. At the same time, noise levels monitored at different locations, e.g., within the vicinity of industry and nearby villages, remained within the values of National Environmental Quality Standards (Table 6).

By computing $\sum$the SI_i of both samples, the water quality index (WQI) of both samples was found. The value of the WQI of the project site sample was 1407.24, while the WQI of sample Baroki Sahi da Pind was 1376.5. Water quality was classified into five sets: unsuitable, very poor, poor, good, and excellent, as shown in Table 7.[26] The water quality index (WQI) of both samples exceeded 300, which means both samples were unsuitable for drinking.

3.1. Pearson’s Correlation between Air Pollutants

The Descriptive statistics and the Pearson correlation were directed to show the relationship between different air pollutants (Table 8). These all showed a high positive substantial correlation *($p<0.01$)* between each other. The highest significant value was found for nitrogen dioxide

Table 1. The relative weight of some physicochemical parameters of Project Site Water Sample

Sr. No	Parameters	Values at Project Site	Weight (WI)	Relative Weight Wi= WI / ∑n=1 WI	Quality Rating Scale q=ci/si*100	Sub- Index SI (wi x qi)
1	pH 25 ºC	8.37	4	0.129032	128.7692	515.0769
2	Total Dissolved Solids (TDS)	1236	5	0.16129	123.6	618
3	Chloride (Cl)	100.52	3	0.096774	40.208	120.624
4	Fluoride	0.312	4	0.129032	20.8	83.2
5	Nitrate	6.47	5	0.16129	12.94	64.7
6	Nitrite	0.003	5	0.16129	0.1	0.5
7	Zinc (Zn)	0.0572	1	0.032258	1.144	1.144
8	Manganese (Mn)	0.005	4	0.129032	1	4
			∑WI= 31	∑wi= 1.00		

Table 2. The relative weight of some physicochemical parameters of Baroki Sahi da Pind Water Sample

Sr. No	Parameters	Values at Baroki Sahi da Pind	Weight (WI)	Relative Weight Wi= WI / ∑n=1 WI	Quality Rating Scale q=ci/si*100	Sub-Index SI (wi x qi)
1	pH 25 ºC	8.25	4	0.129032	126.9231	507.6923
2	Total Dissolved Solids (TDS)	1035	5	0.16129	103.5	517.5
3	Chloride (Cl)	96.8	3	0.096774	38.72	116.16
4	Fluoride	0.17	4	0.129032	11.33333	45.33333
5	Nitrate	18.53	5	0.16129	37.06	185.3
6	Nitrite	0.003	5	0.16129	0.1	0.5
7	Zinc (Zn)	0.0238	1	0.032258	0	0
8	Manganese (Mn)	0.005	4	0.129032	1	4
			∑WI= 31	∑wi= 1.00		

With carbon monoxide (p=0.000) while the lowest statistically significant value was found between particulate matter with carbon monoxide and nitrogen oxide (p=0.830).

3.2. Health Impact Assessment

The questionnaires were given to individuals in adjacent rural areas of the proposed site. The poor health status of the people was noticed due to the high concentration of particulate matter generated from the operational activities and the vehicles, as the high percentage of the people working at the site and nearby areas were suffering from breathing problems, respiratory tract infections, eye infections, heart diseases, and coughing. People suffer from diarrhea due to drinking polluted water. The industrial effluent was rich with Total Suspended Solids (TSS), COD, BOD, Sulfates, and Phenolic Compounds. Diarrhea and intestinal problems were reported in humans because of these compounds, as shown in previous literature. [19,20]

When exposed to pollutants generated by the paint industry, workers may experience eye, skin, lung irritation, headache, dizziness, and nausea. At the same time, long-term exposure is suspected of causing cancer in individuals. It was reported in a research study that people exposed to the paint industry showed symptoms of the nose, eye, and skin irritation. [27]

The respondents in the present study also reported respiratory problems, asthma, circulatory failures, muscle weakness, and liver and kidney damage. Workers did not use personal protective types of equipment. These facilities should be given to the workers as their lives are equally important.

The binary logistic regression analysis was applied to the binary variables (Table 9). Two block models were considered for this analysis. The first block was named block 0, while the second block was named block 1. Bock 0 showed the values of the variables without any factors. On the other hand, block 1 showed the significance of the variable concerning factors.

Table 3. Summary of Parameters for Ground Water Quality

Sr. #	Parameters	Unit	Test Results		National Standards
			Project Site	Bharoki Sahi Da Pind	
01	pH 25 ºC	-	8.37	8.25	6.5-8.5
02	Color	Pt-Co	<5.0	<5.0	-
03	Turbidity	mg/l	0.3	0.5	<5
04	Total Dissolved Solids (TDS)	mg/l	1236	1035	<1000
05	Chloride (Cl)	mg/l	100.52	96.80	250
06	Fluoride	mg/l	0.312	0.170	≤ 1.5
07	Nitrate	mg/l	6.47	18.53	≤50
08	Nitrite	mg/l	<0.003	<0.003	≤3
09	Cyanide (CN)	mg/l	<0.05	<0.05	≤0.05
10	Cadmium (Cd)	mg/l	<0.003	<0.003	0.01
11	Total Chromium (Cr)	mg/l	<0.005	<0.005	≤ 0.05
12	Copper (Cu)	mg/l	0.0062	0.0078	2
13	Lead (Pb)	mg/l	<0.005	<0.005	≤ 0.05
14	Nickel (Ni)	mg/l	<0.005	<0.005	≤ 0.02
15	Zinc (Zn)	mg/l	0.0572	0.0238	5.0
16	Manganese (Mn)	mg/l	<0.005	<0.005	≤ 0.5
17	Aluminum (Al)	mg/l	<0.005	<0.005	≤ 0.2
18	Arsenic (As)	mg/l	<0.005	<0.005	≤ 0.05
19	Boron (B)	mg/l	0.099	<0.005	0.3
20	Barium (Ba)	mg/l	0.366	0.051	0.7

The highest statistical significance of block 0 was noted in the respiratory system disorder variable with a p-value of 0.018. In block 0, the non-significant variable was observed in the diarrhea variable, with the p-value noted as 0.860. While in block 1, the highest statistically significant value was

Table 4. Summary of Parameters for WasteWater Quality

Sr. #	Parameters	Unit	Test Results	NEQS
01	pH	-	8.26	6-9
02	Color	Pt-Co	2800.0	Acceptable
03	Turbidity	NTU	120.0	<5
04	Total Dissolved Solids (TDS)	mg/l	140.0	3500
05	Total Suspended Solids(TSS)	mg/l	1221.0	200
06	COD	mg/l	339.7	150
07	BOD	mg/l	207.3	80
08	Chloride (Cl)	mg/l	67.0	1000
09	Fluoride	mg/l	0.127	10
10	Nitrate	mg/l	4.56	<50
11	Nitrite	mg/l	<0.003	<3
12	Cyanide (CN)	mg/l	<0.05	1.0
13	Phenols	mg/l	0.11	0.1
14	Sulphate	mg/l	890	600
15	Cadmium (Cd)	mg/l	<0.003	0.1
16	Total Chromium (Cr)	mg/l	<0.005	1.0
17	Copper (Cu)	mg/l	0.0084	1.0
18	Lead (Pb)	mg/l	<0.005	0.5
19	Nickel (Ni)	mg/l	<0.005	1.0
20	Zinc (Zn)	mg/l	<0.0442	5.0
21	Manganese (Mn)	mg/l	0.1104	1.5
22	Arsenic (As)	mg/l	<0.005	1.0
23	Boron (B)	mg/l	<0.005	6.0
24	Barium (Ba)	mg/l	0.174	1.5

Table 5. Summary of Ambient Air Quality Analysis of Project Site

Parameter	**Unit**	**Results**	**NEQS**
Nitrogen Dioxide (NO_2)	µg/m^3	27.87	80 (µg/ m^3)
Sulphur Dioxide (SO_2)	µg/m^3	21.46	120 (µg/ m^3)
Carbon Monoxide (CO)	mg/m^3	3.1	05 (mg/m^3)
Particulate Matter (PM_{10})	µg/m^3	170	150 (µg/ m^3)

Table 6. Summary of Noise Level Analysis

Sr. #	**Location**	**Noise Levels (dB)**	**NEQS**
1	Industrial Area	71.4	**75**
2	West Boundary of industry	66.6	
3	East Boundary of industry	65.1	
4	South Boundary of industry	65.9	
5	North Boundary of industry	65.6	
6	Chak 157-RB	69.6	
7	Bharoki	70.7	

Table 7. Water quality classification based on WQI Values

Type of water	**Range**
Excellent	<50
Good	50-100
Poor	100.1- 200
Very Poor	200.1-300
Unsuitable	>300

Obtained in the diarrhea variable with the p-value of 0.115. Non- significant value was noted in breathing issues with a p-value of 0.899.

The multinomial regression analysis was performed on the nominal variables of the questionnaires (Table 10). The variables were separated according to their categories. The multinomial logistic regression analysis relies on the variable's significance and the variable's likelihood significance.

The variable significance highest observed statistical value was noted in the noise and drinking water quality issues

Table 8. Correlation between Air Pollutants

		CO	NO_2	SO_3	pm
CO	Pearson Correlation	1	1.000**	-.481	.264
	Sig. (2-tailed)		.000	.681	.830
NO_2	Pearson Correlation	1.000**	1	-.481	.264
	Sig. (2-tailed)	.000		.681	.830
SO_3	Pearson Correlation	-.481	-.481	1	.719
	Sig. (2-tailed)	.681	.681		.489
pm	Pearson Correlation	.264	.264	.719	1
	Sig. (2-tailed)	.830	.830	.489	
**. Correlation is significant at the 0.01 level (2-tailed).					

Table 9. Binary Logistic Regression Analysis

Parameters	**Block 0**	**Block 1**
	Significance of the variables not in the Equation	**Variable Significance**
Breathing Issues		
Industrial Air Emissions	.147	.223
Air Borne Dust Particle	.615	.899
Respiratory System Disorder		
Industrial Air Emissions	.034	.207
Air Borne Dust Particle	.018	.115
Eye Irritation Issues		
Industrial Air Emissions	.268	.259
Air Borne Dust Particle	.304	.309
Headache		
Industrial Air Emissions	.199	.280
Air Borne Dust Particle	.394	.538
Diarrhea		
Industrial charge	.243	.244
Rusted Pipes	.860	.796

Coughing		
Industrial Air Emissions	.101	.421
Air Borne Dust Particles	.042	.216
Hearing Impairment		
Noise	.089	.148
Heavy Traffic	.490	.545

Variable with the p-value of 0.000. In comparison, the non-significant value was obtained from income. The lowest obtained significant p-value was 0.988. In the likelihood, the statistically significant value was obtained in income and drinking water quality issues with the p-value of 0.000. In contrast, the non-significant value of likelihood was obtained in the blood pressure issues variable with a p-value of 0.920.

Table 10. Multinomial logistic regression analysis

Parameters	**Variables Significance**	**Likelihood Significance**
Blood Pressure Issues		
Noise	1.00	.595
Traffic Load	.869	.920
Income		
Education	1.00	.000
Employment	.988	0.30
Drinking water quality Issues		
Rusted Pipes	0.23	.029
Industrial discharge	.000	000
Noise Issues		
Industrial Noise	.000	0.26
Heavy traffic	.000	0.256
Traffic Issues		
Heavy Traffic because of loaded trucks	.149	.144
Destructed roads	.054	.038
Obstacles	.183	.170
Air Quality Issues		
Industrial Air Emissions	.509	.750
Air borne dust particles	.407	.705

4. Conclusion

The present study showed that the value of PM10 was high at the industrial site, and the levels of TDS, TSS, COD, BOD, sulfates, and phenolic compounds were also elevated in water. The health impact assessment of the proposed industry was also investigated. For ease of study, interviews and questionnaires were prepared for the residents and the industry workers. Major health issues identified included respiratory problems, asthma, heart problems, dizziness, coughing, and diarrhea because of the dust and poor water quality in the study area. These were the outcomes determined in the proposed study area for which management and the authorities should provide mitigation measures.

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