A field study of environment degradation during road construction and its improvement due to sprinkling of water

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Abstract: Road traffic is one of the major sources of environmental pollution in Pakistan that has increased tremendously in the recent past and leads to different challenges to the scientists and researchers. A study was carried out during the construction of an urban highway to investigate its impact on the environmental pollution. Main aim was to assess the effect of highway construction project upon the quality of environment. Sprinkling of water was carried out in 2007 at project site in order to reduce the effect construction on environment. Two major environmental components, ambient air, and noise were studied before and after the sprinkling of water. The effect of asphalt plant activities on portable water quality was also studied. Samples of waste water were collected at asphalt plant sit after a sizeable production. Samples of air and noise were collected before and after the sprinkling of water and analysis of data were performed for the years from 2005 to 2007. Some of the data were obtained from mobile monitoring units and other was collected by spontaneous onsite sampling and surveys. Laboratory tests were also performed where needed to confirm the results. The study revealed that construction of highways adds to a great extent in the environmental pollution. Sprinkling of water at construction site improve the chosen parameters to a great extent. Around 50% of particulate matters in a size of 10 micrometer (PM10) concentration reduce with sprinkling water.

[Hafeez I, Riaz K, Hussain J, Faisal M, Farooqi U, Hussain S, Khitab A, Naveed M, Hayat A. **A field study of environment degradation during road construction and its improvement due to sprinkling of water.** *Life Sci J* 2013;10(12s):888-893]. (ISSN:1097-8135). http://www.lifesciencesite.com. 145

Keywords: Environment, Highways, transport, vehicles, pollution,

1. Introduction

Physical conditions of a major percentage of vehicles in Pakistan are very poor that had contributed significantly in air pollution as engine exhaust gasses. High smoke emissions from diesels vehicles are due to overloading, lack of preventive maintenance, inferior quality of engine replacement parts and fuel adulteration. Density of private vehicles per capita has been increasing alarmingly since the last few decades. Truck especially 2-3 wheelers population in Pakistan is huge and increasing at a significant rate. Unfortunately, contribution of railway as a mean of transportation has been decreasing day by day as compared to highway. The levels of suspended particulate matters (SPM) and other pollutants, which have active co-relation with meteorological conditions, are likely to increase, given the prevailing dry air conditions. [1].

Various surveys conducted in Pakistan show that air pollution levels in cities have either crossed safe limits or have reached the threshold values. The most serious issue of air quality in Pakistan is presence of excessive suspended particulate matter in the ambient air in the form of particulate matters in a size of less than 10 micrometer (PM10). The origin of suspended particulate matter may be a natural phenomenon, such as unpaved roads and places uncovered by green grasses of trees. Fine particles of soil may be raised in the form of dust cloud by driven motor vehicles and by strong wind blow. In Pakistan, the number of vehicles have jumped from 0.8 million to about 4.0 million within 20 years showing an overall increase of more than 500%. The average compound growth of vehicles is about 8.4% per annum. Since 1980, the maximum growth has been seen in 2-stroke vehicles such as delivery vans, which are approximately 1751%, followed by motorcycles 541% and Rickshaws 159% [1].

According to study conducted by Pakistan Environmental Agency in collaboration with Japan International cooperation Agency (JICA) in three major cities of Pakistan; Lahore, Rawalpindi and Islamabad in year 2000, much higher levels of SPM including particulate matters of less than 10 micrometer (PM10) and lead (Pb) is present than the World Health Organization (WHO) standards. Since the study was supported through JICA, comparison with Japanese standards was one of the key analysis parameters. The average SPM data in 3 cities showed that SPM concentration exceeded 3.8 times for the Japanese standards (200µg/m^3) and 6.4 times from WHO standards (120µg/m^3). The levels of Sulpher

dioxide (SO_2), Nitrogen peroxides (NO) and Carbon monoxide (CO) was found in excess of acceptable standards in some areas but the average levels were found below WHO guidelines [2].

2. Literature Review

Road transportation is the major transportation mode that involves significant air pollution factor and Green House Gas (GHG) emission [3]. Construction activities are always considered the main source of environmental pollution. It is therefore important to identify the severity level of environmental impact of construction activities. Noise pollution, dust generation with construction machinery is the major factors involved during this activity, which requires monitoring and documenting. Results of such studies may be useful in predicting the future environmental damage caused by such construction activities [4].

Transportation infrastructure projects involve significant economic and environmental issues that require to be monitored. Considering the sustainability, environmental impact assessment has been mainly focused by planners in the past. Although it involves a large number of independent and dependent variables, but efforts can be made to capture the overall vulnerability of transportation projects and its improvement [5-7].

The effects of freight transport automation have been related by a multimodal approach to the reorganize urban freight transport [8]. The main objective was to build the preconditions for such an efficient multimodal (partly automated) urban freight transport system which will strengthen the economic structure of a city, increase the accessibility for freight and reduce the environmental side-effects of freight transport. The study had focused serious attention on goods transport and its environmental impacts and use theoretical approach to integrate four environment-concerned models, derived from previous studies, into one environment-cored model with emphasis of freight transport pollution. Four environment concerned models have been utilized to integrate them into a single freight transport-oriented environmental modal. Freight transport pollution analysis and assessment at three levels in terms of local level, national level and global level, which could be used as a tool for urban for several selected pollutants, have been investigated[8].

Relative to vehicular fuel consumption, 26 driving pattern parameters were studied and several relationships were developed. The exhaust emissions of oxides of nitrogen (NOx) and hydrocarbons (HC) with vehicular fuel consumption and exhaust emission with the characteristics driving patterns were the main relationships. It was concluded that five driving pattern parameters in terms of relative positive acceleration, number of adjacent speed values of max/min>2 km/h per 100 meter, percentage of time when the speed is between 0~15 km/h, percentage of time during high acceleration of 1.5~2.5 m/s^2 and percentage of time during the heaviest deceleration level< 2.5 m/s^2, had considerable effects on both fuel consumption and exhaust emissions of NOx and HC [9].

Trucks, due to their large size and more powerful engines, produced noise level as much as 15 decibel higher than passenger cars at a distance of 15m [10]. Increasing the utilization factors which lead to fewer truck trips, thus, fewer trucks on the road, emissions from road freight transport would be reduced significantly [11].

Air quality monitoring is critical to assess the existing level of contamination and the inter-relationship of Transport sources of pollution in order to evaluate the character and magnitude of existing problems. Very little work has been initiated in Pakistan on integrated air quality management system. One significant achievement has been the elimination of lead gasoline. Comprehensive background data is however required to assess the impact of transport on the environmental degradation of an urban area.

3. Objectives

The main objectives of the study were to assess;

- The effect of sprinkling of water at road site during the construction activities on the environmental components like air and noise level and
- To investigate the effect of asphalt plant activities on the quality of portable water.

4. Methodology

Road construction project which has a total length of about 30 kilometers was selected in the vicinity of Islamabad (NAAQS). The monitoring was specially conducted during the working hours which were the pre-requisite by the National Highway Authority to simulate the actual situation of air due to the construction activity. city (Pakistan). Samples of air, drinking water and waste water were collected through Environment Management consultants [12], Pakistan and analyzed after every three months; results however were reported on each six month period. This study presents analysis based on a survey conducted for about two years (year 2006, without sprinkling of water & year 2007 with sprinkling of water) and results were tabulated accordingly. Eight Hours monitoring was carried out continuously usually from dawn till dusk on different months of the year. Monitoring results are compared with the United State Environmental Protection Agency (USEPA) guidelines of the compliance of sensitiveness to the receptors for particulate matters

of less than 10 micrometer size (PM10) in the ambient air which is called as National ambient air quality standards

5. Results and Discussions

The results of ambient air tested during the construction of highway construction have been incorporated in Table 1. Continuous sprinkling of water was carried out at project site in year 2007, but no sprinkling of water was made in year 2006. Noise monitoring was carried out during same time as that for air monitoring.

Table1. Ambient Air (PM10 Test Report)

Time	Results (µg/m^3)*					
	Year 2006				Year 2007	
	6th March	21st March	5th June	7th November	25th January	5th March
09:00	198	203	249	231	123	145
10:00	244	252	264	243	125	148
11:00	305	325	288	255	121	143
12:00	282	302	301	263	128	147
13:00	268	251	309	241	122	138
14:00	256	243	313	233	118	135
15:00	232	228	312	251	124	142
16:00	313	321	310	261	126	146

* USEPA Guideline is 150µg/m^3

Particulate matters (PM10) in micrometer (µm) are considered as responsible for the adverse health effects and being replaced with the earlier Total suspended particulate (TSP). This component assesses the presence of micro dust particles in the air that can reach to the lower regions of the respiratory tract. Table 1 shows PM10 concentration, which is very high due to heavy traffic movement in the construction zone of project area. During seven-hour concentration it raised above the limits of 150 µg/m^3. PM10 were within the prescribed limits at noon around 2:00 pm. Monitoring, especially, carried out in the morning time revealed that PM10 is least effected during this time. Movements along the road sides were observed during the latter day time. A very heavy movement of traffic was observed in these timings which resulted in high concentration of this parameter.

Air quality improved especially when sprinkling of water was carried out at site during 2007. Around 50% PM10 concentration reduces with sprinkling water. Variations in the value of PM10 have been shown in Figure 1.

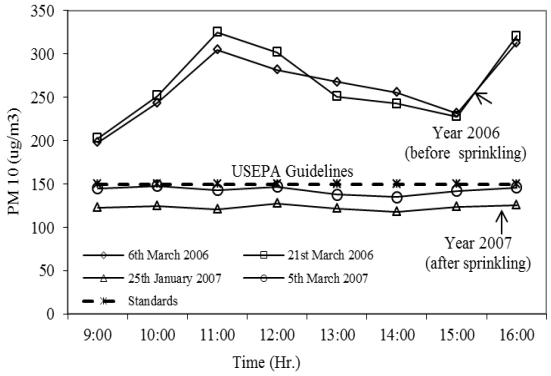

Figure 1. Variation in PM10 value of ambient air

Water quality at asphalt plant was monitored only to compare the effects of road construction. Asphalt plant is considered to be a dust producing source. The main purpose of selecting this site was to assess the effect of asphalt production on the quality of water at plant disposal location. The road construction activities do not affect the quality of aquifer and therefore can be ignorable for the purpose of comparison before and after the study. Samples were collected at regular time interval and the presence of Lead, Faecal Coliform and total Coliform were measured. Results of portable water and waste water have been tabulated in Table 2 and 3 respectively.

Table2. Analysis Results of Drinking water

Date	Parameters		
	Lead	Faecal Coliform (cfu/100ml)	Total Coliform
4th February 2006	0.06	32	535
7th March 2006	0.05	31	528
21st March 2006	0.04	28	536
5th June 2006	0.02	15	184
7th Nov. 2006	BDL*	0.0	0.0
25th January 2007	BDL	1	15
5th March 2007	BDL	0	0
0.01	0	0	

Table 2 shows drinking water quality analyses and the comparison of values with USEPA guidelines. It noted from Table 2 that the available water at asphalt plant site indicates presence of Lead and total Coliform.

Table 3. Summary of waste water results at asphalt plant site

Parameters	Analysis Results				
	2006			2007	
	7th March	5th June	8 November	25th January	5th March
Temperature	25	31	29	28	32
PH	7.1	8.2	7.5	6.2	6.8
BOD	237.9	788	512	194	211
COD	449	1512	1038	498	432
TSS	363	812	412	466	354
TDS (Dissolved)	1060	1798	1236	1115	1023
Grease & Oil	6.0	7.0	2.0	1	3
Phenolic Compounds	0.01	0.08	0.009	0.01	0
Chlorides	100	206	97	152	118
Flourides	0.23	1.12	2.55	2.31	3.22
Cynaide	0.07	0.07	0.085	BDL	0.016
Anionic Detergents	BDL	0.025	0.043	1.023	0.84
Sulphates	300	826	478	144	411
Sulphides	2.3	1.1	0.3	0.8	0.33
Ammonia	146	178	75	18	64
Cadmium	BDL	BDL	BDL	BDL	BDL
Chromium	0.04	0.08	0.028	BDL	0.03
Copper	0.05	0.45	0.41	0.22	0.24
Lead	1.59	0.98	0.236	0.13	0.17
Mercury	BDL	BDL	BDL	BDL	BDL
Selenium	BDL	BDL	BDL	BDL	BDL
Nickel	0.30	0.71	0.71		0.23
Silver	BDL	BDL	BDL		BDL
Total Toxic Metals	1.98	2.23	1.38		0.67
Zinc	0.13	2.11	2.02		1.28
Arsenic	0.07	0.07	0.11		0.06
Barium	BDL	2.5	1.3		0.2
Iron	0.75	5.2	3.4		1.3
Manganese	0.24	0.24	0.555		0.21
Boron	0.7	4.7	2.9		1.6
Chloride	BDL	BDL	BDL		BDL

* USEPA Guideline (ug/m^3)

Also, it may be noted from Table 3 that the waste water from the asphalt plant contains significant amount of harmful elements, which may affect the environmental conditions. Drinking water mainly concerned with the presence of coliform which is high in colony number in the analyzed sample, specially the faucal Coliform. These results have been compared with WHO drinking water guideline values. It also has slightly high concentration of Lead and Coliform counts. Lead is one of the elements in nature, which is a health hazard for humans. Water may contain a dangerously high quantity of Lead that may cause a lot of toxic diseases in human beings and other problems to living creatures. One of the objectives of this study was also to highlight the presence of Lead in the drinking as well as in the contaminated water. A comparison of presence of Lead in the available water and the waste water at asphalt plant site has been presented in Figure 2.

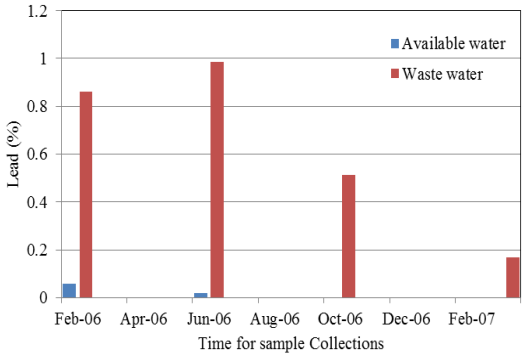

Figure 2. Comparison of Lead in available and waste water at plant site

It may be noted in Figure 2 that after asphalt plant operation, the Lead percentage in water increased significantly. An average percentage increase in Lead quantity in the waste water after the plant operation from the available water for nine data sets (taken at different time period) is more than 35%.

Although, this study does not purport the effect of road construction activities on the water quality, yet it threw light on the quality of the available portable water at construction sites and the presence of harmful components beyond the allowable limits. The present studies also focus on the presence of harmful coliform in the drinking water that may affect the health of workers at specific site.

Noise levels were also measured using sound-level meters (SLM) in parallel with other measurements and the results have been reported in Table 4. Sound-level meters detected and recorded changes in the sound pressure level at regular interval. Averages of descriptors of interest were computed using the integrating SLM and results of continuous eight hours duration have been presented in Table 4.

Table 4 shows that the noise conditions are satisfactory. It reflects that there is no significant impact on sensitive receptors with regard to noise pollution due to the vehicular movements and

machinery works. Results are satisfactory and within the specified limits. They were compared with the National Environmental Quality Standards (NEQS) guidelines for vehicular noise generation and results are well below the limits. Construction activities are not adversely affecting the background noise intensity. No undesirable change has been seen during the monitoring period.

Table 4. Noise level monitoring

Time	Results (decibel)					
	2006				2007	
	6th March	21st March	5th June	7 November	25th January	5th March
09:00	80.4	81.2	79.1	78.9	75.2	73.2
10:00	79.8	78.6	79.9	79.5	75.1	77.6
11:00	81.3	80.8	80.1	79.7	75.6	75.9
12:00	82.4	83.1	80.5	80.2	76.8	78.8
13:00	80.9	80.6	79.6	78.2	75.8	71.2
14:00	83.6	82.9	80.2	77.9	75.1	68.5
15:00	81.5	82.1	79.8	79.9	75.6	74.3
16:00	82.2	82.0	80.6	80.4	76.1	74.9

However 7 % reduction in noise was observed due to sprinkling of water on the construction project. Sprinkling water keeps the soil in its compacted form and also reduces the effect of traffic deterioration on a pavement layers (embankments or structural layers). Lower number of roller passes and motor grader efforts are therefore required to achieve the desired density and grade in case of a regular sprinkling on pavement embankment and on shoulders. In the absence of sprinkling, the compacted material deteriorate or erode away at a higher rate and therefore the amount of compaction and grading effect afterward will increases, once the traffic has passed in the working area. Dry soil loses it strength and dislodged under the traffic operation. Sprinkling of water carried out in year 2007 helped in reducing the number of roller passes and grading efforts on the construction site. The reduction of noise level as shown in Figure 3 has also been attributed due to the effect of reduced number of roller passes and grading efforts. The difference of noise level before and after the sprinkling of water was calculated on the basis of average data obtained at different time periods and at different locations.

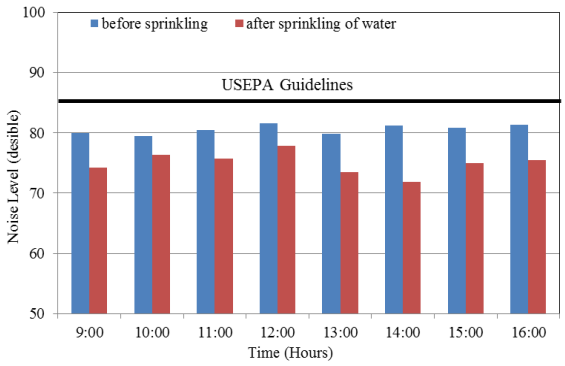

Figure 3. Comparison of noise level before and after sprinkling of water

6. Conclusion

Following conclusions have been drawn from this study:

- Sprinkling of water at highway construction projects is a useful technique to control the environmental pollution. Emission from road construction machinery is a critical source of Particulate Matters in Pakistan that requires diminishing by sprinkling of water.
- Sprinkling of water during construction period had significantly control on ambient air pollution. Sprinkling of water helps in reducing around 50% of PM10 concentration.
- Working of road machinery has relatively less effects on noise level in an urban area. However 7 % reduction in noise was observed due to sprinkling of water on the construction project. This difference was due to lesser machinery efforts after sprinkling of water.

Acknowledgements:

Foundation item: Authors are greatfull to the department of Civil Engineering, University of Engineering and Technology, Taxila, Pakistan for financial support to carry out this work.

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12/12/2013