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Trace Metals Aerosol Pollution in Some Selected Locations of Pollutant Web and Human Health Risk Assessment

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ABSTRACT: ***In this study elemental composition of aerosol particles in some selected sites of identified pollutant web in Faisalabad atmosphere was carried out. The elemental analysis was done by atomic absorption spectrophotometry. The results clearly indicate that the composition of solid aerosols was very complex, it also shows that the presence of elements Cr, Ni, Zn, Pb and Mn following the trends Mn > Zn > Ni> Pb > Cr, Zn > Mn > Cr > Pb > Ni, Zn > Mn > Ni > Pb > Cr in industrial, commercial and transportational sites respectively. Empirical relations developed for this study were applied to check the health hazards on the population residing in the concerned sites. It was found that almost all types of Environment related diseases were found in almost all sites those follow T>I>C. Locality has no significant effect with respect to elemental pollution and associated health hazards.***

Keywords: ***Elemental atmospheric air pollution; positive co-relationship with health hazards, Confirmed through empirical relations, remedial measures were suggested.***

1.0 INTRODUCTION

Environment, in its wider sense, includes everything, which is external to a human being. Environmental Pollution means the accumulation or concentration of wastes that cannot be disposed off by natural recycling process due to their excessive quantity or unique chemical composition [1]. Any substance which is present in nature beyond permissible limits as well as has detrimental effects not only on the environment but also on living organisms is called Pollutant e.g., CO_2, CO, SO_2, Cd, Hg, Cr, Pb, Zn, Cu, Mn, Ca, Co and Mg. These chemicals are released into the atmosphere from different natural and anthropogenic sources. High temperature industrial process release coarse fractions of Mg, Ca, Ni, Mn, Cu and Zn. Automobile exhaust and fertilizer industries also release these metals, their compounds, or other salts [2-8]. The urban population is exposed to the aerosol toxic metals that often are well above natural background [9-13]. Many studies on atmospheric metal concentration and their related health hazards have been conducted in several parts of the world which showed diverse fluctuations and disparities among the trace element constituents [14-24]. All these metals produce different diseases like oxides of Zinc along with oxides of Iron produce gastric disorder and vomiting, irritation of skin and mucous membrane. Nickel, Chromium, Lead, Cadmium, Copper and Carcinogenic calcium causes slowing of heart rate, leukemia and different types of cancer [25-31]. Cobalt and Manganese cause chronic and acute poisoning which results in Anemia and Hypertension [32]. When these chemicals are released into the atmosphere, they enter into the human chain, as soon as they enter biological system cause deaths in some cases. Due to the lack of air quality management capabilities, the Pakistan is suffering from

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deterioration of air quality. Evidence from various governmental organizations and international agencies has indicated that air pollution is a significant risk to the environment, quality of life and human health. Besides health hazards, heavy metal pollution impair visibility, plays an important role in acidic rain, adversely affects the radiation budget and consequently disturbs a variety of environmental processes may change the cloud properties by nucleation, condensation and chemistry of environment by providing the media for various heterogeneous reactions and carriers for chemical species. Atmospheric aerosol particles are solid or liquid particles suspended in air. Processes that control formation, transformation and the removal of atmospheric aerosols is of great interest in atmospheric science. The reason is that these particles, which are often smaller than 1 micrometer in diameter, play an important part in Earth's radiation budget through the scattering of sunlight and through the interaction with clouds. Human activities, such as burning of fossil fuels and land use, change the properties of the aerosol and may therefore influence the climate. This can be either directly through an increase in aerosols or indirectly through the way the anthropogenic aerosols change the way clouds form. Also, heterogeneous reactions on the aerosol particle surfaces influence the gas phase composition and chemistry of the atmosphere. And these particles are responsible for adverse health effects through inhalation. To assess the role of aerosols in our environment and the influence by anthropogenic emissions requires an understanding of the life cycle and transport patterns of solid aerosol particles, their compositional evolution as well as a detailed knowledge of cloud formation and nucleation mechanisms depend on the properties of the pre-existing aerosols [33-36]. Solid aerosol is an important component of the atmosphere and its source composition, distribution and effects on environment and human health are very complex due to which governments and environmental scientists have given much attention to the studies related to aerosols and their interlinked problems, in this way study has become the hot topic of current research. In this study,

1. The importance of solid aerosols in climate change, the atmospheric, environmental and human health related some selected parts of the pollutant web identified by Dr. Khan in his Ph. D. project is summarized.
2. The recent solid aerosol pollution related issues and shortage of data related to Faisalabad are pointed out.
3. And the necessity to enhance solid aerosol research in Pakistan is emphasized.

This effort is the continuation of our Ph. D. project on this issue already presented and published elsewhere.

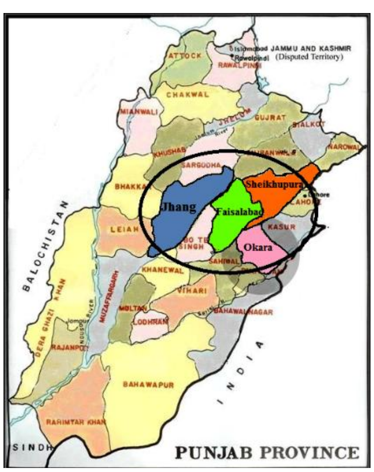

Fig 1: Map showing Identified Pollutant web

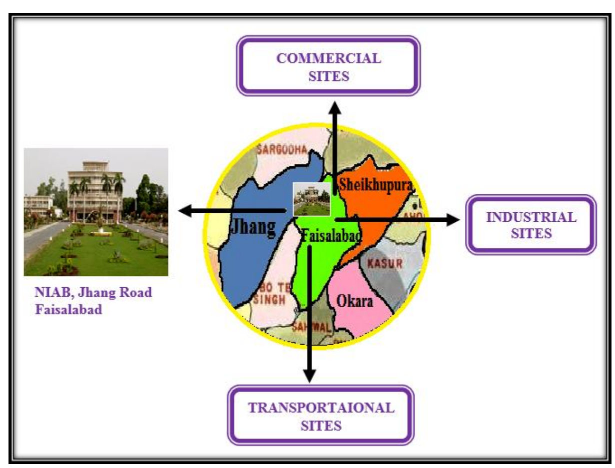

Fig 2: Selection of Site using Grid Method

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2.0 MATERIALS AND METHODS

In this study attempt has been made to estimate the trace elements like Cr, Ni, Zn, Pb and Mn in the atmosphere comprising of various sites of selected pollutant web. 8 sites/pool were randomly selected for analysis covering industrial, transportational, and commercial nature of the Faisalabad environment. Air samples containing solid aerosols were collected using Kimoto high volume air sampler from selected areas of Faisalabad. Samples were collected for a period of 12 hrs with an average flow rate of $0.8m^3$/min. Solid aerosols were trapped on glass fiber filters with the collection efficiency of 90%. The filters were weighed before and after sampling [37]. Then analyzed by atomic absorption spectrophotometer (Model No.: Varian AA-1475).

(AAS) to Atomic absorption Spectrophotometry metal constituents and elemental was used concentrations for 5 elements in the atmosphere of Faisalabad. These elements are capable of reducing visibility due to reduction in solar radiation, increase or decrease of Aledo and lead to atmospheric healing if they absorb radiations and may bring about cooling effect in the earth if there is back scattering of light by solid aerosols in to the space. In order to understand these optical effects, it is compulsory to know the constituents of solid aerosols and their sizes as these parameters not only determine the scattering and absorption properties but also provide us information to interact with gaseous pollutants in the environment and react to form new solid aerosol particles or to modify existing ones by homogeneous, homo molecular nucleation or homogeneous, heterogeneous molecular nucleation and their ability to get into the human respiratory system and generate health hazards.

Atomic absorption spectrometry (AAS) work on the principle that the amount of energy absorbed in flame is proportional to the concentration of the element present in the sample. Since each element has its own characteristic absorption wavelength, when the sample is in solution form it is found that the measured extinction coefficient σ is proportional to the concentration of the absorbing substance and hence may be written as

$$\mu = K \sigma$$

Where μ is the linear extinction coefficient and K is the extinction coefficient per unit concentration. The conversion of the concentration in mg/l to mg/Kg is achieved using the following expression

$$\text{Mg/Kg} = \frac{\text{Reading (mg/l)} \times 50 \text{ ml}}{\text{Weight of the sample (g)}}$$

The results obtained in this study slightly disagreed from similar previous and current studies conducted by other workers. This disagreement is explained not only in terms of climatological, geological, geographical setups and latitude, longitude location with respect to solid aerosol sources but also expansion in industrial and transportational set up [38-40].

3.0 RESULTS AND DISCUSSION

In order to determine trace elements in the Faisalabad environment, 24 sites i.e. 8 from each site, Industrial, Commercial, Transportational covering almost all the aspects of web environment using air volume sampler following standard protocol. Atmospheric solid aerosols were randomly collected in Faisalabad city. All the samples were subjected to trace elemental analysis by the AAS technique for determination of Cr, Ni, Pb, Zn and Mn in solid aerosols the results obtained are given in the following tables.

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Table 1: Data analysis related to Industrial Sites

Metals	Mean	Median	Range	SD	CV
Cr	0.99	0.52	2.9	1.08	1.09
Mn	2.94	1.53	9.73	3.73	1.37
Ni	0.26	0.18	0.54	0.54	0.8
Pb	0.52	0.28	1.37	1.37	1
Zn	2.49	2.5	1.44	1.44	0.18

Table 2: Data analysis related to Commercial Sites

Metals	Mean	Median	Range	SD	CV
Cr	0.26	0.21	0.41	0.14	0.55
Mn	0.77	0.085	3.46	1.29	1.67
Ni	0.12	0.105	0.31	0.1	0.83
Pb	0.2	0.16	0.53	0.16	0.8
Zn	2.41	2.545	2.28	0.75	0.31

Table 3: Data analysis related to Transportational Sites

Metals	Mean	Median	Range	SD	CV
Cr	0.14	0.15	0.08	0.03	0.21
Mn	1.47	0.61	6.04	2.14	1.46
Ni	1.19	1.1	2.39	0.92	0.77
Pb	0.75	0.3	2.56	0.9	1.2
Zn	3.05	3.185	0.99	0.36	0.12

There are 24 sampling sites selected by using SRS and syntax Map methods, to reflect different influences from industrial, commercial and residential parts of city designated as commercial zone, industrial and residential zone. The selected samples of solid aerosols were analysed qualitatively and quantitatively using AAS and the results are shown in the following obtained tables. The maximum concentration of lead in the atmosphere of Faisalabad was observed to be 0.75 ppm.

The city is a major centre of economic growth as well as regional trade, public administration, education communication and transportation hub. Offices shopping plazas, medical, agricultural and educational institutions, industrial units, commercial and residential areas are located too closed that sometimes mixed together makes the environment too complex and more complicated [41-50].

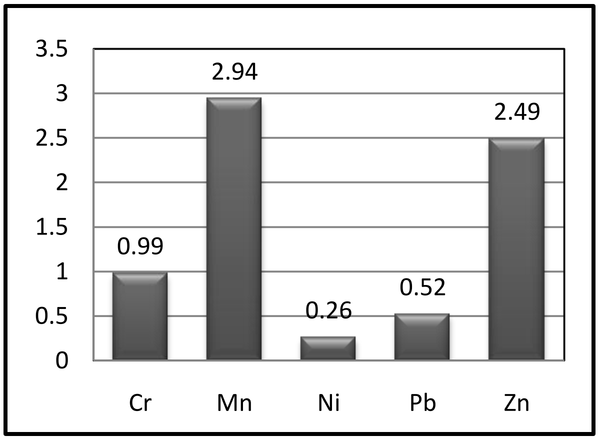

Fig 3: Average Concentration of Cr, Pb, Mn, Ni and Zn (ppm) in Industrial sites*

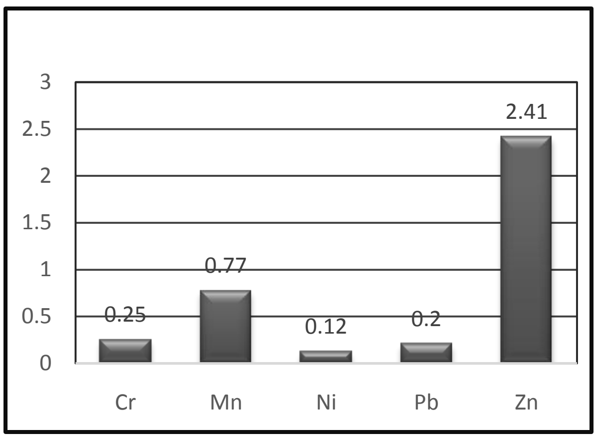

Fig 4: Average Concentration of Cr, Pb, Mn, Ni and Zn (ppm) in Commercial sites*

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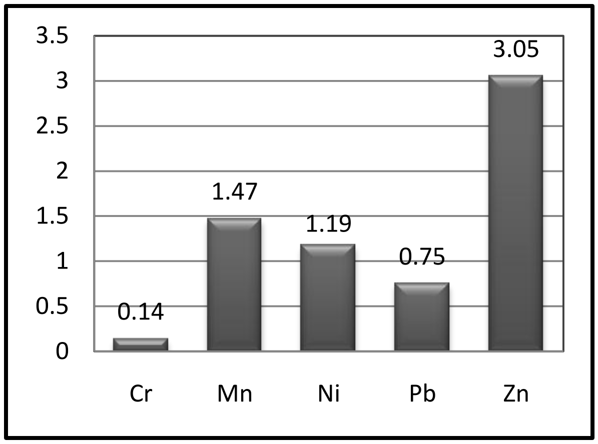

Fig 5: Average Concentration of Cr, Pb, Mn, Ni, Zn (ppm) in Transportational sites*

*** X-axis: Trace elements**
Y-axis: Average concentration

There are four sampling sites selected by using SRS and syntax map method to reflect different influences from residential parts of the city designated as commercial pool, industrial and residential pool. The selected samples of solid aerosols were analyzed qualitatively and quantitatively using AAS technique and the results are shown in the following tables (1-8) and figures (3-9).

The maximum concentration of lead in the atmosphere of Faisalabad was observed to be 0.75 ppm. The concentration of lead is found in various environmental components (compartments) bordering a road way is a function of a number of factors including distance and meteorology. Pb constitutes over 20% of total mass of fine particles emitted from cars burning leaded gasoline ~75% of Pb contained directly to the atmosphere. However it has been recorded that only 25% of lead emitted by vehicle are in coarse fraction and thus deposite close to roads .The remaining 75% is in fine fraction and may remain air borne containing areas more remote from its point of emission.
The maximum concentration of Cr was detected to be 0.99 ppm. Chromium originates from combustion of fossil fuel and industrial activities. The chemical form of chromium in air depends on the source. Cr from metallurgical is usually in the trivalent or zero state.

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Table 4: Site wise Trend pattern of Identified Trace Metals in Solid Aerosols

Identified trace elements	Trend followed
Chromium (Cr)	I>C>T
Manganese (Mn)	I>T>C
Nickel (Ni)	T>I>C
Lead (Pb)	T>I>C
Zinc (Zn)	T>I>C

Table 5: Health Hazards of Industrial Sites using Empirical relations

Sr. No	Health Hazards	Predicted Regression Equation	Total Amount of Health Hazards	Average %age of Health Hazards
1	ENT	14.6+0.2638Ni+2.49Zn+0.525Pb	17.8788	9.2684%
2	Giddiness	61.4+0.2638Ni+2.49Zn+0.525Pb	64.6788	33.5295%
3	Fatigue	-497+0.2638Ni+2.49Zn+0.525Pb	-493.721	-255.945%
4	Gastrointestinal	-19.0+0.2638Ni+2.49Zn+0.525Pb	-15.7212	-8.1499%
5	Urinary	-6.7+0.2638Ni+2.49Zn+0.525Pb	-3.4212	-1.7736%
6	Cancer	06.64+0.2638Ni+2.49Zn+0.525Pb	9.9188	5.1419%
7	Heart Attack	8.1+0.2638Ni+2.49Zn+0.525Pb+2.94Mn	14.3188	7.4229%
8	Headache	75.9+0.2638Ni+2.49Zn+0.525Pb	79.1788	41.0463%
9	Skin Disease	-17.9+Ni+2.49Zn+0.525Pb+2.94Mn	6.2188	3.2238%
10	Respiratory Disease	-5.5+0.2638Ni+2.49Zn+0.525Pb+2.94Mn	0.7188	0.3726%

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Table 6: Health Hazards of Commercial Sites using Empirical relations

Sr. No	Health Hazards	Predicted Regression Equation	Total Amount of Health Hazards	Average %age of Health Hazards
1	ENT	14.6+0.12Ni+2.4113Zn+0.2Pb	17.3313	9.3901%
2	Giddiness	61.4+0.12Ni+2.4113Zn+0.2Pb	64.1313	34.7463%
3	Fatigue	-497+0.12Ni+2.4113Zn+0.2Pb	-494.269	-267.795%
4	Gastrointestinal	-19.0+0.12Ni+2.4113Zn+0.2Pb	-16.2687	-8.8144%
5	Urinary	-6.7+0.12Ni+2.4113Zn+0.2Pb	-3.9687	-2.1502%
6	Cancer	06.64+0.12Ni+2.4113Zn+0.2Pb	9.3713	5.0774%
7	Heart Attack	8.1+0.12Ni+2.4113Zn+0.2Pb+0.7713Mn	11.6026	6.2863%
8	Headache	75.9+0.12Ni+2.4113Zn+0.2Pb	78.6313	42.6024%
9	Skin Disease	0.12Ni+2.4113Zn+0.2Pb+0.7713Mn	3.5026	1.8977%
10	Respiratory Disease	-5.5+0.12Ni+2.4113Zn+0.2Pb+0.7713Mn	-1.9974	-1.0822%

Table 7: Health Hazards of Transportational Sites using Empirical relations

Sr. No	Health Hazards	Predicted Regression Equation	Total Amount of Health Hazards	Average %age of Health Hazards
1	ENT	14.6+1.1875Ni+3.0538Zn+0.75Pb	19.5913	9.7718%
2	Giddiness	61.4+1.1875Ni+3.0538Zn+0.75Pb	66.3913	33.1147%
3	Fatigue	-497+1.1875Ni+3.0538Zn+0.75Pb	-492.009	-245.4044%
4	Gastrointestinal	19.0+1.1875Ni+3.0538Zn+0.75Pb	-14.0088	-6.9873%
5	Urinary	-6.7+1.1875Ni+3.0538Zn+0.75Pb	-1.7088	-0.8523%
6	Cancer	06.64+1.1875Ni+3.0538Zn+0.75Pb	11.6313	5.8015%
7	Heart Attack	8.1+1.1875Ni+3.0538Zn+0.75Pb+1.47Mn	14.5613	7.2629%
8	Headache	75.9+1.1875Ni+3.0538Zn+0.75Pb	80.8913	40.3470%
9	Skin Disease	1.1875Ni+3.0538Zn+0.75Pb+1.47Mn	6.4613	3.2228%
10	Respiratory Disease	-5.5+1.1875Ni+3.0538Zn+0.75Pb+1.47Mn	0.9613	0.4795%

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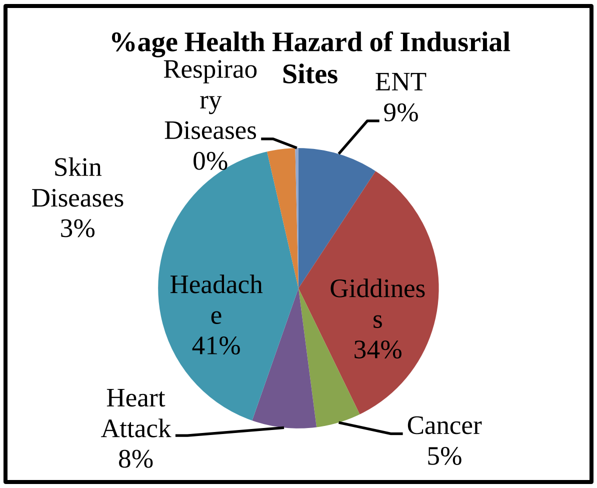

Fig 6: Graphical sketch showing Health Hazards in Industrial Sites

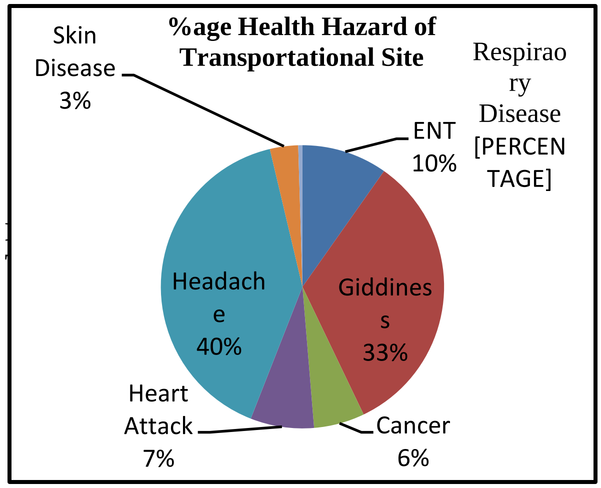

Fig 8: Graphical sketch showing Health Hazards in Transportational Sites

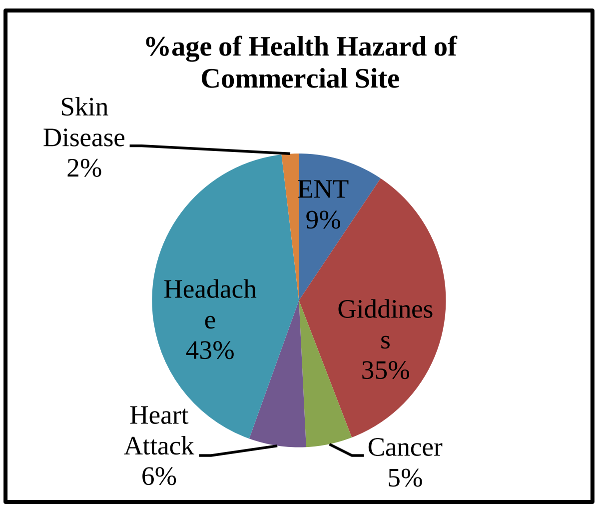

Fig 7: Graphical sketch showing Health Hazards in Commercial Sites

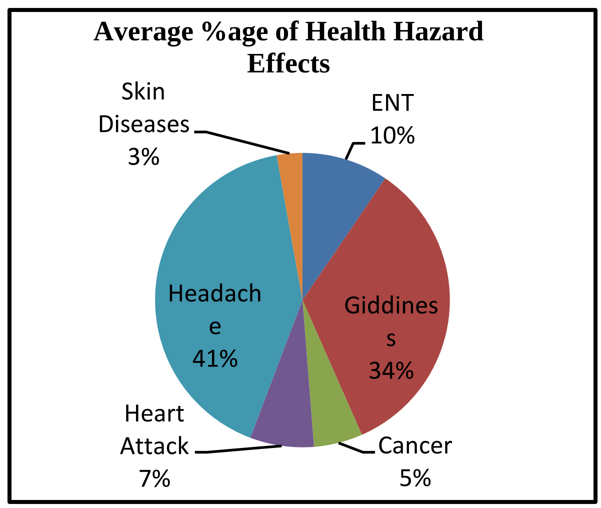

Fig 9: Graphical sketch of Health Hazards comparative study

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Sr. No	Health Hazards	Predicted Regression Equation	Total Amount of Health Hazards	Average %age of Health Hazards
1	ENT	14.6+0.5238Ni+2.6517Zn+0.4917Pb	18.2672	16.2322%
2	Giddiness	61.4+0.5238Ni+2.6517Zn+0.4917Pb	65.0672	57.8187%
3	Fatigue	-497+0.5238Ni+2.6517Zn+0.4917Pb	-493.333	-438.376%
4	Gastrointestinal	-19.0+0.5238Ni+2.6517Zn+0.4917Pb	-15.333	-13.6249%
5	Urinary	-6.7+0.5238Ni+2.6517Zn+0.4917Pb	-3.0328	-2.6949%
6	Cancer	06.64+0.5238Ni+2.6517Zn+0.4917Pb	10.3072	9.1590%
7	Heart Attack	8.1+0.5238Ni+2.6517Zn+0.4917Pb+1.7271Mn	13.4943	11.9910%
8	Headache	75.9+0.5238Ni+2.6517Zn+0.4917Pb	79.5672	70.7034%
9	Skin Disease	0.5238Ni+2.6517Zn+0.4917Pb+1.7271Mn	5.3943	4.7934%
10	Respiratory Disease	-5.5+0.5238Ni+2.6517Zn+0.4917Pb+1.7271Mn	-0.1057	-0.0939%

Table 8: Average %age of Health Hazard of Total Environment using Empirical relations

Long exposure of chromium to workers and neighbours of industries can cause irritation of respiratory system performation of nasal passages and being cancer. Chronic exposure may also lead to liver and kidney damage.

The maximum concentration of Ni was found to be 1.19 ppm. Ni in the atmosphere originates from the combustion of fossil fuels (particularly from oil) smelting crustal and volcanoes. Atmospheric Ni from remote areas that are considered to relatively free from manmade Ni emissions in the range (0.1-1) mg/kg(marine) and (1-3)mg/kg (continental).It is also found that combustion of oil and incineration of waste contributes more than 70% of total Ni sources followed by refining process with 17%. Continuous and prolonged exposure to Ni can produce dermatitis and disorders in the respiratory system and it is also a possible carcinogen.

The maximum concentration of Mn and Zn was found to be 2.94 ppm and 3.05 ppm respectively. The sources of Mn and Zn are metallurgy, industry, pulp, paper mills, textiles, fertilizers petroleum refining, coal burning, mining, ore processing, paints leather, metal production, tier sources like waste incineration, fossil fuel combustion, cement production. Transportational activities like deicing of salts, combustion exhaust, galvanized paints and railings, oil along with rubber tires also contribute in this regard. Their overexposure may cause gastro intestinal irritation vomiting, long tuberculosis, a plastic anaemia and acute leukaemia [51-60].

Empirical relations developed for this study were applied to check the health hazards on the population residing in the concerned pools. It was found that almost all types of Environment related diseases were found in almost all pools. Locality has no significant with respect to elemental pollution and associated health hazards [61-66].

Some data sets about trace metal pollution and related health hazards obtained from our recent research and available literature are presented and evaluated. Our experimental findings give an overview on current status and trends of pollution in the identified pollutant web.

4.0 CONCLUSIONS

1. Trace metal wise pollution trend was found to be

   Mn > Zn > Cr > Pb > Ni,
   Zn > Mn > Cr > Pb > Ni,
   Zn > Mn > Ni > Pb > Cr

   for industrial, commercial and transportational sites respectively.
2. Risk assessment wise trend was found to be
   Headache > Giddiness > ENT > Heart attack > Skin diseases > Respiratory diseases > Gastrointestinal diseases > Fatigue respectively.
3. Trace metal pollution has positive co-relationship with risk assessment.
4. Site wise classification of the areas comprising of pollutant web has shown no significant effect with respect to aerosol pollution and health hazards which indicates the total environment of Faisalabad has been degraded adversely and may not be considered as environment friendly.
5. Site wise trend was found to be I>C>T, I>T>C, T>I>C, T>I>C, T>I>C respectively. As far as pollutant risk is concerned commercial sites has shown safe trend while industrial and transportational sites has shown mix trend which clearly indicates the complexity of the pollutant web hence protective measures were recommended urgently.

5.0 FUTURE RECOMMENDATIONS

Because of the importance, complexity and uncertainty of the effects of solid aerosols on atmospheric environment and human health aerosol studies have gained extra importance and drawing more and more attention from scientists, public and governments world-wide. Aerosol pollution in Pakistan especially in Faisalabad city is a serious issue; investigation of solid aerosols therefore is urgent need of the day. Due to shortage of data, population explosion and limited resources, the general living environment in Faisalabad is fragile. Furthermore human activates like urbanization and modernization in transportation, industry and agriculture have introduced serious atmospheric environmental related issues in Pakistan like other developing countries. Recently solid aerosol related investigations in Pakistan has been increased considerably and luckily have obtained good results. However these studies still not achieved their global status due to the shortage in depth investigation, creativity, data share, interdisciplinary and synthesis of results. To ensure it the friendly environment, stable economy and better standard of living the Pakistan government and environment related agencies / organizations must play their role to the solid aerosol research and consequently put more efforts in studying their impact on environment and human health.

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