A Review on the Identified Phases of Suspended Particulate Matter (SPM) & Heavy Metals in the Environment from Different World Locations

[1]Syed Kamran Ajmal*, [2]Shabir Mahar, [1]Shahzadi Sheher Bano, [1]Iqra Mushtaq and [1]Iqra Ahmad
[1]Department of Physics, Punjab Group:
Constituent College of University of Central Punjab (UCP), Faisalabad
[2]Department of Physics, University of Agriculture (UAF), Faisalabad
ucpkamranajmal@gmail.com*

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Summary: Suspended particulate matter (SPM) is a significant source of environmental contamination and it has a variety of physical and chemical properties. Pollution has a wide range of effects on living creatures. It exists in varied quantities at various locations and levels in the atmosphere. Noise pollution, water pollution, chemical pollution and air pollution are all examples of environmental pollution. Air pollution has been researched in the indoor and outdoor atmospheres of the world. Over the last 40 years, many studies have studied of air particulates in different countries. This study also analyzed and reviewed various sample collection, pre-treatment and analytical methodologies used in SPM during the four decades. The findings revealed that traffic exhausts are the primary source of SPM. In Asian countries (China, Pakistan, India, Nepal) of traffic areas followed by urban regions and lowest in rural areas similarly in African countries (Nigeria, Sudan, Kenya, Tanzania, Mali), Western countries (UK, USA, Spain, Greece) and in Arabian countries (Iran, Iraq, Libya, Saudi Arabia) were found SPM and heavy metals. During the period of (1980-2020), this study elucidates the sources, analytical techniques, for the SPM and related metallic components. The metallic elements for SPM were Fe, Mg, Zn, Pb, Cu, Mn, Cr, Cd found during the past ten years in Asian countries. Using powder techniques, clay minerals were discovered in examined articles (SPM, free fall dust, indoor, outdoor, and under carpet dust). The study is being carryout to examine the presence of heavy metals and SPM in various ecosystems around the world. This research paper provides a comprehensive overview of heavy metals and SPM. Previous research on this topic over the previous four decades was thoroughly examined, in order to conduct experimental research; various equipments for collecting SPM samples were used.

Keywords: Suspended particulate matter, Heavy metals, X-ray diffraction, Air conditioner filter, High volume air sampler, Low volume air sampler.

Introduction

A suspension of coarse and tiny particles in a gas medium is known as a solid aerosol [1, 2]. It is referred to specifically as the mixed phase/combination system that develops when liquid or solid particles are scattered in a gas. The quantity of suspended particles present in the atmosphere is influenced by both natural and man-made processes [3]. Pollution particles are called particulate matter, which is made up of fine and coarse solid aerosols that are suspended in the air [4]. Particulate matter in air can be classified into two types using approved standard methods of suspended matter [5]. Smaller particles are more likely to enter the respiratory system, coarse particles deposited in the pharynx and larynx, causing nasal and throat dryness but having no influence on muco-ciliary clearance. The Environmental Protection Agency (EPA) is developing standards for air quality based on the precise measurement of particles that can enter the trachea. The three main sources of airborne particles are wind-borne particles, ocean showers, and combustible fillers. Natural and inorganic elements are broken down and crushed to create clean [6].

The World Health Organization (WHO) launched the global discussion observation programme for the study of SPM as part of the global environment monitoring framework [7]. Most of the particles are wind-blown dust that comes from the surface of the earth. Some is created as a result of the combustion of fuels like coal, oil and diesel in automobiles and furnaces. SPM consist of solid particles suspended in the air in the form of dust for extended period's of time, is the primary generator of haze, which impair visibility [4].

A variety of inorganic element was introduced in to the atmosphere by both natural and manmade causes [8]. Usually an airborne particle type that can travel over great distances before being dropped on the ground by dry drops, but mist sometimes forms. Their primary sources include activities, the combustion of fossil fuels, car exhaust emissions, and emissions from various activities [9].

*To whom all correspondence should be addressed.

Ammonium sulfate, ammonium nitrate, sodium chloride, metals, carbonaceous material and water are all components of the stratospheric aerosols, which exist at temperatures between 45 and 80 °C. Since the anthropogenic emissions that contribute to atmospheric aerosol have significantly increased and they have been connected to concerns about human health as well as effects on visibility reduction in urban and rural regions [10]. The inhalable percentage of airborne particles is the primary cause of respiratory disease incidence and atmosphere wide particle pollution. There may be relatively high quantities of these potentially hazardous elements in the composition of these particles [11].

The particles which cause air pollution increase atmospheric capacity and reduce visibility. These effects are forced where the focal points of industrial emissions are located within urban areas with their corresponding vehicle pollution. Environmental pollution may be defined as the unfavorable alteration of our surroundings and occurs mainly through different activities of man [12]. Definitely, the development of science and technology has made life easier for people by enabling them to use cars, electrical appliances, better medicines, and chemicals to combat disease. However, these factors have contributed to environmental pollution issues [4-6].

The changes in vitality designs, radiation levels, and chemical and physical constitutions of organisms are the indicators of environmental pollution. The combinations in such amounts and tends to be injurious the human, plant and creature life. Nowadays, the pollution in air is increasing rapidly almost in whole world but increasing at a faster rate in the developing countries such as Pakistan [1-5] and also in advanced countries. Scientists are trying their best to overcome this problem for which it is necessary to known about the actual particles present in the atmosphere.

The SPM particles become inhalable if the size is less than 15 μm, whereas they are suspended in air when their size is less than 10 μm and become respirable [2]. These particles when inhaled can penetrate the lungs of a person and can cause harmful diseases. Statistical analysis indicated a correlation between rising levels of particulate matter and a rise in the frequency of visits to doctor offices and hospitals for upper respiratory infections, heart conditions, bronchitis, asthma, pneumonia, skin conditions, emphysema, and lung problems [6]. Because of its action in neutralizing acidic aerosols, a full research of $CaCO_3$ might be advantageous [13].

The majority of air pollution is brought on by the improper combustion of fuels and other materials like trash. Many researchers have reported that gas stoves are a significant source of indoor air pollution in Western countries. Air pollution can either be particulate or gaseous in nature. Particulates can take the form of dust, haze, mist, smoke, fog and can be solid or liquid containing chemicals (pesticides) in powder form [14].

SPM in any scattered matter, solid or liquid, who's each particle is larger than a single molecule, exists in a gas or air stream (about 0.002 μm in diameter) but smaller than about 500 μm and are suspended in the atmosphere for long time. SPM has different physical (shape, size, density) and chemical characteristics. The particle size, shape, chemical composition and their levels in atmosphere play a crucial part in numerous microphysical processes such as in the crystal formation and also in the degree of air pollution.

Human activity-related particulate matter emissions come from a variety of sources fuel combustion, industrial processes, and non-industrial fugitive sources (such as wind, construction, and transportation sources like cars) [1]. Auxiliary aerosols, for the most part having a distance across >2.5 μm are delivered within the atmosphere from reaction including essential and auxiliary gasses [15].

The largest industrial city in Pakistan is Faisalabad, known as Manchester; textile-related industries are dispersed throughout the entire city, regardless of location. The primary source of air pollution in Faisalabad is this heavy industry. In addition, the city has eight intercity highways that enter and exit it, roads, there is a vast network of city streets in urban and suburban areas where traffic of all kinds flows throughout the majority of the day [2].

Particles of diameters ranging from a few nanometers (nm) to tens of micro meters (μm) are referred to as atmospheric aerosols. The diameter of coarse particles are 10 μm, and they are the small particles that are scattered in gases. Coarse particles are formed by mechanical interference (e.g. crushing, grinding, abrasion of surfaces) consists of man-made; evaporation of sprays; suspension of dust particles. Coarse particles are aerosols, smog, fog, mists, sea-salt, pollens and plant spores, soot, sand, coal dust, black carbon, cement dust and combustion particles [16].

A group of Pakistani and American experts investigated airborne particles gathered from Lahore, Karachi, and Rawalpindi, between January (2007 to 2008) in Peshawar [1, 3, 7]. Everything that is external to a human being is included in the term of environment in its broadest sense. Environmental contamination refers to the collection and concentration of wastes that are too vast and have unique chemical compositions to be sorted

by standard reuse techniques. Substances that are found in nature that exceed permissible limits and harm both the environment and living things are known as toxins [17].

There are many different natural and artificial sources that emit chemicals into the atmosphere [11]. Coarse fractions of Mg, Ca, Ni, Mn, Cu, and Zn are released during high temperature industrial processes. These metals, their compounds, other salts are also released by the automobile and fertilizer industries [12]. The urban population is frequently exposed to airborne contaminants that are dangerous and above background values. Along with posing health risks, heavy metal pollution also reduces visibility, contributes to acid rain, has a negative impact on the radioactive budget, and interferes with a number of environmental processes. Heavy metal pollution can alter the characteristics of clouds through nucleation, condensation, and environmental chemistry by serving as transporters for chemical species and mediums for heterogeneous reactions [16].

Aerosol particles in the atmosphere are solid or liquid particles suspended in the air. The method administers the creation, change and evacuation of atmospheric aerosols are of specific scheme in climatic science. Aerosol particles which are habitually less than 1.0 μm in distance across play an imperative role within the Earth's radiation budget by scrambling daylight and association with it [18].

Human actions, such as the utilization of fossil fuels, modify the properties of aerosols, which can impact on climate [11]. These can happen either specifically through an increment in aerosols or in a roundabout way through the way anthropogenic aerosols modify the arrangement of clouds. Moreover, heterogeneous interaction on the surfaces of aerosol particles change the gas stage composition and chemistry of the atmosphere. These particles are to fault for negative wellbeing impacts caused by inward breath.

To evaluate the impact of anthropogenic emissions on the environment and the function of pressurized canned goods one must to begin with comprehend the life cycle and transport designs of slid vaporized particles. As well as their compositional advancement and an intensive understanding of cloud arrangement and nucleation instruments, which are subordinate on the properties of pre-existing particles [12]. The importance of a solid aerosols depends on the impact on human health and the environment, as well as, their usefulness as they are physical, chemical, and biological the elements of the individual source of air pollution [19]. The preservation of the environment has been a persistent problem since the advent of civilization. Industry, agriculture, household, and activities of use in the environment, as well as physical, chemical, and biological changes, have all had a negative impact. In recent years, environmental pollution has been the topic of major difficulties on both a local and global basis [2].

The completely degradation of environment for all of living beings, humans, animals, and plants attention of the direction to the problem of air pollution caused by the large the risk that the humanity is facing today [19]. The study of the chemical characteristics of the solid products with the use of XRD has been undertaken by many researchers in the past years. The first is the analysis of individuals are minerals and chemical the associations that arise in the relationships which were carried out by the workers and the most important thing, the goal of these studies in order to identify the role of the solid aerosols in the formation of the atmospheric microphysical processes [11].

The objective of this work is to review the identified phases in SPM samples and heavy metals from different environments of various worldwide areas. Already analyzed data from different locations in the worldwide are presented in this research project. Every country is facing the problem of air pollution all over the world. The study of SPM research is active in other nations, but it is only in its early stages in Pakistan. Unfortunately, no thorough study of the SPM has been conducted as yet. A few researchers carried and performed an initial study all over the world. This study will provide the useful and effective to overcome this natural abuse from the atmosphere of different world locations.

Experimental

From literature review it was found, every researcher have used different sample collection technique. SPM samples were obtained using the AC filter from an air conditioner [1, 2, 4], low volume air sampler [20-22], high volume air sampler [23], under carpet dust [20], glass fibre filters [22, 24] and from vacuum cleaner [7, 20]. The experimental technique was used for identification of phases and heavy metals in SPM samples were carried out by XRD and AAS. For qualitative analysis of the samples JCPDS cards/ Hanawalt method was used.

Qualitative Phase Analysis/Hanawalt Method

Hanawalt method was used for qualitative phase analysis of the materials. In this method at least three d-values obtained from XRD pattern of the unknown sample are matched with the JCPDS cards. This search processes continuous until all the peaks are identified. The strangest line of the unknown pattern is

found in the numerical component of the powder diffraction file index book. A match for the pattern second strangest line can be found by reading down the second column. The entries with the strongest line that also coincide with the pattern within the experimental error are found. All relative intensities are compared with the values on the identifying card to ensure identification. The appearance of these lines in the index book, on the other hand, implies that the assumption that the three strangest lines are diffracted from the same material is erroneous. The data is then matched with JCPDS card data to identify the chemical after three further lines are selected and inspected from the index book. This strategy is revised until all of the tests have been perceived.

Be that as it may, the nearness of these lines within the list book shows that the suspicions that the three most grounded lines are diffracted from the same fabric is off base. Then, three more lines are picked and examined from the index book, and the data is matched with JCPDS card data to identify the substance. This technique is repeated until all of the samples have been recognized.

Hanawalt method was used to carry out the qualitative phase evaluations on each SPM sample. Phases were determined by comparing observed and calculated d-values (supplied by ICDD in the form of JCPDS cards). The identified phases were quartz, illite, albite, calcite, clinochlore, halite, talc, kaolinite, dolomite and gypsum etc. The literature review showed quartz, albite, illite, calcite, halite, clinochlore (chlorite), gypsum and talc were found in all SPM samples but talc, halite were not observed in all SPM samples.

Quantitative Phase Analysis/X-ray Diffraction

Each crystallized substance has a distinct XRD pattern that is a property of that substance. Qualitative phase analysis is the study of the unknown phases/minerals of the material. The scattering angle ($2\theta^{\circ}$) and integrated intensities of the diffraction peaks are two characteristics in the XRD pattern. Bragg's equation can be used to calculate the d-values associated with the scattering angle ($2\theta^{\circ}$). The d-values and integrated intensities are used for qualitative phase analysis, which is accomplished using the well-known Hanawalt method. All samples diffraction patterns as well as the diffractometer output were obtained. Hanawalt methodology was used to compare the computed "d-values" from JCPDS (Joint Committee Powder and Diffraction Standards) cards with the observed "d-values" (from XRD data) to identify the mineral phases.

Atomic Absorption Spectroscopy (AAS)

The technique known as atomic absorption spectroscopy (AAS) is used to identify trace metals and metallic elements in a variety of samples [1, 3]. It employs electromagnetic wavelengths, which are emitted by a light source and are absorbed differently by different elements.

Optical Microscopy (OM)

According to literature other many experimental techniques were used in obtains the particle size by using high magnification Optical Microscopy (OM). The size distribution of aerosol particulates has been investigated in relation to air pollution using a scanning electron microscope (SEM) and samples were analyzed using SEM, elemental analysis (an analytical facility) utilizing an Energy Dispersive System (EDS) and electron probe microanalysis (EPMA) [2]. SEM displays the surface and form of even big particles. A stream of high-energy electrons is passed through a solid material to image its interior structure using a process known as transmission electron microscopy (TEM). This configuration is comparable to the simple transmission-illuminated optical microscope (also known as a biological microscope).

Results and Discussion

In this section, the data of the identified phases and metals from various atmospheric settings of world locations are discussed in Table-1 and Table-2. The microphysical process in the atmosphere and its fine particles stay long in the air, the spread of illness like bronchitis is probably due to this pollutant, as its tiny particles enter the lungs deeply and are unable to leave [4, 12]. The silicates are formed as a result of inhaling silica particles, silicates or other mineral fibres [9]. The workers of foundries were exposed not only to quartz particles but also to ceramic fibres, asbestos, metallic, non-fibrous particles and their lungs were affected and they suffered from tuberculosis [13]. In the atmosphere of Faisalabad, quartz is the major phase present and may cause these dangerous diseases like Bronchitis, Tuberculosis, Skin disease, Asthma and Black lung diseases in the city. According to medical and health encyclopaedia, black lung disease and silicosis from inhaling coal and other dusts asbestos fibres have been more lung cancer then the general population and risk several other lung diseases among them silicosis. The air pollutants enter the human body mainly via the respiratory track and cause illnesses like asthma, bronchitis and even lung cancer [21].

Table-1: Identified Phases in several SPM sample environments.

Research Location	Sample Collection Methodology	Experimental Technique	Identified Phases in SPM Samples	Accomplish Task	Reference
Tokyo (Japan)	Air cleaner filters	XRD	Quartz, Gypsum, Halite, Calcite, Albite, Hematite, Magnetite, Chlorite	Heavy liquid separation and X-ray diffraction analysis of airborne particulates	[11]
Denver (USA)	Low-volume and dichotomous filter	XRD	Quartz, Clays, Feldspar Muscovite	X-ray diffraction analysis and source apportionment of Denver aerosols	[21]
Sahara desert (West Africa)	High volume air sampler	XRD	Calcite Quartz, Illite, Dolomite Gypsum, Chlorite, Kaolinite	Mineral aerosols and source identification	[39]
Tsukuba (Japan)	High volume air sampler	XRPD	Calcium sulphate, Calcium carbonate	Quantitative determination by X-ray diffractometry of calcium sulphate and calcium carbonate in airborne dusts	[24]
Nigeria (Africa)	High volume air sampler	XRD	Quartz, Kaolinite, Illite, Muscovite	Physical, mineralogical and chemical properties of Harmattan dust at Nigeria	[12]
Elazig (Turkey)	High volume air sampler	XRD	Quartz, Albite, Calcite, Muscovite, Dolomite	A study on the characterization of dust fall	[15]
Lahore (Pakistan)	AC Filters	XRD	Quartz, Albite, Calcite, Talc, Illite	A study of suspended particulate matter in Lahore	[4]
Salton Sea Core (USA)	Glass fibre filter (Whatman GF/C)	XRD	Orthoclase, Quartz, Albite, Illite, Chlorite, Calcite, Magnitite	X-ray reference intensity and X-ray fluorescence analyses of Salton sea core	[23]
Matsue (Japan)	High volume air sampler	XRD	Gypsum, Glauberite, Ferri-copiapite, Metavoltine	Seasonal variation of gypsum in aerosol and its effect on the acidity of wet precipitation on the Japan Sea side of Japan.	[18]
Spain (Europe)	Cascade impactor sampling	XRD	Quartz, Calcite, Gypsum	Quantitative X-ray diffraction phase analysis of coarse air borne particulate collected by cascade impactor sampling	[13]
China (Asia)	Low volume pump	XRD	Quartz, Illite, Dolomite, Chlorite, Calcite	Air borne particulate study in five cities of China	[22]
Castellon de la Plana (Eastern part of Spain)	High volume sampler	XRD	Quartz, Calcite, Dolomite, Kaolinite, Illite, Gypsum	X-ray diffraction analysis of atmospheric dust using low background supports	[27]
Castellon (Industrial site) Spain	Millipore AAWPO-4700 Filters	XRPD	Illite, Quartz, Kaolinite, Dolomite, Calcite	A powder diffraction quantification method (ALJOR) for atmospheric particulate matter	[37]
Eastern Spain (Spain)	Air sampler	XRD	Sulphate, Nitrate, Mineral dust	Monitoring of atmospheric particulate matter around sources of secondary inorganic aerosol	[28]
Western Macedonia (Greece)	Stationary and Portable Collector	XRD	Quartz, Calcite, Feldspar, Zircon, Mica, Clays	ESEM–EDX characterization of airborne particles from an industrialized area of Northern Greece	[29]
Desert regions of Northern China (China)	Air sampler	XRD	Illite, Chlorite, Kaolinite, Quartz, Feldspar, Calcite, Dolomite. Gypsum, Hornblende, Halite	Mineralogical characteristics of soil dust from source regions in northern China	[26]

Pune (India)	**Mini-Vol TAS air sampler**	**XRD**	**Quartz, Kaolinite, Magnetite, Wuestite, Gypsum, Dolomite, Aenigmatite, Halite**	**Characterization of $PM_{2.5}$ by X-ray diffraction and scanning electron microscopy–energy dispersive spectrometer: its relation with different pollution sources**	**[30]**
Faisalabad (Pakistan)	**AC Filters**	**XRPD**	**Albite, Calcite, Clinochlore, Halite, Illite, Gypsum, Quartz, Talc**	**Identification and investigation of halite in suspended particulate matter by X-ray diffraction and scanning electron microscope-energy dispersive system (SEM-EDS) in the environment of an industrial city Faisalabad (Pakistan)**	**[2]**
Kathmandu Valley (Nepal)	**Sterile Polystyrene Petri Dish**	**XRD**	**Dolomite, Montmorrilonite, Calcite, Quartz, Kaolinite, Illite, Hematite, Vaterite, Chrysotile**	**Characterization of airborne dust samples collected from core areas of Kathmandu Valley**	**[36]**

Table-2: Identified heavy metals in SPM sample.

Research Location	Sample Collection Methodology	Experimental Technique	Identified Metals	Accomplish Task	Reference
La Plata city (Argentina)	**High volume sampler**	**XRD**	**Pb, Zn, Cd, Cu, Mn, Cr, Ni, Ca, Mg**	**Sources, distribution and variability of airborne trace metals in La Plata city area, Argentina**	**[35]**
Raipur (India)	**High volume sampler**	**XRD**	**Fe, Ca, Na, K, S, P**	**Seasonal evaluation and spatial variability of suspended particulate matter in the vicinity of a large coal fired power station in India**	**[31]**
Sagamu (Nigeria)	**Air dust sampler**	**AAS**	**As, Al, Ca, Cd, Pb, Co, Zn, Fe, Cr**	**Analysis of potentially toxic metals in airborne cement dust around Sagamu, Southwestern Nigeria**	**[32]**
Faisalabad & Layyah (Pakistan)	**High volume air sampler**	**XRD**	**Mn, Zn, Pb, Cu, Ni**	**Qualitative analysis of the SPM in the environment of an industrial and a non industrial city of Pakistan**	**[33]**
Kuala Terengganu (Malaysia)	**High volume air sampler**	**XRD**	**Pb, Cd, Zn, Al, Fe, Mn, Cr**	**Determination of trace metals in airborne particulate matter of Kuala Terengganu, Malaysia**	**[34]**
Lahore (Pakistan)	**AC filter & High volume air sampler**	**AAS**	**Cu, Cd, Zn, Pb, Ni**	**The study of concentration of Lahore (Pakistan) puspended particulates and their trace elemental loadings**	**[7]**
Faisalabad (Pakistan)	**High volume air sampler**	**AAS**	**Zn, Cu, Cr, Ni, Pb, Cd**	**Elemental analysis of solid aerosols using AAS technique and estimation of their effect on atmospheric radiation budget**	**[1]**

Albite, calcite among quartz behaves as pollutants if they are suspended in air [11]. Other recognised minerals, such as albite, calcite, and illite, may also contribute the pollution of Faisalabad atmosphere. Another bothersome effect of air pollution is decreased visibility caused by the scattering and absorption of sunlight by airborne pollutants [25]. This effect can be observed in the heavy industrial areas of Faisalabad and is one of the well known side effect of industrial growth. The major phases (quartz, albite, illite, and calcite) identified for Lahore city were soil oriented [4] while minor phases (gypsum and talc) were not present in the soil samples. The majority of detected chemicals are derived via soil dispersion like quartz, albite, clinochlore, calcite and illite. Species composition of soil dust from northern Chinese city Chengdu source regions are clay minerals enhanced the mineralogical composition of dust collected in the deposition area [26].

In Eastern part of Spain analysis of atmospheric dust by X-ray diffraction utilizing light background supports found the quartz, calcite, dolomite, kaolinite, illite, gypsum [27]. In the presence of H_2SO_4, the reaction between calcite and induced acid rain solution produced gypsum in 12 hours, implying calcite can be transformed to gypsum [18]. The photochemical formation of gypsum and talc in the atmosphere is not conceivable since the circumstances for their growth in the atmosphere do not exists. As a result, the occurrence of talc and gypsum may be traced sources other than Faisalabad. The ratio of heavy metals such as Pb, Mn, Ni and Co is considerable and the maximum concentration of lead was found [15]. In Eastern Spain monitoring the Sulphate, Nitrate & Mineral dust airborne particles around sources of secondary organic air pollution [28].

Perhaps gypsum come from the field because farmers use it as a fertilizer and talc comes from the talcum powder industries. Halite phase is also non-soil oriented compound and is transported to Faisalabad atmosphere through heavy winds from the other parts where its sources occur. Calcite had the tendency to neutralize the acidity, its presence in the atmosphere of Faisalabad in different environment may rule out any chance of acid rain in the city. The airborne particles from a northern Greece industrial region found the Quartz, calcite, feldspar, zircon, mica & clays by using ESEM-EDX [29].

The quartz, gypsum, plagioclase, bassinette, calcite and halite in the dust samples collected in Japan [24]. Nigerian dust samples were analyzed and phases such as quartz, halleysite/kaolinite, illite, muscovite, microline were identified [12]. In Turkish dust samples contain albite, dolomite, quartz, albite, muscovite, and sulfide were found [15]. Halite is only one phase detected in some of the SPM samples of Pune (India) and Faisalabad (Pakistan) [2, 30]. Quantitative studies [4] showed the quartz, illite, albite and clinochlore were the major phases while talc and gypsum were minor phases. The comparison demonstrates that the findings are in agreement, and the current study is consistent with the findings of earlier investigations. Seasonal assessment and geographic variation of suspended particle matter near a significant coal-fired power plant in Raipur India found the metals like Fe, Ca, Na, K, S, & P [31]. By using High volume air sampler XRD technique was carried out to analysis of possibly harmful elements in the airborne cement dust in the vicinity of Sagamu, Southwest Nigeria [32].

The five heavy metals [33] were found in the atmosphere of Faisalabad and Layyah city as described in Table 2. These components are competent of limiting deceivability due to a diminish in sun oriented radiation, improving or diminishing atmospheric recuperating on the off chance that they absorb radiation and cooling the soil on the off chance that solid aerosols diffuse light into space. It means there was a file for the chemical phase not only caused the disappearance of the subgroups but also affected them the values of the major categories. The emerging categories were quartz, calcite and illite while the missing categories were albite, clinoclore, gypsum and talc. XRD analysis of airborne particulate matter used high volume air sampler to find out trace metals Pb, Cd, Zn, Al, Fe, Mn, & Cr in Kuala Terengganu (Malaysia) [34] similarly the airborne trace metal sources, distribution, and fluctuation in the La Plata metropolitan area, Argentina was studied [35].

With a focus on the four dominant phases of calcite, quartz, albite, and mica, the ANOVA technique was used to analyze the data for each mineral in the samples that were gathered from residential, commercial, and industrial locations, the results are shown in Table-3. The p-values of 0.495, 0.744, 0.273, and 0.249 indicate that there is no significant difference between the minerals calcite, quartz, albite, and illite for any of the three areas [5].

Atomic absorption spectroscopy (AAS) was used to detect the metal components and concentrations of six metals in the atmosphere of Faisalabad due to its selectivity, sensitivity, repeatability and large dynamic concentration range. The aerosol samples were obtained from June (2011 to 2012) using an air volume sampler using watmann filter paper, and the maximum elemental constituent for Zn, Cu, Cr, Ni, Pb, and Cd was determined [7].

Table-3: Analysis of variance for the mineral phases identified in the air samples that were taken in commercial, industrial, and residential settings [5].

Pollutants	DF.	MS	MSE	P-Values
Illite	2	12.6	14	0.495
Quartz	2	0.45	1.37	0.744
Albite	2	1.635	0.791	0.273
Calcite	2	10.07	4.4	0.249

The air quality of Lahore, a densely populated city in Punjab, was measured by collecting various sorts of samples. The research was conducted on samples gathered between December 2001 and January 2002. Indoor suspended particles were collected using AC filters, as well as dust from room carpets [1-3]. Properties of airborne dust samples studied by XRD obtained from Kathmandu Valley's central locations [36]. Using powder diffraction technique to quantify airborne particle matter i.e., illite, quartz, kaolinite, dolomite, calcite were determined [37].

Minerals such as quartz, illite, cholrite, calcite, albite and others were discovered using the powder technique in all samples including SPM, free-fall dust, indoor suspended particle samples, and carpet dust [3]. The atomic absorption spectroscopy (AAS) was used to determine the element loadings of all samples. Cu, Ni, Cd, Zn, and Pb were all found in the samples [1]. The major identified phases and heavy metals in the samples by the different techniques are described in Tables 1 and 2, discussed in this review article, gave a detailed review on SPM and heavy metals in world locations of different countries.

In literature O, C, Al, Si, Mg, Na, K, Ca, Fe, N, Mo, B, S, and Cl were among the elements found in PM_1, while O, C, Si, B, Ca, Al, N, Fe, Mg, S, Na, K, and Mo were found in $PM_{2.5}$ and C, O, Si, Na, Cl, Al, K, Fe, Ca, and Mg were discovered in PM_{10}. The powder pattern was created and classed based on the three most intense lines in the pattern [38-40]. According to the most intense d-spacing values, phases are classified into one of forty Hanawalt categories. Within a group, phases are presented in descending order from the most intense line to the least intense line. Normally, this categorization approach will restrict phase candidates to a few compounds that may be tested for the presence of the third and fourth, less intense lines [41-44].

Due to a combination of factors including mining, industrialization, transportation growth, building and road construction, the bulk concentration of particulate matter in different locations, there had been a rise in the mass concentration of particle matter throughout the earth [45]. Principal component factor analysis (PCA) was used to identify source categories for aerosol constituents [46]. Harrison and Pio *et al*. used the methodology and SYSTAT statistical software carried out by keeping the primary components whose eigen-values were greater than unity and applying the orthogonal transformation method with varimax rotation [19, 47].

Conclusion

After literature review, we found the most of the experimental work especially indoor study on SPM has done world-wide especially in Pakistan. According to the review of different research papers found various kinds of SPM phases like Albite, calcite, chlinochlore, halite, illite, gypsum, quartz, kolinate and talc detected by different cities of Punjab (Pakistan), similarly in different portions of Asia like India, China, Malaysia, and Japan. The Sulphate ion, ammonium ion, Ba, Cr, Cu, Mn, Mo, Ni, Sr, Ti, Zn, quartz, feldspar, clays, calcium sulphate, carbonate have been detected which can cause a sever issue of health. Pollution is caused not only by the hazardous phases in aerosols and SPM but also due to the concentration of heavy metals in soil and air which can cause serious destruction. The numbers of heavy metals in Pakistan (Lahore and Faisalabad) and in Asia (India, China, Malaysia, Japan) have been detected like Cr, Ni, Ca, Pb, Zn, Cd, Cu and Mg. Moreover, similar kind of metals also have been detected out of Asia, Greece, Spain, Argentina and many more. Number of similar and different kinds of phases has been detected like feldspar, zircon, mica, clay, quartz, calcite, dolomite, kaolinite, gypsum, sulphate, nitrate and mineral dust in Greece, Barcelon and Argentina. Pollution can be managed and the amount of identified phases and heavy metals can be minimized by limiting the usage of heavy industries, heavy chemicals, physical and biological changes, and human activities. The current study reviewed the levels of heavy metals and inorganic compounds in the atmospheres of several nations. The principal stages nearly every country has quartz, calcite, and gypsum; these materials were used to study SPM phases and heavy metals including Pb, Fe, Cd, Ni, Cu, and Zn that were obtained experimentally using various methods.

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