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Impacts of Harmful Emissions Nearby Chemical based Industries in Gujarat on Environment with Major Focus on Human Health and Methods to Scale down its Impacts- A Review

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***Abstract*: Harmful chemicals in and around chemical industries causes cancer, reproductive damage, breathing problems such as asthma and emphysema, and birth defects, as well as other health problems such as headache, nausea, dizziness, and stress. Chemical industries are also a major source of the gases that causes global warming.Air pollution and climate change are two closely connected environmental concerns. The major source of global climate change is human-lured changes in atmospheric composition. India is making swift progress in terms of economic development but it has also caused change in air quality to reach a global scale. Particulate matter, Ozone, Eutrophication from high emissions of $NO_x$and NH_3, CO, CFC, CO_2, Pb are the major air pollutants those are released from chemical based industries in Gujarat. The deposition of nitrogen compounds leads to the chemical disruption of a long list of ecosystems on land and in the sea, and results in the impoverishment of biodiversity. In this paper, we have discussed various problems caused to human health due to these emissions and their adverse effects on quality of air. We have also suggested some methods those may be employed to reduce the emission of these pollutants into the atmosphere.**

Keywords*: *Chemicals, Emissions, Industries, Air pollution

I. INTRODUCTION

India is a preponderantly agriculture rich country. The well-being of Indian economy is directly connected with the welfare of her masses dwelling in the rural areas. With the scientific, methodical, systematic, analytical and industrial advancement, we had to go for a vivacious industrial approach.It is not only the industrialization which produces adverse effect on the moral and spiritual life of people, but the greed, insatiability and selfishness behind the industrialization are the major culprits [1]. Chemicals are the elementary units that creates all living and non-living organisms on earth. Many chemicals exist naturally in the surroundings, and may constitute major part of our air, water, food, and homes. Some of these chemicals are artificial, and are used in conventional products from medicines to computers to fabrics and fuels. Other chemicals are not produced intentionally but are after-effects of chemical processes. Many chemicals are used to ameliorate the quality of our lives and most are not hazardous to the surroundings or human health. However, some chemicals have the promising history to cause damage, in certain amounts, and should only be used when the potential exposures are suitably managed. Some chemicals are of major concern as they can find their way into the food chain and eventually into the food web, spoiling the food cycle by accumulating and/or persisting in the environment for many years [2]. Air pollutants and other harmful toxic chemicals are poured in the atmosphere from different sources that may be man-made or natural and have the capability to change the structure of air and affect the environment to huge extent. The concentrations of both depend on the ability of the atmosphere to either absorb or disperse these emissions and also on the quantities that are emitted from air pollution sources [3]. There are various sources of these emissions which include vehicles, industries, domestic and natural sources [4]. Out of all these sources, industries are the major cause of concern. As per the recent data, there are about 10,711,841 tons of toxic chemicals released by industries this year. 310 kg (approximately 10 million tons or over 21 billion pounds) of toxic chemicals are released into our air, land, and water each and every second by industrial facilities around the world. Of these, over 2 million tons (over 4.5 billion pounds) per year are acknowledged as carcinogens as given by the Occupational Safety & Health Administration (OSHA) [5]. This amounts to about 65 kg each and every second [6]. The existence of air pollutants and toxic chemicals in the ambient air skeptically affects the health of the population. The Air (Prevention and Control of Pollution) Act was enacted in 1981 in order to prevent and control air pollution. The responsibility has been further articulated under Environment (Protection) Act, 1986. Despite of these Acts there is continuous pollution of environment and hence it is necessary to determine the present and expected air pollution through air quality survey/monitoring programs [7].

II. METHODOLOGY

A. Study Area

The study area is Gujarat which is based between 22.2587˚N & 71.1924˚E in India. Sometimes referred to as the "Jewel of Western India", it is a state in Western India [8].It has an area of 1,96,024 km^2 (75,685 Sq. m.) with a coastline of 1,600 km (990 m.) and a population in excess of 60 million. It is approximately 53 metres (174 ft.) above the sea level. Its capital city is Gandhinagar, while its largest city is Ahmedabad. Major industrial cities (study areas) of Gujarat shown in Fig. 1. include Bharuch (21.7051°N, 72.9959°E), Ankleshwar (21.6264°N, 73.0152°E), Vapi (20.3893°N, 72.9106°E), Panoli (21.5311°N, 72.9638°E), Vadodra (22.3072°N, 73.1812°E), Kandla (23.0081°N, 70.1873°E), Ahmedabad (23.0225°N, 72.5714°E), Rajkot (22.3039°N, 70.8022°E), Valsad (20.4925°N, 73.1350°E), Bhavnagar (21.7645°N, 72.1519°E) and Junagadh (21.5222°N, 70.4579°E.

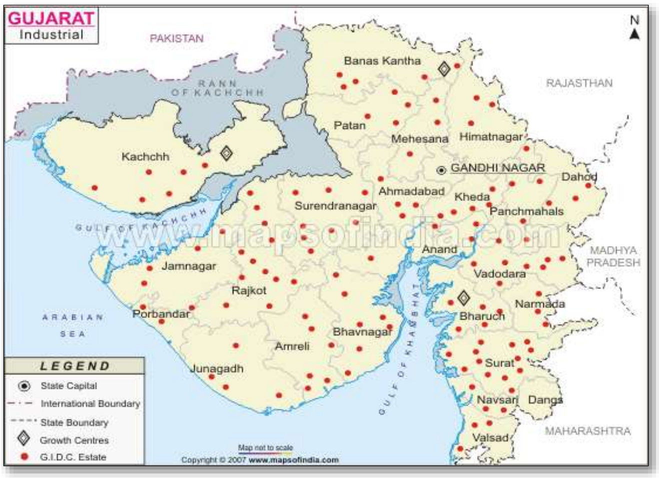

Fig. 1. Gujarat Industrial Development Corporation Estate of Gujarat (Source: http://www.mapsofindia.com/maps/gujarat/gujaratindustry.htm)

Table 1. Top 10 Polluted Places of India (2011)
(Source: https://gsuryalss.wordpress.com/2011/03/21/top-20-polluted-cities-in-india/)

Places	Pollution Score
Ankleshwar (Gujarat)	88.50/100
Vapi (Gujarat)	88.09/100
Ghaziabad (Uttar Pradesh)	87.37/100
Chandrapur (Maharashtra)	83.88/100
Korba (Chhattisgarh)	83.00/100
Bhiwadi (Rajasthan)	82.91/100
Angul Talcher (Orissa)	82.09/100
Vellore (Tamilnadu)	81.79/100
Singrauli (Uttar Pradesh)	81.73/100
Ludhiana (Punjab)	81.66/100

B. Climatic Condition

The climate of Gujarat involves assorted conditions. The winters are gentle, affable, and arid with average daytime temperatures around 29°C (84°F) and nights around 12°C (54°F) with 100% sunny days and clear nights. The summers are intensely hot and dry with daytime temperatures around 49°C (120°F) and at night not lower than 30°C (86°F). The sun is often impeded during the monsoon season. Though generally dry, it is desertic in the north-west, and wet in the southern districts due to a heavy monsoon season.

C. Why Gujarat?

The Central Pollution Control Board (CPCB) in affiliation with IIT-Delhi recently surveyed 88 industrial clusters around the country, and found 43 “critically polluted” (score above 70 on a 100 point scale) while 32 were "severely polluted" (score 60-70).Out of the top 20 “critically polluted” industrial clusters, 2 are from Gujarat which is a house of almost 10,000 major industries as shown in Table 1. Ankleshwar situated in the Bharuch district of Gujarat tops the list of the 'critically polluted places' with a score of 88.5. Ankleshwar is well-known for its industrial township which is one of the largest in Asia. Ankleshwar also has an office of the ONGC (Oil and Natural Gas Corporation Limited). Today, Ankleshwar has over 5000 big and small chemical plants. These chemical plants manufacture products such as pesticides, pharmaceuticals, paint and speciality chemicals. Situated in the Valsad district of Gujarat, for Vapi, the consequences of growth have become grave: levels of mercury in the groundwater are reported 96 times higher than WHO safety levels (WHO Factsheet, September, 2016), and heavy metals are present in the air. The industrial township of Vapi has an important place on the "industrial" map and it is the largest industrial area in Asia in terms of small-scale industries, dominated by chemical industry plants, along with their disastrous hazards. Vapi has also gained a position in the top 10 most polluted places in the world by the US-based Blacksmith Institute.

Almost all giant chemical and allied companies have their manufacturing units as well as offices. The companies are into many sectors including petrochemicals, oil & surfactants, metallurgy, polymers and so on. About 2% of the world’s industrial development is contributed by the companies in Gujarat Industrial Development Corporation (GIDC) [9]. Some of the major companies those have their existence in GIDC are listed in Table 2.

Table 2. Top Companies in GIDC (2016)
(Source: http://gidc.gujarat.gov.in/major_indian_co_in_GIDC.htm)

Sr. No.	Company Name	Place	Major Sector
1.	Reliance	Jamnagar	Petrochemicals
2.	Essar	Vadinar	Petrochemicals
3.	Solvay	Panoli	Speciality Polymers
4.	GSFC	Jamnagar	Fertilizers
5.	BASF	Ankleshwar, Dahej	Performance Chemicals, Catalysts, Plastics
6.	DuPont	Savli	Polymers
7.	GHCL	Sutrapada	Chemicals
8.	Pidilite	Vapi	Adhesive, Chemicals
9.	Asian Paints	Ankleshwar, Sarigam	Paints
10.	ONGC	Vadodra, Ankleshwar, Hazira	Oil Exploration

D. Various Industries Considered

Gujarat has accelerated its overall economic development during last 44 years and has witnessed structural change in economic development. The share of Primary, Secondary and Tertiary sectors has been at 19.3%, 39.2% and 41.5% respectively of the total Gross State Domestic Product (GSDP) which was at Rs. 83537 crore in 2001-02 at constant (1993-94) prices.Various Industries that contribute their part in the economic development of Gujarat are considered. They are as follows:

1. Pharmaceutical Industry (4.23%)
2. Textile Industry (5.78%)
3. Oil & Surfactants Industry (3.45%)
4. Agrochemical Industry (2.75%)
5. Metallurgical Industry (5.32%)
6. Dyeing Industry (5.25%)
7. Fine Chemicals (complex, single, pure chemical substances) Industry (7.28%)

The industrial sector has alleged impressive development in small, medium & large factory sectors. The number of Small Scale Industrial units (SSIs) increased from 2169 to 15,849 in 1970; 43,712 in 1980; 1,15,384 in 1990; crossed a cipher of 2,50,000 to become 2,51,088 in 2000 and 2,78,656 in march 2003.Ahmedabad tops the list with 61,185 units and is followed by Surat with 41,509 units (14.90%) and Rajkot with 30,077 units (10.80%). Textiles, Machinery and Parts, and Metal Products have observed influential development. Textile sector with 60,168 units has secured top position among SSI units followed by Machinery and parts (22,931), Metal products (22,218), Rubber and Plastic products (11,025), Non Metallic Mineral products (10,831), Basic Metal industries (8007), Paper and Printing (7789) and Electrical Machinery and Apparatus (6023). The other substantial sectors having contribution in Gujarat's economy include Electrical Tele & Electronic (19.73%), Glass Ceramic & Cement (7.01%) Infrastructure project (6.54%), Textile (5.78%), Metallurgical industry (5.32%), Food processing (4.19%) and other (28.02%) [10]. Different types of industries present in GIDC along with the total number of units are given in Table 3. Talking about large scale industries, there were about 3911 registered industries in 1960 employing 3.46 lakh workers but the number of industries increased to 27,089 employing 7.78 lakh workers in 2001. The districts having more than 1000 industries are listed in Table 3. Among industry sectors, Petroleum, Petrochemicals and Plastic products account for 41.62% share in total industrial output in the state. This is followed by Chemicals & Chemical Products with 10.98%, Food Products with 9.94%, Machinery with Electricals with 6.65%, Synthetic and Fibre Textile with 6.49%. Basic Metal industries with 6.17%, Cotton Textile with 6.08%, Non-Metallic Mineral product with 3.07%, Paper product and Printing with 2.17%, Transport Equipment and parts with 1.76% and others. All these groups put together an account of 95% of total industrial outputs in the state [11].

Table 3. Different types of industries in Gujarat (2014)
(Source: https://gidc.gujarat.gov.in/index.html)

District	Types of industries	Total number of industries		
		SSI*	MSI**	LSI***
Ahmedabad	Machinery & Parts, Metal Products, Wollen Textile	61,185	69,014	4916
Surat	Textile, Diamond	41,509	1,16,183	19,116
Rajkot	Foundry & Forging, Ceramics, Chemicals,	30,077	20,431	1784
Valsad	Basic Metal industries,	17,077	4589	1291
Vadodra	Cotton Textiles, Fertilizers	15,873	12,312	2062
Mehsana	Rubber & Plastic products	14,843	2049	1391
Kheda	Electrical Machinery & Apparatus	13,586	1053	<1000
Bharuch	Cotton Textiles	12,766	5431	1510
Jamnagar	Petroleum products, Fertilizers	11,846	4966	<800
Bhavnagar	Rubber, Ceramics	11,196	4389	<400

*Small Scale Industries
**Medium Scale Industries
***Large Scale Industries

E. Parameters/Toxic Chemicals Considered

The air that we breathe in is crucial for leading a healthy life but air pollution is harmful for our well-being. Air pollution which is a mixture of solid particles and gases in the air is a major problem that has been recognized throughout the world for the past century. In the Medieval Age, the combustion of coal released proliferating amounts of smoke and sulphur dioxide into the atmosphere [12]. The major pollutants found in the air consists of Particulate Matter ($PM_{2.5}$& PM_{10}), Polycyclic Aromatic Hydrocarbons (PAHs), ground-level ozone, lead, heavy metals, benzene, carbon monoxide, sulphur dioxide, and nitrogen dioxide [13]. According to recent survey, rapid growth in urban population, increasing industrialization, poor environmental regulations, less efficient technology of production were found to be the major factors for the worsening air pollution levels [14]. Both man-made and natural sources are equally responsible for the worsening scenario of this devil. Man-made sources include major industrial development of various sectors such as pesticides industry, petrochemical industry, textile industry and so on. Natural sources include forest fires, volcanic eruptions, wind erosion, pollen dispersal evaporation of organic compounds, natural radioactivity, and so on [13]. We have considered various toxic metals and parameters for the review work as shown in table 5 & 6.

III. RESULT AND DISCUSSION

Air Pollution is the exoneration of unwanted materials and energy into the environment. Pollution is a sign of incompetence in industrial manufacturing and it can be considered as ejaculation of money from the chimney, thus causing huge loss to the producers. Major sources of air pollution in any industry are boiler, thermo pack and diesel generator which generate almost all types of pollutants those are listed in table 5 & 6. Air emissions also include dust, acid vapors, oil mists and odours [15]. Pharmaceutical industry emits more amount of iron into the atmosphere followed by copper and zinc [17-19]; they are also the major sources of $PM_{2.5}$ and PM_{10} emissions [20, 21]. Textile mills usually are the major sources of nitrogen and sulphur oxides from boiler [16, 22-24]. Fine chemicals industry also pour huge amount of toxic metals and harmful pollutants into the environment. High amounts of iron and copper are sent to the environment by this industry [34]. Dyeing industry is responsible for high amounts of lead emissions as well as PM_{10} and $PM_{2.5}$ emissions [32, 33]. Oil & Surfactants industry, Metallurgical industry and Agrochemical industry are also responsible for release of toxic metals such as lead, nickel, copper and zinc and also lead to release of Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2). It has been observed and proved that the emissions by these industries is adversely affecting the air quality and human health. It can be clearly observed from table 4 that the level of emission is much higher than the maximum tolerable limit standards stipulated by CPCB [7]. These higher levels of toxicity in the atmosphere cause many health affects in human beings. Copper causes anemia, liver & kidney damage and many more diseases. Nickel causes heart disorder and lung embolism and much more. Lead is responsible for almost all the diseases that one can recall, from mental retardation to neural deafness and even also to death. Iron and Zinc also cause cancer and nervous membrane damage respectively. SO_2 and NO_2 are responsible for Nose & Throat irritation, respiratory illness, eyes irritation, etc. $PM_{2.5}$& PM_{10} are responsible for chronic pulmonary diseases and cardiovascular illness in human beings. Table 7 lists all the major sources of toxic metals and their impacts on human health. This condition has arisen due to the severe neglect of standard methods of controlling industrial air quality. All the major industries in GIDC are contributing their hand in reducing the air pollution in and around their vicinity. At least 10 lakh Nilgiri tree saplings were planted on 300 acres of land in Panoli to improve the quality of its soil, water and the general environment. The plantation drive was launched by Harikrishna group a few months ago. At present, some 1.70 lakh tree saplings have been planted in 300 acres of land located on the west side of Panoli GIDC. The drive will continue till Diwali of next year. Reliance, Essar and Sanghi groups are growing mangoes in Jamnagar district of Gujarat. Reliance has also developed one of the world's largest green belt in its Jamnagar refinery.

A. *National Ambient Air Quality Standards*

Table 4. Concentration in Ambient Air for Industries (1931)
(Source: http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php)

Sr. No.	Pollutant (µg/m³)	Time Weighted Average	Concentration in Ambient Air for Industrial Area
(1)	(2)	(3)	(4)
1.	Sulphur Dioxide (SO_2)	Annual* 24 hours**	50 80
2.	Nitrogen Dioxide (NO_2)	Annual* 24 hours**	40 80
3.	Particulate Matter (size less than 10µm) or PM_{10}	Annual* 24 hours**	60 100
4.	Particulate Matter (size less than 2.5µm) or $PM_{2.5}$	Annual* 24 hours**	40 60
6.	Lead (Pb)	Annual* 24 hours**	0.50 1.0
7.	Ammonia (NH_3)	Annual* 24 hours**	100 400
8.	Benzene (C_6H_6)	Annual*	05
9.	Arsenic (As)	Annual*	06
10.	Nickel (Ni)	Annual*	20

*Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.
**24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time, they may exceed the limits but not on two consecutive days of monitoring

B. Emissions from Chemical based industries

Table 5. Toxic Metals Release from Various Chemical based industries

Toxic Metals (mg/l or ppm) Industries	Cu	Ni	Pb	Fe	Zn	References
Pharmaceuticals	4.36	0.34	0.36	7.68	1.45	Ramola & Singh [17], James et al. [18], Idris et al. [19], Sankpal & Naikwade [20], Singare et al. [21]
Textile	22.13	1.10	1.15	27.98	4.95	Weldemariam [22], Ghaly et al. [23], R. Kant [24], Tiwari et al. [16]
Oil & Surfactants	6.45	0.90	1.26	9.11	1.79	T. Zhu et al. [25], Silva et al. [26], Rebello et al. [27]
Agrochemicals	14.33	0.70	0.90	31.74	3.69	Dumalas et al. [28], Aktar et al. [29]
Metallurgical	14.17	0.72	1.59	14.40	4.85	Cirțină et al. [30], Durube et al. [31]
Dyeing	22.53	0.82	13.14	37.70	9.39	Jaganathan [32], Chequer et al. [33]
Fine Chemicals	18.68	0.75	1.74	51.14	9.49	Singare et al. [34]
Maximum Tolerable Limit (mg/L or ppm)	0.1	3.00	0.1	3.00	15	Retrieved on October 16, 2016, from http://cpcb.nic.in/Industry_Specific_Standards.php

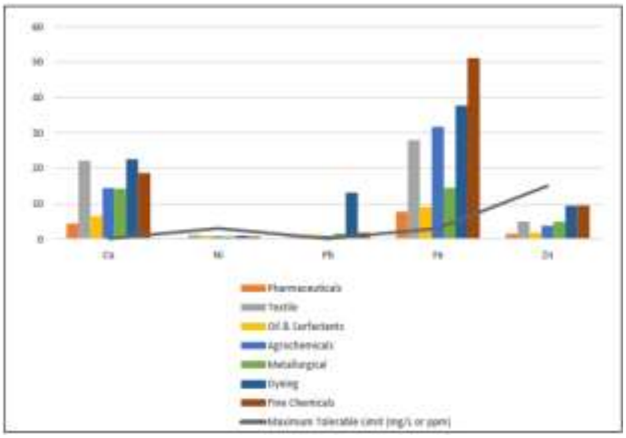

Fig. 2. Graph showing release of toxic metals from various industries w.r.t. maximum tolerable limit

Table 6. Harmful Emissions from various Chemical based industries

Parameters ($\mu g/m^3$) Industries	SO_2	NO_2	$PM_{2.5}$	PM_{10}
Pharmaceuticals	11	34	88.23	294.85
Textile	12	39	90.56	170.4
Oil & Surfactants	17	31	98.8	283.35
Agrochemicals	11	29	82.64	224.87
Metallurgical	11	25.8	110.77	294.9
Dyeing	11.6	28	109.5	285.97
Fine Chemicals	14	28.9	85.42	342.59
Maximum Tolerable Limit ($\mu g/m^3$)	50	40	40	60

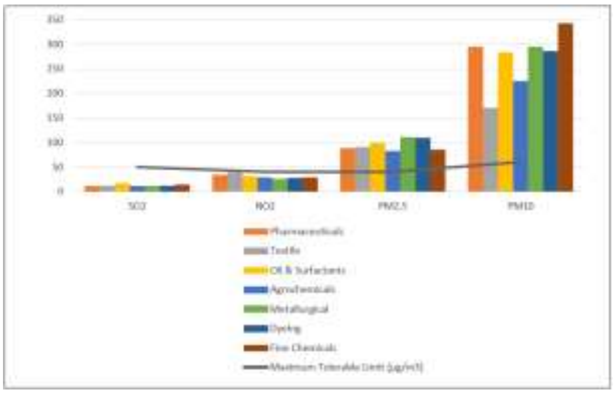

Fig. 3. Graph showing release of harmful emissions from various industries w.r.t. their maximum tolerable limit

C. Impact on Human Health

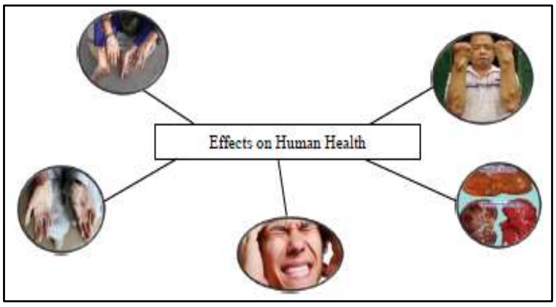

Fig. 4. Effects on Human Health

Table 7. Various Pollutants, their sources and their effects on Human Health

Pollutants	Major Sources	Effects on Human Health
Copper (Cu)	Mining, Pesticide Production, Chemical Industry, Metal Piping	Anemia, Liver and Kidney damage, Stomach and Intestinal irritation, Wilson's disease
Nickel (Ni)	Combustion of coal, Gasoline and oil, Alloy manufacturing, Electroplating, Batteries, Dyeing	Respiratory disorder, Lung cancer, Nose cancer, Larynx cancer, Prostate cancer, Sickness and dizziness, Lung embolism, Birth defects, Heart disorder
Lead (Pb)	Combustion of coal, Gasoline and oil, Iron and Steel production, Paint, Pesticide, Mining	Mental Retardation in children, Systemic Poison, Affects kidney, liver and gastrointestinal function, Developmental delay, Fatal infant encephalopathy, Congenital paralysis, Sensor neural deafness, Epilepticus
Iron (Fe)	Foundry & Forging, Mining, Automotive Industry	Conjunctivitis, Choroiditis, Retinitis, Benign pneumoconiosis (Siderosis), Lung cancer
Zinc (Zn)	Refineries, Brass manufacturing, Metal Plating, Plumbing	Zn flumes have corrosive effects on skin and damage to nervous membrane
SO_2	Power houses, Smelters, Coal and other fossil fuel combustion, Sulphuric acid plant	Noise and throat irritation, Respiratory illness, Prolonged exposure may lead to chronic bronchitis
NO_2	Combustion (Transportation and Power Plants)	Irritation of eyes, nose and throat, Airway inflammation, Asthma, Respiratory stress
$PM_{2.5}$ & PM_{10}	Chemical reaction of gases such as SO_2 and $NO+NO_2$, Combustion-stationary(Power plants, quarries and other industry) and mobile (Transport)	Chronic pulmonary diseases, Asthma, Respiratory and Cardiovascular illness

IV. RECOMMENDATIONS

There can be many methods that may be practiced which may help in absorbing toxic metals and harmful emissions around us without affecting the health. Physical methods may include the use of following:

1. Cyclone Separator
2. Fabric Filter Baghouse
3. Lime/Limestone Wet Scrubbing System for Flue Gas Desulfurization
4. Electrostatic Precipitator
5. Oxidizer
6. Overhead pneumatic cleaners
7. Cloth filters

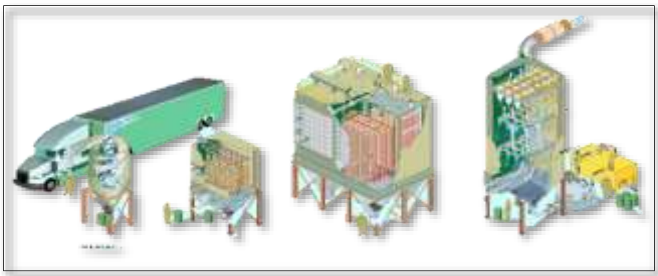

Fig. 5. Physical Methods

Chimneys height should not be less than 30 meters and release the pollutants not in the vicinity of living organisms. Gravitational and inertial separators are working on gravitational and inertial conceptsof collecting, filtering etc. of the particulate matter, eg. Settlingchambers, dynamic separator and wet cyclones and multiplecyclones.Woven or sintered metal beds of fibres, metal turning,fibrous mats and aggregate bed filter, paper filters and fabricfilters are used for the filtration of particulate matter likedust, lint and fumes [35]. Chemical and biological methods like recycling and planting of tress may also be used in order to reduce the effects of harmful emissions to much extent. Using unleaded petrol; Using fuels with low sulphur and ash content; Encouraging people to use public transport, walk or use a cycle as opposed to private vehicles; Ensuring that houses, schools, restaurants and playgrounds are not located on busy streets; Plant trees along busy streets as they remove particulates, carbon dioxide and absorb noise; Ensuring industries and waste disposal sites are situated outside the city preferably on the downwind of the city are some of the other major steps that may be helpful in reducing the harmful effects of air pollution. Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons.

Due to the high cost of the conventional physical and chemical engineering technologies, biological methods likephytoremediation and microbial remediation are emerging as a cost-effective, easy to implement, eco-friendly alternative green cleanup technologies for metal-contaminated soils [36]. It has been known that plants including trees, shrubs and grasses can significantly improve the quality of air in urban and rural areas by reduction and removal of pollutants like SO_2, NO_2, CO and particulate pollutants. They can also utilize selected air pollutants (like Zn, Fe, Mn, Ni and Cu as essential micronutrients) for their growth and metabolism, or can accumulate various substances and transform into less toxic thus resulting in significant decrease in the concentration of these air pollutants. The gaseous and particulate pollutants can be absorbed by plant surface along with CO_2 during photosynthesis and can be further transported or assimilated by the plant tissue. The particulate matter on the other hand can deposit on the plant surface, and then depending on the density and atmospheric conditions can be washed off, suspended again in the air and transported, or they can drop on the ground e.g. with the plant leaves. Due to various conditions (e.g. atmospheric conditions, vegetation) trees can have different abilities for reducing or removing air pollutants [37]. According to the investigations in the US urban area, the annual removal of air pollutants like O_3, PM_{10}, NO_2, SO_2, CO by trees was estimated approximately 711,000 tonnes [38]. Many of the hyperaccumulator plants accumulate high levels of essential heavy metals. To date, approximately 400 plant species from at least 45 plant families have been reported to hyperaccumulate metals. Phytoaccumulation, rhizofiltration, phytovolatilization, phytoextraction, phytodegradation, and phytostabilization are perhaps the probable mechanism involved in transition of metal accumulation by plants [39].

Camagro et al. [40] stated that sunflower, indian mustard, tobacco, rye, spinach, and corn can remove lead from water or soil. *Brassica juncea*, *Vetiveriazizanioides*, *Cardaminopsishalleri* play a significant role in the removal of lead from contaminated soil. Plants growing in northern Europe (blueberry, vacciniummyrtillus, cowberry, vacciniumvitis-idaea, crowberry, empetrumnigrum, birch, betulapubescens, willow, salix spp., pine, pinussylvestris, and spruce, piceaabies) could not accumulate lead into their shoots but when metal chelators like EDTA has been supplied to soils then they can remediate the lead from soil [41].

Current research also indicates bioremediation by microorganisms like bacteria, fungi, yeast and algae can remove heavy metals in substantial quantities by biosorption and bioaccumulation processes. White et al. [42, 43] reported that microbial remediation is an effective process of using microbes to break down the metal contaminants. For this purpose the metal-reducing bacteria have evolved several mechanisms to immobilize, mobilize or transform toxic metals to non-toxic. The important bacteria involved in this process are *bacillus*, *pseudomonas*, *streptomyces* and *P. aeroginosa* [44, 45]. Some of the bacteria responsible for the bioremediation of lead include *Bacillus* sp. and *P. aeruginosa* [46]. Similarly, fungal biosorbents [47, 48] includes *Aspergillus*, *Penicillium* spp., *Rhizopus*, *Streptoverticullum* and *Sacchromyces* while the algal biosorbents include red, green and brown sea weeds.

V. CONCLUSION

The greatest threat to our planet is the belief that someone else will do it. This belief is the major factor for the worst air pollution scenario that India is facing at present. The discharge of harmful emmisions and heavy metals from industries is causing pollution and posing serious health problems to human and other animals. As compared to conventional engineering technologies, bioremediation through plants and microbes provides Green, cost effective innovative and long term solution for cleaning , reduction and removal of environmental pollutants owing to their bioindication and bioaccumulation abilities. Cleaner production is an attractive approach to tackle environmental problems associated with industrial production and poor material efficiency. Since the cleaner production approach has been successfully implemented in some areas in the factory sector, it shows that significant financial saving and environmental improvements can be made by relatively low-cost and straightforward interventions. This improves the quality of products and minimises the cost of production, enabling the branch to compete in the global market. Healthy people mean healthy human resources are the main object of any successful business or in any country. These societal beneficial efforts need to carefully adapt available knowledge from other settings, keeping in mind the differences in pollutant mixtures, concentration levels, exposure patterns, and various underlying population characteristics.

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