MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY,
ENGINEERING, AND TECHNOLOGIES
ECOLOGY DEPARTMENT

APPROVED TO DEFENCE
Head of the Graduate Department
_____________ V.F. Frolov
«_____» ____________ 2020

MASTER THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 "ECOLOGY",
TRAINING PROFESSIONAL PROGRAM
"ECOLOGY AND ENVIRONMENTAL PROTECTION"

Theme: **«Assessment of health risks for the population of the city of Ivano-Frankivsk due to air pollution»**

Done by: student of the EK– 202 ма group, Oyewole Grace Titilope
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KYIV 2020

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____________ В.Ф. Фролов
«_____» ____________ 2020 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»,
ОСВІТНЬО-ПРОФЕСІЙНОЮ ПРОГРАМОЮ
«ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Оцінка ризиків для здоров'я населення міста Івано-Франківська у зв'язку з забрудненням атмосферного повітря»

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КИЇВ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Environmental Safety, Engineering and Technologies

Ecology Department

Direction (speciality, major): specialty 101 "Ecology", Training Professional Program "Ecology and Environmental Protection"

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APPROVED
Head of the Department
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«____» _________ 2020

QUALIFICATION PAPER ASSIGNMENT

Oyewole Grace Titilope

1. Theme: «Assessment of health risks for the population of the city of Ivano-Frankivsk due to air pollution» approved by the Rector on September 06, 2020, № 1937/ст.

2. Duration of work: from 05.10.2020 to 21.12.2020.

3. Input data: the morbidity data for the city of Ivano-Frankivsk, the results of the air pollution control at the territory of the city of Ivano-Frankivsk, the industrial pressure distribution over the territory of the city, administrative maps.

4. Content of explanatory note: Interactions between the human health and environmental conditions, statistical analysis of morbidity, city under investigation, Results

5. The list of mandatory graphic (illustrated materials): tables, figures, graphs.

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Receive themes task, search the literature and legislation	05.09.2020-15.09.2020	
2	Preparing the main part (Chapter I)	16.09.2020-30.09.2020	
3	Preparing the main part (Chapter II)	01.10.2020-15.10.2020	
4	Preparing the main part (Chapter III)	16.10.2020-26.10.2020	
	Preparation of the main part (Chapter IV)	27.10.2020-04.11.2020	
	Consultation on section V (Occupational safety)	05.11.2020	
	Preparation of the main part (Chapter V)	05.11.2020-20.11.2020	
5	Formulating conclusions and recommendations of the thesis	21.11.2020-25.11.2020	
6	Making an explanatory note to the previous presentation of the department, consultation with the norms controller	26.11.2020-30.11.2020	
7	Presentation of the work at the department	01.12.2020	
8	Taking into account the comments and recommendations and training to protect	01.12.2020-20.12.2020	
9	Thesis defense at the department	21.12.2020	

7. Consultant(s) of certain chapter(s):

Chapter	Consultant (academic rank, S.N.P)	Date, signature	
		Given by	Accepted by
Labor Precaution	Olena V. Konovalova, Associate professor Chair of Civil and Industrial Safety		

8. Date of task issue: «05» September 2020

Qualification Paper Advisor: ________________ Radomska M.M.
(advisor's signature) (S.N.P.)

Task is taken to perform: ________________ ___Oyewole G.T.__
(graduate's signature) (S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет екологічної безпеки, інженерії та технологій

Кафедра екології

Напрям (спеціальність, спеціалізація): напрям 6.040106 «Екологія, охорона навколишнього середовища та збалансоване природокористування»

(шифр, найменування)

ЗАТВЕРДЖУЮ

Завідувач кафедри

___________Фролов В.Ф.

«____» _________ 20__ р.

ЗАВДАННЯ

на виконання дипломної роботи

Оєволе Грейс Тітілопе

1. Тема роботи «Оцінка ризиків для здоров'я населення Івано-Франківська через забруднення повітря» затверджена наказом ректора від 06 вересня , 2020, № 1937/ст.

2. Термін виконання роботи: з 05.10.2020 р. по 21.12.2020 р.

3. Вихідні дані роботи: дані про захворюваність для міста Івано-Франківськ, результати контролю забруднення атмосфери на території міста Івано-Франківськ, розподіл промислового навантаження на території міста, адміністративні карти.

4. Зміст пояснювальної записки: Взаємодія між здоров'ям людини та умовами навколишнього середовища, статистичний аналіз захворюваності, місто, що досліджується, результати

5. Перелік обов'язкового графічного (ілюстративного) матеріалу: таблиці, рисунки, графіки.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання теми завдання, пошук літературних джерел та законодавчої бази	05.09.2020-15.09.2020	
2	Підготовка основної частини (Розділ I)	16.09.2020-30.09.2020	
3	Підготовка основної частини (Розділ II)	01.10.2020-15.10.2020	
4	Підготовка основної частини (Розділ III)	16.10.2020-26.10.2020	
5	Підготовка основної частини (Розділ IV)	27.10.2020-04.11.2020	
6	Консультація щодо розділу V(Охорона праці)	05.11.2020	
7	Підготовка основної частини (Розділ V)	05.11.2020-20.11.2020	
8	Формулювання висновків та рекомендацій дипломної роботи	21.11.2020-25.11.2020	
9	Оформлення пояснювальної записки до попереднього представлення на кафедрі, консультація з нормоконтролером	26.11.2020-30.11.2020	
10	Представлення роботи на кафедрі	01.12.2020	
11	Урахування зауважень, рекомендацій та підготовка до захисту	01.12.2020-20.12.2020	
12	Захист роботи на кафедрі	21.12.2020	

7. Консультація з окремого(мих) розділу(ів):

Розділ	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
Охорона праці	Коновалова Олена Вікторівна, доцент кафедри цивільної та промислової безпеки		

8. Дата видачі завдання: «05» вересня 2020 р.

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Завдання прийняв до виконання: _____________ Оєволе Г.Т.
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ABSTRACT

Explanatory note to thesis «Assessment of health risks for the population of the city of Ivano-Frankivsk due to air pollution»: 96 pages, 14 figures, 14 tables, 110 references.

Object of research – Impacts of air pollution.

Subject – Relationship between air pollutants and ailments

Aim of work – To investigate the possible health risks caused by air pollution among the population in the study area

Methods of research: Statistical Data Analysis, Air Quality Evaluation.

AIR POLLUTION, AILMENTS, AIR QUALITY, POLLUTANTS, IVANO-FRANKVISK, HEALTH RISKS.

CONTENT

INTRODUCTION

Relevance. The air pollution at the territory of Ivano – Frankvisk is conditioned by the intensive traffic, both road way and railway, especially in the center and heavy industrial enterprises, in particular, cement plant, machine building and electronic equipment. Additionally, the territory of the city is exposed to pollution transported from the refining and mining industries located in the adjoined areas. The historical part of the city, as well as densely built residential districts are poorly aerated and that contributes to pollution accumulation and retention. However, there has been no research to measure the impact of this pollution on the health of the people of Ivano- Frankvisk. This research therefore investigates to substantiate if there's a relationship between air pollution and human health.

Aim and tasks of graduate work. The aim of the work is to investigate the possible health risks caused by air pollution among the population in the study area

Tasks of work:

1. To study the evidence based data on the relationships between air pollution and health disorders among population of cities.
2. To characterize the possible sources of anthropogenic pressure on the environment of Ivano-Frankivsk
3. To find possible relationships between air pollutants and ailments
4. To know the degree of impacts (if relationships exists) of the pollutants on the residents
5. To make recommendations for policy makers based on findings of this research.

Object – degradation of health status under the influence of environment pollution .

Subject – Relationship between air pollution and ailments.

Methods of research. Regression analysis, correlation analysis, statistical data processing.

Scientific novelty of the results. This is the first time the relationship between air pollution and human health is investigated for Ivano-Frankivsk.

The practical value of the results obtained. The practical recommendations for improved data collection and air quality improvement were proposed

Personal contribution of the graduate. Data gotten was analyzed and results interpreted. Factors defining air pollution in some selected cities were analyzed, specific effects of air pollution on humans were considered.

Approval of the results:

Radomska, M.M. and Oyewole, G.T. 2020. The Assessment of the Airborne Health Risks at the City of Ivano – Frankvisk. Proceedings of the X All – Ukrainian scientific-practical internet conference, "Technogenic and ecological security of Ukraine: State and prospects of development/ TEB 2020". 20-29 October, University of the State Fiscal Service of Ukraine, Irpin, Ukraine, 64-66.

CHAPTER 1

INTERACTIONS BETWEEN THE HUMAN HEALTH AND ENVIRONMENTAL CONDITIONS

1.1. Factors affecting air quality in cities

The two main types of air pollution are ambient air pollution (outdoor pollution) and household (or indoor) air pollution. Indoor pollution is the pollution generated by household combustion of fuels which is caused by burning fuel such as coal, wood or kerosene while using open fires or basic stoves in poorly ventilated spaces. Common sources of outdoor air pollution however are emissions mostly caused by combustion processes from vehicles, fuel burning and industries.

Both indoor and outdoor air pollution can contribute to each other because air normally moves from inside buildings to the outside, and from outside to the inside. There are a lot of factors that affect the air quality of both indoors and outdoors among which are climate change, weather, transport of pollutants, emissions, topography, exposure to pollutants, time, Hvac system, etc.

1.1.1. Factors affecting outdoor air quality

Climate change. Changes in the climate mostly affect the air humans breathe, both indoors and outdoors. Taken together, changes in the climate affect air quality through three pathways: outdoor air pollution, aeroallergens , and indoor air pollution. The changing climate has modified weather patterns, which have in turn influenced the levels and location of outdoor air pollutants such as ground-level ozone and fine particulate matter. Also, increasing carbon dioxide levels promote the growth of plants that release airborne allergens. Overall, these changes to outdoor air quality and aeroallergens affect indoor air quality as both pollutants and aeroallergens infiltrate homes, schools, offices etc.

It has been established that climate change influences outdoor air pollutant concentrations in many ways like temperatures, cloudiness, humidity, the frequency and intensity of precipitation, and wind patterns [10]. Climate-driven changes in meteorology can also lead to changes in naturally occurring emissions that influence air quality (for example, wildfires, wind-blown dust, and emissions from vegetation). Over time, human responses to climate change has affected the amount of energy that humans use, how land is used and where people live. The changes would in turn modify emissions and continue to influence air quality. Some air pollutants such as ozone, sulfates, and black carbon can also cause changes in climate [17].

Changes in climate results in negative impacts to local air quality. Atmospheric warming associated with climate change has the potential to increase ground-level ozone which presents challenges for compliance with the ozone standards. Emissions of pollutants into the air can also result in changes to the climate. Ozone in the atmosphere warms the climate, while different components of particulate matter can have either warming or cooling effects on the climate.

Topography: Pollutants concentrations can sometimes be greater in valleys than in areas of higher ground because under certain weather conditions, pollutants can become trapped in low lying areas such as valleys. An example is on still sunny days, pollution levels can build up due to a lack of wind to disperse which can also happen on cold calm and foggy days during winter. If towns and cities are surrounded by hills, wintertime smogs may also occur. Pollution from vehicles, homes and other sources may become trapped in the valley, often following a clear cloudless night. Cold air then becomes trapped by a layer of warmer air above the valley.

Weather Conditions: The weather is an important factor on air pollution levels. Generally, windy weather causes pollution disperse while still weather allows pollution to build up. Coastal locations and open areas often experience more windy weather and are therefore likely to experience better air quality and the wind direction also affects air pollution. If the wind is blowing towards an urban area from an industrial area, the pollution levels are likely to be higher in the town or city than if the air is blowing from another direction. Sunshine can also affect pollution levels like on hot, summer days, pollution from vehicles can react in the presence of sunlight to form ozone. The pollution that causes ozone to be formed is usually generated from vehicles in cities and towns but because this pollution can be transported by winds, high levels of ozone may be found in the rural countryside. The pressure of the air also affects whether pollution levels build up. During high pressure systems, the air is usually still and this allows pollution levels to build up but during low pressure systems the weather is often wet and windy, causing pollutants to be dispersed or washed out of the atmosphere by rain.

Exposure to Pollution: Air pollution is mostly concentrated in underground car parks, tunnels and near petrol stations therefore levels of air pollution are likely to be higher in the vicinity of industrial processing works, power stations and waste incineration plants thereby affecting the air quality.

Time: Pollution levels vary over time. Variations occur throughout the day and over seasons depending on weather conditions and emission sources. Often in urban areas, rush hour traffic can cause emissions of vehicle pollution to peak in the early morning and evening to correspond with high levels of traffic and congestion. Some pollutants are emitted in greater amounts during the winter season due to the increase in use of fuel for domestic and industrial heating.

Pollution Emissions: Some pollutants are more heavily concentrated in different areas depending upon emission sources and this affects air quality which is why areas that mostly use solid fuel for domestic heating are likely to have higher emissions of sulphur dioxide pollution. Motor vehicle pollution can generate high levels of nitrogen dioxide, carbon monoxide and hydrocarbons in urban cities. Particulate pollution may be high as a result of vehicle pollution, fuel burning, building work, industrial emissions, soil and road dust and quarrying. Pollution emissions can cross from one country to another by the transportation of high levels of pollutants like Ozone across international borders.

1.1.1. Factors affecting indoor air quality

- Personal Activities like smoking;
- Housekeeping and cleaning materials;
- Maintenance Activities e.g remodeling, new furniture/carpet, or pest contro;.
- Emissions from office equipment e.g photocopier machines;
- Office supplies : toners, carbonless paper products;
- Liquid spills or leaks;
- Room occupant load;
- Thermal and/or humidity comfort;
- Contaminated outdoor air : vehicle exhaust, pollen, or industrial pollutants;
- Nearby source emissions : garbage dumpsters, loading docks, or re-entrained exhaust from buildings;
- Soil gas : radon, underground storage tanks, or pesticides;
- HVAC Systems;
- Inadequate distribution of fresh air in ventilation system;
- Dust in ductwork;
- Dirty air filters;
- Microbiological growth in ductworks and/or humidifiers;

1.2. Common and specific pollutants

The Environmental Protection Agency (EPA) has identified six pollutants as “criteria” air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. These six pollutants are carbon monoxide, lead, nitrogen oxides, ground-level ozone, particle pollution (often referred to as particulate matter), and sulfur oxides.

Carbon monoxide: CO is a colorless, odorless gas that can be harmful when inhaled in large amounts. CO is released when something is burned. The greatest sources of CO to outdoor air are cars, trucks and other vehicles or machinery that burn fossil fuels. A variety of items in your home such as unvented kerosene and gas space heaters, leaking chimneys and furnaces, and gas stoves also release CO and can affect air quality indoors.

The most common sources of CO in urban are cigarette smokes and vehicle exhaust [31]. The daily mean ambient levels of CO in the United States of America range from 0.5 to 2 ppm [86]. Exhaled carbon monoxide levels range from 0 to 21 ppm in non smokers, and from 2 to 50 ppm in smokers [56]. The highest levels of carbon monoxide exposure were found mostly in car park/garages, private car/taxi and bar/pub/nights club [26]. In urban environments carbon monoxide concentration usually varies from 2 to 40 ppm, but during heavy traffic or when peoples are exposed to second-hand cigarette smoke it could be as high as 170 ppm [18]. Although carbon monoxide levels are relatively low in urban environment, data from the APHEA-2 project (Air Pollution and Health: A European Approach) studying the relation between air pollution and total cardiovascular mortality in 19 European cities, reported a significant association of carbon monoxide with cardiovascular mortality [87].

Lead: Lead is a naturally occurring element found in small amounts in the earth's crust. While it has some beneficial uses, it can be toxic to humans and animals, causing health effects. Sources of lead emissions vary from one area to another. At the national level, major sources of lead in the air are ore and metals processing and piston- engine aircraft operating on leaded aviation fuel. Other sources are waste incinerators, utilities, and lead-acid battery manufacturers. The highest air concentrations of lead are usually found near lead smelters. Lead is persistent in the environment and can be added to soils and sediments through deposition from sources of lead air pollution. Other sources of lead to ecosystems include direct discharge of waste streams to water bodies and mining. Elevated lead in the environment can result in decreased growth and reproductive rates in plants and animals, and neurological effects in vertebrates.

Primary stationary sources of lead in urban areas include:

- Waste incinerators;
- Lead smelters;
- Utilities;
- Lead – acid battery manufacturers and recyclers.

Other industrial sources of lead emissions can include:

- Metals processing;
- Iron and steel foundries;
- Copper smelters
- Industrial, commercial, and institutional boilers;
- Glass manufacturers;
- Cement manufacturers.

Nitrogen dioxide: Nitrogen Dioxide (NO_2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NO_x). Other nitrogen oxides include nitrous acid and nitric acid. NO_2 is used as the indicator for the larger group of nitrogen oxides.

NO_2 primarily gets in the air from the burning of fuel. NO2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment. NO_2 along with other NO_x reacts with other chemicals in the air to form both particulate matter and ozone. NO_2 and other NO_x interact with water, oxygen and other chemicals in the atmosphere to form acid rain. Acid rain harms sensitive ecosystems such as lakes and forests. The nitrate particles that result from NO_x make the air hazy and difficult to see through. NOx in the atmosphere contributes to nutrient pollution in coastal waters. Traffic is a major source of nitrogen oxides, especially in urban areas where the traffic density is high. Dispersion of nitrogen oxides in urban areas is governed mainly by wind conditions.

Ozone: Ozone at ground level is a harmful air pollutant, because of its effects on people and the environment, and it is the main ingredient in "smog." Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC). This happens when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight.

Ozone is most likely to reach unhealthy levels on hot sunny days in urban environments, but can still reach high levels during colder months. Ozone can also be transported long distances by wind, so even rural areas can experience high ozone levels. Ozone affects sensitive vegetation and ecosystems, including forests, parks, wildlife refuges and wilderness areas. In particular, ozone harms sensitive vegetation during the growing season.

Particulate matter: Particulate matter is the mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope.

Particle pollution includes:

- PM10: inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- PM2.5: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

How small is 2.5 micrometers? Think of it as a single hair from the head. The average human hair is about 70 micrometers in diameter, thus, making hair 30 times larger than the largest fine particle.

Some of these particles come in many sizes and shapes and can be made up of hundreds of different chemicals.

Some are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires.
Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles.
Particles can be carried over long distances by wind and then settle on ground or water. Depending on their chemical composition, the effects of this settling may include:

- making lakes and streams acidic;
- changing the nutrient balance in coastal waters and large river basins;
- depleting the nutrients in soil;
- damaging sensitive forests and farm crops;
- affecting the diversity of ecosystems;

The particulate matters (PM) are very important compounds of urban air pollution. There are a lot of air pollution sources who can generate PM and one of the most important of them is urban traffic car. Traffic, combustion and agriculture, domestic fuel burning, natural dust and salt, and industrial activities are the main sources of particulate matter contributing to cities' air pollution.

Sulfur dioxide: SO_2 is the component of greatest concern and is used as the indicator for the larger group of gaseous sulfur oxides (SO_x). Other gaseous SO_x (such as SO_3) are found in the atmosphere at concentrations much lower than SO2. Emissions that lead to high concentrations of SO_2 generally also lead to the formation of other SO_x. The largest sources of SO_2 emissions are from fossil fuel combustion at power plants and other industrial facilities.
Smaller sources of SO_2 emissions include: industrial processes such as extracting metal from ore; natural sources such as volcanoes; and locomotives, ships and other vehicles and heavy equipment that burn fuel with a high sulfur content.
At high concentrations, gaseous SO_x can harm trees and plants by damaging foliage and decreasing growth. SO_2 and other sulfur oxides can contribute to acid rain which can harm sensitive ecosystems.

1.3. Effects of pollutants on human health

• *Carbon Monoxide:* Breathing air with a high concentration of CO reduces the amount of oxygen that can be transported in the blood stream to critical organs like the heart and brain. At very high levels, which are possible indoors or in other enclosed environments, CO can cause nausea, fatigue, headaches dizziness, confusion, unconsciousness and death. CO can also cause chest pain in people with coronary heart disease.

Carbon monoxide resulting from the partial oxidation of carbon-containing compound has been reported in epidemiological studies as one of the main pollutants responsible for the development of cardiovascular diseases [19]. Carbon monoxide at low concentration, as found in urban environment, has also been correlated with hospital admissions, mortality and morbidity related to cardiovascular dysfunctions [24].

• *Lead:* Once lead is ingested into the body, it distributes throughout the body in the blood and is accumulated in the bones. Depending on the level of exposure, lead can seriously affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. Effects of lead that is commonly encountered in current populations are neurological effects in children and cardiovascular effects (e.g., high blood pressure and heart disease) in adults. Infants and young children are especially sensitive to even the lowest levels of lead, which may contribute to behavioral problems, learning deficits and lowered IQ.

• *Nitrogen Dioxide*: Breathing air with a high concentration of NO2 can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing).

Longer exposures to elevated concentrations of NO_2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections.

• *Particulate Matter:* The size of particles is directly linked to their potential for causing health problems. Small particles less than 10 micrometers in diameter pose the greatest problems, because they can get deep in the lungs, and some may even get into the bloodstream. Exposure to such particles can affect both lungs and heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including:

- premature death in people with heart or lung disease;
- nonfatal heart attacks;
- irregular heartbeat;
- aggravated asthma;
- decreased lung function;
- Increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

• *Sulfur Oxide*: Short-term exposures to SO_2 can harm the human respiratory system and make breathing difficult. People with asthma, particularly children, are sensitive to these effects of SO_2. SO_2 emissions that lead to high concentrations of SO_2 in the air generally also lead to the formation of other sulfur oxides (SOx). SOx can react with other compounds in the atmosphere to form small particles. These particles contribute to particulate matter (PM) pollution. Small particles may penetrate deeply into the lungs and when in sufficient quantity, it can contribute to health problems.

1.3.1. Specific effects of air pollution on humans

Cancer: Cancers is a group of diseases which causes abnormal cell growth with the potential to spread to other parts of the body. About 22% of cancer deaths are caused by tobacco use while another 10% are due to obesity, poor diet, lack of physical activity or excessive drinking of alcohol [53]. Other factors causing cancers include certain infections, exposure to ionizing radiation and environmental pollutants [8].

Common environmental factors that contribute to cancer death include tobacco, diet and obesity, infections, radiation, sedentary lifestyle, and pollution [78]. About 10-15% cases of lung cancers are often caused by a combination of genetic factors and exposure to radon gas, asbestos, second-hand smoke, or other forms of air pollution [81].

Some epidemiological studies in the United States and Japan show an association between the incidence of disease (lung cancer and respiratory disease) and long-term exposure to air pollution including SPM with a diameter below 2.5 μm (PM2.5) [57, 68].

The earliest discovered air-born carcinogen is soot generated by combustion of coal and the discovery was made in the 18th century and it was also discovered that heavy exposure to soot causes skin tumors in humans, however, in the early 20th century, benzo[a]pyrene (BaP), a polycyclic aromatic hydrocarbon contained in soot has been identified as a carcinogen [70].

In recent decades, some PAHs, including nitrated PAHs, contained in SPM have been shown to be genotoxic and have been categorized as IARC Group 1 (e.g., BaP) or IARC Group 2A/2B (suspected human carcinogens) [47]. For instance, the exhaust of diesel engines is classified as IARC Group 1 [48]. These facts indicate that mixtures of mutagenic and/or carcinogenic combustion products have been released into the air and inhaled by habitats in urban areas.

Mutagenic Effects: Mutagens are ubiquitously present in air-borne particles collected in large cities according to studies in Japan by the World Health Organization [51]. It was reported that the contents of the PM2.5 fraction collected at an intersection with heavy traffic in Tokyo exerted higher mutagenicity than did larger air-borne particles from the same location. The identification of various mutagens in ambient air indicates that people inhale a mixture of various mutagens, rather than a single mutagen. Inhalation of a mixture of mutagens has been suspected to induce DNA damage resulting in carcinogenesis in target organs and, in some cases, mutagenesis in the germ cells [46].

Environmental mutagens, such as polycyclic aromatic hydrocarbons (PAH) and heterocyclic amines are known to bind to nucleotides, resulting in the formation of DNA adducts. Some DNA adducts are fixed as mutations through replication of DNA. Reactive oxygen species generated by pollutants also induce the formation of DNA adducts. DNA adducts have been detected as a marker for the exposure of humans and wild life to mutagens [11].

It has equally been documented the fact that atmospheric pollution resulting from point sources such as industries and waste incinerators, mobile sources such as motor vehicles, or indoor environments may contribute to increase the rate of genetic mutation in exposed organisms [35, 15]. It is plausible that such genetic alterations lead to deleterious consequences both to individual organisms, due to tumors and malignancies, and to whole populations, due to incidence of congenital diseases.

Teratogenic Effects: Teratogenesis is the creation of a deformed organism. A teratogen is any agent that physically or chemically alters developmental processes and produces congenital deformities. Teratogens affect the DNA in a developing fetus, often causing gross abnormalities or severe deformities such as the shortening or absence of arms or legs. The nature of the teratogen and developmental stage during which the alteration occurs is critical to the type and severity of abnormality it will produce. Biological factors such as the organism's gestation process, developmental pathways, and life-cycle characteristics also influence the exposure and effect of a teratogen. Mechanical disruptors, environmental factors, and chemical contaminants are the primary categories of teratogens affecting wildlife species. Exposure of an embryo, fetus, or larva to a teratogen may result in death, structural malformation, functional disorder, or growth retardation.

There is growing epidemiologic evidence for adverse effects on the fetus and newborn from maternal prenatal exposure to ambient air pollution [40]. Air pollutants such as carbon monoxide, sulfur dioxide, and particulate matter have been associated with increased infant mortality, particularly postneonatal respiratory mortality, low birth weight, and preterm birth [71].

1.3.2. Health disorders due to air pollution

Air pollution majorly cause diseases, allergies and even death to humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment. Both human activity and natural processes can generate air pollution. Below are health disorders caused by air pollution in humans:

Respiratory Diseases: Respiratory diseases, also known as lung diseases, are pathological conditions affecting the organs and tissues that make gas exchange difficult. They include conditions of the respiratory tract including the trachea, bronchi, bronchioles, alveoli, pleurae, pleural cavity, and the nerves and muscles of respiration. Respiratory diseases range from mild and self-limiting, such as the common cold, to life-threatening diseases such as bacterial pneumonia, pulmonary embolism, acute asthma, lung cancer, and severe acute respiratory syndromes.

Asthma: Asthma is defined as a common, chronic respiratory condition that causes difficulty breathing due to inflammation of the airways. Asthma symptoms include dry cough, wheezing, chest tightness and shortness of breath. Allergic reactions, infections and pollution can all trigger an asthma attack. According to WHO estimates, there were 417,918 deaths due to asthma at the global level and 24.8 million DALYS attributable to Asthma in in 2016 [107].

Chronic Obstructive Pulmonary Disease (Copd): Chronic obstructive pulmonary disease is an umbrella term that encompasses several respiratory illnesses that cause breathlessness, or the inability to exhale normally [9].

People usually experience symptoms, including shortness of breath, and normally cough up sputum (mucus from the lungs). This disease is generally associated with cigarette smoking but other risk factors include:

- indoor air pollution (such as solid fuel used for cooking and heating);
- outdoor air pollution occupational dusts and chemicals (such as vapors, irritants, and fumes) frequent lower respiratory infections during childhood.

Globally, it is estimated that 3.17 million deaths were caused by the disease in 2015 (that is, 5% of all deaths globally in that year) according to the World Health Organization.

Lung Cancer: With the ability to develop in any part of the lungs, this cancer is difficult to detect. Most often, the cancer develops in the main part of the lungs near the air sacs. DNA mutations in the lungs cause irregular cells to multiply and create an uncontrolled growth of abnormal cells, or a tumor. These tumors interfere with the regular functions of the lungs.

Pneumonia: Pneumonia is a common lung disease caused by an infection in the air sacs in the lungs. The infections can be bacterial, viral or fungal.

Pleural Effusion: Pleural effusion is a collection of fluid between the lung and the chest wall in what's called the pleural space. The fluid can collect for a variety of reasons, including pneumonia, cancer or congestive heart failure.

Cardiovascular Disease: Cardiovascular disease (CVD) is a class of diseases that involve the heart or blood vessels. CVD includes coronary artery diseases (CAD) such as angina and myocardial infarction (commonly known as a heart attack). Other CVDs include stroke, heart failure, hypertensive heart disease, rheumatic heart disease, cardiomyopathy, abnormal heart rhythms, congenital heart disease, valvular heart disease, carditis, aortic aneurysms, peripheral artery disease, thromboembolic disease, and venous thrombosis. According to the World Health Organization (WHO), CVDs are the number 1 cause of death globally: more people die annually from CVDs than from any other cause. An estimated 17.9 million people died from CVDs in 2016, representing 31% of all global deaths. Of these deaths, 85% are due to heart attack and stroke. Over three quarters of CVD deaths take place in low- and middle-income countries.

Types of CVD

There are many different types of CVD. Four of the main types are described below.

1. *Coronary heart disease:* Coronary heart disease occurs when the flow of oxygen-rich blood to the heart muscle is blocked or reduced. This puts an increased strain on the heart and can lead to:
   - Angina – chest pain caused by restricted blood flow to the heart muscle;
   - Heart attacks – where the blood flow to the heart is suddenly blocked;
   - Heart failure – where the heart is unable to pump blood around the body properly.
2. *Strokes and TIAs:* A stroke is where the blood supply to part of the brain is cut off, which can cause brain damage and possibly death. A transient ischaemic attack (also called a TIA or "mini-stroke") is similar, but the blood flow to the brain is only temporarily disrupted.The main symptoms of a stroke or TIA can be remembered with the word FAST, which stands for:
   - Face – the face may have dropped on one side, the person may be unable to smile, or their mouth or eye may have dropped;
   - Arms – the person may not be able to lift both arms and keep them there because of arm weakness or numbness in one arm;
   - Speech- their speech may be slurred or garbled, or they may not be able to talk at all;
   - Time- it's time to dial 999 immediately if you see any of these signs or symptoms.
3. *Peripheral arterial disease:* Peripheral arterial disease occurs when there's a blockage in the arteries to the limbs, usually the legs. This can cause:
   - Dull or cramping leg pain, which is worse when walking and gets better with rest;
   - Hair loss on the legs and feet;
   - Numbness or weakness in the legs;

- Persistent ulcers (open sores) on the feet and legs.

4. *Aortic disease:* Aortic diseases are a group of conditions affecting the aorta. This is the largest blood vessel in the body, which carries blood from the heart to the rest of the body. One of the most common aortic diseases is an aortic aneurysm, where the aorta becomes weakened and bulges outwards. This doesn’t usually have any symptoms, but there’s a chance it could burst and cause life – threatening bleeding.

1.3.4. Non-specific effects of air pollution on humans

- Fatigue, headaches and anxiety;
- Irritation of the eyes, nose and throat;
- Damage to reproductive organs;
- Harm to the liver, spleen and blood;
- Nervous system damage.

1.4. Analysis of air quality and health issues of selected cities of the world

1.4.1. Industrial cities

*Al jubail, Saudi Arabia***:** Al Jubail is an industrial city on the Persian Gulf. Because of its rapid industrialization in the 1970s, it has a high amount of air pollution that's been noted since the 1980s [5]. Saudi Arabia as a whole does not have a strong history in environmentalism. Thus, as the number of population increases and the industrial activity grows, environmental issues pose a real challenge to the country especially to their industrial cities like Al Jubail [73]. Lack of environmental policy can be linked to an enormous reliance on oil. Due to intense fossil fuel usage, Saudi Arabia has generated a number of environmental issues. Urbanization and high standards of living contribute to ground, water, and air pollution. Agriculture and overconsumption of natural resources cause deforestation and desertification.

Likewise, Saudi Arabia's oil industry subsidizes energy use and magnifies carbon dioxide emissions. These environmental issues cause a variety of health problems including asthma and cancer. As the largest oil exporter in OPEC, Saudi Arabia contributes to the immense environmental impacts associated with oil drilling [45]. This includes hydraulic fracturing, oil spills, and air pollution. Saudi Arabia contributed to the world's most severe spill, the 1991 Gulf War Oil Spill.

Alberta, Canada: Alberta's Industrial Heartland is also known as the Heartland or Upgrader Alley and is located just outside of Edmonton, Canada. The Heartland is not only the largest industrial area in Western Canada but also a cooperative land use planning and development initiative that is formed between five municipalities found in the capital region of Edmonton. The primary purpose of this cooperation is to draw investment in the oil, chemical, gas and petrochemical industries to the region. The Headland is the largest petrochemical processing regions in Canada covering over 40 petrochemical companies.

Air pollution in Canada is contributed by industrial and vehicular emissions, agriculture, construction, wood burning and energy production [4].

Rotterdam, Netherlands: Rotterdam Harbor, also known as the Port of Rotterdam, is Europe's largest port and is located in Rotterdam in the Netherlands. Rotterdam Harbor was the busiest port in the world between the years of 1962 to 2004 when it was overtaken by Singapore and later Shanghai. Rotterdam was the 11th largest container port in the world in 2011 regarding 20-foot equivalent units (TEU) handled, in 2009 it was the tenth, in 2008 it was the ninth, and 2006 it was the sixth.

In 2012, the port was the sixth-largest port in the world regarding annual cargo tonnage. The Harbor covers an area of 41 square miles and stretches over a distance of 25miles. It consists of five separate port areas and three distribution parks that attend to the needs of 40,000,000 customers. Cargo transshipment handling and petrochemical industries are the most significant activities at the port of Rotterdam.

The port serves as an important point for the transit of goods between continental Europe and the rest of the world.

The association between daily mortality and short-term variations in the ambient levels of ozone, black smoke, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter was studied in the Netherlands and it was established that there's an association between outdoor air pollution and effects on both acute and chronic mortality and hospital admissions in the Netherlands [98].

Khed City, India: Khed City is an Industrial park near Pune, India with an area of over 4200 acres, The 4200 acres of land is divided into Domestic Tariff Area, a sector specific SEZ (Engineering and Electronic sector), and social infrastructure along with a rehabilitation and resettlement area for the displaced locals [60]. As of 2019, Khed City has over 47 domestic and multinational companies. The 51% of pollution in India including Khed city is caused by the industrial pollution, 27% by vehicles, 17% by crop burning and 5% by diwali fireworks. Air pollution contributes to the premature deaths of 2 million Indians every year. Emissions on khed city mainly come from vehicles and industry. During autumn and winter months, there is large scale crop residue burning in agriculture fields because it is a cheaper alternative to mechanical tilling and this is a major source of smoke, smog and particulate pollution [13].

New York, United States Of America: New York City is the most populous city in the United States with an estimated 2019 population of 8,336,817 distributed over about 302.6 square miles (784 km2). Air pollution is a leading environmental threat to the health of urban populations overall and New York residents aren't left out. Health Department in the United States estimates that each year, PM2.5 pollution in New York City causes more than 3,000 deaths, 2,000 hospital admissions for lung and heart conditions, and approximately 6,000 emergency department visits for asthma in children and adults. Ozone on the other hand causes an estimated of 400 deaths from all causes, more than 800 hospital admissions and more than 4,000 emergency department visits among children and adults. This estimates further show that effects of air pollution in New York City fall heavily on seniors, children with asthma and people living in low-income neighborhoods [25]. The major sources of PM2.5 in New York are from vehicles e.g trucks, buses and cars, fossil fuel combustion for generating electric power and heating residential and commercial buildings. Due to the enormous amount of manufacturing industries and traffic congestion in the city, fine particles can also become airborne from mechanical processes such as construction or demolition, industrial metal fabrication, or when traffic or wind stirs up road dust [25].

1.4.1. Megacities

London, United Kingdom: Air pollution in the United Kingdom has been considered a significant health issue for a long time now. Many areas, including major cities like London are found to be significantly and regularly above legal and recommended levels of air quality. Air pollution in the UK is a major cause of diseases such as asthma, lung disease, stroke, and heart disease, and is estimated to cause forty thousand premature deaths each year, which is about 8.3% of deaths, while costing around £40 billion each year [84,91].

In early of December 1952, a cold fog descended upon London and due to the cold, Londoners began to burn more coal than usual and the resulting air pollution was trapped by the inversion layer formed by the dense mass of cold air. This made the concentration of pollutants, coal smoke in particular, build up dramatically. The problem was worsen by use of low-quality, high-sulphur coal for home heating in London in order to permit export of higher-quality coal, because of the country's tenuous postwar economic situation [76].

New Delhi, India: A report by the Indian Ministry of Environment and Forests in 1997 reviewed the environmental situation in New Delhi over concerns of deteriorating conditions and air pollution was one of the areas of concern identified in the study [30]. It was estimated that about 3000 metric tons of air pollutants were emitted every day in New Delhi, with the major contributions by vehicular pollution followed by coal-based thermal power plants.[14]. In 1989 to 1997, there was a rising trend as monitored by the Central Pollution Control Board (CPCB) in India. The concentrations of carbon monoxide from vehicular emissions in 1996 showed an increase of 92% over the values observed in 1989, consequent upon the increase in vehicular population. The particulate lead concentrations appeared to be in control and this was attributed to the de-leading of petrol and restrictions on lead-handling industrial units.

Pollution from motor vehicles is an important contributor to air pollution in New Delhi and according to the Department of Transport, Government of National Capital Territory of Delhi, vehicular population is estimated at more than 3.4 million, reaching there at a growth rate of 7% per annum. Major concerns for human health from exposure to particulate matter in New Delhi include effects on breathing and respiratory systems, damage to lung tissue, cancer and premature death [3]. Elderly people, children and people with chronic lung disease, influenza or asthma are especially sensitive to the effects of particulate matter. The urban air database released by the World Health Organization in September 2011 reported that Delhi has exceeded the maximum PM10 limit by almost 10-times at 198 μg/m3, trailing in the third position after Ludhiana and Kanpur.Vehicular emissions and industrial activities were found to be associated with indoor as well as outdoor air pollution in Delhi [44].

Several other community-based studies have found that air pollution is associated with respiratory morbidity [52]. Numerous studies have also reported an association between indoor air pollution and respiratory morbidity in New Delhi [36]. Some of these studies concentrated on children's respiratory morbidity while other studies in children have found similar correlations between particulate matter in ambient air and attention-deficit hyperactivity disorder between vehicular air pollution and increased blood levels of lead which is a potential risk factor for abnormal mental development in children [58].

Shanghai, China: Shanghai with a population of 24.28 million as of 2019 is the most populous urban area in China, the second most populous city proper in the world and the Port of Shanghai is the world's busiest container port. Air pollution in Shanghai is considered substantial by world standards [37]. During the December 2013 Eastern China smog, air pollution rates in Shanghai reached between 23 and 31 times the international standard [90]. Also, levels of PM2.5 particulate matter in Shanghai rose above 600 micrograms per cubic meter and in the surrounding area, above 700 micrograms per cubic meter and levels of PM2.5 in Putuo District reached 726 micrograms per cubic meter.

Lagos, Nigeria: Lagos is a state located in the southwest region of Nigeria, is the most populous city in Nigeria and the African continent with a population of about 15million and houses one of the largest and busiest seaports on the continent. Lagos is also one of the fastest growing city in the world and it is estimated that 75 percent of Nigeria industries are located in Lagos [79]. Since the mid-1970s, urban landscape development in Lagos has been characterized by the rapid growth of residential and business settlements around busy and often congested road networks. Traffic congestion, petrol and diesel powered generators, and uncontrolled open incineration of waste and major thermal power stations are the main sources of air pollution within the city. [32]. Growing evidence has substantiated a causal relationship between air pollution and mortality, hospital admissions for respiratory or cardiovascular diseases and an associated increased risk of myocardial infarction among the residents of Lagos [95].

Seoul, South Korea: Seoul is the capital and largest metropolis of South Korea with a growing population of 9.7 million people [16]. Air pollution in South Korea is an increasing threat to people and the environment, this air pollution comes from many sources, both domestic and international and this is due to the rapid industrialization in the city. These sources include: traffic congestion, factories and power plants emission and fossil fuel combustion.

According to, National Aeronautics and Space Administration (NASA), Seoul is amongst one of the world's cities with the worst air pollution and from 2009 and

2013, the city's mean Pm10 were higher than in many of the largest metropolitan cities in the world. It is also estimated that air quality accounted for about 16 percent of deaths in the Seoul Metropolitan Area in 2010.

1.4.2. Other cities in the world

Port Harcourt, Nigeria: In the last quarter of 2016, residents of Port Harcourt in Rivers State, Nigeria, and its environs started experiencing adverse environmental impacts of particle pollution called 'SOOT'. The whole state was covered in the black particle and people could see the particle even inside their houses.

In recent years, studies carried out to assess the levels of criteria air pollutants in cities of Rivers State, including Port Harcourt, and their probable association with air borne diseases, provide evidence of correlation. A survey on air quality in four different locations in Rivers state at varying distances (60, 100, and 500 m) from emission source reported that almost all the samples complied with (Department of Petroleum Resources (DPR)) guidelines for annual average apart from SOx and NOx whose annual means exceeded specification at only one location [2].

Non-conformity occurred mostly in the dry season during which levels of the pollutants tended to be higher in the evenings and sustained through the early hours of the morning. In all four locations, suspended particulate matter (SPM) conformed to specification of 230 μg/m3 with the highest annual mean being 129 μg/m3. Like with Nitrogen oxide and Sulfur oxide,, season significantly influenced their concentrations [2].

In another survey of a 5 year term (2003−2007), epidemiological data discovered that the levels of all the criteria air pollutants in Rivers State was significantly higher than the WHO specification [77] and it was determined that air pollution was associated with air related morbidities and mortalities in the state. Amongst the air-related morbidity assessed, including cerebrospinal meningitis, chronic bronchitis, measles, pertussis, pulmonary tuberculosis, pneumonia, and upper respiratory tract infection, pneumonia was the most prevalent for all of the years that were studied, and was responsible for the highest number of deaths in 2005 [77].

In a previous study to ascertain the disease prevalence associated with industrial-related air pollution in specified Niger Delta communities, a strong relationships was established between air pollutants, including PM with morbidities, such as respiratory diseases, traumatic skin outgrowth, and child deformities [41]. The study compared health effects in Eleme, a highly industrialized community with those observed in Ahoada East, a less industrialized community. Particularly, air pollution significantly correlated with painful outgrowths as well as respiratory health conditions and the analysis of data to determine the probable relationship of the use of firewood as domestic cooking fuel with health outcomes, detected significant association with child deformities.

Findings from a different study indicates that adverse health conditions, such as eye and skin disorders, occurred amongst workers who spent eight hours per day working at facilities with poor air quality due to ineffective control. For these workers, strong association of health disorders with occupational exposures was established. Additionally, statistical analysis indicated a strong association of number of hours of residence in homes with cancers, deformed children, health effects that are related to air pollutants, miscarriages or still births, and respiratory diseases [41].

A separate study conducted in 2010 further corroborated that the health consequences of air pollution in Port Harcourt is seen in the prevalence of lung and skin cancers which were found to be higher in Port Harcourt than in Ibadan, Oyo State, Nigeria [41].

Berlin, Germany: In the 1970s and 80s, the city of Berlin tackled its huge smog problem through a concerted campaign to get rid of coal-burning stoves.

In the 90s and 2000s, particulate matter was the main issue, prompting the city to introduce an environment zone within the city center, where only low-emission vehicles are allowed to drive. In recent days, the city is fighting a different class of dangerous air pollutants invisible and odorless: nitrogen oxides (NOx). The main problem is with nitrogen dioxide (NO_2), mainly emitted by diesel-powered cars and trucks.

A new study by the German Environment Agency supports these findings and shows that even a very low concentration of NO_2 is linked to diseases such as diabetes, high blood pressure, heart failure, strokes, lung cancer, asthma, chronic bronchitis and premature birth. The study proves that every year, more than 800,000 people become ill in Germany because of NO_2 emissions and these illnesses even result in death. In fact, the European Environment Agency (EEA) calculated that nitrogen dioxide is responsible for more than 12,800 premature deaths in Germany every year.

Kraków, Poland: Air pollution has been a considerable problem in the city of Kraków for several years. With increased development of industries and the operation of combined heat, power plants and steelworks in Kraków between the 1950s and the 1980s, the rate of gaseous and dust air pollution rapidly increased. The concentrations of particulate matter, nitrogen oxide and Ozone in Kraków caused nowadays by power plants, low emissions and traffic remain high. Also, the unfavorable meteorological conditions like the low wind speed and low mixing-layer height worsen the air quality in Kraków, especially in winter months [80]. Some research projects confirmed high cardiovascular and respiratory system disease incidence, mainly of asthma and allergies and increased mortality rates associated with air pollution in the city [105].

Accra, Ghana: Ghana is undoubtedly one of the fast-developing African countries. However, the rapid economic growth appears to have influenced gradual increases in air pollution in the country [7]. Air pollution in Ghana was said to have caused more than 28,000 deaths as of September 2018. The WHO further reports that the annual mean level of PM2.5 in Ghana as of 2016 was 31.1 $\mu g/m_3$ which far exceeds the recommended annual guideline of 10 $\mu g/m_3$ [12]. This indicates the obvious poor air quality in Ghana and its repercussions on human health.

A study on the health of women trading at Agbogbloshie a popular market which is situated near a large e-waste recycling site at Accra, Ghana found that majority of female traders showed symptoms of sore throats, cough, colds, and persistent sneezing among other respiratory health-related problems. Apart from these market women, street hawkers and vendors who trade along major traffic-prone roads throughout Accra are equally exposed to air pollution from heavy car traffic as well as the drivers themselves [74]. Additionally, pregnant women could lose their foetus prematurely if they are frequently exposed to air pollution from vehicular traffic [58].

Dubai, United Arab Emirates: In the last few decades, the UAE saw a tremendous growth which has improved the living conditions of its people but this may have created conditions that lead to health risks considering the alarming increase in the number of cars, large developments and industrial processes [61].

Research records high prevalence of asthma and cardiovascular diseases, which are the leading cause of overall death in the UAE [6].

In a 2012 study, indoor air pollution was however been linked to asthma and wheeze and it is reported to be one of the first assessments of the relationship between indoor air pollutant exposure and health outcomes in a region where environmental health studies are rare [109].

Sydney, Australia: Sydney is Australia's largest city with over five million people and is rapidly growing [1]. Also, Sydney's geography is a basin bounded to the east by the Pacific Ocean and to the south, west and north by elevated terrain, occasionally delays air pollutants from dispersing. This, along with other factors, can cause ground level ozone and particulate matter to exceed the national standards on occasion. The current concentration of PM2.5 in Sydney is responsible for about 2.1% of deaths per year and 1.8% of total years of life lost [22]. Ozone is responsible for an additional 0.8% of total deaths per year in Sydney [22].

1.4.3. Factors defining air pollution on selected cities.

Table 1.1.

A table showing cities, factors responsible for pollution and weighted impact

Example	Factors and Description	Weight
New York	Population: emissions from heating objects, both from households and offices.	4/5
	Industrialization: Fuel burning sources from factories.	5/5
	Government Policy: The United States government is continually working on reducing the causes of air pollution in New York city and the U.S. as a whole by reducing their carbon footprints. This can be seen in them introducing hybrid taxis and clean diesel vehicles. The Environmental Protection Agency regulates greenhouse gases as pollutants. The city is also a leader in the construction of energy-efficient green office buildings. However, much more can still be done in the fight against air pollution and its impacts on human health.	2/5
London	Population: coal burning and home heating appliances.	3/5
	Industrialization: atmospheric pollution containing lead due to high numbers of industries. Sulphuric emissions caused by factories	5/5
	Government Policy: The UK government in its efforts to improve air pollution is banning the sale of new fossil fuel cars by 2040, and is phasing out the use of coal in its electrical power generation.	2/5
New Delhi	Population: Overpopulation.	5/5

	Motor vehicles emissions. Fire in Bhalswa landfill. Industrialization: particulate matter emissions from the badarpur thermal station Animal Agriculture: harmful particles produced by farmers burning their crops. Mist emissions wet cooling towers used in industries. Government Policy: lack of active monitoring by the government, lack of political priority	 5/5 4/5
Lagos	Population: Waste burning as a way of waste disposals. Exhausts from petrol fuelled generators and kerosene fuelled stoves and lanterns. Exhaust from wood burning which is a means of cooking. Industrialization: Establishment of many manufacturing factories within and outskirts of the city. Exhaust form their generators. Government Policy: the Lagos state government is complacent about the issue of air quality as there is hardly any data or research for its monitoring and improvement.	5/5 5/5 4/5
Seoul	Population: coal-fired power appliances high diesel vehicle emissions. Fossil fuel combustion Industrialization: construction equipment, heating and air conditioning, and power plants. Government Policy: The government plan to cut domestic emissions by 30% and shut down old coal plants.	4/5 5/5 1/5

	The Korean Government is planning on providing air purification systems for public facilities and schools consisting of air purifiers and air purifying plants	

1.5. **Conclusion of Chapter**

The interactions between the human health and environmental conditions was discussed including factors affecting outdoor and indoor air quality in cities, common and specific pollutants of urban air, effects of pollutants on human health, specific effects of air pollution on humans, health disorders due to air pollution. Some selected countries in the world's air quality and health issues were analyzed and also the factors defining air pollution on some other selected cities. The next section discussed methodology of the research.

CHAPTER 2
METHODOLOGY

2.1 Statistical analysis of morbidity

2.1.1 Quantifying disease in ppopulations

What is a case?

Measuring disease frequency in populations requires the determination of diagnostic criteria. The central notion to be considered is “a case”. In clinical practice, at the level of hospitals and medical establishments of any kind, the definition of "a case" means that there are people affected and the non-affected. This is reflected in statistical data, submitted by such establishment to local and national authorities. However, some diseases in populations are active in continuous form, but not as discrete phenomena.

Thus, it is possible to say that a person has certain genetic disorder of not and count the real number of such cases. But if we deal with the chronic diseases and infectious process it is necessary to set the conditions and limitations, which are used in the definition of cases related to the target of research. For example, it can be some specific morphological or physiological parameter that is used to divide the population into people affected and not affected. This is the case for hypertension incidence. The major task is to define and substantiate the threshold of cut off point. There are few approaches that can be applied:

Statistical: the benchmark value of partition criteria is calculated as the age specific mean and its two standard deviations. This is the simplest and widespread guide, but it must be considered with awareness about the fact that it usually outputs around 5% frequency of "abnormal" values in every population.

Clinical: is the level of a criterion, above which symptoms become more frequent. For example, reduction of a joint space to less than 2 mm on x-ray is the border line for osteoarthritis, as such close location of surfaces is associated with noticeable increase in symptoms.

Prognostic: the prognosis of negative health changes based on other parameters, which play the role of drivers for the given disorder development. For example, high systolic blood pressure or poor glucose tolerance may have no clear symptoms, but could eventually lead to various serious disorders, like diabetes.

Operational: some diseases cannot be measured with the above mentioned criteria, fit into variation of normal condition or represent the general trend of health status change in the future. Still a case definition is made on the basis for decisions, even if somewhat arbitrary. The definition comes from the answer to the question is there a need for any kind of treatment. A person may have no symptoms, but the prognosis or condition will improve in case of treatment application.

Each of these approaches to case definition should be used under specific conditions. Independent from the exact choice, the case definition parameters must be precise and clear, especially if the research involves comparison of different studies.

It is also essential to define and standardise the methods of measuring the chosen criteria. Cases in a survey are defined not by theoretical criteria, but based on the chosen technique of investigation, which must also be defined, standardised, and reported adequately. As a result, epidemiological case definitions are narrower and more rigid than clinical ones, leading to lower incidence but higher standardisation.

Measures of disease frequency: For the research purposes the occurrence of cases of disease must be related to the "population at risk" giving rise to the cases. Few measures of disease frequency can be used for this.

i. *Incidence:* The incidence of a disease is the rate at which new cases occur in a population during a specified period. When the population at risk is roughly constant, incidence is measured as:

Number of new cases: Population at risk × period under study

The measurement of incidence is complicated by changes in the number of exposed population during the period under study due to births, deaths, or migrations. This issue is tackled by relating the numbers of new cases to the person-years at risk, calculated by adding together the periods during which each individual member of the population is at risk during the measurement period.

It should be noted that once a person is classified as a case, it cannot be included into new cases later. If the same pathological event happens more than once to the same individual, it is considered only once, in case of chronic diseases, and every time for infectious diseases. The corresponding reports should state whether incidence refers only to first diagnosis or to all episodes.

ii. *Prevalence:* The prevalence of a disease is the proportion of a population having specific disorder in certain moment. Prevalence can be used to evaluate the situation if it is relatively stable, but acute disorders cannot be measured this way. Even in a chronic disease, the manifestations are often intermittent. As a result the final assessment underestimates the total frequency. It is possible to increase the reliability of data by repeated or continuous assessments of the same individuals

iii. *Mortality:* Mortality is the incidence of death from a disease

Interrelation of incidence, prevalence, and mortality

A new incident enters a prevalence pool and remains there until either recovery or death. If recovery and death rates are low, then chronicity is high and even a low incidence will produce a high prevalence:

*Prevalence = incidence * average duration*

Mortality must be chosen as a research criterion and applied in those cases when survival is not related to the risk factors under investigation. The reduced mortality could be a product of better treatment, which will not affect the incidence.

Prevalence is often used as an alternative to incidence in the study of rarer chronic diseases, for which it is difficult to collect large numbers of incident cases. From the other side, different parts of the world may demonstrate differences in survival and recovery as well as in incidence.

iv. *Crude and specific rates:* A crude incidence, prevalence, or mortality (death rate) is one that relates to results for a population taken as a whole, without subdivision or refinement. The most important refinements are those related to sexual and age differences. To provide comparable data it is also advisable to avoid using absolute data. Instead the cases and any other parameters must be attributed to the total population under investigation by recalculating data per 1000 or 10000 of population.

Another important issue is enumeration of population risks in relation to groups of population: for example, the data on incidence of disease people with certain profession within a territory cannot be appropriately interpreted if the number of people of the given profession within this territory is unknown. Incidence and prevalence are preferable to proportions if they can be adequately measured.

2.2. Assessment of morbidity in Ukraine

For the purposes of the given research the analysis of the correlation between diseases and level of environment pollution was based on the official morbidity statistics collected and submitted by medical establishment of Ukraine according to the state regulations. Morbidity is a medical-statistical indicator that determines the number of diseases first registered in a calendar year among the population living in a particular territory. It is one of the criteria for assessing the health of the population.

Calculation Method: It is calculated by the number of diseases per 1000 inhabitants as the ratio of the number of newly emerging diseases (diseases newly diagnosed) to the average population, multiplied by 1000. In the practice of Ukrainian health care, the calculation is often used per 100,000 of the total population. If we are talking about the incidence of certain groups, for example, children, then the calculation is made per 100,000 of the child population.

General morbidity is the study of the overall morbidity in the current calendar year for this disease and it includes primary referral of a patient to the medical institution and the first visit for a chronic disease identified in previous years. Chronic and long-term diseases are taken into account only once a year, and they are not recorded during repeated visits for exacerbations of these diseases.
Diagnoses of acute diseases (including acute respiratory infections, trauma, etc.) are recorded with each new case of their occurrence.
One of the methods for studying the general morbidity of the population is the study of the general morbidity by referral to outpatient clinics, in the order of current registration, on the basis of a complete registration of all patients

Morbidity Rate: The incidence rate shows the level, frequency of the spread of all diseases combined and each separately among the entire population, as well as in age, sex, social, professional and other population groups.
The incidence rate in the past calendar year and its dynamics over a number of previous years are the most important indicators of the health status of the population and the efficiency of health care institutions services provision, the basis for planning all therapeutic and prophylactic measures. The international nomenclature and classification of diseases and causes of death makes it possible to study morbidity according to uniform principles and obtain comparable results. The complete registration of diseases covers not only the newly registered diseases in a given year, but all diseases, including those that have been going on for a long time, were identified in the past and served as a reason for regular appeals this year - a medical-statistical indicator, in contrast to the incidence, which is similar to prevalence.

Hospital Morbidity: The incidence of hospitalized patients is a record of persons treated in a hospital during the year; it is studied according to the data of the "Card of the patient leaving the hospital", which is filled in for each case of hospitalization. Information on hospital morbidity makes it possible to judge the timeliness of hospitalization, the duration and outcome of treatment, the coincidence or discrepancy of diagnoses, the volume of medical care provided. An important role is played by the study of mortality, both general and nosological forms.

The Value Of Morbidity As An Indicator For Research Purpose: Morbidity is an indicator that is sensitive to changes in environmental conditions in the studied year. When analyzing this indicator over a number of years, one can get the most correct idea of the frequency of occurrence and dynamics of morbidity, as well as the effectiveness of a complex of social, hygienic and therapeutic measures aimed at reducing it and possible effects of environmental factors, causing health disorders magnification or reduction.

Reliable information on the level and nature of morbidity in various population groups and at the territories with various levels of anthropogenic transformation and technogenic pressure is necessary to assess trends in the health of the population, the effectiveness of medical and pollution control measures, planning various types of specialized medical care, rational use of natural resources and ecosystems.

To analyze morbidity and air pollution, the measurements of pollutants by stations that residents of the study area can be exposed will be highlighted. Correlation analysis will be done to observe for any correlation over time between different air pollutants and illness data provided. A multiple regression analysis is often carried out between social-economic data of reported cases of illness of residents and various air pollutants. The social economic data like age, sex and race will be independent variables while each pollutant will be the dependent. This should show which demographic variable (who are ill) is most vulnerable to the air pollutant.

2.2.1. Possible Challenge With Analyzing Morbidity Data

An issue with the data collection of morbidity is about the correctness/accuracy of reporting. Two factors, according to several studies increase the chances of accuracy of these reports, and they are:

i. The importance of the illness: An illness can be termed important depending on the following :

- How the report was obtained. Self-report or by proxy;

- The attention the illness had from physicians at the point it was reported;
- Duration of the attention;
- Extent of the illness (requiring surgery, for example);
- Length of recall time (if required).

ii. Removal of possible social and psychological obstacles to credible reporting

2.3. Integeral indices of air pollution levels

It is important to transform the weighted values of air pollutants into numbers. This transformation usually takes the form of mathematical equations that can accommodate other pollutants. In a more simplistic form, it is a way of mapping several pollutants with one equation. Therefore, a pollutant (element) in a sample space can be mapped into another space using an equation. There are many indices for air pollution levels and there are four criteria for evaluating them namely:

A. Number of variables included in the index: The number shows the amount of variables added to a pollution index.

B. Calculation method used to complete the index: This is about the linearity (No variable raised to a power in the equation) and non-linearity (at least one variable raised to the power) of the functions. Actual values based on direct scientific measurements in standard units. An example is (jug/m3, ppm) for coefficient of haze.

C. Calculation mode (combined or I combined): This is about how the index variable is reported and calculated. The index variable can be reported individually (minimum and maximum values of variable are considered), or ink the index of the maximum variable are considered. It can also be a hybrid if both forms (combined).

D. Descriptor categories reported with the index: This is about categorizing numeric measurements and analyzing these categories qualitatively.

The method mentioned is for review purpose and will not be applied in this paper.

However, in Ukraine Air quality is evaluated according to the standards for dwelling and production areas in the form of MPC.

MPCw.a. (maximum permissible concentration at working area) is a concentration, which during every day job 8 hours a day or at other duration (but not more than 41 hour a week) during all working experience must not cause any disease or health condition deterioration, which could be detected with modern methods of research, or in remote life time and next generation.

Working area is a space 2 meters above the floor level or areas of permanent or temporal stay of man.

MPCmax (maximum one-time permissible concentration) - is concentration of a substance in the mid air, which does not cause reflex reactions in human organism after 20 minutes of exposure.

MPCdaily (average permissible concentration during day) - concentration of a substance in the mid air of settlements, which must not produce any direct or indirect influence on humans at unlimitted inhalation; it is the most strict from norms.

In accordance with the above mentioned standards the degree of atmospheric air pollution is estimated separately for all substances. The complex index of atmosphere pollution (IAP) is the most widespread presently and recommended methodical approach to the assessment of air condition. IAP is defined as the sum of ratio to MPC and resulted to SO_2 concentrations of average content of different

$$IAP = \left(\frac{C_i}{MPC_i} \right)^{K_i},$$

substances:

See and make all formulas numeration as in template

Ci - average concentration of i substance; mg/m³; MPCi - average daily maximum possible concentration of i substance; Ki - dimensionless constant to account the toxicity of substance (Table 2.1) as compared with SO2

Table 2.1

Average value of constant K

Hazard class	Description of class	Constant
1	extraordinarily	2,4
2	dangerous	1,3
3	highly dangerous	1,0
4	medium dangerous	0,85
	low dangerous	

IAP characterizes the level of the chronic, prolonged air pollution.

SI is a standard index, the highest measured one time concentration of substance, shares of MPC. It is determined from the data of monitoring of a territory during a month or a year. It characterizes the level of short-term pollution.

NP is the most repeatable concentration (in percents) exceeding MPC based on monitoring data of a certain territory during a month or a year.

In accordance with these indexes the pollution of atmosphere is described as follows:

1. Low at IAP from 0 to 4, SI<1, NP<10%;
2. Increased at IAP from 5 to 6, SI<5, NP from 10 to 20%;
3. High at IAP from 7 to 13, SI from 5 to 10, NP from 20 to 50%;
4. Extremely high at IAP over 14, SI>10, NP>50%.

For the estimation of atmosphere pollution in separate city districts or separate cities for the purpose of comparison and analysis, few identical substances having the highest concentration in the air are analyzed. Usually the index of atmosphere pollution is calculated based on 5 substances, which are five most harmful substances, present in mid air, or five substances with the highest exceed of MPC.

The results obtained are interpreted according to the following scale:

IAP5 < 2,5 - clean atmosphere;

2,5 - 7,5 – slightly polluted atmosphere;

7,5 - 12,5 - polluted atmosphere;

12,5 - 22,5 - strongly polluted atmosphere;

22,5 - 52,5 - extremely polluted atmosphere;

more than 52,5 - the extremely polluted atmosphere.

Calculations are done to establish the integral indices of air pollution level for each compound. The thresholds above aids the conclusion of the pollution status of each region.

2.4. Methods of statistical analysis

Linear Regression: This is a statistical method for expressing the relationship between variables. The dependent variable is a function of the slope and intercept between it (dependent) and independent variables. The dependent variables are always on the right side of the equation while the independent variables are on the right side. The combination of these presents a study with the opportunity to establish the extent of relationship between the dependent and independent variables. The relationship is thus expressed on terms of the value of the intercept © , slope (m), and the value of the Spearman Coefficient ®.

Generally, the equation for the relationship is written as:

$$Y=mX+C.$$

Where; Y= the dependent variable; X= the independent variable; C= intercept.

The statistical relationship table contains the following:

1. Slope.

2. Intercept.

3. R: Pearson correlation: The relationship between the independent variable X and dependent variable Y. The values lie between -1 and 1.

4. Multiple R-squared: This is the square of Pearson correlation.

R studio software was used to code and design the graphs and generate statistical results.

Correlation Coefficients: This was used to examine the relationship amongst pollutants and between pollutants and diseases. To investigate relationships between pollutants and diseases, the Pearson's coefficient was used as a tool for regression analysis.

Multi-Linear Regression Analysis: It is important to know the relationship between the dependent variables like Morbidity and the other independent variables (Population, Industrial pressure, etc.). A multi-linear regression model was generated only WHEN all or some of the independent variables show significant relationship with the dependent variables (morbidity and cancer cases). This relationship is then rated by the p-values, R and multiple R-squared values of each independent variable as it relates to the dependent variables.

2.5. Conclusion to Chapter

The methods that was used to analyze the results was discussed. Complex index of atmosphere pollution (IAP) was used to determine the level of pollution in the districts while linear regression was used to analyzed if a relationship exists between pollutants and morbidity and cancer cases. The next chapter discussed the city under investigation.

CHAPTER 3
CITY UNDER INVESTIGATION

3.1. Characteristics of city's environment condition

Ivano-Frankivsk is a city with significant industrial, economic and scientific potential, wide opportunities for the development of both internal and regional interregional interstate relations. The great prospects of the city are connected with the proximity of the Carpathians as unique region of tourism, recreation and recreation. The city has a developed transport network. Air, rail and road by transport the city is connected with all regional centers of Ukraine, the cities of Moldova, Belarus, Poland, Slovakia, the Czech Republic. Ivano-Frankivsk has a radial road system.

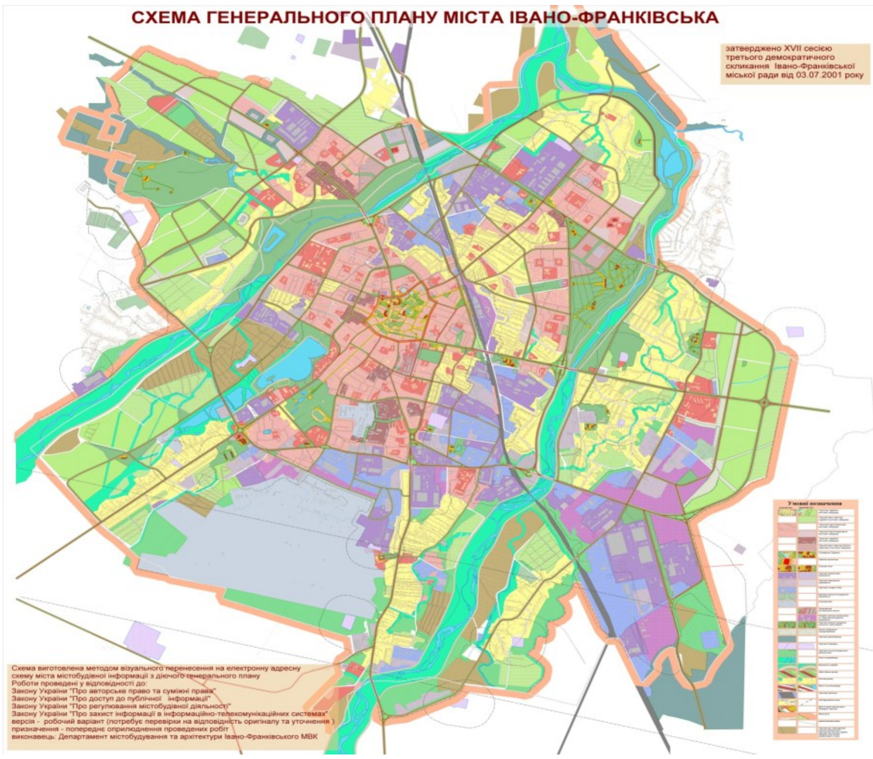

Fig. 3.1 – Major plan of the city of Ivano-Frankivsk

The city has an international airport, converging railways and highways. Industrial enterprises are located on the perimeter of the city, and socio-cultural institutions, administrative and banking institutions - in its central part. The city of Ivano-Frankivsk is characterized with high integrated indicator of anthropogenic loads on the environment. Production and economic activity in the city causes negative impacts on the environment and living conditions of the population.

The key environmental problems of the city are as follows:

1. Atmospheric air pollution by vehicle emissions;
2. Pollution of water bodies by discharges of pollutants with waste waters of industrial enterprises and housing and municipal services;
3. Low level of alternative energy sources development;
4. Unsatisfactory condition of the landfill;
5. Placement and disposal of solid waste;
6. Physical wear and tear of water supply networks;
7. Lack of solid waste processing enterprises;
8. Low level of implementation of energy efficient technologies;
9. Unsatisfactory sanitary condition of urban lakes;
10. High energy and resource consumption of production;
11. Low level of ecological culture among representatives of business and population;
12. Significant volumes of waste generation of the I-III hazard classes;
13. Unsatisfactory condition of sewerage networks and pumping stations;
14. Insufficient funding for the development of urban electric transport;
15. Insufficiency of levers of influence of local governments on management in the city.

The representatives of the local authorities with the assistance of the Partnership for Local Economic Development and Democratic Governance Project (PLEDDG), a 6-year technical assistance project implemented by the Federation of Canadian Municipalities (FCM) and financed by Global Affairs Canada, have developed the integrated SWOT-analysis of environment condition in the city (Table 3.1) (Звіт про стратегічну екологічну оцінку Стратегії розвитку міста Івано-Франківська на період до 2028 року, Івано-Франківськ, 2017).

Table 3.1

Strength and weakness of the city

Strength	Weakness
The city's proximity to Western Europe • Minimal risks of man-made and natural disasters • Availability of transport infrastructure for the Carpathian tourist hub • Positive demographic situation • Activity, creativity of the community • Established communication between the population and the government, open government • Diversified economy • Cooperation between business and government • Active development of small and medium business • Development of the city in the direction of European integration • Preservation of cultural and architectural heritage and national traditions • High educational potential • Favorable conditions for the development of high-tech production, IT industry • Active public organizations, including	Incomplete inventory of city council lands • Lack of updated city master plan • Unregulated urban development and insufficient green areas • Insufficient transport infrastructure (parking lots, bicycle and pedestrian zones, modern public transport) • Deterioration of public transport rolling stock • Lack of an efficient system of separate collection, sorting, processing and utilization of household waste • Lack of solid waste processing and sorting plant • Low level of environmental awareness of residents of the city and surrounding villages • Deterioration of underground communications • Low level of implementation of energy efficient technologies in municipal sector • Incomplete equipping of budget institutions and the city's housing stock with

those working in the field of environmental protection • Modern view of the city (houses, roads, infrastructure, parks, squares) • Proximity to the tourist attraction of Ukraine - the Carpathians • The City Sustainable Energy Development Program is being implemented	means of accounting and regulation of energy consumption • Insufficient quality of tourist products for different target groups of tourists
Opportunities	Threats
Further integration into the EU • Further implementation of reforms, in particular in terms of decentralization • Increasing the level of access to international financial resources • Modernization of production facilities at enterprises, introduction of the latest energy-saving ones into production technologies (state support and incentives) • Introduction of the use of alternative energy sources • Improving the level of environmental safety	• Political instability in Ukraine Presence of corruption in government • Inability to modernize the production capacity of enterprises due to lack of resources • Rising energy costs • Increasing the level of environmental and man-made disasters • Deterioration of the demographic situation, further "aging" of the population • Inhibiting the implementation of reforms in the medical, educational and social spheres

3.2. Atmospheric air pollution by vehicles

One of the main environmental problems of Ivano-Frankivsk is air pollution by vehicles (about 96% of all emissions in the city). Most pollutants come from trucks (69%) and passenger cars (19%). In 2014, in Ivano-Frankivsk, the structure of pollutant emissions from mobile sources was dominated by carbon monoxide - 8366.7 tons (71.4%). Mobile sources also discharged: nitrogen compounds - 1633.1

tons (14%), non-methane volatile compounds - 1213.3 tons (10.4%), soot - 279.3 tons, sulfur dioxide - 194.1 tons, methane - 35.6 t.
The problem of air pollution by vehicle emissions primarily affects the central part of the city, which includes the historic center, which preserves the radial planning structure and is a densely built-up area, difficult to reconstruct given the massiveness of housing and public buildings. In the central part of the city there are significant difficulties associated with the organization of traffic. The capacity of the street network does not correspond to the intensity of traffic flows and, in addition, cannot withstand the load of transit flows going through the city center. These features of the central part of the city lead to a significant excess of permissible levels of pollutants in the air.
Weather conditions affect air pollution, especially dust and carbon monoxide. In the absence of precipitation and at high temperatures, the concentration of these substances in the air increases significantly.

3.3. Water use

Two water intakes are used for water supply in Ivano-Frankivsk: Nadvirnyanky - in the village of Berezivka on the river Bystrytsia Nadvirnyanska (capacity about 50 thousand m_3 / day) and Solotvynsky - in the village Skobychivka on the river Bystrytsia Solotvynska (capacity 40 thousand m_3 / day). The total productivity of both water intakes is 90.0 thousand m_3 / day (32.85 million m_3 / year). In 2018, 21.7 million m_3 of water was taken away, including 19.0 million m_3 (88.6%) from the Bystrytsia Nadvirnyanska River. From the water intakes, water is supplied to the Chernivtsi complex of water treatment facilities for treatment and disinfection.
According to the ecological classification of water in the rivers Bystrytsia Solotvynska and Bystrytsia Nadvirnyanska there are II class of quality, 2 categories, according to the condition - "good", according to the degree of purity - "clean". The

dynamics of water intake in the city in 2013-2018 indicates a decrease in water intake. Compared to 2010, water intake decreased by almost 32%.

Physical wear and tear and failure of water supply networks, lack of funds to maintain them in good condition and construction of new ones are the cause of significant water losses during its transportation. In 2018, water losses amounted to 8.7 million m_3 (40.1%).

Sewage volumes in 2018 decreased by 23% compared to 2015. This is due to the reduction of water consumption for production (industrial) needs. The share of polluted return water in 2018 was 27.3% of the total volume of wastewater.

Contaminated wastewater generated in the city is treated at the Ivano-Frankivsk aeration station (treatment plant), located in the village Yamnytsia on the left bank of the Bystritsa river. The capacity of treatment facilities is 145 thousand m_3 / day (53.1 million m_3 / year). A network of sewers and sewers has been built to supply wastewater to treatment facilities pumping stations. Most sewers were built in 1920-1939, are in disrepair and need to be replaced. There are unsewered streets and settlements on the territory of Ivano-Frankivsk City Council. Therefore, an important task is the reconstruction of existing and construction of new sewerage networks.

3.4. Waste

In 2017, significant amount of wastes (1,948.8 t) were generated in Ivano-Frankivsk, with 76.5% of all generated waste coming from households and 23.4% - from economic activity of enterprises and organizations. Of the total amount of waste generated, 138.7 thousand tons were wastes of hazard class IV and 39.8 tons were wastes of hazard class I-III [83].

In the structure of generated waste, other wastes predominate in terms of hazardous components (118.8 thousand tons, or 85.7%). Waste from industrial and municipal wastewater treatment accounted for 10.9%. The total amount of accumulated waste is growing, but in recent years the growth rate has decreased.

The MSW of the city are collected without segregation and sent to the landfill. The landfill is located in the Rybne tract, Tysmenytsia district of Ivano-Frankivsk region. The distance to the nearest landfill settlement (Rybne village) is 3.2 km. Landfill area - 20.8 hectares, design capacity - 8.3 million m_3. The landfill has been operated since 1992. Anually, approximately 500,000 m_3 of waste are accepted at the landfill, including 60,000 m_3 from outside the city of Ivano-Frankivsk. During the year, the landfill accumulates approximately 20 thousand m_3 of filtrate, which contains highly toxic substances. The landfill area is mainly used, so the landfill needs to be expanded, and the completed working maps for storage need to be reclaimed.

3.5 Green infrastructure and protected areas and objects

The total area of greenery on the territory of Ivano-Frankivsk is 1140 hectares. Area of green plantations (coverage of crown projections) in the city districts is as follows: Central part - 545 ha, Pasichna - 87 ha, Positron - 194 ha, Uhornyky - 29 ha, Mykytyntsi - 59 ha, Khryplyn - 64 ha, Opryshivtsi - 66 ha, Krykhivtsi - 96 hectares.

The total area of green facilities of the city (except for parks) is 161.1 hectares, of which 29.8 hectares - greenery along the roads, 131.3 hectares - greenery on adjacent territories. The area of the boundaries of the plots of existing green landscaping facilities is 155.1 hectares. Care for 43.5 hectares of greenery (public gardens - 14.86 ha, street plantings - 28.64 ha) is carried out by PJSC "Green Economy".

Ivano-Frankivsk has a large number of parks and squares for recreation, including the Park of Culture and Recreation. Shevchenko (in the past - Princess Elzhbeta Park); Warriors-Internationalists Park (formerly Pionersky, Vasilianok Street); Park on Molodizhna (Molodizhna Street); Memorial Square (in the past - the city cemetery, the so-called Stanislavivsky necropolis, Stepana Bandera Street); Square of Glory (Lepkoho Street); Privokzalny Square (Privokzalna Square).

On the territory of Ivano-Frankivsk City Council there are 8 territories and objects of the nature reserve fund with a total area of 64.46 hectares, including 1 of national importance (Druzhba Arboretum) and 7 of local significance.

3.6. Level of air pollution

For the purpose of the work it is necessary to evaluate the level of air pollution within the city. This was done using the data of the State Environment Monitoring system at the territory of the city for 29 points within the urban districts of Railway, Cascade, South, Old city, Apiary, Central (Table 3.2). The air pollution with CO, PM10, Pb, and Phenol was evaluated and compared with hygienic characteristics (Table 3.3).

Table 3.2

Air pollution parameters

Point number	**Urban district**	**Medical district**	**CO, mg/m3**	**PM10, mg/m3**	**Pb, mg/m3**	**Phenol, mg/m3**
1	Railway	5	2.3	0.45	0.0009	0.004
2	Old city	3	2.1	0.63	0.0007	0.01
3	Central	2	1.3	0.29	0.0004	0.008
4	Central	2	2.8	0.37	0.0008	0.003
5	Apiary	4	2.9	0.54	0.0011	0.009
6	Cascade	11	1.3	0.21	0.0008	0.002
7	South	6	0.5	0.11	0.0002	0.0008
8	Cascade	11	3.4	0.69	0.0014	0.008
9	Railway	5	0.4	0.08	0.0001	0.0005

10	Central	1	0.7	0.59	0.0012	0.015
11	Railway	5	0.7	0.07	0.0003	0.0004
12	Railway	5	4.8	0.69	0.0015	0.009
13	South	9	3.5	0.58	0.0013	0.012
14	Central	2	3.1	1.23	0.0011	0.014
15	Railway	1	4.6	1.54	0.0016	0.017
16	Cascade	1	2.1	0.96	0.001	0.008
17	Central	2	1.5	0.64	0.0009	0.009
18	Cascade	1	1.5	0.38	0.0004	0.008
19	South	7	2.5	0.54	0.001	0.008
20	Old city	3	3.5	0.75	0.0011	0.007
21	Old city	3	1.2	0.25	0.0006	0.0009
22	Apiary	10	1	0.31	0.0007	0.005
23	South	9	2.8	0.54	0.0008	0.008
24	South	9	4.1	0.85	0.0014	0.014
25	Apiary	10	3.5	0.95	0.0012	0.017
26	South	7	3.6	0.54	0.001	0.011
27	Central	2	2.9	1.12	0.001	0.008
28	Apiary	4	2.4	0.57	0.0008	0.007
29	Central	2	1.3	0.34	0.0004	0.0015

Table 3.3

Hygienic parameter of pollutants

Parameters	CO, mg/m3	PM10, mg/m3	Pb, mg/m3	Phenol, mg/m3
Permissible concentrations of pollutants	5	0.5	0.001	0.01
Hazard class	4	3	1	2
Effect index	0.86	1	2.4	1.3

Using the approaches to the integrated assessment of air pollution presented in Section 2 the Index of air pollution was calculated (Table 3.4).

Table 3.4

Index of atmosphere pollution

Number of point	IAP (CO)	IAP (PM10)	IAP (Pb)	IAP (Phenol)	IAP Total	Gradation
1	0.51	0.9	0.77	0.3	0.51+0.9+0.77+0.3= 2.48	clean
2	0.5	1.26	0.42	1.0	0.5+1.36+0.42+1.0=3.18	Slightly Polluted
3	0.3	0.58	0.11	0.74	0.3+0.58+0.11+0.74=1.73	Clean
4	0.7	0.74	0.58	0.21	0.7+0.74+0.58+0.21=2.23	Clean
5	0.7	1.08	1.25	0.87	0.7+1.08+1.25+0.87=3.9	Slightly Polluted
6	0.3	0.42	0.58	0.12	0.3+0.42+0.58+0.23=1.42	Clean
7	0.1	0.22	0.021	0.037	0.1+0.22+0.021+0.037=0.378	Clean
8	0.81	1.38	2.24	0.74	0.81+1.38+2.24+0.74=5.17	Slightly Polluted
9	0.10	0.16	0.003	0.02	0.10+0.16+0.003+0.02=0.283	Clean
10	0.18	1.18	1.54	1.69	0.18+1.18+1.54+1.69=4.59	Slightly Polluted
11	0.18	0.14	0.055	0.015	0.18+0.14+0.055+0.015=0.39	Clean
12	1.22	1.38	2.64	0.87	1.22+1.38+2.64+0.87=6.11	Slightly Polluted
13	0.89	1.16	1.87	1.26	0.89+1.16+1.87+1.26=5.18	Slightly Polluted
14	0.78	2.46	1.25	1.54	0.78+2.46+1.25+1.54=6.03	Slightly Polluted
15	1.71	3.08	3.08	1.99	1.71+3.08+3.08+1.99=9.86	Polluted
16	0.5	1.92	1	0.74	0.5+1.92+1+0.74=4.16	Slightly

						Polluted
17	0.38	1.28	0.77	0.87	0.38+1.28+0.77+0.87=3.3	Slightly Polluted
18	0.38	0.76	0.11	0.74	0.38+0.76+0.11+0.74=1.99	Clean
19	0.63	1.08	1	0.74	0.63+1.08+1+0.74=3.45	Slightly Polluted
20	0.89	1.5	1.25	0.62	0.89+1.5+1.25+0.62=4.26	Slightly Polluted
21	0.31	0.5	0.29	0.043	0.32+0.5+0.29+0.044=1.143	Clean
22	0.25	0.62	0.42	0.5	0.25+0.62+0.42+0.5=1.79	Clean
23	0.71	1.08	0.58	0.74	0.71+1.08+0.58+0.74=3.11	Slightly Polluted
24	1.04	1.7	0.24	1.54	1.04+1.7+0.24+1.54=4.52	Slightly Polluted
25	0.89	1.9	1.54	1.99	0.89+1.9+1.54+1.99=6.28	Slightly Polluted
26	0.91	1.08	1	1.13	0.91+1.08+1+1.13=4.12	Slightly Polluted
27	0.74	2.24	1	0.74	0.74+2.34+1+0.74=4.72	Slightly Polluted
28	0.6	1.14	0.58	0.62	0.6+1.14+0.58+0.62=2.94	Slightly Polluted
29	0.33	0.68	0.11	0.084	0.33+0.68+0.11+0.084=1.204	Clean

The analysis of spatial distribution of air pollution shows that the urban district with the highest level of pollution is the railway district with lead and PM10 being the highest pollutants in the district, apiary district followed railway district closely as the second highest polluted district with PM10 also as the highest pollutant. Old city district has the lowest level of pollution out of all the urban districts while central and south district are slightly polluted.

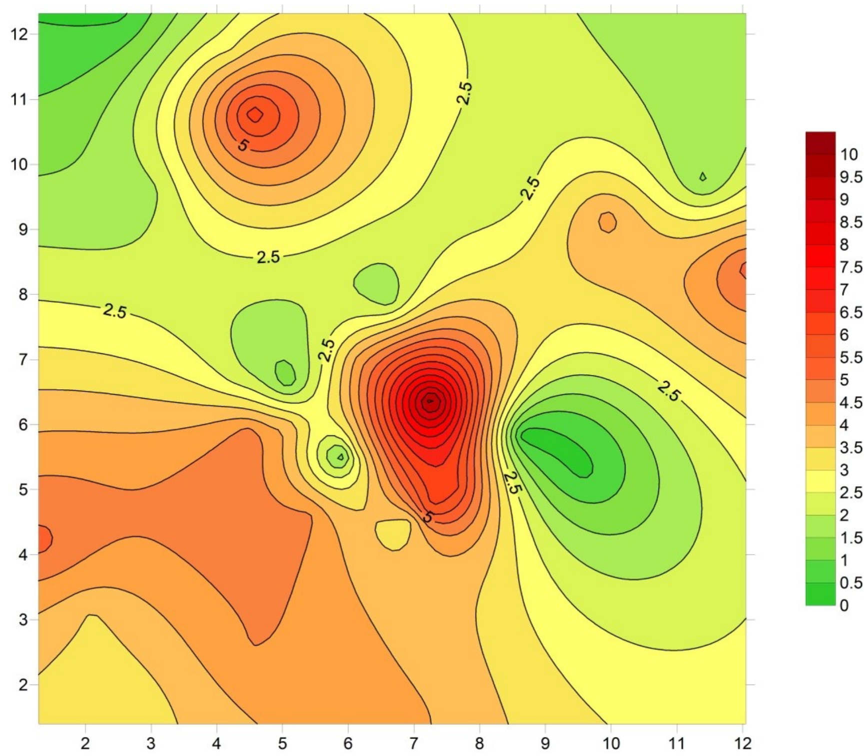

Fig. 3.1 – Distribution of air pollution levels (IAP) at the territory of the city

3.7. Conclusion to Chapter

In this chapter, the city under investigation was analyzed. The characteristic of its natural condition, sources of technogenic pressure and level of environmental pollution was described. The main sources of technogenic pollution in Ivano-Frankivsk include: insufficiently treated wastewaters, solid technogenic wastes, and emissions of harmful substances into the atmosphere, which are mostly generated at industrial companies and as a result of their production and livelihood of employees. This have a significant impact onto the health of the local population, biodiversity, and environmental safety of the city.

CHAPTER 4

4.1. The analysis of interactions between morbidity and air pollution

Using the data about the pollution of air within the city of Ivano-Frankivsk (Table 3.4), the averaged values of IAP were calculated, as well as the mean data about content of individual pollutants (Table 4.1 and 4.2).

Table 4.1

IAP Average by district

District	IAP Average
Railway	19.95
Central	14.25
Cascade	24.9
Old city	33.25
Apiary	24.9
South	16.62

Table 4.2

Average data of pollutants concentration by district

Urban District	CO Mg/m3	PM10 Mg/m3	Pb Mg/m3	Phenol Mg/m3
Railway	0.512	1.132	0.88	0.618
Cascade	0.415	1.2	0.9	0.65
South	0.566	1.04	0.95	0.089
Old City	0.452	1.08	0.8	1.2
Apiary	0.49	1.18	0.95	0.95
Central	0.388	1.3	0.8	0.8

To analyze the dependencies the data on morbidity were obtained from the department of medical statistics of the Municipal Non-Profit Medical Enterprise (Table 4.3) and attributed to the demographic characteristics of urban districts

(Table 4.4). Additionally the data on the level of industrial pressure by districts were collected and averaged for urban districts (Table 4.5)

Table 4.3

Morbidity

Urban district	Children morbidity (incidence per 1000 children)	Cancer cases (incidence per 1000 children)
Railway	1234	5.8
Cascade	1167	4.5
South	1389	6.5
Old city	984	3.8
Apiary	1121	4.8
Central	1013	4.3

Table 4.4

Data about the city

Urban district	Industrial pressure	Number of population
Railway	3	40733
Cascade	2	61417
South	3	78633
Old city	1	41583
Apiary	2	63200
Central	1	29317

Table 4.5

Average Morbidity and industrial pressure by district.

Urban district	Average morbidity	Industrial pressure	Average cancer
Railway	308.5	0.75	1.16
Cascade	291.75	0.5	1.125
South	231.5	0.5	1.08
Old city	328	0.3	1.26
Apiary	280.25	0.5	1.2
Central	144.71	0.14	0.61

Table 4.6

Correlation Analysis of IAP average with morbidity and cancer cases

R Morbidity	R cancer cases
0.16	0.10

Table 4.7

Correlation Analysis of industrial pressure average with morbidity and cancer cases

R Morbidity	R cancer cases
0.67	0.64

The methods of regression and correlation analysis were applied to analyze the dependencies between pollutants average and morbidity/cancer cases, IAP average and morbidity /cancer cases, average industrial pressure and morbidity/cancer cases.
The results for pollutant average and morbidity/ cancer cases are given in figures 4.1 to 4.8. The result for IAP average and morbidity/cancer cases has given R values 0.16 and 0.1 correspondingly, while the relation to the average industrial pressure is much stronger and reaches 0.67 for general morbidity and 0.64 for cancer cases (Fig. 4.9-4.12).
The aggregated results of the analysis (Table 4.6) demonstrate that the factor of the highest importance for the health status of the Ivano-Frankivsk population is CO content.

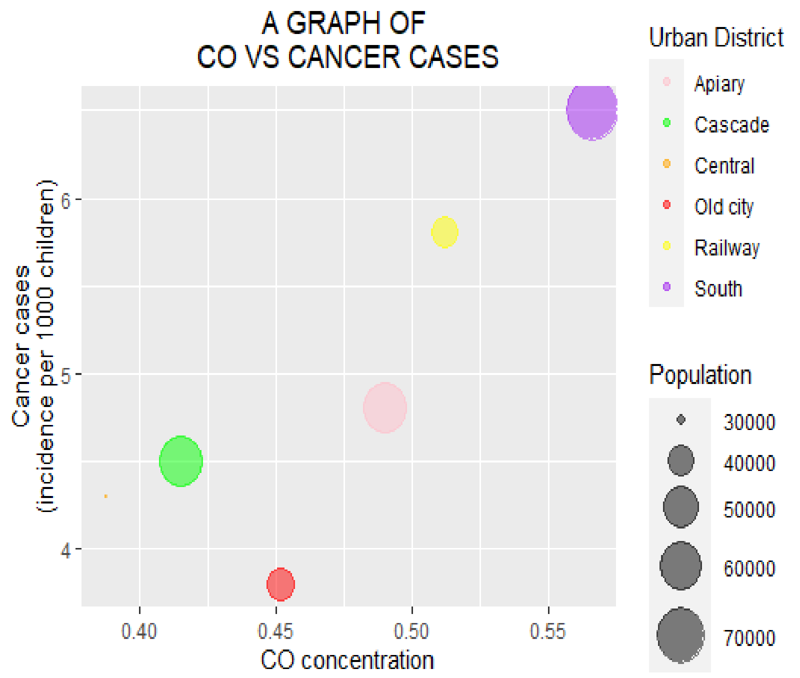

Fig. 4.1. A graph of CO concentration against Cancer cases (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant.

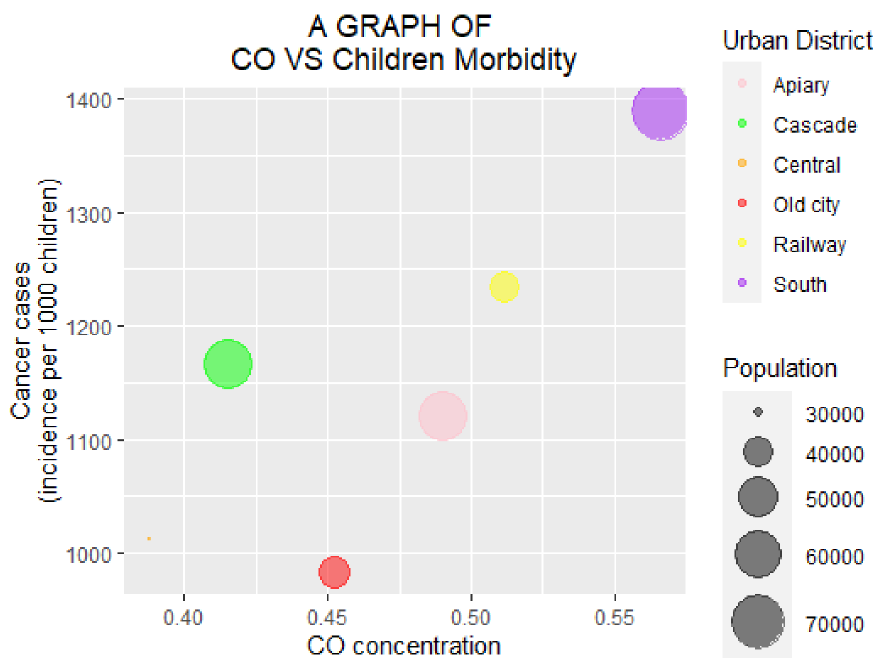

Fig. 4.2. A graph of CO concentration against Morbidity (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant.

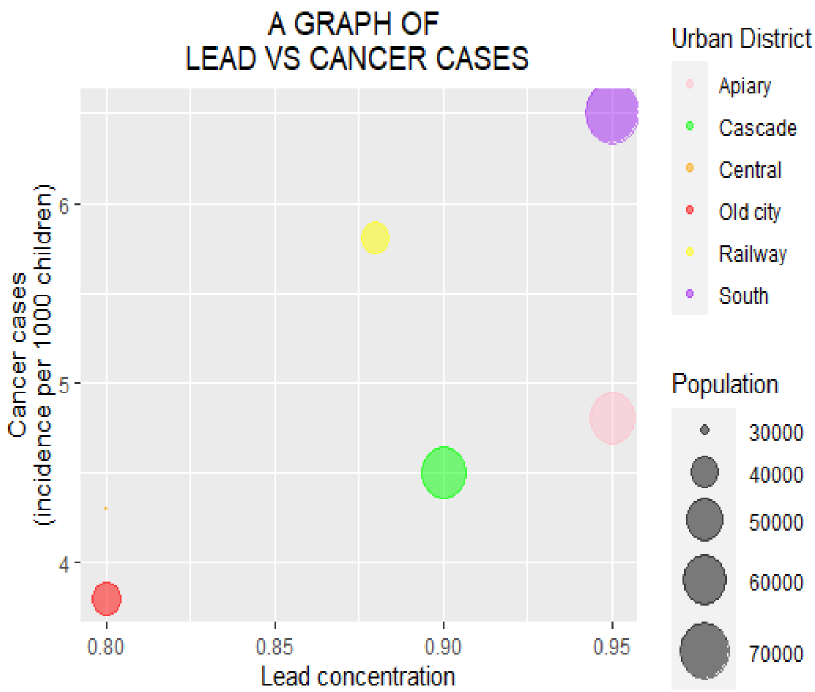

Fig. 4.3. A graph of Lead concentration against Cancer Cases (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

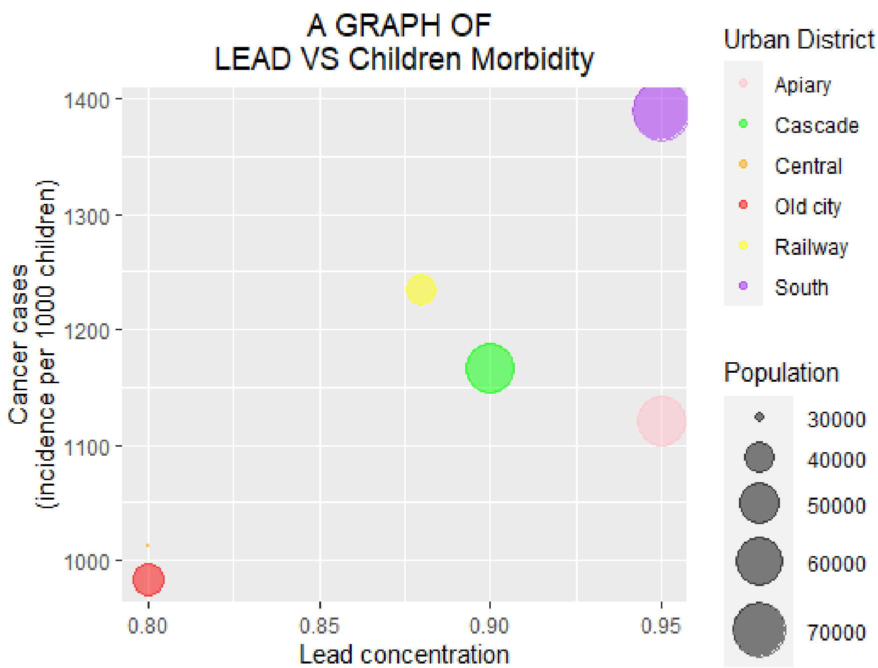

Fig. 4.4. A graph of Lead concentration against Morbidity (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

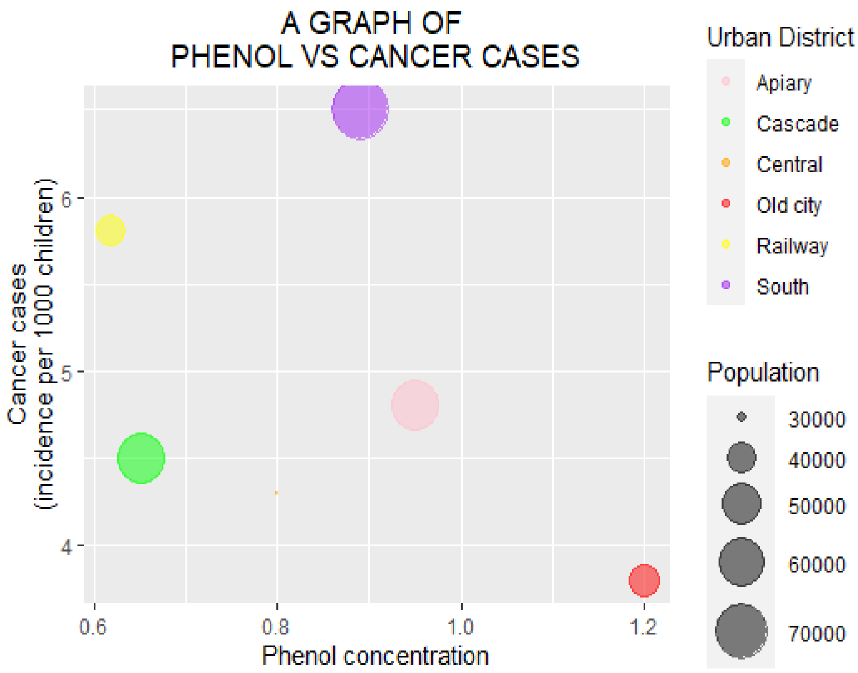

Fig. 4.5. A graph of Phenol concentration against Cancer Cases (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

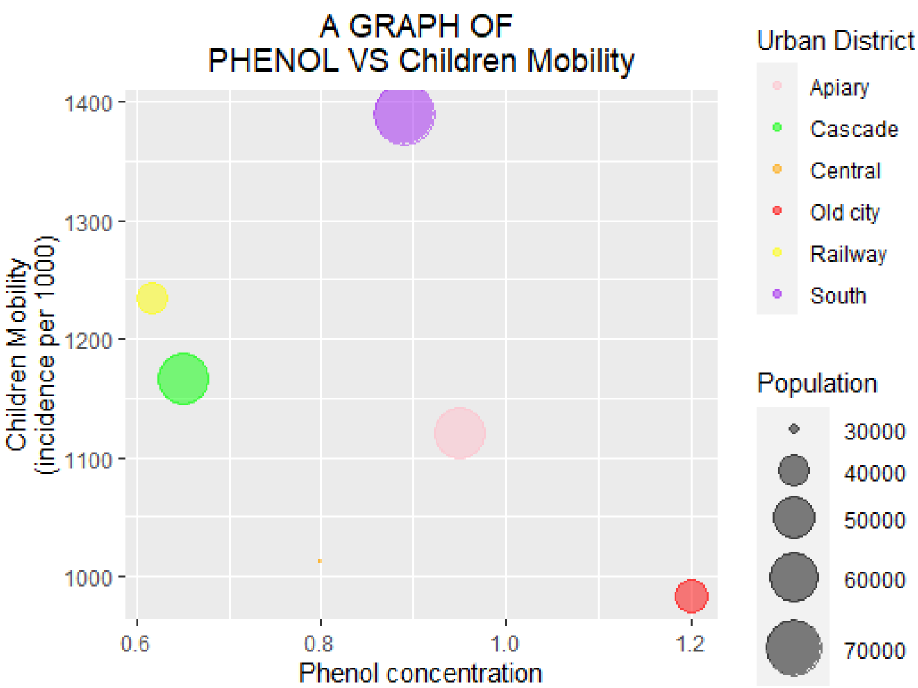

Fig. 4.6. A graph of Phenol concentration against Morbidity (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

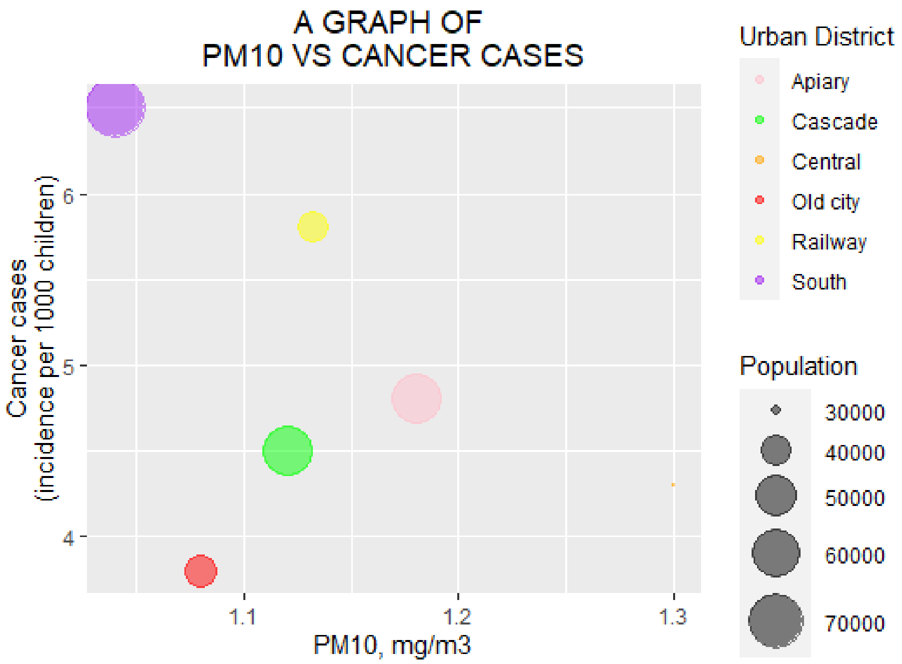

Fig. 4.7. A graph of PM10 concentration against Cancer Cases (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

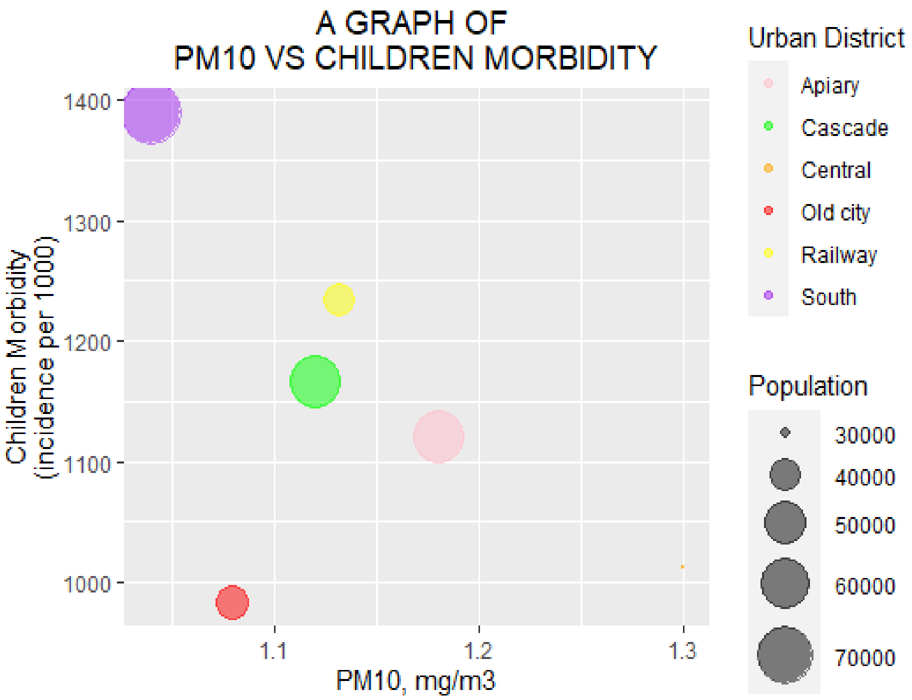

Fig. 4.8. A graph of PM10 concentration against Morbidity (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

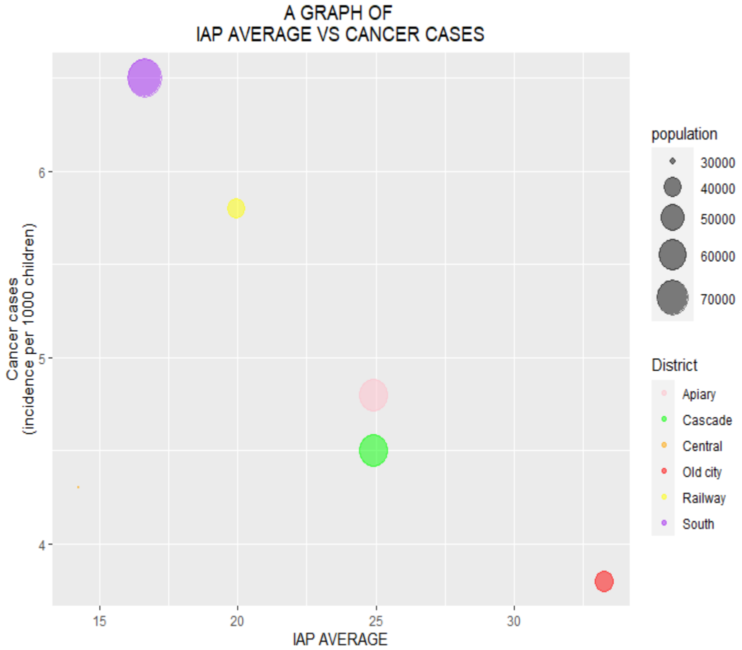

Fig. 4.9. A graph of IAP average against Cancer cases (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

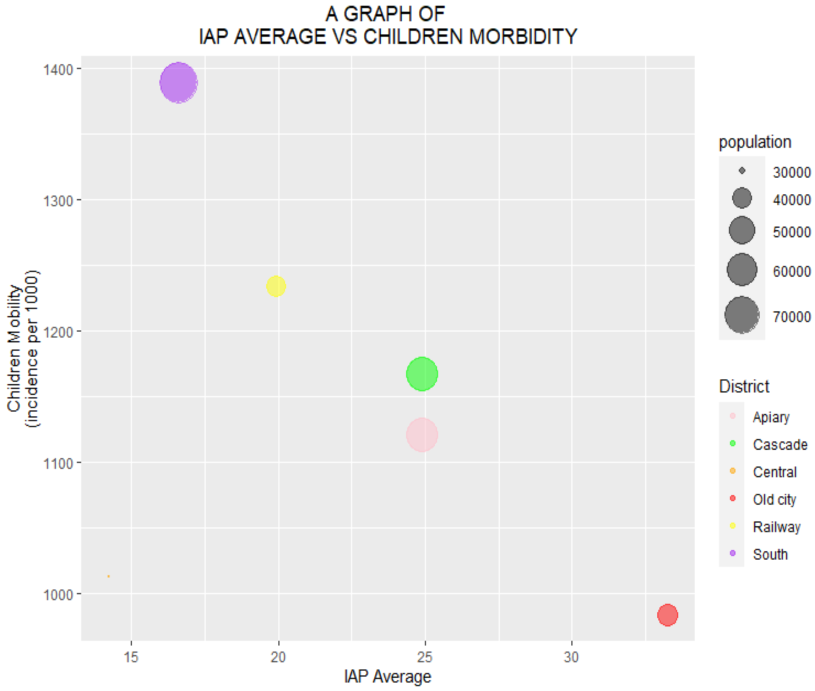

Fig. 4.10. A graph of IAP average against Morbidity (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

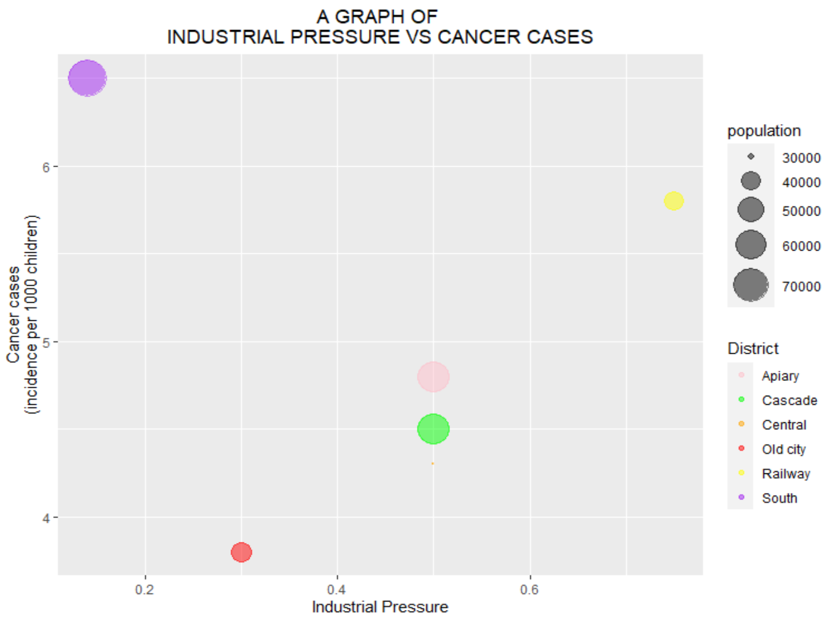

Fig. 4.11. A graph of industrial pressure average against Cancer cases (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

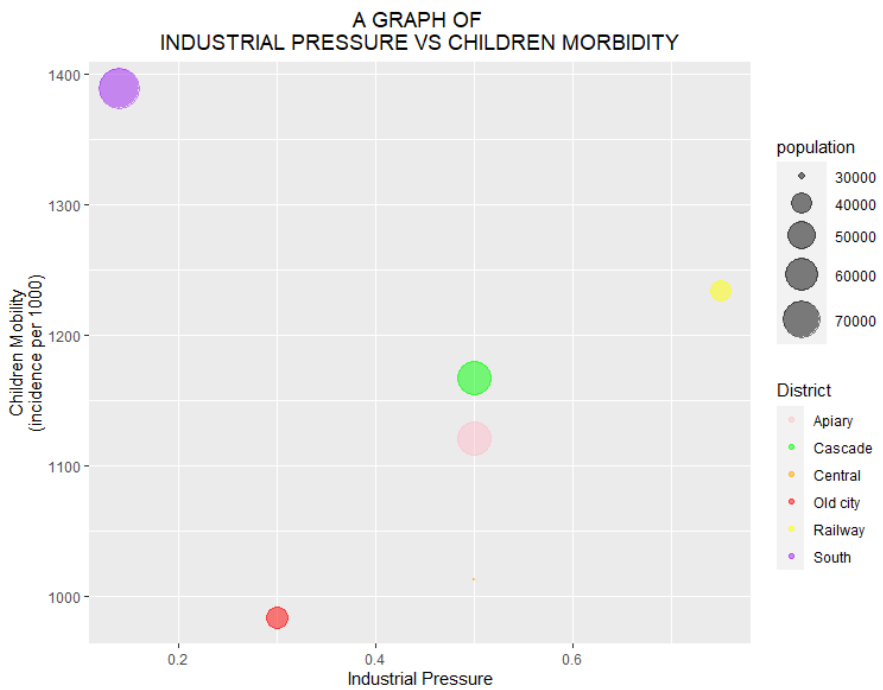

Fig. 4.12. A graph of industrial pressure average against Morbidity (per 1000 persons). The bigger the bubble, the larger the population of the district inhabitant

Table 4.11

The statistical relationship between pollutants and health cases (Cancer and Morbidity)

	Slope (Morbidity)	Slope (Cancer Cases)	Intercept (Morbidity)	Intercept (Cancer Cases)	R (Morbidity)	R(Cancer Cases)	R Squared (Morbidity)	R Squared (Cancer Cases)
CO	0.0003	0.05	0.066	0.198	0.800	0.847	0.55	0.64
Pb	0.000351	0.045	0.47	0.65	0.77	0.68	0.50	0.32
PM10	-0.00034	-0.038	1.53	1.33	-0.56	-0.422	-0.31	-0.178
Phenol	-0.00060	-0.084	1.54	1.26	-0.42	-0.39	-0.177	-0.15
IAP	-0.02	-3.87	4.605	4.14	0.16	0.10	0.02	0.01
Industrial Pressure	-0.02	-3.88	4.6	4.15	0.67	0.64	0.445	0.43

4.2. The analysis of relationship between human health and air pollution

The pollutants analyzed are Carbon monoxide, PM10, Lead and Phenol. Each of their concentration were calculated to determine their complex index of atmosphere pollution and then their sum was used to grade the level of pollution in a particular district using Ukraine's standard on air pollution assessment. The result showed that Carbon monoxide's concentration was steadily lower compared to other pollutants. PM10 and lead had consistently high concentration among the pollutants as shown from the IAP results while phenol's concentration alternated between high and low.

Further analysis was done by calculating the pollutants average concentration by district and ruining it in the R studio open source software for their correlation coefficient with the health data. The results showed positive correlation for carbon monoxide when it was plotted against health data (morbidity (R=0.8) and cancer cases (R=0.85). PM10 showed no dependence on the health data (R = -0.56) when plotted against children morbidity and (R = -0.42) when plotted against cancer cases. Another pollutant that showed a positive correlation with health data is lead (R= 0.68 for cancer cases and R = 0.77 for morbidity). Phenol also showed no dependence on the health data (R = -0.42) when plotted against children morbidity and (R = -0.39) when plotted against data cancer cases.

Additionally, correlation analysis was carried out between IAP average by district with cancer cases and morbidity and the results showed no dependence (R = 0.16 for morbidity) and (R = 0.10 for cancer cases). Also, correlation analysis was carried out between industrial pressure average with cancer cases and morbidity and the result showed a positive correlation with both cancer cases and morbidity (R = 0.67 for morbidity) and (R = 0.64 for cancer cases).

Industrial pressure, Lead and Carbon monoxide showed a positive correlation with cancer cases and morbidity which can mean that they influence the health of the population, while they may not be the primary cause of morbidity in Ivano-Frankvisk, they can be part of the contributing factors. Moreover, lead has been indicated to cause neurological effects in children. Railway district maintained the highest pollution levels when classified as urban or medical district.

4.3.Conclusion to Section

The results from the correlation analysis showed a positive correlation between industrial pressure, lead and carbon monoxide with morbidity and cancer cases. In order to mitigate the possible health risks it is necessary to run continuous air monitoring and account the threats from sub-threshold pollution. The levels of air pollution with phenol and PM10 should be analyzed against other diseases such as respiratory diseases, chronic obstructive pulmonary diseases, cardiovascular diseases etc.

CHAPTER 5
LABOR PRECAUTION

5.1. Analysis of harmful and dangerous production factors

According to the theme of my diploma project "The Assessment of health risks for the population of Ivano-Frankivsk due to air pollution' The workplace of an environmental manager in an oil refinery and the entire refinery is chosen to be analyzed with focus on the pollutants that may be lingering in the workplace.
The duties of an environmental manager include:

- Develops and implements environmental strategies, policies, practices and action plans to ensure corporate sustainable development.
- Managing the development and implementation of environmental management systems within organisations by identifying, solving and alleviating environmental issues, such as pollution and waste treatment, in compliance with environmental legislation and to ensure corporate sustainable development.
- Co-ordinates all aspects of pollution control, waste management, recycling, environmental health, conservation and renewable energy to ensure compliance with environmental legislation.
- Audits, analyses and reports environmental performance to internal and external clients and regulatory bodies.
- Carries out impact assessments to identify, assess and reduce an organisation's environmental risks and financial costs.
- Promotes, raises awareness and trains staff at all levels on environmental issues and responsibilities.
- Negotiates environmental service agreements and manages associated costs and revenues.

In the process of performing work, the environmental manager may be affected by the following hazardous and harmful production factors according to standard ГОСТ 12.0.003-74 "Occupational safety standards system. Dangerous and harmful production effects. Classification":

1. Factors which belong to physical harmful factor

- Burns
- Asphyxiation
- Increased noise level
- Insufficient illumination of the working area.
- Explosions
- Headaches

2. Factors which belong to chemical harmful factor

- Exposure to gas
- Exposure to pollutants
- Exposure to toxic chemicals
- Health disorders resulting from exposures

3. Factors which belong to psychophysiological factor:

- Anxiety
- Mood disorders
- Increased nervous stress
- Psycho-emotional stress, overwork
- Insomnia
- Fatigue

5.2. Measures to reduce the impact of harmful and dangerous production factors.

Clean indoor and outdoor air, absence of or reduced levels of pollutants are required in a workplace to maintain good health of the employees.

Air quality index (AQI) is used by different governments to explain to the public how polluted the air currently is or how polluted it is projected to become. Public health risks increase as the AQI rises. Different countries have their own air quality indices, corresponding to different national air quality standards. They are different in terms of determination methods and consideration period. However, in air, consideration periods are represented in the following standards:

Maximal One Time: concentration which doesn't cause irritating reactions in human after twenty minutes of exposure

Daily Concentration: concentration which doesn't cause negative human health changes during life time exposure.

Working Area Concentration: concentration which is safe during eight hours a day, forty-one hours a week exposure for twenty years

To determine if air is indeed polluted, the complex index of atmosphere pollution

$$IAP = \left(\frac{C_i}{MPC_i}\right)^{K_i},$$

(IAP) is calculated as :

Where: Ci - average concentration of i substance; mg/m³; MPCi - average daily maximum possible concentration of i substance; Ki - dimensionless constant to account the toxicity of substance (Table 1) as compared with SO2.

Table 5.1

Average value of constant K

Hazard class	Description of class	Constant
1	extraordinarily dangerous	2,4
2	highly dangerous	1,3
3	medium dangerous	1,0
4	low dangerous	0,85

The results obtained are then interpreted according to the following scale:

IAP5 < 2,5 - clean atmosphere;

2,5 - 7,5 – slightly polluted atmosphere;

7,5 - 12,5 - polluted atmosphere;

12,5 - 22,5 - strongly polluted atmosphere;

22,5 - 52,5 - extremely polluted atmosphere;

more than 52,5 - the extremely polluted atmosphere.

A lot of time, outdoor air quality affects indoor air quality so some places outside and indoors in the refinery is usually analyzed.

Table 5.2

Pollutants Concentration

	SO2	NO2	PM10	CO	O3
MPCdaily	0.05	0.02	25	5	0.03
Hazard level	3(1.0)	3(1.0)	4(0.85)	2(1.3)	1(2.4)
Control room	0.06	0.039	17	1.7	0.049
Entrance	0.06	0.048	16	1.6	0.031
Env. Manager office	0.02	0.019	7	0.8	0.019
Cafeteria	0.5	0.045	19	1.3	0.022
Car park	0.06	0.049	26	1,6	0.051
Open field (30m to the refinery)	0.6	0.051	45	4.8	0.051

Table 5.3

Gradiation of pollution

	IAP(SO2)	IAP(NO2)	IAP(PM10)	IAP(CO)	IAP(O3)	TOTAL	GRADIATION
C. Room	1.2	1.95	0.72	0.24	3.24	7.35	Slightly Polluted
Entrance	1.2	2.4	0.68	0.22	1.08	5.58	Slightly Polluted
Env. Manager office	0.3	0.95	0.33	0.09	0.33	2.0	Clean
Cafeteria	8.3	2.35	0.79	0.17	0.47	12.08	Polluted
Car park	1	2.45	1.03	0.22	3.57	8.27	Slightly Polluted
Open field	10	2.55	1.64	0.94	3.57	18.7	Strongly Polluted

Essentially, it is important for refineries to have established goals related to air quality and pollution which include:

- Establish an acceptable level of pollutant in air that will not harm employees health.
- Determining how much emission reductions are required.
- Evaluating air pollution constantly to be able to immediately flag when there's an abnormal level of pollutant outside and inside the refinery.
- Develop control strategies for pollution prevention.
- Undergo on-going evaluation to determine if air quality goals are being met.

5.3. Occupational Safety Instructions

5.3.1. *General Safety Requirements.*

- The refinery should be big and spacious to allow employees move safely and unhindered.
- It should have the right ventilation and building care.

- It should be well illuminated.
- Standard safety Instructions should be displayed where it can be easily seen.
- All Employees should be trained on operational hazards
- Procedures for the management of change in operations, process hazard analysis, maintenance of mechanical integrity, pre-start review, hot work permits, safe systems of work and other essential aspects of process safety should be easily accessible.
- Safe Transportation Management System should be maintained
- Procedures for handling, transportation, and storage of hazardous materials should be made known to employees
- Short breaks are necessary to avoid sedentary lifestyle.
- Operating instructions and emergency response procedures should be developed.
- Effective preventive maintenance routines and examination of the mechanical integrity of the process equipment.
- Hazard analysis studies to review the process chemistry and engineering practices, including thermodynamics and kinetics.
- Physical hazard testing of materials and reaction.
- Work should be stopped when deemed unsafe.
- There should be emergency exit routes

Prevention against Emissions

- Combustion air preheaters should be installed.
- Optimization of furnace operations.
- Prevention of the condensation of exhaust gas on surfaces.
- Minimization of power requirements by use of high-efficiency pumps, fans, and other equipment.
- High – thermal – efficiency heater designs with good control systems.

Control Measures Against Gas Flaring

- Implementation of source gas reduction measures to the maximum extent possible.
- Using efficient flare tips.
- Using a reliable pilot auto-ignition system.
- Implementing burner maintenance planning and replacement programs to ensure continuous maximum flare efficiency;

Wastewater Management

- Prevention and control of accidental releases of liquids through regular inspections.
- Provision of sufficient capacity for storing process fluids to enable maximum recovery into the process.
- Design and construction of wastewater and hazardous materials storage containment basins

Management of hazardous wastes

- It should be ensured that excessive cracking is avoided to prevent production of an unstable fuel oil.
- Recovery of oil from oily wastewaters and sludges should be maximized.

Prevention of Fires and explosions

- Designing, constructing, and operating petroleum refineries according to international standards.
- Provision of early warning systems, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires.
- Potential for vapor accumulation in storage tanks and implementation of prevention and control techniques should be evaluated.
- Potential sources of ignition should be avoided.

5.3.2. Safety Requirements before starting work

- Implement work permit when required.
- Implement electrical safety procedures
- Implement confined space procedures.
- Know where all emergency exits are situated.
- Follow rigging and lifting procedures.
- Know the location of fire extinguishers.
- Wear full personal protective equipment when working

5.3.3. Safety Requirements during operation

- Full personal protective equipment should be worn.
- Prevent leakages and spills.
- Dispose waste according to instructions
- Work consistently and systematically
- Move tools in tool bags and avoid littering.
- Prevent ignition and explosions.

5.4. Conclusion to Chapter

Guidelines for environmental, health and safety of petroleum refining was followed. Air quality index was according to Ukraine's air quality index.

CONCLUSIONS

Air pollution is a serious threat to the environment and the resulting health effects on humans can be fatal. This study analyzed the relationship between air pollutants and ailments. The results are formulated as follows:

1) The impacts of air pollution on human health are proved and studied in a variety of research works. The intensity of air pollution seems to be one of the major factors reducing quality of life at urban areas around the world independent from the level of economic development. The exact interaction between specific air pollution at any given city and population's morbidity is of high importance for the reduction of human health risks and prevention of disease burden growth.

2) Ivano-Frankivsk is a city with well developed infrastructure; it is densely populated and faces a range of environmental problems due to excessive traffic and industrial pressure. The major issues are air pollution and poor waste management.

3) The level of pollution in Ivano-Frankvisk was evaluated in integrated form by the air quality index. It has showed that most of the territory is slightly polluted, while the central part of the city affected by the most intensive traffic and railway station has the polluted status.

4) To determine the relationship between air pollutants and ailments, correlation analysis was carried out. The results of level of pollution analysis showed the Railway district as the most polluted with PM10 and lead as the highest pollutant. It also showed the Old city district is the less polluted. Carbon monoxide concentration was relatively low in all districts.

5) The results from the correlation analysis showed a positive correlation between industrial pressure, lead and carbon monoxide with morbidity and cancer cases, thus, it can be concluded that even the lowest concentration of pollutants in air are still harmful to humans. However, the impact of carbon monoxide can be attributed to the heavy traffic in the city of Ivano-Frankvisk.

6) The recommendation for pollutants concentrations in the air to be monitored and regulated was developed. Other recommendations are for phenol and PM10 that

showed no dependence on morbidity, they should be analyzed against other diseases such as respiratory diseases, chronic obstructive pulmonary diseases, cardiovascular diseases etc. The reduction of carbon footprint in the city of Ivano-Frankvisk, availability of air quality and health data for more analysis and a general sensitization of the public about the impacts of air pollution are the necessary conditions for the improvement of the situation.

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