ZEUGMA
BIOLOGICAL SCIENCE

2024

v:5 n:1 p:21-43

Possible Public health Effects Resulting from Exposure to Air Pollution of Particulate Matter Generated from Limestone Industry

Hilmi S. Salem

Sustainable Development Research Institute Bethlehem, West Bank, Palestine (Occupied)
hilmisalem@yahoo.com

Abstract

Significant Statement: Air pollution is a catastrophic problem that affects the lives of people all over the world. This includes the diverse impacts of air pollution on public health, the environment, and ecosystems in general, including the biosphere, hydrosphere, and geosphere. This paper addressed the issue of air pollution in the West Bank, Historic Palestine, and specifically discussed the potential effects of air pollution on the public health of Palestinian communities in the areas of research, and provided the necessary recommendations to reduce those effects.

Abstract: The Limestone Industry (LSI) in the Occupied Palestinian Territories (OPT), erroneously known as the “Stone and Marble Industry (SMI)”, is a highly lucrative industry, contributing about 25% of the total Palestinian industrial revenues, and about 4.5% of the Gross National Product (GNP). However, although this industry is rewarding to Palestinians in the OPT, in terms of socioeconomics, employment, culture, and heritage, it comes with heavy burdens on the environment and public health. Long-term exposure to air pollution from particulate matter (PM_s), generated particularly by LSI, increases the risk of many diseases and problems, including cardiovascular, respiratory, cancers, pregnancy problems, and newborn defects. This paper investigates the effects of LSI on public health in the OPT, by analyzing PM_s measurements of different particulate sizes (1.0, 2.5, 7.5, and 10.0 µg/m3) emitted by LSI. The PM_s measurements are compared with the World Health Organization’s (WHO) guidelines. It has been found that fine PM_s, which fly into the air and settle in slurry waste (wet and dry) and dumped in open areas, cause high levels of pollution to the air, water, soil, and green cover, leading to damages of citizens’ health, especially those citizens who are living within the LSI’s proximities. More research is needed to further clarify the direct effects of LSI on public health, the environment, green cover, water systems and, in general, quality of life. Population should also exert more pressures on those in charge and the LSI’s owners to make them abide with, and ensure that, the maximum levels of various pollutants recommended by WHO are not violated.

Keywords: *Limestone industry; Particulate matter; Air pollution’s impacts on public health; Occupied Palestinian Territories.*

https://doi.org/10.55549/zbs.1406526

Abbreviations and units used

AQI	Air Quality Index	PNA	Palestinian National Authority
$CaCO_3$	Calcite and Aragonite Minerals	SMI	Stone and Marble Industry
$CaMg(CO_3)_2$	Dolomite Mineral	SO_2	Sulfur Dioxide
C	Black Carbon	SO_4	Sulfate
CO	Carbon Monoxide	TDS	Total Dissolved Solids
CO_2	Carbon Dioxide	TSP	Total Suspended Particulates
DNA	Deoxyribonucleic Acid	UFPs	Ultrafine Particulates
FRM	Free Radical Molecules	UN	United Nations
GHG	Greenhouse Gas (emissions)	USD	United States Dollar
GNP	Gross National Product	WASH	Water, Sanitation, and Hygiene
IL-6	Interleukin 6	WHO	World Health Organization, UN
IL-8	Interleukin 8	h	hour
IMM	Infant Mortality and Morbidity	km2	kilometer square
LCPH	Lancet Commission on Pollution and Health	m	meter
LSI	Limestone Industry	m3	cubic meter
LSSW	Limestone's Slurry Waste	mg	milligram
NaCl	Sodium Chloride	mg/l	milligram per liter
NH_3	Ammonia	µg	micrometer (micron)
NO	Nitric Oxide	µg/m3	microgram per cubic meter
NO_2	Nitrogen Dioxide	$\leq PM_1$	particulate matter's size of 1.0 µm or less
NO_3	Nitrates	$\leq PM_{2.5}$	particulate matter's size of 2.5 µm or less
NTD	Neural Tube Defects	$\leq PM_7$	particulate matter's size of 7.0 µm or less
O_3	Ozone	$\leq PM_{10}$	particulate matter's size of 10.0 µm or less
OPT	Occupied Palestinian Territories (Part of Historic Palestine)		
PM_s	Particulate Matter of Various Sizes		

Introduction

1. Review of some previous studies

The stone industry, in general, which includes quarrying, transportation, cutting, polishing, etc., has severe negative impacts on the environment and public health. This industry causes, primarily, air pollution that results in pneumonia. Pneumonia is defined as the accumulation of dust in the lungs and the reaction of tissues to its presence [1]. The term "fibrogenic mineral dust," referring to the ability of any chemical agent, especially particulate solids (i.e. dust), is defined as an aerosol composed of solid particulates to trigger biochemical reactions in living tissues that eventually produce a fibrous protein substance (collagen) at the place where living cells have been destroyed. This phenomenon leads to a weakening and, sometimes, destruction of the functions of tissues and organs, which may lead to further health complications including cancers.

As this research paper focuses on air pollution resulting from the limestone industry and its effects on public health in the Occupied Palestinian Territories (OPT) of Historic Palestine, this is a brief review of some previous studies conducted in the past few years in different regions of the world, focusing, in particular, on the limestone industry (LSI) and its negative impacts on workers and public health. The health impacts of the limestone industry on 140 workers in Zambia, Africa were investigated, and found that the workers were heavily coughing and under significant risk of increased coughing with sputum. It was concluded that exposure to limestone dust is associated with an increased prevalence of respiratory symptoms, and until the latest

https://doi.org/10.55549/zbs.1406526

technology would be installed, the proper use of personal protective equipment should be emphasized [2]. A study was conducted on the limestone industry in India, Asia, to determine the pattern of disease prevalence amongst workers involved in the industry. The results showed a poor literacy rate amongst the miners, and lung function testing showed limited impairment in about 15% of the workers. Hypertension (high blood pressure), diabetes, and musculoskeletal morbidity were prevalent amongst the LSI's workers. It was concluded that mining is a dangerous profession, as workers were exposed to poor sanitary conditions [3]. Thus, the need for regular health checks, health education, awareness programs, personal protective equipment, and engineering control to improve health and productivity were recommended. Some researchers in Indonesia, Asia analyzed the effect of exposure of limestone mining industry's workers to limestone dust, and found increased Interleukin 8 (IL-8) serum and pulmonary function decline by those workers [4]. Accordingly, it was recommended that regular monitoring to assess changes in pulmonary function of workers, using personal protective equipment and air-purifying respirator, must be done, and a wet method in mining activities must be used. IL-8 (or chemokine) is a chemotactic factor for monocytes that attracts neutrophils, basophils, and T-cells during the inflammatory process. In more detail, IL-8 is a chemical compound produced by macrophages and other cell types, such as epithelial cells, airway smooth muscle cells, and endothelial cells [5]. In humans, the IL-8 protein is encoded by the CXCL8 gene. IL-8 is initially produced as a precursor peptide of 99 amino acids that then undergoes cleavage to form several active isoforms of IL-8 [6]. A study on the dust's effects on the respiratory system of LSI's workers was conducted in Indonesia, Asia, and found that exposure to limestone dust significantly affected the level's increase of serum Interleukin 6 (IL-6) [7]. Each individual's physical activity and immune system were factors that could influence respiratory symptoms, due to increased serum levels of IL-6. Interleukin 6, encoded by the IL-6 gene, which is an immune protein and endogenous chemical that is active in inflammation and in B-cell maturation, is a substance that acts as a pro-inflammatory cytokine and an anti-inflammatory myokine [8]. Researchers carried out a study on the impacts of LSI in areas of Pakistan, Asia and found that levels of pollutants, namely particulate matter's size of 10.0 μm or less (PM_{10}), nitrogen dioxide (NO_2), total suspended particulates (TSP), and total dissolved solids (TDS), were observed to rise, along with health effects including asthma, heart problems, coughing, and diarrhea [9]

Use of personal protective equipment, such as non-powered respirators, is important to prevent the entry of dust from limestone processing to the respiratory system of workers. A study was conducted on the LSI's workers in Indonesia to determine the relationship of exposure to limestone dust with lung function's capacity in workers of the industry. It was found that 56.2% of the LSI's workers have a normal capacity for lung function, and 43.8% of them have an abnormal capacity for lung function [10]. A cross-sectional comparative study was conducted in the occupied Palestinian Territories (OPT) on 79 exposed participants, who live less than 500 m away from limestone quarry sites and on 79 control group participants who live more than 500 m away. People living near quarry sites reported experiencing house dust (98%), land destruction (85%), plant leaves covered in dust (97%), and the inability to grow crops (92%). The exposed group to those who live away from the quarry sites reported significantly higher eye and nasal sensitivity (22% vs. 3%), eye soreness (18% vs. 1%), dryness (17% vs. 3%), chest tightness (9% vs. 1%), and chronic cough (11% vs 0%). It was also found that lung functioning was significantly lower amongst the exposed group compared to the control group [11].

A study was conducted on the limestone industry in Brazil, South America to evaluate the applicability of a hospital questionnaire to the quality of life of workers in mineral exploration companies and people living near mining activities, particularly LSI. That study aimed to apply the hospital questionnaire, in a broader and more general way, as a tool to investigate quality of

https://doi.org/10.55549/zbs.1406526

life of the people exposed to risk factors even before they were diagnosed with chronic respiratory diseases. It was found that residents of peri-industrial areas have the highest averages of symptoms and effects. Thus, the study indicated that the residents affected by air pollution, resulting from LSI, are highly susceptible to respiratory diseases and, consequently, loss of quality of life [12].

A study was conducted on persons working on cutting and polishing limestone exported from the West Bank to Gaza Strip in occupied Palestine, using questionnaires and interviewing tools, and conducting some clinical tests to measure breathing. It was found that the workers complained coughing, chest pain, and wheezing, with 50%, 30%, and 26.7%, respectively. The study recommended that necessary precautions should be taken to maintain safety of workers in rock cutting places and improve ventilation quality by increasing air change rates [13]. A study was conducted to identify pneumoconiosis amongst LSI's workers in Indonesia. The study found that dust concentration was highest at the mining site in pneumoconiosis group compared to the mining site of the non-pneumoconiosis group. The study also showed that the duration of labor and the concentration of mining site's dust are risk factors for lung disease [14]. Researchers carried out a study to determine the correlation exposure of particulate matter ($PM_{2.5}$) with lung function impairment in LSI's workers. It was found a correlation between $PM_{2.5}$ concentration (within a range of 14– 987 $\mu g/m^3$) and pulmonary function impairment [15].

A comprehensive study was conducted on cancer status in the Occupied Palestinian Territories (OPT) that comprised of the West Bank (including Jerusalem) and the Gaza Strip, which also analyzed cancer status in some other regions and countries of the world. The study found that air pollution, caused by rock industry as well as other kinds of industries, is behind several kinds of cancer [16]. A study was carried out on limestone quarries in India, and found that the high concentration of dust particles generated in the air by the limestone quarrying processes causes vision troubles by workers and inhabitants living in close proximity to the quarrying sites. This means that the limestone dust reduces the vision of the eyesight, and also reduces the intensity of the light. Also, breathing problems in the locals are common, as confirmed by the obtained health data [17]. A study was conducted on the limestone pollution and its effect ecophysiology of some selected urban tree species. It was found that the photosynthetic rates, stomatal conductance, evapotranspiration rates, and transpiration rates of the trees investigated were negatively influenced in response to different levels of limestone dust's applications [18]. A study was undertaken on the limestone industry in the occupied West Bank and its impacts on energy consumption. The study concluded that LSI results in greenhouse gas (GHG) emissions. Accordingly, the study recommended that environmental impacts of LSI can be reduced by locating workshops (such as stone-cutting facilities) directly near the stone quarries, as being the raw material supplying points [19].

In brief, the mining activities (including limestone industry) have many negative consequences and negative impacts on the atmosphere, biosphere, and hydrosphere, including amongst other things: air, soil, and water pollution; land degradation; hydrodynamic imbalance of underground and surface waters; loss of organic matter from the soils affected; destruction and decay of fauna and flora; and species reduction in natural ecosystems. In view of these negative impacts and much more, resulting from the mining industry including LSI, it can be concluded that if the current practices of rock and mineral exploitation cannot be adjusted, as being necessary for industrial and community development, certain practices must be reached to reduce at least the negative impacts of the industry on the environment and public health [20].

https://doi.org/10.55549/zbs.1406526

2. Background: Geology, culture & heritage, socioeconomics, geopolitics, and environmental impacts of the Limestone Industry (LSI) in Palestine

In one of the most comprehensive publications on the Stone and Marble Industry (SMI) in Historic Palestine (specifically in the Occupied Palestinian Territories – OPT), a recent study thoroughly investigated several issues related to this important industry in the country [21]. The OPT has a total area of approximately 6,000 km2, which constitutes of the West Bank (including East Jerusalem) and the Gaza Strip, and has a population of approximately 5.4 million, as recently indicated [22]. These issues include geology, culture and heritage, socioeconomics, environmental impacts, regularity and legality, geopolitics, and, very briefly, health-related impacts. In this current research, these issues are represented briefly, while the health impacts of the industry are thoroughly investigated, analyzed, and discussed. Another research paper has been recently published, which investigated comprehensively the state of cancer in the OPT and the possible association of air pollution to some cancer cases [16].

Geology: The surface of the land of the occupied West Bank in Historic Palestine, where the stone industry exists, is mainly covered by a rock, geologically known as "limestone" (Fig. 1–Left), which is largely exposed in mountainous and hilly areas, extending from north to south of the West Bank. The outcrops of this rock form the backbone of mountainous and hilly regions, where limestone dominates its geological range (≈ 800 m), as well as some rock layers of dolomite, marl, and chalk. The outcrops in the West Bank, as being part of Historic Palestine, are mainly composed of limestone, dolomite, and dolomitic limestone rocks of, geologically, Upper Cretaceous age that lasted from around 145 to 66 million years ago. The limestone ranges in color from white to pink, yellow, and tawny, underlain by Nubian sandstone of Lower Cretaceous age [21,23].

Figure 1–Left. A view of limestone outcrops in Bethlehem area, occupied West Bank, Historic Palestine [21]; Right: A natural beautiful plate made from the Jerusalem (Al-Quds) Limestone [21].

Limestone formations consist of the following minerals: calcite ($CaCO_3$) with a trigonal crystal system, aragonite ($CaCO_3$) with an orthorhombic crystal system, and dolomite ($CaMg(CO_3)_2$) with a trigonal-rhombohedral crystal system. Limestone also contains varying amounts of interfering minerals of clays and marls, some siliceous rocks in the form of chert nodules, and quartz geodes. Notably, the term "marble", which is included in the industry's name – Stone and Marble Industry (SMI) – is widely and erroneously used in Palestine as a trade (commercial) name rather than a scientific term. Scientifically, marble refers to a metamorphic rock, which arose from the process of natural geological and mineralogical metamorphism passing through high pressures and temperatures, whereby the sedimentary rock – limestone – is transformed into the metamorphic rock – marble. However, the metamorphic rock "marble" does not occur in Historic Palestine as an outcrop rock, and if it is used on a small scale in Historic Palestine, it is imported from abroad. Accordingly, it has been recommended that this industry in Palestine is

https://doi.org/10.55549/zbs.1406526

to be named “Limestone Industry (LSI)” for the sake of correctness and to avoid ambiguity [21]. Hence, going forward, this term – Limestone Industry (LSI) – will be used throughout the rest of this paper, as also used above.

Culture and heritage: From a cultural and heritage point of view, LSI was and is still one of the fundamental industries in Historic Palestine, as it has contributed to the beauty, glory, and luster of the successive civilizations that occurred in Historic Palestine over thousands of years. The glory of this industry demonstrates the knowledge, splendor, magnificence, creativity, ingeniousness, cultural development, and architectural wealth of the Palestinian people and their culture and civilizations throughout history (Fig. 1–Right). Assessed 3,000 years ago, hard, white, pink, fine-grained, durable, and generally pure limestone of high quality has greatly contributed to the Palestinian culture and heritage, as well as to Palestine’s civilizations throughout history. In addition to the ancient architecture found in rural and urban areas of Historic Palestine, the country is rich in its great monuments, as evidenced by the construction of a large number of cultural, religious, historic, and heritage sites in Historic Palestine [21]. This can be clearly seen in many old cities of Historic Palestine, such as Acre, Jaffa, Nazareth, Nablus, Jerusalem, Bethlehem, Hebron, and Jericho, as well as in many other major cities, towns, and small villages throughout the country. In the past and present, most of the houses, monuments, and impressive buildings in Historic Palestine were built from what is known as the “Jerusalem (Al-Quds) Limestone” (Fig. 1–Right).

Socioeconomics: There are approximately 1,200–1,700 quarries, stone-cutting facilities, workshops, and crushers, scattering throughout the Occupied Palestinian Territories, whereas LSI employs some 15,000–20,000 employees [21]. It is noteworthy to mention that the Gaza Strip, in particular, has no limestone quarries but rather sand quarries, because it is located on the cost of the Mediterranean Sea. LSI contributes, in total, around 20–25% of the Palestinian industrial revenues, and 4.5% of the Palestinian GNP [21]. Due to the presence of large quantities of limestone in Palestine, this rock has become, for many years now, a national reserve estimated to be worth USD 30 billion [21] and, thus, described locally as the “White Gold” [21,24,25]. The Palestinian large reserves of limestone have increased the value and importance, as well as the positive and negative impacts of LSI in the country.

Geopolitics: The main areas of LSI are located in the Nablus and Jenin districts in the northern parts of the occupied West Bank of Historic Palestine; in the Ramallah district in the central part of the West Bank, and in the Bethlehem and Hebron districts in the southern part of the West Bank, taking into account the fact that most of the quarries are located in *Area C*. According to the Oslo Accords signed in 1993/1995 between the Israeli and Palestinian leaderships, the occupied West Bank was divided into *Area A* (forming about 18% of the West Bank’s area and is controlled by the Palestinian National Authority (PNA), in terms of security and administration); *Area B* (constituting about 22% of the West Bank’s area and is controlled by PNA, administratively and by the Israeli occupation authorities, security-wise); and *Area C* (constituting about 60% of the West Bank’s area, and is completely controlled by the Israeli occupation authorities, in administrative and security terms) [21,26,27]. It is noteworthy to mention that despite the fact that almost 30 years have passed since the signing of the Oslo Agreements in September 1993, currently the Israeli occupation authorities do have a total control on the OPT (administration-wise and security-wise) with its three areas *A*, *B,* and *C*, in opposite with what agreed [27].

Challenges facing LSI in Palestine: Most of the major quarrying sites and natural rock reserves are located in *Area C*, while PNA is supposed to impose a ban on quarries in the densely populated areas located in *Area A* and *Area B*. According to a representative of the LSI’s Union in Palestine, the industry – LSI – suffers from a range of various challenges; many of which are

https://doi.org/10.55549/zbs.1406526

common to all Palestinian industries, namely those imposed by the Israeli occupation authorities. The major natural rock reserves are located in the Israeli-fully controlled *Area C*, where obtaining permits to open new quarries is extremely difficult and close to impossible. Accordingly, LSI has been facing serious problems and challenges, considering the fact that the Palestinian owners of the quarries are unable to expand their operational works in *Area C*. Also, the currently accessible reserves in *Area A* and *Area B* are mostly depleted, and any more expansion of the quarries will reach the Palestinian inhabited areas. Moreover, quarries, stone-cutting plants, crushers, and other LSI's related activities are spreading randomly across the occupied West Bank, badly affecting the arable land, the environment, water systems, ecosystems, and public health. However, it is noteworthy to mention that all life aspects of the Palestinian population living under the Israeli occupation in the OPT are deeply and profoundly mixed with politics. These, include, for instance, the environment [26]; renewable energies [28,29]; gender and agriculture [30]; land [27]; air pollution [31,32]; industry [21]; public health [16,33]; water resources and food security [34,35]; governance and socioeconomic issues [33]; and so forth.

Environment: Although LSI in Palestine is largely a rewarding industry, it comes with severe negative impacts on the environment, biodiversity, surface water and groundwater systems, and ecosystems in general (Fig. 2), as well as public health, as discussed later.

Figure 2. Examples of the wet and dry limestone's slurry waste (LSSW) generated from quarrying and stone-cutting sites, flowing to agricultural and residential areas in different localities in the occupied West Bank, Historic Palestine [21].

The environmental impacts of the limestone's slurry waste (LSSW), resulting from quarries and stone-cut processing plants, are devastating. This is because LSSW (wet and dry) causes high levels of pollution to the air, water (surface and underground), agricultural soils, biodiversity (fauna and flora), and ecosystems (Fig. 2). Some Palestinians even lost their lives after they slipped while walking near ponds that collect sluggish water generated from limestone cutting's facilities. This is because those ponds are located in open areas and are filled with heavy, highly viscus LSSW, and those open areas are devoid of warning signs. LSSW contains a suspension of solids, between 5,000 and 12,000 mg/l, which consists mainly of highly purified $CaCO_3$ with a ratio of 94–98% [21]. Fortunately, LSSW in Palestine does not contain hazardous heavy metals and, if any, its concentration is very low, indicating the presence of inert waste. The physical and

https://doi.org/10.55549/zbs.1406526

chemical properties of rock's slurry waste, in general, depend, to a large extent, on the type of the rock used in the cutting operations (which is, in the present case, limestone); on the mineral that makes up the rock under the cut (which is, in the present case, $CaCO_3$); on the metal and other materials existing in saws (blades) used for stone cutting; and on the chemical additives mixed in water used in saw-cooling and stone-cutting processes.

The powder produced from cut stones, which turns into a slurry when mixed with cooling water, is remarkably large in size. About 49 m3 of stone is wasted as powder when 181 m3 of stone blocks are cut into 2cm thick stone slabs, and about 78 m3 of stone is wasted as powder when 365 m3 of stone blocks are cut into 3cm thick stone slabs [21]. This means that wasted stone powder ranges in quantity from about 21% (78/365) to about 27% (49/181) for slabs of 3cm and 2cm thick, respectively. This indicates that the smaller the thickness of the cut or produced slabs, the greater the amount of powder's waste generated, and vice versa, indicating an inverse relationship between the two quantities.

Purpose of current paper

This paper focuses on air pollution caused by particulate matter (PM_s), representing fine particulates with the following sizes: 1 µm or less ($\leq PM_1$), 2.5 µm or less ($\leq PM_{2.5}$), 7 µm or less ($\leq PM_7$), and 10 µm or less ($\leq PM_{10}$), as well as total suspended particulates (TSP). These various sizes and even smaller ones, causing air pollution, generally include particulates generated naturally (from sand and dust storms, volcanoes, etc.) and/or those produced from anthropogenic activities, such as power generation, mining, industrial and agricultural emissions, residential heating, cooking, etc. In the present case, those particulates are primarily generated from the limestone industry in the occupied West Bank. Air pollution is also caused by sulfur dioxide (SO_2), sulfates (SO_4), nitric oxide (NO), nitrogen dioxide (NO_2), nitrates (NO_3), ammonia (NH_3), carbon monoxide (CO), carbon dioxide (CO_2), ozone (O_3), sodium chloride (NaCl), and black carbon (C). These pollutants or some of them are also associated with LSI. These are some examples of measurement of particulate matter PM_s (with various sizes of particulates), as well as of gaseous pollutants in various areas of the world, including Bangladesh, Ethiopia, Nigeria, Palestine, and China [21, 36-40]. These studies found that higher levels of particulate matter – indoors and outdoors – and inhaling more fine and ultrafine particulate matter lead to obstruction of the airways and reduction of lung efficiency. It was found that the effect of PM_1 on childhood pneumonia is greater than that of $PM_{2.5}$ and PM_{10}. In addition, compared with the effects of $PM_{2.5}$ and PM_{10}, the effects of PM_1 were evident in more subgroups of adolescents (boys and girls) and children aged 4 years or less [39]. These and many other studies have indicated that health conditions associated with exposure to particulate matter include, but not limited to, early death in people who are suffering from heart or lung infections, severe asthma, heart attacks, arrhythmias (asymmetrical heartbeat), deteriorating lung function, and enlargement of the lungs, resulting in amplifying respiratory symptoms that include steady coughing, irritated airways, and trouble breathing. These health impacts and other ones, resulting from air pollution, are discussed below in further detail.

Materials and methods

Ultrafine particulates (UFPs) or particulate matter of various sizes – PM_s – are generally expressed in micrograms per cubic meter (µg/m3) to show their concentration in the air. The Air Quality Index (AQI) for PM_s is often used to express what this concentration means, dividing air quality into categories based on the level of health concerns associated with current pollution. Measuring PM_s can help determine air pollution from various resources, including mining activities, like quarries and stone-cutting industry and their associated activities as in the case of the current study. UFPs are released during quarrying and stone-cutting processes, as well as

https://doi.org/10.55549/zbs.1406526

when soils and vegetation are removed, exposing the excavated rocks, cut stones, and removed soils, causing particulates to fly into the air. Particulate meters (or instruments) can help determine the effects of quarrying and stone cutting on overall air quality. In this research paper, the results of two studies related to air pollution in two different sites in the northern and southern parts of the occupied West Bank, Historic Palestine, were analyzed and evaluated. Comparisons were made between the results obtained from both studies for the two sites, and between them and the World Health Organization's (WHO) guidelines. Particulate matter's measurements in both sites were carried out using an air pollution meter (device) in highly polluted areas, where quarries and stone-cutting facilities are located. The results were analyzed in terms of air pollution's impacts on public health.

Results and discussion

In this paper, the results of the two studies carried out in Beit Fajjar (southern West Bank) and Jamma'in (northern West Bank, occupied Palestine) were analyzed and evaluated (Table 1). Comparisons between the results of air pollution's measurements in both localities in the occupied West Bank, and between them and the WHO's guidelines were also made available and provided in Table 1.

Table 1. Measurements of particulate matter (PM_s) of various sizes (1, 2.5, 7, and 10 or less in µg/m3) and the total suspended particulates (TSP) (in µg/m3) for the Beit Fajjar area, southern West Bank; and the Jamma'in area, northern West Bank, occupied West Bank, Historic Palestine, compared with the WHO's guidelines [21].

Investigated Areas and WHO's Air Quality Guidelines	**≤ PM_1 (µg/m3)**	**≤ $PM_{2.5}$ (µg/m3)**	**≤ PM_7 (µg/m3)**	**≤ PM_{10} (µg/m3)**	**TSP (µg/m3)**
Beit Fajjar (South West Bank)	0.0–2.0	5.3–17.0	32.7–237.0	24.7–441.5	273.3–724.0
Jamma'in (North West Bank)	3.6–6.9	34.4–79.2	236.7–651.6	325.0–1079.7	418.8–1535.9
WHO's Air Quality Guidelines1	Not Available	10–25	Not Available	20–50	60–80

1United Nations' (UN) World Health Organization's (WHO) standard values: The lower limits denote annual values and the upper limits denote 24-h values [21, 41-43]. *The WHO's guidelines for PM_1 and PM_7 were unavailable.*

As shown in Table 1, the first study was conducted on air quality in Beit Fajjar village, south of the city of Bethlehem, southern West Bank, while the second study was conducted on air quality and green cover in Jamma'in village, south of the city of Nablus, northern West Bank. The two studies included in-situ measurements of particulate matter of all sizes (PM_s) and total suspended particulates (TSP) in µg/m3 (µg = 0.001 mg), whereas PM_s included measurements of particulate matter of 1 µm or less (≤ PM_1), of 2.5 µm or less (≤ $PM_{2.5}$), of 7 µm or less (≤ PM_7), and of 10 µm or less (≤ PM_{10}), as well as TSP (Table 1).

The results indicate that both areas examined are highly polluted with PM_s of all particulate sizes. However, the sites examined in the Beit Fajjar area, southern West Bank, are less polluted than those examined in the Jamma'in area, northern West Bank (Table 1). The results of the measurements in the two areas show significant differences with the WHO's guidelines for $PM_{2.5}$, PM_{10}, and TSP (Table 1). The particulates emitted from the LSI's facilities in both areas are believed to be relatively large, with the readings evidently increasing gradually from PM_1 to

https://doi.org/10.55549/zbs.1406526

$PM_{2.5}$ to PM_7, and to PM_{10} (Table 1). This may indicate that the emitted particulates were not carried long distances from the pollution sources, where the measurements were conducted. This generally depends on weather conditions, especially wind speed and humidity, as well as whether it was raining or not at the times of measurements (see, for instance, [44-47]). These results (Table 1) indicate that very high concentrations of all particulate sizes of the dust emitted in the air by the limestone industry in both investigated areas present real problems regarding air pollution. These air pollution's problems greatly affect the environment, green cover, surface water and groundwater systems, and ecosystems in general, as well as the health of people living in the LSI's proximities.

1. Air pollution's effects on public health

One in three people globally (or approximately one-third of the world's population) does not have access to safe drinking water [35,48]. Also, regarding inequalities in access to water, sanitation, and hygiene (WASH), more than half of the world's population does not have access to safe sanitation services. Some 2.2 billion people around the world do not have safely managed drinking water services, 4.2 billion people do not have safely managed sanitation services, and 3 billion people lack basic hand-washing facilities [35,48]. The world's population suffers from WASH-related problems (lack of access to fresh water, sanitation, and hygiene), resulting in premature death and illnesses, worldwide.

As the world suffers from water-related problems, likewise it considerably suffers from air-related problems, namely air pollution. It is estimated that air pollution (indoors and outdoors) causes approximately 8 million premature deaths worldwide each year [49]. This includes 3.8 million deaths every year as a result of household exposure to smoke from dirty cook-stoves and fuels, and 4.2 million deaths every year occur as a result of exposure to ambient (outdoor) air pollution. More recently, the Lancet Commission on Pollution and Health (LCPH) reported that air pollution was responsible for 9 million premature deaths in 2015, making it the world's largest environmental risk factor for disease and premature death (Fig. 3). LCPH updated this estimate using data from the 2019 Global Burden of Diseases, Injuries, and Risk Factors, and found that air pollution remains responsible for approximately 9 million deaths per year (Fig. 3), corresponding to one in six deaths worldwide [50].

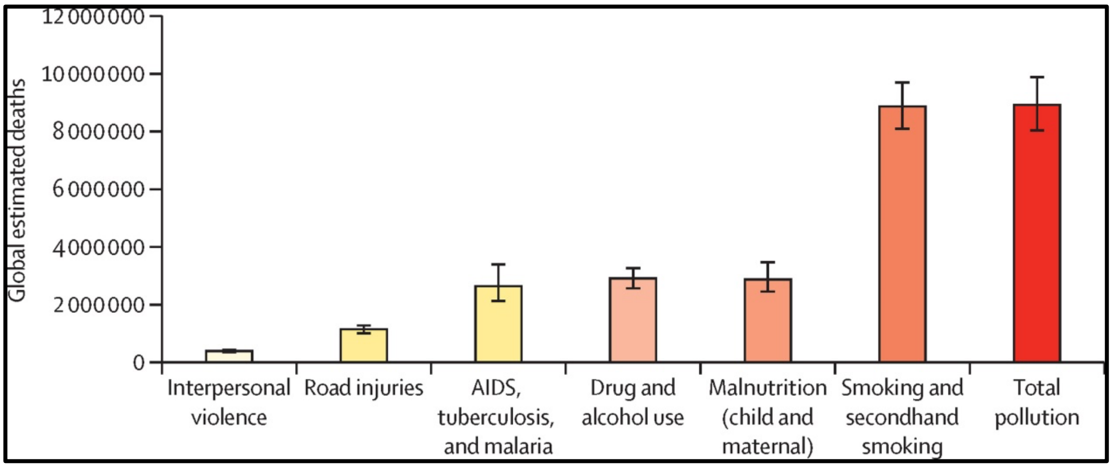

Figure 3. Global estimated deaths by major risk factor or cause [50].

This is in addition to the fact that 9 out of 10 people, worldwide, live in places where air quality exceeds WHO's guideline limits [49]. Almost all of the world's population (99%) breathes air that exceeds the air quality limits set by WHO, and that threatens their health. Air quality is now monitored by a record number of more than 6,000 cities in 117 countries, but the people who

https://doi.org/10.55549/zbs.1406526

live in them are still breathing in unhealthy levels of pollutants, including fine and ultrafine particulates – UFPs – and nitrogen dioxide, as well as other toxic gases, whereas people in low- and middle-income countries experience the highest rates of exposure to those pollutants [51].

Small particulates' pollution has health effects even at extremely low concentrations – in fact no threshold has been set without which no harm to health is observed [52]. Therefore, the limits of the WHO's global guidelines aim to achieve the lowest possible particulates' concentrations. Regarding the health effects of air pollution (outdoors and indoors), polluted air can enter the thorax and cause or exacerbate chronic bronchitis, asthma, pneumonia, emphysema, stroke, heart disease, and acute and chronic respiratory diseases, including lower respiratory disease, as well as different kinds of cancer [16,21,31,32,43, 53-58]. These health effects of ambient air pollution, in particular, as being the focus of this work, can lead to mortality resulted from chronic exposure to particulate matter of various sizes (PM_s), including PM_{10}, PM_7, $PM_{2.5}$, and PM_1 (Fig. 4–Left and Right).

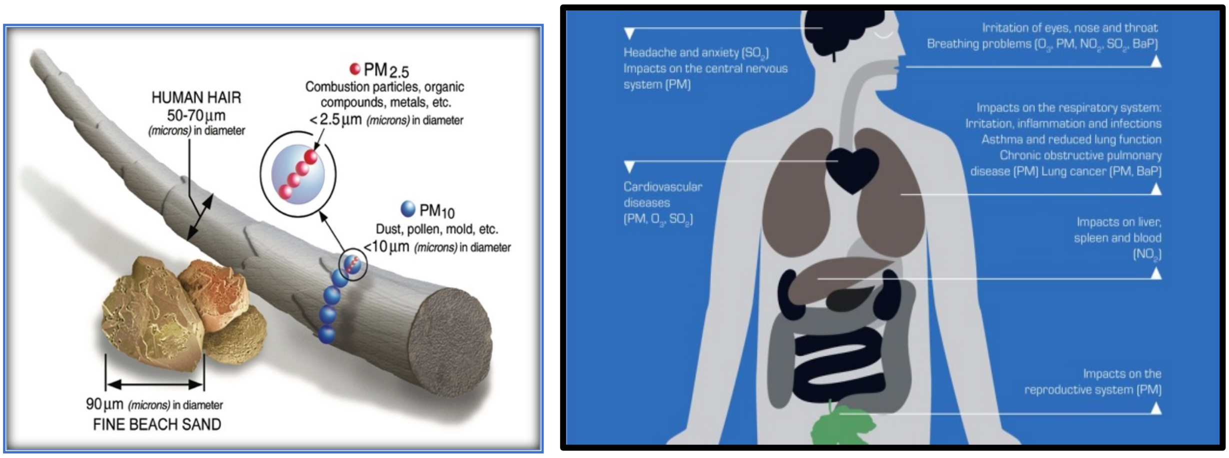

Figure 4–Left: Comparison for particulate matter (PM_s) sizes [59]; Right: An infographic showing the range of health impacts associated with PM_s and other air pollutants [60,61].

While PM_{10} and PM_7 particulates can penetrate and settle deep within the lungs, the particulates most harmful to health are $PM_{2.5}$ and PM_1 [16,21,27,28,51,52,56,62]. The $PM_{2.5}$ particulates can penetrate the lungs' barrier and enter the bloodstream, making their effects through the blood's circulation and contributing to the risk of developing cardiovascular and respiratory diseases, as well as various kinds of cancer. PM_1 is considered by WHO the most harmful, dangerous, and lethal component of PM_s (group 1 of carcinogens), due to its (PM_1) finest size and ability to easily penetrate the lungs and bloodstream, causing DNA's (Deoxyribonucleic Acid) mutation, heart attack, and even infant mortality [16,21,60-62]. DNA is defined as the molecule inside the cells that contains the genetic information responsible for an organism's development and function. DNA's molecules allow this information to pass from one generation to the next [16,63,64].

Following are some health impacts, resulting from exposure to air pollution, as reported by medical and environmental research scientists in various countries of the world. As related to the Occupied Palestinian Territories, it has been indicated that an increasing trend of air pollution and other risk factors are responsible for the rising burden of non-communicable diseases, including the ones mentioned below [16,65]. Unfortunately, due to the ongoing emergency situations and military occupation of the OPT (Gaza Strip and West Bank, including East Jerusalem), the status of the environment and the levels of environmental well-being are, considerably, deteriorating, as well as data are unavailable.

https://doi.org/10.55549/zbs.1406526

Neonatal (newborn) death: This occurs when women lose their infants during pregnancy or shortly after birth. The loss of infants/babies, ranging in age from newborn to one year, may be attributed to higher levels of air pollution, amongst other causes as well. In 2019, air pollution killed nearly half a million newborns, mostly in India and Sub-Saharan Africa [66]. Noxious (harmful) fumes from cooking fuel are blamed for causing the majority of child deaths. A recent study, conducted on nearly 8 million live births and presented at the International Congress of the European Respiratory Society, indicated that external air pollutants (such as PM_s, NO_2, and SO_2) cause neonatal death and are associated, separately and jointly, by a 20–50% increased mortality risk amongst infants and older children born in the most polluted areas compared to infants/children born in least polluted areas [67].

While the biological causes of the relationship between air pollution and adverse childbirth outcomes are not fully known or understood, it is believed that air pollution may affect a pregnant woman, her developing fetus, or both in ways similar to tobacco smoking, which is a well-known risk factor for low-birth weight and preterm birth [66]. Furthermore, outdoor air pollution, which is associated with an increased risk of infant mortality and morbidity (IMM), contributes to the immaturity of the immune system; a decrease in the function, growth, and development of the lungs; and common viral infections in infants [67-70]. Associations between PM_{10} and IMM have been observed in cities known for high levels of pollution, namely Mexico City (Mexico), Seoul (South Korea), and Sao Paulo (Brazil) [69], and also in Sub-Saharan Africa, where the death of 400,000 infants in 2015 could be, partially, attributed to exposure to high particulate matter concentration [70], and due to other reasons such as malnutrition (Fig. 3; above), poverty, and climate change impacts [71,72].

As related to the Occupied Palestinian Territories, the neonatal mortality rate in 2020 was 10.3 deaths per 1,000 live births. However, between 2001 and 2020, the neonatal mortality rate in the OPT decreased at a moderate rate, i.e. from 16.8 deaths per 1,000 live births in 2001 to 10.3 deaths per 1,000 live births in 2020 [73]. However, there is no mention of the reasons behind the cases of neonatal death in the OPT, which could be attributed to various reasons, including, amongst others, malnutrition and poverty [74], as well as air pollution, acid rain, and climate change impacts [21]. The impacts of the Khamsin (or Khamasini) winds in Historic Palestine and neighboring countries get more and more adversely influential on public health as well as the ecosystems [21,75,76] (Fig. 5).

https://doi.org/10.55549/zbs.1406526

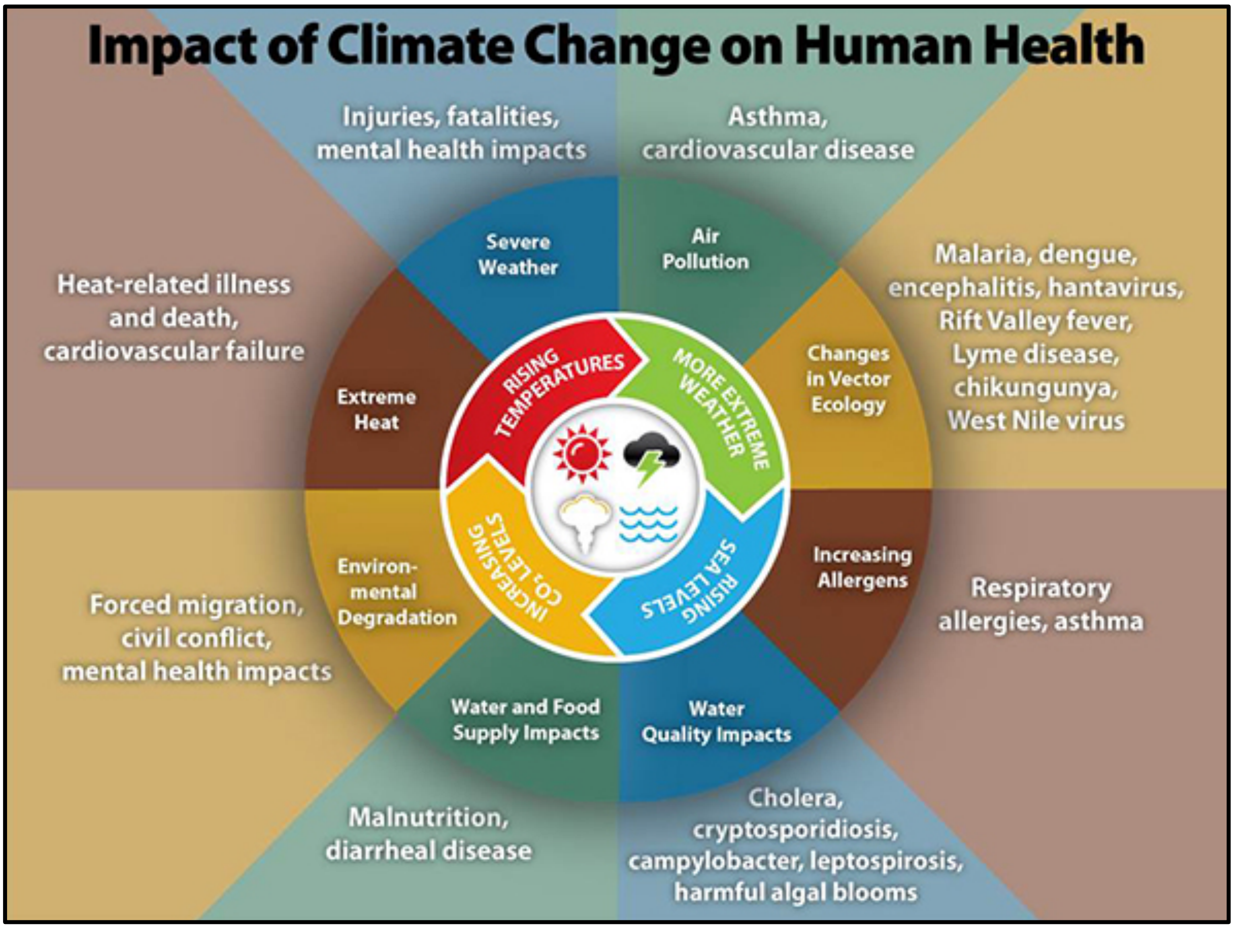

Figure 5. The most significant climate change impacts (rising temperatures, more extreme weather, rising sea level, and increasing carbon dioxide levels); their effect on exposures; and the subsequent health outcomes that can result from these climate change impacts [77].

Although it is unclear how air pollution may affect children's lungs' function, especially during pregnancy, one mechanism is that fine particulates cross the placenta and disturb the development of the fetus' lungs through oxidative stress, representing an imbalance between free radical molecules (FRM) and antioxidants [78-80] and, hence, the balance between them is essential for the proper function of the lungs. If FRM overwhelm the body's ability to regulate antioxidants, a state of oxidative stress will follow and dominate. Another mechanism is that prenatal exposure to pollutants can induce epigenetic changes in gene function that may involve changes in DNA, lipids, and proteins, which are negatively altered by FRM, leading to a number of diseases in humans [67,81].

Congenital anomalies (birth deformities or birth defects): Changes in DNA also cause birth defects in newborns. Women who are exposed to outdoor air pollution, due to the presence of PM_s and other pollutants in the air, just before pregnancy or during the first few months of pregnancy, are at increased risk that their babies will be born with birth defects, such as cleft lip or palate, abnormal hearts, or other defects [82,83]. There is an association between specific air pollutants generated from traffic and industry, such as PM_s, CO, NO, NO_2, SO_2, O_3, on the one hand, and neural tube defects (NTD), on the other [83,84]. These include two types of NTD (spina bifida, which is a malformation of the spine; and anencephaly, which is an underdeveloped brain or an absent brain), as well as cleft lip, with or without cleft palate, cleft palate only, and gastroschisis, in which the infant is born with some of the intestines are outside the body.

https://doi.org/10.55549/zbs.1406526

Exposure to fine particulate matter – PM_s – during pregnancy is associated with a high risk of birth defects, negative long-term health after birth (postnatal health problems), or mortality [85]. However, limited mechanistic data are available to assess the detailed effects of prenatal exposure to particulate matter. Unfortunately, there are no available studies related to birth defects in the Occupied Palestinian Territories, which may be related to air pollution, which may be attributed to the geopolitical conditions prevailing in the OPT.

Various kinds of cancer: It is estimated that hundreds of thousands of deaths from lung cancer, annually worldwide, are attributable to air pollution; that is from air pollution, in general, and from PM_s, in particular. Some studies reported that air pollution is associated with an increased risk of mortality for several types of cancer, including lung cancer, breast cancer, liver cancer, bladder cancer, pancreatic cancer, and other kinds of cancer as well [16,21,56, 86-89]. However, epidemiological evidence on outdoor air pollution and the risk of various kinds of cancer is still limited and, accordingly, requires more research [16].

A geographical correlation's study revealed a positive association between $PM_{2.5}$ levels and age-adjusted cancer rates, which remained significant after careful correction for multiple comparisons [90]. In the United Kingdom, for example, one in every 10-lung cancer patients suffers from cancer due to exposure to outdoor air pollution [88]. As indicated above, exposure to air pollution, resulting from particulate matter – PM_s – can cause several lung diseases, which, in some cases, lead to lung cancer due to the damages caused to DNA. There are several different ways in which PM_s in polluted air can damage DNA in cells and cause lung cancer and other kinds of cancer as well [16]. For example, PM_s may accumulate in the lungs and change how cells multiply. This can lead to DNA's damage that can cause cancer. Genetic instability is the hallmark of various kinds of cancer with increased accumulation of DNA's damage, so that the application of radiotherapy and chemotherapy in the treatment of cancer is usually based on this characteristic of the cancer [16,91,92].

As indicated above, air pollution can be associated with several kinds of cancer, with an increased risk of mortality. For every 10 μg/m3 increased exposure to $PM_{2.5}$, there is a significant risk of death from various kinds of cancer [16,21,56] (Table 2).

Table 2. Risk percentage (percentage of mortality or death risk) of different kinds of cancer, as related to increased exposure to $PM_{2.5}$ by every 10 μg/m3 [16,21,56].

Percentage of Mortality (Death) Risk	Kind of Cancer
22% higher	For any kind of cancer
35% higher	For accessory digestive organs, including the liver, bile ducts, gall bladder, and pancreatic cancer
36% higher	For lung cancer
42% higher	For cancers of the upper digestive tract
80% higher	For breast cancer

Scientists identified some possible explanations for the increased association between $PM_{2.5}$ exposure and cancer's incidence [56]. Air pollution may cause defects in DNA's repair function, changes in the body's immune system and its response, inflammation that leads to angiogenesis,

https://doi.org/10.55549/zbs.1406526

and/or the growth of new blood vessels that allow tumors to spread. In the case of the gastrointestinal tract (digestive organs), air pollution can affect the gut microbiota – the human's gastrointestinal microbiota [93] and, thus, can influence the development of cancer diseases.

Recent clinical and pathological evidence has indicated that the gut microbiota acts as an interactor to regulate the homeostasis of the human body, influencing conditions ranging from cancer and dementia to obesity and social behavior. It has the potential to influence cancer prognosis and the outcome of cancer treatments, such as chemotherapy, radiotherapy, and immunotherapy [94]. To reduce air pollution's effects and their associated diseases and mortality resulted from various kinds of cancer, the World Health Organization recommended the reduction of PM_s [41,42]. For example, by reducing PM_{10} from 70 μg/m3 to 20 μg/m3 (that is by 350%), air pollution's mortality rate can be reduced by about 15%. Thus, lower levels of air pollution can improve the health of population, with respect to cardiovascular and respiratory diseases, various kinds of cancer, women's pregnancy, neonatal defects, etc. – short-term and long-term.

Two recent research papers have recently investigated cancer's incidence and mortality rates amongst the Palestinian population in the Occupied Palestinian Territories, providing comprehensive analyses and in-depth discussion of the different types of cancer and their potential causes, including possible links to air pollution, as well as the difficulties, problems, and challenges facing the Palestinian cancer patients in the OPT [16,33].

Conclusions and recommendations

The air in the Occupied Palestinian Territories – OPT – is highly polluted, where the ambient (outdoor) air pollution is caused by various sources, including activities related to the limestone industry – LSI – or what is erroneously known as the "Stone and Marble Industry" – SMI. This is in addition to air pollution caused by other sources, such as the burning of Israeli and Palestinian scrap dumped throughout the Occupied West Bank, without regulations, control, and monitoring, causing enormous negative impacts on public health and the environment [16].

The LSI's activities, including quarrying, cutting, crushing, transportation, etc., represent real problems that severely affect public health and the environment and its ecosystem constituents (atmosphere, hydrosphere, biosphere, and geosphere: air, water, soil, green cover, and biodiversity in general). Based on interviews with citizens living in proximities of the industry – LSI, people (males and females) of all ages (infants, children, young, and old) are suffering from several health problems, some of which are serious and severe. This is due to the fact that waste slurries and particulate matter of all sizes – PM_s, generated by the LSI, cause many problems; both from an environmental and health points of view.

People suffer from several health problems, including cardiovascular and respiratory diseases, various kinds of cancer, birth defects, and newborn mortality. Although it is unclear that these health problems and high mortality rates are directly or indirectly associated with, or caused by, air pollution, many people believe that the deterioration of the health situation in the OPT must, in one way or another, be related to the limestone industry's activities, especially where this industry operates, as well as to other factors discussed in this paper, including the waste (Israeli and Palestinian) dumped in the OPT without any regulations or monitoring systems, as well as climate change impacts, malnutrition, stress, lack of activity, etc. However, long-term exposure to air pollution does not solely increase the risk of lung cancer, but it also increases the risk of cancer development in other organs of the body.

More research, however, is urgently needed to further clarify whether there are direct effects of LSI on public health, the environment, green cover, water systems, and, generally, quality of

https://doi.org/10.55549/zbs.1406526

life. Nevertheless, people should not give up “the fight for the right” to breathe clean fresh air, by putting more pressures on politicians, policy- and strategy-makers, and the LSI’s owners, as well as human (including children) rights’ organizations. However, international organizations, such as “Save the Children” [95], have done good job in this direction. This is to ensure that the maximum levels of various pollutants recommended by the World Health Organization – WHO – are not violated by the limestone industry in the Occupied Palestinian Territories. Also, more pressures should be exerted on those who dumped waste in open environments, in order to reduce or completely stop the dumping of their waste and burning it in the OPT, in order to protect people’s health, the environment, and ecosystems [16], and also to reduce the stresses imposed on Palestinian cancer patients while getting cancer treatments [33].

Declarations

- *Ethics approval and consent to participate:* They have been completely observed by the author; including informed consent, misconduct, data fabrication and/or falsification, redundancy, etc.

- *Consent for publication:* All material presented in this research paper does not need consent to publish.

- *Availability of data and materials:* All the data generated and/or analyzed during this study are included in this published article.

- *Competing interests:* There is no potential of conflict of interest of any kind (financial or otherwise).

- *Funding:* The author declares that the research presented in this paper did not receive any funding either from individuals or from organizations.

- *Authors’ contributions:* The author, as single author, has alone contributed to this study, entirely.

- *Acknowledgements:* The author extends his sincere thanks to the friends and colleagues who critically reviewed the paper.

https://doi.org/10.55549/zbs.1406526

References

[1] ILO (International Labour Organization). Diagnostic and exposure criteria for occupational diseases Guidance notes for diagnosis and prevention of the diseases in the ILO List of Occupational Diseases (revised 2010). Niu S, Colosio C, Carugno M, Adisesh A (Eds.). ILO, Geneva, Switzerland. ISBN 978-92-2-035683-8 (Print), ISBN 978-92-2-035682-1 (Web PDF). 2022.

[2] Bwalya D, Bråtveit M, Moen BE. Chronic respiratory symptoms among workers at a limestone factory in Zambia. *Archives of Environmental & Occupational Health*. 2011;66(1):47–50. doi:10.1080/19338244.2010.506498. https://pubmed.ncbi.nlm.nih.gov/21337186/

[3] Dhatrak SV, Nandi SS, Chatterjee DM, Dhumne UL. Health status evaluation of limestone mine workers. *National Journal of Community Medicine*. 2014;5(4, October–December):410–413. https://njcmindia.com/index.php/file/article/view/1425

[4] Tolinggi S, Nakoe R, Inne A, Gobel J, Sengke S, Keman I, Sudiana R, Yudhastuti R, Mukono R, Azizah R. Effect inhaling of limestone dust exposure on increased level of il-8 serum and pulmonary function decline to workers of limestone mining. *International Refereed Journal of Engineering and Science*. 2014;3(8-August):66-72.

[5] Hedges JC, Singer CA, Gerthoffer WT. Mitogen-activated protein kinases regulate cytokine gene expression in human airway myocytes. *American Journal of Respiratory Cell and Molecular Biology*, 2000;23(1):86–94.

[6] Brat DJ, Bellail AC, Van Meir EG. The role of interleukin-8 and its receptors in gliomagenesis and tumoral angiogenesis. *Neuro-Oncology*. 2005;7(2):122–133.

[7] Gobel IA, Mukono J, Sukmono RE. Effect of limestone dust exposure on lung physiology decline and increase of interleukin6 level of blood serum of limestone processing workers in Kesamben Village, Plumpang Sub-district of Tuban Regency. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 2015;6(4-June-August):530–538.

[8] Ferguson-Smith AC, Chen YF, Newman MS, May LT, Sehgal PB, Ruddle FH. Regional localization of the interferon-beta 2/B-cell stimulatory factor 2/hepatocyte stimulating factor gene to human chromosome 7p15-p21. *Genomics*. 1988;2(3):203–208. doi:10.1016/0888-7543(88)90003-1.

[9] Haseeb Z, Rana A, Naseer N, Aftab A, Haseeb A, Chaudhry MN, Majid M. Monitoring of environment, health and socio-economic impacts of limestone quarrying near Chakwal, Pakistan. *Pakistan Journal of Science*. 2018;70(4 December): 334-341.

[10] Suherdin S, Molya KD, Kurniawati RD. Dust exposure to the lung function capacity of limestone industry workers in West Bandung Regency. *Jurnal Ilmu Kesehatan Masyarakat (JIKM)*. 2019;10(3):172183.

[11] Nemer M, Giacaman R, Husseini A. Lung function and respiratory health of populations living close to quarry sites in Palestine: A cross-sectional study. *International Journal of Environmental Research and Public Health.* 2020;17(17):6068. https://doi.org/10.3390/ijerph17176068

[12] Krause AAK, Souza EHdaS, Soares JCM. Quality of life of limestone industry workers and the community around the industrial district in Caçapava Do Sul-Rs. *BioMedical*. 2021;40(2-November):32043–32046. DOI: 10.26717/BJSTR.2021.40.006420.

[13] Hamdan FS, NM, El-Ashgarm, Musalam AMA. Respiratory health risks of limestone factories' dust: Gaza City as a case study. *Israa University Journal of Applied Science*. 2021;5(1-October):74–86.

[14] Nalapraya WY, Susanto AD, Ikhsan M, Mansyur M, Marliana M. Proportion of Pneumoconiosis in limestone mining workers in Citatah Village, West Bandung District. *Respiratory Science*. 2021;1(2):98–115. https://respiratoryscience.or.id/index.php/journal/article/download/10/10

[15] Utomo SW, Ni'mah Z, Asyary A. The correlation of limestone dust exposure to lung function impairment in limestone mining's workers, Centre Java, Indonesia. *Open Access Macedonian Journal of Medical Sciences*, 2021;11(9-E):265–272.

https://doi.org/10.55549/zbs.1406526

[16] Salem HS. Cancer status in the Occupied Palestinian Territories: Types; incidence; mortality; sex, age, and geography distribution; and possible causes. *Journal of Cancer Research and Clinical Oncology*. 2022; 149:5139–5163 https://doi.org/10.1007/s00432-022-04430-2
[17] Vats, S. Impact of stone mining on the health and environment: A study of the village of Mewat, India. *Journal of Earth and Environmental Sciences Research*, 2022;4(5):1–4. DOI:10.47363/JEESR/2022(4)185
[18] Sabir MA, Guo W, Nawaz MF, Yasin G, Yousaf MTB, Gul S, Hussain T, Rahman SU. Assessing the effects of limestone dust and lead pollution on the ecophysiology of some selected urban tree species. *Frontiers in Plant Science*. 2023;14:1144145. doi: 10.3389/fpls.2023.1144145.
[19] Alqadi SB, Alamleh D, Naser Eldin I, Naser Eldin H. A comparative life cycle energy and greenhouse emissions of natural and artificial stone-manufacturing phase. *Results in Engineering*. 2023;18, June: 101055. https://doi.org/10.1016/j.rineng.2023.101055
[20] STRATOS. Effects of limestone mining on the environment and human health. 2023. https://stratos.ro/en/blog-efectele-exploatarii-calcarului-asupra-mediului-inconjurator-si-sanatatii-umane/ Accessed 17 December 2023.
[21] Salem HS. Evaluation of the Stone and Marble Industry in Palestine: environmental, geological, health, socioeconomic, cultural, and legal perspectives, in view of sustainable development. *Environmental Science and Pollution Research*. 2021;28:28058–28080.
[22] PCBS (Palestinian Central Bureau of Statistics). Palestinian Central Bureau of Statistics (PCBS) presents the conditions of Palestinian populations on the occasion of the International Population Day, 11/07/2022 – A world of 8 billion: “Towards a resilient future: Harnessing opportunities and ensuring rights and choices for all.” About 14.3 Million Palestinians in Historical Palestine and Diaspora. Ramallah, Palestine. 2022 (July 11). https://pcbs.gov.ps/post.aspx?lang=en&ItemID=4279 Accessed 17 December 2023.
[23] Orr JMA (Ed). Entry for “Geology of Palestine.” International Standard Bible Encyclopedia. 1915. https://www.biblestudytools.com/dictionary/geology-of-palestine/ Accessed 17 December 2023.
[24] Makhool B, Abu-Alrob M. Quarrying, crushing and stone industries in Palestine: Current situation and prospects. Palestine Economic Policy Research Institute (MAS), Ramallah, Palestine. 1999 (April). https://library.palestineeconomy.ps/public/files/server/20142511163038-1.pdf
[25] Qanazi S, Zawawi Z. Stone-Industry in Palestine: Bridging the gap between environmental sustainability and economical value. *Papers in Applied Geography*. 2021;8(1):12–34.
[26] Salem HS. No sustainable development in the lack of environmental justice. *Environmental Justice*. 2019a;12(3):140–157. https://www.liebertpub.com/doi/10.1089/env.2018.0040
[27] Salem HS. Geopolitical challenges, complexities, and future uncertainties in the Occupied Palestinian Territories: Land and population’s perspectives. *New Middle Eastern Studies*. 2020a;10(1):45–82.
[28] Salem HS. The potential of wind energy in Palestine with healthcare and residential examples in the West Bank and the Gaza Strip. *Journal of Nature Science and Sustainable Technology*. 2019b;13(2):73–97.
[29] Salem HS. The necessity of rural electrification in the Occupied Palestinian Territories: Status, challenges, and opportunities, with the case study of the Jubbet Ad-Dib village, Bethlehem Governorate. *Journal of Nature Science and Sustainable Technology*. 2019c;13(2): 99–131.
[30] Salem HS. Agriculture status and women’s role in agriculture production and rural transformation in the Occupied Palestinian Territories. *Journal of Agriculture and Crops*. 2019d;5(8-August):132–150. DOI:https://doi.org/10.32861/jac.5(8)132.150
[31] Salem HS. Sources of indoor air pollutants in the Occupied Palestinian Territories, including Skunk liquid, household cleaning products, and others. *Journal of Environmental Pollution and Control*. 2019e;2(1):106.
[32] Salem HS. Air pollution caused by stone and marble industry in Palestine and its impacts on health. A Paper presented at the First International Conference on Applications of Air Quality in Science

https://doi.org/10.55549/zbs.1406526

and Engineering Purposes, Kuwait Institute for Scientific Research (KISR), Shuwaikh, Kuwait City, Kuwait. 10–12 February 2020b.

[33] Salem HS. Difficulties, problems, limitations, challenges, and corruption facing cancer patients in the Occupied Palestinian Territories: The West Bank, including East Jerusalem, and the Gaza Strip. *Med Discoveries*, 2023b;2(3): 1024.

[34] Salem HS. Potential Solutions for the Water Conflict between Palestinians and Israelis. In: Hussein Amery (Ed.). *Enhancing Water Security in the Middle East.* MENA Water Security Task Force, Al Sharq Strategic Research, Al Sharq Forum, Istanbul, Turkey; and Colorado School of Mines, Denver, CO, USA. Published on 20 March 2023. 2023a.

[35] Salem HS, Pudza MY, Yihdego Y. Water strategies and water–food Nexus: challenges and opportunities towards sustainable development in various regions of the World. *Sustainable Water Resources Management*. 2022;8:114:54p.

[36] Akther T, Ahmed M, Shohel M, Ferdousi FK, Salam A. Particulate matters and gaseous pollutants in indoor environment and association of ultra-fine particulate matters (PM_1) with lung function. *Environmental Science and Pollution Research*. 2019; 26:5475–5484.

[37] Embiale A, Zewge F, Chandravanshi BS, Sahle-Demessie E. Short-term exposure assessment to particulate matter and total volatile organic compounds in indoor air during cooking Ethiopian sauces (Wot) using electricity, kerosene and charcoal fuels. *Indoor and Built Environment.* 2019;28(8):1140–1154.

[38] Seiyaboh EI, Angaye TCN, Ogidi OI. Environmental and health risk assessment of particulate matter associated with dusty football field. *Journal of Experimental and Clinical Toxicology*. 2019;1(2). DOI: 10.14302/issn.2641-7669.ject-19-

[39] Wang X, Xu Z, Su H, Ho HC, Song Y, Zheng H, Hossain MZ, Khan MA, Bogale D, Zhang H, Wei J, Cheng J. Ambient particulate matter (PM_1, $PM_{2.5}$, PM_{10}) and childhood pneumonia: The smaller particle, the greater short-term impact? *Science of The Total Environment*. 2021;772:145509.

[40] Wang Z, Zhai Z, Chen C, Tian X, Xing Z, Xing P, Yang Y, Zhang J, Wang C, Dong L. Air pollution particles hijack peroxidasin to disrupt immunosurveillance and promote lung cancer. *eLife*. 2022;11:e75345.

[41] WHO (World Health Organization). Air quality guidelines. global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide. WHO, Geneva, Switzerland. WHO, Geneva, Switzerland. 2005a. ISBN 92 890 2192 6.

[42] WHO (World Health Organization). WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005 - Summary of risk assessment. WHO, Geneva, Switzerland. 2005b.

[43] WHO (World Health Organization). Report - WHO Air Quality Database (Update 2022). WHO, Geneva, Switzerland. 2022a. https://www.who.int/data/gho/data/themes/air-pollution/who-air-quality-database Accessed 17 December 2023.

[44] Bluvshtein N, Mahrer Y, Sandler A, Rytwo G. Evaluating the impact of a limestone quarry on suspended and accumulated dust. *Atmospheric Environment*. 2011;45, 9(March):1732–1739.

[45] Csavina J, Field J, Félix O, Corral-Avitia AY, Sáez AE, Betterton EA. Effect of wind speed and relative humidity on atmospheric dust concentrations in semi-arid climates. *Science of The Total Environment.* 2014;487:82–90. https://doi.org/10.1016/j.scitotenv.2014.03.138

[46] Drahler D, Fishbain B. Studying the effects of a limestone quarry on the nearby population's exposure to PM. The ISES-ISEE 2018 Joint Annual Meeting theme is "Addressing Complex Local and Global Issues in Environmental Exposure and Health. ISES-ISEE 2018, 26–30 August 2018, Ottawa, Canada.

[47] IQAir (2022). How wind and weather affect air pollution. Updated 16 November 2022. https://www.iqair.com/newsroom/wind-weather-air-pollution Accessed 17 December 2023.

[48] WHO (World Health Organization). 1 in 3 people globally do not have access to safe drinking water – UNICEF, WHO. 18 June 2019.

https://doi.org/10.55549/zbs.1406526

[49] WHO (World Health Organization). Air Pollution. WHO, Geneva, Switzerland. 2022b. https://www.who.int/health-topics/air-pollution#tab=tab_1 Accessed 17 December 2023.

[50] Fuller R, Landrigan PJ, Balakrishnan K, Bathan G, Bose-O'Reilly S, Brauer M, et al. Pollution and health: a progress update. *The Lancet Planetary Health*. 2022;6(6-June):E535-E547.

[51] WHO (World Health Organization). Billions of people still breathe unhealthy air: new WHO data. Over 6000 cities now monitor air quality. WHO, WHO, Geneva, Switzerland. 2022c. https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data Accessed 17 December 2023.

[52] WHO (World Health Organization). Ambient (outdoor) air pollution. WHO, Geneva, Switzerland. 22 September 2021. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health Accessed 17 December 2023.

[53] Salem HS. Health aspects of air quality in Palestine (Occupied). The First Africa/Middle East Expert Consultation/Workshop on the Impact of Airborne Dust on Health. WHO-CEHA, UNEP, WMO, EUMSTAT, and AEMET, Amman, Jordan, 2–5 November 2015.

[54] Salem HS. Indoor air pollution sources (particularly Skunk) and their impacts on health and the environment in the Occupied Palestinian Territories. In Yassin, MF (Ed): Proceeding of Workshop on Air Quality in Hot Arid Climate (IAQHAC). Kuwait Institute for Scientific Research (KISR), Shuwaikh, Kuwait City, Kuwait, 3–4 April 2017. pp: 204–221.

[55] Sivacoumar R, Jayabalou R, Subrahmanyam YV, Jothikumar N, Swarnalatha S. Air pollution in stone crushing industry, and associated health effects. *Indian Journal of Environmental Health*. 2001;43(4-October):169–173. https://pubmed.ncbi.nlm.nih.gov/12395522/

[56] Wong CM, Tsang H, Lai HK, Thomas GN, Lam KB, Chan KP, Zheng Q, Ayres JG, Lee SY, Lam TH, Thach TQ. Cancer mortality risks from long-term exposure to ambient fine particle. *Cancer Epidemiology Biomarkers & Preention*. 2016;25(5):839–845. DOI: 10.1158/1055-9965.EPI-15-0626.

[57] Leon-Kabamba N, Ngatu NR, Kakoma, SJ, Nyembo C, Mbelambela EP, Moribe RJ, Wembonyama S, Danuser B, Oscar-Luboya N. Respiratory health of dust-exposed Congolese coltan miners. *International Archives of Occupational and Environmental Health*. 2018;91(7-October):859–864. doi: 10.1007/s00420-018-1329-0. https://pubmed.ncbi.nlm.nih.gov/29951778/

[58] Encecopedia.Com. Total suspended particles (TSP). Encyclopedia of Public Health. The Gale Group Inc. 2019. https://www.encyclopedia.com/education/encyclopedias-almanacs-transcripts-and-maps/total-suspended-particles-tsp Accessed 17 December 2023.

[59] EPA (Environmental Protection Agency, USA). Particulate Matter (PM) Pollution: Particulate Matter (PM) Basics. Last updated 11 July 2023. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics Accessed 17 December 2023.

[60] EEA (European Environmental Agency). Air pollution: Most European city dwellers are exposed to unsafe levels of air pollution. Improving air quality to match World Health Organization (WHO)-recommended levels could prevent more than half of premature deaths caused by exposure to fine particulate matter. Last modified 21 July 2022.

[61] Clarity. Particulate matter – Air quality measurements series: particulate matter. 2021 (September 16). https://www.clarity.io/blog/air-quality-measurements-series-particulate-matter Accessed 17 December 2023.

[62] EPA (Environmental Protection Agency, USA). Review of the National Ambient Air Quality Standards for Particulate Matter – Policy Assessment of Scientific and Technical Information. OAQPS Staff Paper – Second Draft. January 2005.

[63] NCI (National Cancer Institute). DNA. National Cancer Institute at the National Institutes of Health, U.S. Department of Health and Human Services. 2023.

https://doi.org/10.55549/zbs.1406526

https://www.cancer.gov/publications/dictionaries/genetics-dictionary/def/dna Accessed 17 December 2023.
[64] NHGRI (National Human Genome Research Institute). Deoxyribonucleic Acid (DNA). Updated 23 July 2023. https://www.genome.gov/genetics-glossary/Deoxyribonucleic-Acid Accessed 17 December 2023.
[65] WHO (World Health Organization). Health Profile 2015 – Palestine. WHO's Regional Office for the Eastern Mediterranean, Amman, Jordan. WHO-EM/HST/232/E. 2016. https://rho.emro.who.int/sites/default/files/Profiles-briefs-files/EMROPUB_EN_18926-PAL.pdf

[66] SGA (State of Global Air). Impacts on newborns: Nearly 500,000 newborns died in 2019 as a result of air pollution exposure. 2020. https://www.stateofglobalair.org/health/newborns Accessed 17 December 2023.
[67] ERS (European Respiratory Society). Air pollution linked to increased risk of infant death and reduced lung function in children. 2023. https://www.ersnet.org/news-and-features/news/air-pollution-linked-to-increased-risk-of-infant-deaths-and-reduced-lung-function-in-children/ Accessed 17 December 2023.
[68] Glinianaia SV, Rankin J, Bell R, Pless-Mulloli T, Howel D. Does particulate air pollution contribute to infant death? A systematic review. *Environmental Health Perspectives*. 2004;112(14-October):1365–1370.
[69] Hajat S, Armstrong B, Wilkinson P, Busby A, Dolk H. Outdoor air pollution and infant mortality: Analysis of daily time-series data in 10 English cities. *Journal of Epidemiology and Community Health*. 2007;61(8-August):719–722. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2653013/
[70] Heft-Neal S, Burney J, Bendavid E, Voss KK, Burke M. Dust pollution from the Sahara and African infant mortality. *Nature Sustainability*. 2020;3:863–871.
[71] Godfrey S, Tunhuma FA. The Climate Crisis Climate Change Impacts, Trends and Vulnerabilities of Children in Sub Saharan Africa. United Nations Children's Fund Eastern and Southern Africa Regional Office, (UNICEF), Nairobi, Kenya. 2020
[72] StC (Save the Children). Sub-Saharan Africa: 426 children per day at risk of death from hunger following impact of COVID-19. 1 September 2020. https://www.savethechildren.net/news/sub-saharan-africa-426-children-day-risk-death-hunger-following-impact-covid-19 Accessed 17 December 2023.
[73] Knoema. Palestine - Neonatal mortality rate. World Data Atlas Palestine Health. 2021. Accessed 17 December 2023.
[74] UNICEF (United Nations Children's Fund). State of Palestine: Humanitarian Situation Report, January–June 2019. July 26, 2019. https://www.unicef.org/media/76961/file/SoP-SitRep-Mid-Year-2019.pdf
[75] Solomos S, Kalivitis N, Mihalopoulos N, Amiridis V, Kouvarakis G, Gkikas A, Binietoglou I, Tsekeri A, Kazadzis S, Kottas M, Pradhan Y. From tropospheric folding to Khamsin and Foehn winds: How atmospheric dynamics advanced a record-breaking dust episode in Crete. *Atmosphere*. 2018;9(7):240
[76] Kaskaoutis DG, Dumka UC, Rashki A, Psiloglou BE, Gavriil A, Mofidi A, Petrinoli K, Karagiannis D, Kambezidis HD. Analysis of intense dust storms over the eastern Mediterranean in March 2018: Impact on radiative forcing and Athens air quality. *Atmospheric Environment*. 2019;209:23–39
[77] CDCP (Centers for Disease Control and Prevention). Climate effects on health. April 25, 2022. https://www.cdc.gov/climateandhealth/effects/default.htm Accessed 17 December 2023.
[78] TNAS (Technology Networks Applied Sciences). Link made between air pollution, infant death and lung impairment. Original story from the European Lung Foundation. 27 September 2019. https://www.technologynetworks.com/applied-sciences/news/link-made-between-air-pollution-infant-death-and-lung-impairment-324425 Accessed 17 December 2023.

https://doi.org/10.55549/zbs.1406526

[79] Chiarello DI, Abad C, Rojas D, Toledo F, Vázquez CM, Mate A, Sobrevia L, Marín R. Oxidative stress: Normal pregnancy versus preeclampsia. *Biochimica et Biophysica Acta - Molecular Basis of Disease.* 2020;1866,2:165354. https://doi.org/10.1016/j.bbadis.2018.12.005 https://www.sciencedirect.com/science/article/pii/S0925443918304915

[80] Vona R, Pallotta L, Cappelletti M, Severi C, Matarrese P. The impact of oxidative stress in human pathology: Focus on gastrointestinal disorders. *Antioxidants (Basil) (A Special Issue Oxidative Stress and Inflammation in Health and Diseases)*. 2021;10(2):201

[81] Lobo V, Patil A, Phatak A, Chandra N. Free radicals, antioxidants and functional foods: impact on human health. *Pharmacognosy Reviews*. 2010;4(8–Jul.-Dec.):118–126.

[82] Ren S, Haynes E, Hall E, Hossain M, Chen A, Muglia L, Lu L, DeFranco E. Periconception exposure to air pollution and risk of congenital malformations. *The Journal of Pediatrics*. 2018;193(February):76–84.e6

[83] Xiong L, Xu Z, Wang H, Liu Z, Xie D, Wang A, Kong F. The association between ambient air pollution and birth defects in four cities in Hunan province, China, from 2014 to 2016. *Medicine*. 2019;98(4):e14253. doi: 10.1097/MD.0000000000014253.

[84] Padula AM, Tager IB, Carmichael SI, Hammond SK, Lurmann F, Shaw GM. The association of ambient air pollution and traffic exposures with selected congenital anomalies in the San Joaquin Valley of California. *American Journal of Epidemiology*. 2013;177(10-May):1074–1085.

[85] Wu G, Brown J, Zamora ML, Miller A, Satterfield MC, Meininger CJ, Steinhauser CB, Johnson GA, Burghardt, RC, Bazer FW, Lie Y, Johnson NM, Molina MJ, Zhang R. Adverse organogenesis and predisposed long-term metabolic syndrome from prenatal exposure to fine particulate matter. *The Proceedings of the National Academy of Sciences USA (PNAS USA)*. 2019;116(24):11590–11595

[86] AACR (American Association for Cancer Research). Air pollution may be associated with many kinds of cancer. Researchers urge better regulation to protect public health. 2013. https://www.aacr.org/patients-caregivers/progress-against-cancer/air-pollution-associated-cancer/ http://thisweekinpalestine.com/marble-from-the-holy-land-the-pillar-of-the-palestinian-export-sector/ Accessed 17 December 2023.

[87] Turner M, Andersen ZJ, Baccarelli A, Diver WR, Gapstur SM, Pope III CA, Diddier P, Samet J, Thurston G, Cohen A. Outdoor air pollution and cancer: an overview of the current evidence and public health recommendations. *CA: A Cancer Journal for Clinicians*. 2020;76(6):460–479.

[88] CR UK (Cancer Research UK). How can air pollution cause cancer? Last reviewed: August 17, 2021. https://www.cancerresearchuk.org/about-cancer/causes-of-cancer/air-pollution-radon-gas-and-cancer/how-can-air-pollution-cause-cancer Accessed 17 December 2023.

[89] Chen K-C, Tsai S-W, Shie R-H, Zeng C, Yang HY. Indoor air pollution increases the risk of lung cancer. *International Journal of Environmental Research and Public Health*. 2022;19:1164. https://doi.org/10.3390/ijerph19031164

[90] Su S-Y, Liaw Y-P, Jhuang JR, Hsu S-Y, Chiang C-J, Yang Y-W, Lee W-C. Associations between ambient air pollution and cancer incidence in Taiwan: An ecological study of geographical variations. *BMC Public Health*. 2019;19:1496. https://doi.org/10.1186/s12889-019-7849-z

[91] Alhmoud JF, Woolley JF, Al Moustafa AE, Malki MI. DNA damage/repair management in cancers. *Cancers (Basel)*. 2020;12(4):1050. doi: 10.3390/cancers12041050.

[92] Huang R, Zhou P-K. DNA damage repair: historical perspectives, mechanistic pathways and clinical translation for targeted cancer therapy. *Signal Transduction and Targeted Therapy*. 2021;6:254.

[93] GMfH (Gut Microbiota for Health). Gut Microbiota Info. Everything you always wanted to know about the gut microbiota. 2023. https://www.gutmicrobiotaforhealth.com/en/about-gut-microbiota-info/ Accessed 17 December 2023.

https://doi.org/10.55549/zbs.1406526

[94] Jalil, AT, Thabit SN, Hanan ZK, Alasheqi MQ, Al-Azzawi AKJ, Zabibah RS, Fadhil AA (2023). Modulating gut microbiota using nanotechnology to increase anticancer efficacy of the treatments. *Macromolecular Research*, Published online: 4 May 2023. https://doi.org/10.1007/s13233-023-00168-z

[95] StC (Save the Children). The impact of air pollution on child health. 25 January 2022. https://www.savethechildren.in/emergencies/the-impact-of-air-pollution-on-child-health/ Accessed 17 December 2023.

https://doi.org/10.55549/zbs.1406526