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How Air Pollution Affects Subjective Well-Being

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Abstract

Clean air is considered as one of the basic requirements for human being. Pollution-related diseases due to air pollution continue to rise at an alarming rate and affect people's quality of life. Air pollution also adversely affects welfare inequality. Air pollution as a significant risk factor affects health and sense of subjective well-being (SWB). In this study, the effect of air pollution on subjective well-being (life satisfaction, happiness, and optimism) is investigated. Relationship between well-being and air quality is a fundamental issue to design public policies. Hence, the studies about the link are of growing interest in the literature. The results show that air pollutants have an effect on subjective well-being. The link between life satisfaction and happiness is very strong. Optimism is also positively correlated with life satisfaction and happiness. Good air quality and optimism make people happier. Air quality is likely to have an effect on people's sense of life satisfaction, happiness, and optimistic view. The results indicate that the PM 2.5 level is significantly and negatively related to on optimism. It is obvious that there is a very strong relationship between air quality and subjective wellbeing. Relationship between wellbeing and air quality is a fundamental issue to design public policies.

Keywords: air pollution, happiness, optimism, life satisfaction, subjective wellbeing

1. Introduction

Air is the most important natural resource that forms the basis of life on Earth. The air in the atmosphere provides oxygen and other gases that are essential elements for survival of life for living beings. Clean air is vital to sustain the delicate balance of life on the Earth. However, the quality of air can be affected by air pollution. To maintain human life in a healthy environment is becoming increasingly difficult because of pollution caused by power plants, transportation, industry, agriculture, and naturally occurring sources [1].

The European Environment Agency defines air pollution as “the presence of contaminant or pollutant substances in the air at a concentration that interferes with human health or welfare, or produces other harmful environmental effects” [2]. Air pollution may also be defined as any atmospheric condition in which chemicals, particulate matter, or biological materials are present in the air at concentrations high enough above their normal atmospheric levels, causing diseases, allergies, death, harm or discomfort to humans, damage to other living organisms such as animals and food crops, or the natural or built environment [3]. Air pollution also affects the quality of life and subjective well-being (SWB) [4, 5].

Air pollution occurs when certain gases and dust particles are introduced into the atmosphere in a way to such levels that they can cause harm to our health, causing breathing and respiratory problems, and even resulting in premature death, as well as damaging the environment, animals, and plant around us [6]. Air pollutants can originate from manmade sources, including emissions from internal combustion engines or the burning of fossil fuels such as coal, oil, petrol, or diesel, but can also come from natural sources such as forest fires, wind erosion, and volcanic eruptions.

A new World Health Organization (WHO) air quality model reveals that 92% of the world’s population lives in places where air quality levels exceed the WHO limits. Exposure to outdoor air pollution is the actual cause of death for as many as three million people worldwide each year [7]. According to the WHO, it is known that air pollution is even the most dangerous environmental risk affecting everyone [8]. As an important public health threat of this century, the level of air pollution increases the risk of the global burden of disease from respiratory infections, heart disease, and lung cancer [9]. Since people might adapt to poor environmental quality, it has to be assumed that negative effects of pollution are even underestimated [8].

Pollution-related diseases due to air pollution continue to rise at an alarming rate, and affects people’s quality of life [5]. Air pollution also adversely affects welfare inequality [10]. Association between well-being and air quality is one of the fundamental issues in designing public policies about health of society as a whole. Therefore, the studies about the relation are of growing interest in the literature [11–18]. These literatures propose that air quality is likely to have an effect on life satisfaction, happiness, and optimism. This chapter is concerned with the effects of air pollution on human well-being. The relationship between air pollution and subjective well-being is analyzed by using data about air pollutants and quality of life. The chapter is organized as follows:

- Section 2 describes major air pollutants.
- Section 3 reveals effect of pollutants on human health.
- Section 4 responds to the question “What is subjective well-being?”
- Section 5 analyzes the link between air pollution and subjective well-being.
- Section 6 evaluates the link between air pollution and subjective well-being.
- Section 7 gives conclusion remarks.

2. Major air pollutants

Major primary air pollutants, which can have effects as both directly and precursors of secondary air pollutants (chemicals are formed as a result of reactions between primary pollutants and other elements in the atmosphere), include the following [19–21].

- sulfur oxides (SO_x)
- nitrogen oxides (NO_x; NO, and NO₂ referred together as NO_x)
- carbon monoxide (CO)/carbon dioxide (CO₂)
- volatile organic compounds (VOCs)
- particulate matter (PM)
- chlorofluorocarbons (CFCs)
- ammonia (NH₃)

Primary pollutants are emitted directly into the air from its man-made or natural sources. Sources of air pollution, primary and secondary pollutants are shown in **Figure 1**.

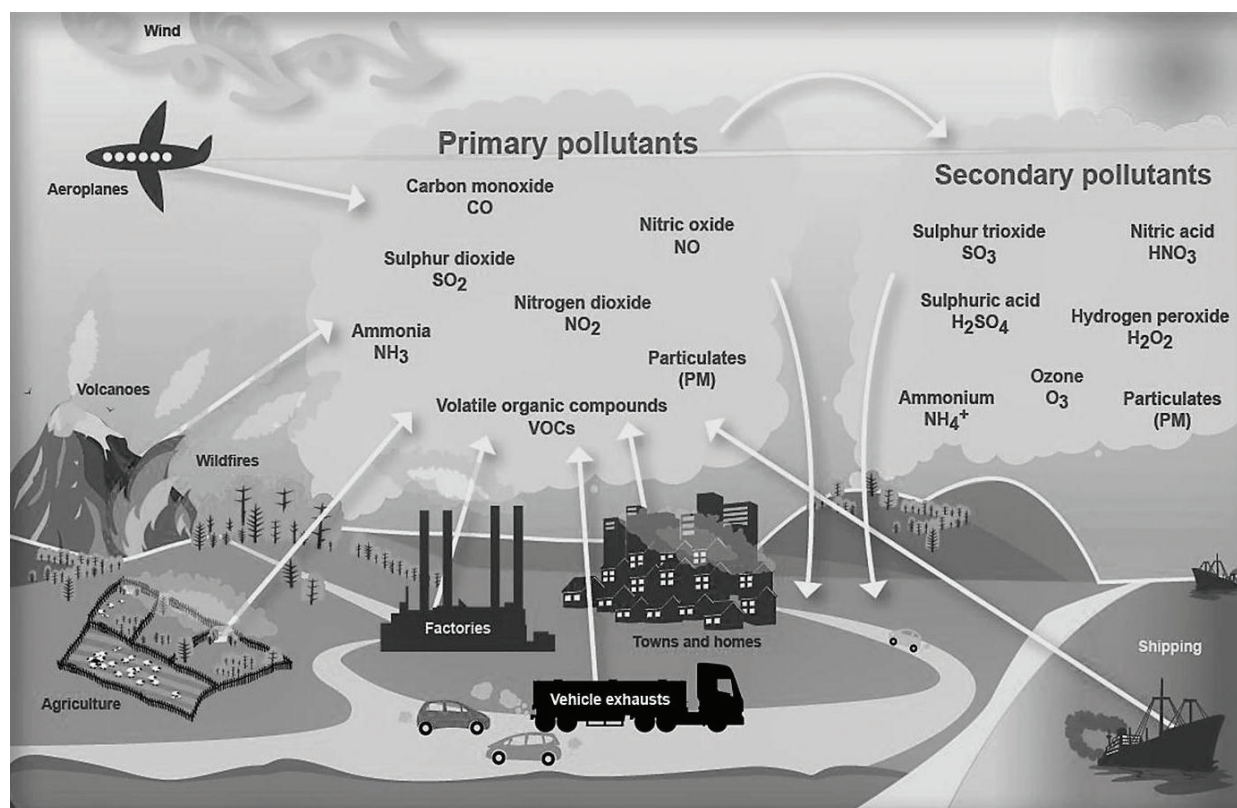


Figure 1. Sources of air pollution [22].

3. Effect of pollutants on human health

Clean air is considered as one of the basic requirements for human health and subjective well-being. Air pollutants, such as nitrogen dioxide (NO_x), sulfur dioxide (SO_x), particulate matter (PM), carbon monoxide (CO), ozone (O₃), can cause serious health problems [23]. The associations between pollutants and health have usually been reported in previous epidemiological studies that air pollution is an important risk to public health. Air pollution leads to the deterioration of people's health conditions and damage to human health [24–27]. People's exposure to air pollutants is also more likely to experience anxiety and depression [28, 29].

Air pollution is regarded as one of the most serious public health threats facing by countries throughout the world [9]. Results from the studies about health and air pollution have evidenced that exposure to pollution is associated with a very wide range of adverse health or health-related outcomes such as cardiovascular diseases, heart attacks, decreased lung function, chronic non-cancer lung disease, chronic bronchitis, increased respiratory symptoms, asthma exacerbations, emphysema, earlier death from cardiovascular as well as respiratory causes, and cancer, especially lung cancer [3, 25, 30].

The World Health Organization reports that in 2012 alone, around seven million people died as a result of air pollution exposure [30]. A 2016 comparative risk assessment of the Global Burden of Disease 2015 study found similar estimates. It was found that air pollution exposure was linked with almost 6.5 million deaths worldwide [31]. In 2012, air pollution was linked with one out of eight deaths across the world [30]. Particularly, vulnerable groups to air pollution include elderly people, children, people with a preexisting chronic condition [3] such as heart or lung disease, asthmatics, and socially disadvantaged groups. Air pollution is also one of the leading dangers to children's health [31]. It is linked with diseases and infections, which kills around 600,000 children under 5 years old per year, globally [32]. Risk assessment of the Global Burden of Disease 2015 study estimates that a nearly one in 10 under-five deaths is linked to the air pollution [31]. Almost one million children die from pneumonia each year. Air pollution is directly linked with pneumonia and other respiratory diseases [31]. Pneumonia accounts for up to 16% of all under-five deaths [33]; more than half of childhood pneumonia deaths are directly associated with air pollution [31, 34].

These findings confirm that air pollution is the single most deadly environmental health risk. About 3.3 million people a year are killed prematurely by outdoor air pollution, meaning that only outdoor air pollution is responsible for more deaths than both of terrible scourges, HIV/AIDS and malaria combined, each year [30]. Around 18,000 people die each day as a result of air pollution. In fact, the number of deaths due to air pollution each year is more than the number from HIV/AIDS, tuberculosis, and road injuries combined [32, 35].

World Health Organization defines health as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.” It also recognizes health as all physical condition, mental, and social well-being, and does not realize it as merely the absence of disease or infirmity. Thus, health is both absence of disease and presence of well-being [36]. The 1947 World Health Organization definition of health includes not just physical health but complete social well-being [37]. The quality of air and current potential risk to our health play

a crucial role in state of people’s physical, mental, and social well-being. It is obvious that reducing air pollution not only saves millions of lives but also prevents the damage resulting from air pollution to people’s well-being [36]. Many aspects of the physical environmental quality can affect people’s lives and well-being as a key factor in people’s well-being [38–40]. There is a close relationship between quality of life and the environment, which has a direct impact on human health and well-being [38, 41, 42]. However, much less is known about how air pollution damages well-being, quality of life, and mental health of people. Some major pollutants, their sources, and health effects are listed in **Table 1**.

Pollutant	Sources	Health effects
Nitrogen dioxide (NO₂)		
<ul style="list-style-type: none">• A brownish highly reactive gas that forms quickly when fuels burned at high temperatures.• In the atmosphere can be converted to nitric acid (HNO₃).• Contributes to the formation of ground-level ozone and fine particle pollution.• A main component of acid deposition.	<ul style="list-style-type: none">• Motor vehicles.• Power plants.• Industrial plants.	<ul style="list-style-type: none">• Reduction in overall lung functions.• Increases symptoms of chronic lung disease.• Lung inflammation, irritation and damage.• Respiratory infections.• Symptoms of bronchitis and asthmatic diseases in children increase with long term exposure.• Wheezing and exacerbation of pneumonia, asthma, bronchial symptoms.• High risk factor of emphysema.• Premature death.• Aggravate existing hearth disease exacerbation of lung.
Particulate matter (PM) (fine dust)		
<ul style="list-style-type: none">• Mixture of visible or microscopic solid particles and liquid droplets in the air.	<ul style="list-style-type: none">• Burning coal and solid fuel in power and industrial plants.• Combustion – including emission from vehicles, ships, power generation and households.• Natural sources, such as sea salt, wind-blown soil and sand.• Road dust.• Sea spray.• Construction.	<ul style="list-style-type: none">• Wheezing and exacerbation of asthma.• Respiratory infections.• Chronic bronchitis and chronic obstructive pulmonary disease.• Exacerbation of chronic obstructive pulmonary disease.• Decreased lung function.• Eye, nose, and throat irritation.• Irregular heartbeat/Nonfatal heart attacks.• Premature death• Mutations, reproductive problems or even cancer.

Pollutant	Sources	Health effects
Sulfur dioxide (SO₂)		
<ul style="list-style-type: none">Highly reactive colorless and irritating gas.Odorless at low concentrations.Pungent at very high concentrations.Related with the formation of acid rain and aerosols.	<ul style="list-style-type: none">Produced by volcanoes, power plants, and other industrial facilities.Mainly generated from combustion of sulfur-containing fossil fuels, such as coal and petroleum.	<ul style="list-style-type: none">Wheezing and aggravation of asthma and chronic bronchitis/Breathing problems/Respiratory illness.Exacerbation of chronic obstructive pulmonary disease.Cardiovascular disease.Eye, nose and throat irritation.Increases symptoms of chronic lung disease.Causing coughing.Mucus secretion.
Ammonia (NH₃)		
<ul style="list-style-type: none">The most abundant alkaline gas in the atmosphere.Major component of total reactive nitrogen.A gas with a pungent odor characteristic.Colorless, pungent-smelling, caustic (corrosive) gas.	<ul style="list-style-type: none">Decaying organic matters.The excreta of humans and animals.Agricultural processes, including animal husbandry and NH₃-based fertilizer applications.Industrial processes.Vehicular emissions.Volatilization from soils and oceans.	<ul style="list-style-type: none">Eye, nose, and throat irritation.Burning the skin eyes, throat, or lungs might be cause permanent blindness, lung disease, or death.Can cause life-threatening accumulation of fluid in the lungs (pulmonary edema).Long-term exposure may harm the respiratory system.
Volatile organic compounds (VOCs)		
<ul style="list-style-type: none">They are often divided into separate categories of methane (CH₄) and nonmethane (NMVOCs).Contain carbon.Along with carbon, they contain elements such as oxygen, hydrogen, bromine, chlorine, fluorine, sulfur, or nitrogen.Organic chemicals that have a high vapor pressure.	<ul style="list-style-type: none">Fossil fuel combustion.Industrial activities.Solvents, paints, glues, and other products that are used and stored at home and at work.Oil and gas fields.Road vehicles.Household heating.Power generation.Natural emissions from vegetation and fires.	<ul style="list-style-type: none">Eye, nose, and throat irritation.Headaches.Dizziness.Fatigue.Nausea.Emesis.Epistaxis.Loss of co-ordination.Damage to liver.Damage to kidney.Damage to central nervous system.Allergic skin reaction dyspnea.Cancer in humans.

Pollutant	Sources	Health effects
Ozone (O₃)		
<ul style="list-style-type: none">• Secondary pollutant.• Colorless gas with a strong odor.• Forms as a result of chemical reactions between NO_x, VOCs, and oxygen.• Highly active oxidization gas.	<p>Is not emitted directly from any source but is formed in sunlight when certain chemicals react. These chemicals from:</p> <ul style="list-style-type: none">• Motor vehicles.• Electric utilities.• Refineries.• Factories.• Petrochemicals.• Vegetation.• Landfills.• Miscellaneous small sources such as gas stations.	<ul style="list-style-type: none">• Coughing, chest tightness, chest pain, and wheezing.• Throat irritation and congestion.• Worsen bronchitis, emphysema, and asthma.• Asthma attacks.• Decreased lung function.• Permanent lung damage.• Damage to lung tissue.• Aggravates chronic lung disease.• Irritates respiratory system.• Headaches and weariness.• Increase premature death.

Table 1. Main air pollutants, sources, and effects [22, 43–46].

4. What is subjective well-being (SWB)

Interest in SWB has been increasing rapidly in recent years. SWB that refers to how people experience and evaluate their lives and specific domains and activities in their lives [47, 48] encompasses both cognitive judgments of satisfaction and effective appraisals of moods and emotions [49]. There is no generally-accepted single definition of SWB. Diener et al. [41] define SWB as judging life positively and feeling good. “Thus a person is said to have high [SWB] if she or he experiences life satisfaction and frequent joy, and only infrequently experiences unpleasant emotions such as sadness or anger. Contrariwise, a person is said to have low [SWB] if she or he is dissatisfied with life, experiences little joy and affection and frequently feels negative emotions such as anger or anxiety” [50].

“SWB is a broad category of phenomena that includes people’s emotional responses, domain satisfactions, and global judgments of life satisfaction” [51]. SWB is defined as a person’s cognitive and affective evaluations of his or her life [52].

Snyder and Lopez [53] define SWB as “a broad concept that includes experiencing pleasant emotions, low levels of negative moods, and high life satisfaction.” Eid and Diener [54] proposed that SWB “refers to one’s multidimensional evaluation of their lives, including cognitive judgments of life satisfaction as well as affective evaluations of moods and emotions.” “Well-being, which we define as people’s positive evaluations of their lives, includes positive emotions, engagement, satisfaction, and meaning” [55]. Kahnemann and Riis [56] consider SWB as being a hybrid concept with two components, which can be labeled “experienced well-being” and “evaluated well-being.” Both components are subjective and refer to a time of Ref. [56].

In the terms of Diener [57], “SWB is an umbrella term for the different valuations people make regarding their lives, the events happening to them, their bodies and minds, and the circumstances in which they live.” Lyubomirsky [58] defines SWB as “the experience of joy, contentment, or positive well-being, combined with a sense that one’s life is good, meaningful, and worthwhile.” According to Friedman, SWB refers to “the psychological wellbeing of a person and how satisfying a person believes his or her life is” [59].

Reconciling these various definitions, OECD [60] builds an inclusive definition of SWB as: “good mental states, including all of the various evaluations, positive and negative, that people make of their lives and the affective reactions of people to their experiences.” This definition of subjective wellbeing includes three elements:

- Life evaluation—a reflective assessment on a person’s life or some specific aspects of it.
- Affect—a person’s feelings or emotional states, typically measured with reference to a particular point in time.
- Eudaimonia—a sense of meaning and purpose in life, or good psychological functioning.

The three primary components of SWB include positive/negative affect, happiness, and life satisfaction [45, 61–63]. Affect represents the emotional side of SWB. The balance of positive and negative affects refers to the emotions, moods, and feelings a person has. These can be all negative, positive, or a mix of both positive and negative [64]. Subjective well-being is at the heart of happiness. In fact, SWB is considered to be a much broader concept than just happiness. In other words, happiness is only one element of SWB. Veenhoven [65] defines happiness as “the degree to which an individual judges the overall quality of his/her own life-as-a-whole favorably.” Life satisfaction global judgments of one’s life and satisfaction with specific life domains (e.g. work satisfaction) are considered cognitive components of SWB [63] because they are based on evaluative beliefs (attitudes) about one’s life. Positive and negative affects assess the affective component of SWB [51]. Life satisfaction represents one’s assessment of one’s own life. It is described by the OECD as “measures how people evaluate their life as a whole rather than their current feelings” [66].

Figure 2, summarizing the various items of a simple measurement frame for subjective well-being, shows the different dimensions of the three measurement concepts and how they relate to the subjective well-being determinants [60].

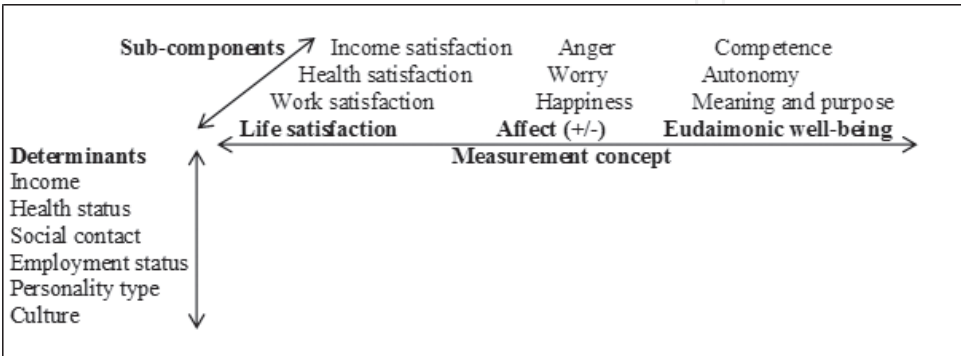


Figure 2. A simple model of subjective well-being.

SWB is strongly correlated to personality characters [67]. Higher incomes, unemployment, poor health, poor work/life balance and higher time spent commuting, social connections, democracy and levels of generalized trust in a country, higher quality environment, and lower crime are associated with subjective well-being [61, 68–72].

5. Analysis of the link between air pollution and subjective well-being

5.1. Methodology

The data used in this research is derived from the European Environment Agency (EEA), the European Commission—Joint Research Centre (JRC)/Netherlands, the Environmental Assessment Agency (PBL), OECD, and the 3rd European Quality of Life Survey (3EQLS). The countries included in this study are Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Romania, Spain, Sweden, and the United Kingdom. For this study, the countries were selected due to the data quality and data availability of (EEA), the European Commission—(JRC)/(PBL), OECD, and (3EQLS).

Air pollutants data set (Y variables) is defined as, y_1 : NH_3 ; y_2 : NO_x ; y_3 : NMVOCs; y_4 : SO_x ; y_5 : CO_2 ; and y_6 : PM 2.5. Emissions of NH_3 , NO_x , NMVOCs, and SO_x are provided from EEA statistics in 2014. CO_2 emission from fossil fuel use and cement production in 2014 is taken from the European Commission—(JRC)/(PBL) statistics. Mean population exposure to PM 2.5 $\mu\text{g}/\text{m}^3$ in 2013 is extracted from OECD statistics [73–75]. The 3rd European Quality of Life Survey is used as the basic source of subjective well-being data set (X variables set).

The 3rd European Quality of Life Survey (3EQLS) is a conventional tool for recording and examining quality of life in the EU. Research for the (3EQLS) in 27 member states took place from September 2011 to February 2012. This is a survey of people aged 18 and above, residents in EU for at least 6 months. Depending on the size of population 1000–3000 interviews were finished in each member states [76]. There are a large number of possible indicators of SWB in the (3EQLS) data, such as satisfaction with life, happiness, optimism about future, liking one's life, and perceived social exclusion [76]. The most widely used indicators of subjective well-being have chosen for this study as, x_1 : life satisfaction; x_2 : happiness; and x_3 : optimism.

In this study, one of the most common multivariate techniques—canonical correlation analysis (CCA) is used to explore the link between air pollutant variables set and subjective well-being variables set. CCA is a multivariate statistical analysis method that describes the associations between two sets of variables. For more information about CCA, see the study of Darcin and Darcin [77].

5.2. Results

Descriptive statistics (the mean values and standard deviation) of each variable measured in both sets are presented in **Table 2**.

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
NH ₃	20.00	1.59	739.79	170.07	223.10
NMVOC	20.00	3.00	1041.36	275.83	324.05
NOx	20.00	6.46	1224.29	311.70	372.18
SO ₂	20.00	1.56	388.03	100.24	113.62
CO ₂	20.00	2.41	767.15	143.89	191.01
PM 2.5	20.00	7.07	18.58	13.41	3.56
life satisfaction	20.00	5.50	8.40	7.18	0.72
happiness	20.00	6.30	8.20	7.40	0.49
optimism	20.00	33.00	85.00	59.20	12.94

Table 2. Descriptive statistics.

The Pearson’s correlations between air pollutant and subjective well-being variables are presented in **Table 3**. According to the result of the present study, the relationship between life satisfaction and happiness is very strong. Optimism is also positively correlated with life satisfaction and happiness. Similar results are found in a study from Turkey [5]. The present study also suggests that there is a negative association between optimism and PM 2.5.

The CC (0.913) between the first pair was found significant ($p < 0.01$) from the likelihood ratio test. The remaining canonical correlation is not statistically significant ($p > 0.05$). By construing the first canonical variable, it is possible to find relationship between air pollution and subjective well-being as rate of 83.3%. For the variable, there is very strong negative significant correlation between air pollution and subjective well-being.

Variables	NH ₃	NMVOC	NOx	SO ₂	CO ₂	PM 2.5	life satisfaction	happiness	optimism
NH ₃	1.00	0.89	0.93	0.76	0.89	0.20	0.05	0.07	−0.33
NMVOC	0.89	1.00	0.98	0.86	0.93	0.20	0.02	0.05	−0.36
NOx	0.93	0.98	1.00	0.87	0.95	0.18	0.05	0.09	−0.34
SO ₂	0.76	0.86	0.87	1.00	0.86	0.21	−0.23	−0.16	−0.33
CO ₂	0.89	0.93	0.95	0.86	1.00	0.23	0.04	0.07	−0.25
PM 2.5	0.20	0.20	0.18	0.21	0.23	1.00	−0.31	−0.34	−0.65
Life satisfaction	0.05	0.02	0.05	−0.23	0.04	−0.31	1.00	0.97	0.58
Happiness	0.07	0.05	0.09	−0.16	0.07	−0.34	0.97	1.00	0.55
Optimism	−0.33	−0.36	−0.34	−0.33	−0.25	−0.65	0.58	0.55	1.00

Table 3. Correlation matrix.

6. Evaluating relationship between air pollution and SWB

Studies about the effect of air quality on public welfare are of vital importance for policy development and evaluation [45]. However, there is relatively little empirical evidence available on the relationship between air pollution and well-being [3]. Because it is difficult to make a clear relationship between pollution and well-being when air pollution tends to be reported at a country level and well-being is an individual measure [45]. Air quality is an important determinant of subjective wellbeing and an important policy issue [12]. Environmental policies and regulations are realized to improve air quality and thus subjective well-being [78].

There are a number of papers analyzing the relationship between air pollution and subjective well-being. The significant effects of air pollution on people's subjective well-being have been explored by using measures of self-reported well-being and cross-sectional and panel data measured for air quality and for several pollutants [11, 12, 79].

The relationship between subjective measures of well-being and individual environmental attitudes, using data from the British Household Panel Survey, is examined by Ferrer-i-Carbonell and Gowdy [80]. They find that people's attitudes and experiences toward effects of environmental issues have an effect on individual's well-being. Rehdanz and Maddison [15], using data drawn from the German socio-economic panel, make an attempt to explain differences in self-reported levels of well-being in terms of environmental quality. They find that air pollution and noise levels significantly reduce subjective well-being [15]. A paper with a focus on Spanish regions recommends that environmental variables have a significant impact on individual reported subjective well-being [81]. The results of present study are also compatible with the results of work done in different countries that suggest a relationship between air pollution and subjective well-being.

In the literature, different air pollutants, such as PM₁₀ [12, 16, 83], SO₂ [18, 82], and NO₂ [12, 17], were evidenced a negative impact on individual well-being in different studies for different countries or areas. Being exposed to local air pollution in terms of mass concentration of PM₁₀ significantly reduces individual's well-being [45, 83]. A significant negative and robust relationship between sulfur dioxide (SO₂) emissions at the country level and subjective well-being data in several European countries is found [82]. Smyth et al. [18], using pollution data in 30 cities in urban China, also find a clear negative impact of SO₂ emission on subjective well-being. Luechinger [84] finds a significant negative impact of SO₂ pollution on well-being by using annual mean concentrations of SO₂ at 533 monitoring stations in Germany over a 19-year period. Welsch [85] suggests that air pollution plays a statistically significant role as a predictor of differences in subjective well-being between countries and between time periods. The relationship was stronger for NO₂ than for total suspended particulate (TSP) concentration [85].

Several studies show the impact of air pollution on life satisfaction that has been considered as one of the fundamental indicators of subjective well-being. Air pollution, which has objective indicators, such as air pollutants including SO₂, NO₂, and PM₁₀, is significantly and negatively associated with the life satisfaction [8, 12, 17, 82, 84, 86]. The SO₂ concentration negatively

affects selfreported life satisfaction [45, 84]. Ferreira et al. [45], using detailed regional data, report a negative and significant relationship between air pollution and individual selfreported life satisfaction. An increase in SO_2 concentrations by $1 \mu\text{g}/\text{m}^3$ is associated with a reduction in life satisfaction of between 0.016 and 0.030 points on the 11-point life satisfaction scale [45]. Furthermore, local NO_2 concentrations significantly reduce the life satisfaction. MacKerron and Mourato [17], in a study in London, find that an increase in air pollution has a negative effect on the life satisfaction. They estimate that an increase of $10 \mu\text{g}/\text{m}^3$ in annual means nitrogen dioxide concentration is associated with a drop of nearly half a point of life satisfaction on the 11-point scale [17].

Menz and Welsch [87], using data on life satisfaction for 25 OECD countries from the World Database of Happiness, report that the link between air pollution (PM10 concentration) and life satisfaction is significantly negative and stronger for young and old people than for middle-aged individuals.

A number of studies have examined the effect of air pollution on happiness [12, 14, 15, 17, 79–82, 84, 85, 87, 88]. Environmental concern can affect happiness either positively or negatively [80]. Objective measures of air pollution have significantly negative impacts on the national happiness level [12, 81]. Air pollution significantly reduces shorter-term hedonic happiness and increases the rate of depressive symptoms [88]. The association between perceived levels of noise and air pollution and selfreported happiness, using individual level data from the German socio-economic panel (SOEP) surveys which contains a total number of about 23,000 observations, is considered by Rehdanz and Maddison [15]. It is found that higher perceived air pollution significantly diminishes happiness [15]. It is found that happiness responses of around 350,000 people living in the OECD between 1975 and 1997 are negatively correlated with environmental degradation (measured by SO_x emissions) [14]. Regional air pollution (measured by CO_2 emissions and number of days that PM10 exceeds a certain limit, $50 \text{ g}/\text{m}^3$) has a negative effect on happiness. In other words, air quality affects individual happiness positively [81]. Giovanis examines the association between happiness and air pollution using the life satisfaction approach (LSA). The results of the study suggest that the O_3 and SO_2 present the strongest negative effects on happiness followed by CO and NO_x [89]. Air pollution can significantly affect both human health and subjective well-being. There is evidence that health and SWB may also equally affect each other [90]. For instance, positive emotions and optimism as factors of SWB can have a positive influence on health [91].

7. Conclusion

It is obvious that air pollution has a negative significant impact on subjective well-being. This chapter also explores the association between air pollution and subjective well-being (life satisfaction-happiness-optimism). The present results also give reason for policy-maker to create clean environment. The findings propose that air pollutants, such as NH_3 , NO_x , NMVOCs, SO_x , CO_2 , and PM 2.5, may affect life satisfaction, happiness, or optimism, suggesting that

environmental policies focused on reducing air pollution will not only have a positive impact on the health of future generations, but at the same time will increase present individual's quality of life. The clean air can be expected to make people who live elsewhere in the world happier. There should be stronger and more stable approaches to general environmental problems and air pollution. Fight against air pollution is the responsibility of all individuals. The sensitivity of people to the environmental issue should be increased for healthier generation. The most important step to acquire awareness and sensitivity toward the environment is education. Teaching correctly and consistent information about environmental problems in schools are very important factors to raise awareness about air pollutants [92–95].

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