



## AN EXAMINATION OF SCIENCE TEACHER CANDIDATES' AWARENESS ABOUT THE CONCEPT OF GLOBAL POLLUTION AND ITS EFFECTS ON LIVING THINGS

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### **Abstract:**

The purpose of this study is defined as examining the awareness of preservice science teachers studying in faculties of education regarding the concept of global pollution and its effects on living things. The study group consisted of first- and fourth-year students studying in the Science Education Departments of the Education Faculties of four public universities in Turkiye using a convenient sampling method, a purposive sampling method. The study was conducted with a total of 80 prospective teachers, 10 from each grade. The study employed a semi-structured interview technique, a qualitative research method. The researcher developed an interview form containing six open-ended questions on "Biological Effects of Global Pollution on Living Organisms" as the data collection tool, and content validity was ensured through expert opinion. The research data were analyzed using descriptive analysis. The research findings indicated that prospective science teachers had a high level of awareness regarding the biological effects of air and water pollution on living organisms. It was determined that science teacher candidates have a higher awareness of the negative effects of global pollution on humans, but a lower awareness of its negative effects on plants and animals. Furthermore, it was determined that science teacher candidates and female teacher candidates who take

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environmental courses have a higher awareness of the biological effects of global pollution on living things.

**Keywords:** science, global pollution, teacher candidate

## 1. Introduction

In its simplest definition, the environment is the environment in which living things live. This environment is comprised of both living and non-living entities. Living entities include animals, humans, plants, and microorganisms; non-living entities include air, water, soil, temperature, and light (Gunay, 1995).

All living species interact with each other and contribute to the renewal of nature. However, after the industrial revolution, humans' negative impacts on nature (soil, air, water, etc.) increased, disrupting this balance mechanism (Basoglu, 2014).

As industrialization increased and developed, the use of fossil fuels such as oil and coal to meet energy needs increased the levels of gases which create a greenhouse effect in the atmosphere (Akin, 2009). Global warming has emerged as a result of the greenhouse effect created by increased fossil fuel consumption (Maslin, 2011).

Environmental problems and the resulting pollution began to be seen as a problem in the 1970s, and environmental awareness and sensitivity began to grow worldwide from that time on (Akin, 2009). At the 1971 SMIC (Scientific Activities on Climate Impact) conference, scientists' research highlighted the danger of rapid global change due to human-related factors (Basoglu, 2014). In the 1980s, evidence demonstrated that environmental problems negatively impact all living things. Previously thought to be limited to water, air, and soil pollution in industrial zones, environmental problems were later found to have many other consequences (Akin, 2009). In 1988, the Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Panel and the World Meteorological Organization due to concerns about the possibility of global warming (Maslin, 2011). Numerous NGOs worldwide conducted studies to draw attention to climate change, and in 1992, at the RIO Earth Summit, the United Nations Framework Convention on Climate Change (UNFCCC) was signed to protect the global climate.

Advancements in technology, industrial development, and population growth have disrupted the natural balance of the environment. This disruption has led to a significant increase in environmental pollution. One of the major causes of environmental pollution is the activities within the agriculture, industry, transportation, and tourism sectors. However, in order to achieve sustainable development in these sectors, investments must be environmentally compatible. As in the rest of the world, environmental pollution in Türkiye has been increasing due to a lack of sufficient sensitivity and awareness (Çınar, 2013)

## 2. Literature Review

A study conducted by Tikka *et al.* (2000) in Finland aimed to examine the effects of students' educational backgrounds at universities and other schools on their attitudes toward the environment and nature, their activities related to the environment and nature, and their knowledge. The findings indicated that female students are more environmentally responsible than male students.

A study conducted by McMillan *et al.* (2004) in Canada aimed to investigate the impact of a university-level environmental studies course on students' environmental values. The results indicated that students' environmental values deepened after taking these courses, shifting from an anthropocentric to an ecocentric state.

A study conducted by Zak and Munson (2008) aimed to determine preservice primary school teachers' understanding of basic ecological concepts. It was observed that, in general, preservice teachers concentrated on developing two sets of concepts related to nutrition and ecosystems and did not include concepts such as biotic and abiotic factors at all. A study conducted in Greece by Barbas *et al.* (2009) aimed to investigate the impact of various nature documentaries on students' environmental awareness at the primary school level. The results indicated that nature documentaries can increase environmental awareness.

A study conducted in Nigeria by Ajiboye and Olatundun (2010) aimed to examine the lasting effects of environmental education supplemented with out-of-school learning activities on environmental knowledge in primary school students. The study revealed that environmental education supplemented with out-of-school learning activities was more effective on environmental achievement than traditional methods. A study by Fettahlioglu (2018) aimed to analyze the social and environmental problems perceived by science teacher candidates based on their classroom and environmental literacy levels. The study concluded that teacher candidates' knowledge of environmental issues was superficial, meaning they were primarily concerned with problems they encountered in their immediate environment and were unable to fully grasp environmental issues that pose a global problem.

A study by Esme *et al.* (2021) found that mathematics and science teacher candidates had a high level of awareness of environmental issues and the concept of renewable energy. It was determined that there were significant differences in awareness levels of environmental problems based on department, relevant course taking, and grade level variables, but no significant differences were found based on gender and family income. In a study conducted by Torun (2024), science teacher candidates' general awareness of sustainable development and awareness of economic, environmental, and social sustainability were found to be high. However, no significant difference was found based on the parents' level of education or grade level. When gender, environmental course taking, and the high school they graduated from were examined, significant differences were found between the teacher candidates' sustainable development awareness scores. The purpose of this study is to determine the awareness of preservice

science teachers studying in faculties of education regarding the biological effects of global pollution on living organisms, and to examine their levels of awareness in relation to various variables. The research problem of this study is stated as follows:

- What is the level of awareness of preservice science teachers studying in faculties of education regarding the biological effects of global pollution on living organisms?

The sub-problem statements of the research are as follows:

1. Do the examples provided by preservice science teachers regarding global pollution differ based on:
  - (a) Whether they have taken an environmental course,
  - (b) Their gender?
2. Does the awareness of preservice science teachers regarding the negative effects of air pollution on humans, animals, and plants differ based on:
  - (a) Whether they have taken an environmental course,
  - (b) Their gender?
3. Does the awareness of preservice science teachers regarding the negative effects of water pollution on humans, animals, and plants differ based on:
  - (a) Whether they have taken an environmental course,
  - (b) Their gender?

It is imperative that the teachers who will educate future generations will also raise students who, in the future, will enter various professions, respond to different environmental problems, and play influential roles in environmental matters. In this context, it is particularly important to investigate and reveal the awareness levels of preservice science teachers regarding the biological effects of global pollution, which constitutes one of the most significant aspects of environmental problems affecting human life.

### **3. Material and Methods**

This research was designed using the phenomenological design, a qualitative research design. A phenomenological design focuses on phenomena we are aware of but lack detailed knowledge about (Yıldırım & Simsek, 2016). A case study, on the other hand, investigates a situation within a real-life context or environment. A case study should provide an in-depth understanding of the situation. For this purpose, a variety of data, from observation and interviews to documents and audiovisual materials, is used (Bal, 2016).

#### **3.1. Study Group**

This study employed a conveniently accessible case sample, a purposive sampling method. Purposive sampling is useful in explaining phenomena and events in many situations. Because in this method, the researcher prefers the situation that will reach them most closely and quickly (Yıldırım and Simsek, 2016).

The study group consisted of prospective teachers studying in the first and fourth years of the Science Education Departments of the Education Faculties of four public universities. The study was conducted with a total of 80 prospective teachers, 10 from each class. However, insignificant data were excluded from the study, and the opinions of 5 prospective teachers from each class were evaluated, and the data from a total of 40 prospective teachers were analyzed. In order to administer the questionnaires to the relevant students within the scope of the study, the necessary official permissions were obtained respectively through documents dated 02.02.2017 (No: 19125448-730.08.03), 02.01.2017 (No: 27224817-044), 13.03.2017 (No: 13466035-805.02.02.02), and 15.12.2016 (No: 76218066-302.14.01).

**Table 1:** Demographic Characteristics

| Demographic Characteristics | Frequency | Percentage (%) |    |
|-----------------------------|-----------|----------------|----|
| Gender                      | Female    | 26             | 65 |
|                             | Male      | 14             | 35 |
| University                  | 1         | 10             | 25 |
|                             | 2         | 10             | 25 |
|                             | 3         | 10             | 25 |
|                             | 4         | 10             | 25 |
| Grade Level                 | 1st Grade | 20             | 50 |
|                             | 4th Grade | 20             | 50 |

The demographic characteristics of the participants in the study are presented in Table 1. A total of 40 prospective teachers participated in the study, 26 of whom were female and 14 were male. Ten prospective teachers were interviewed from each university. Twenty of the prospective teachers were in their first year and 20 were in their fourth year.

### 3.2. Data Collection Tool

The semi-structured interview technique, a qualitative research method, was used in the study. Interviewing involves collecting data from relevant individuals within the framework of the research questions (Buyukozturk, 2014). A semi-structured interview form developed by the researcher was used as the data collection tool in the study. The researcher reviewed the relevant literature and examined qualitative and quantitative studies. The theoretical basis of the study was established through the literature review, and the questions planned to be included in the interview form were determined. Questions about the biological effects of global pollution were then posed to prospective teachers and faculty members for the measurement tool, and their opinions were obtained. The interview form was prepared to evaluate the questions in terms of purpose and scope, and validity was obtained through expert opinion. The prepared interview questions were finalized based on the opinions of two science education experts, one biology expert, one measurement and evaluation expert, one public health expert, two science teachers, and one Turkish language expression teacher.

### 3.3. Validity and Reliability Study

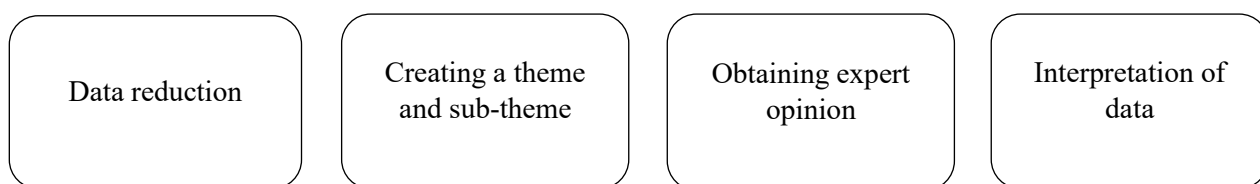
To ensure the credibility of the study, the semi-structured interview form was shown to eight experts and revised after their review. A pilot study was then conducted with 10 prospective teachers. The researcher, along with a field expert, evaluated the pilot study results to determine whether the questions were clear and understandable and whether the answers provided reflected the answers to the questions posed. At the end of this study, the credibility of the question items was ensured. Furthermore, the consistency of the study was enhanced by recording the interviews with a voice recorder and transcribing them accurately.

### 3.4. Data Collection and Analysis

The universities where the study would be conducted were identified, the necessary legal permissions were obtained, and data was collected during the 2016-2017 academic year. Before the interviews, the volunteered preservice teachers were informed about the interview process and the interview form. Face-to-face interviews with the participating preservice teachers were conducted using a voice recorder. Interviews lasted an average of 45 minutes for each preservice teacher.

Descriptive analysis was used to analyze the data collected through the interviews and transcribed into text. In conveying the participants' opinions, the teacher candidates were given numbers from 1 to 40. A total of four public universities were included in the study, with 10 participants selected from each university. In descriptive analysis, a framework for data analysis is created based on the interviews. According to this framework, the themes under which the data will be organized are determined. In descriptive analysis, the opinions of the participants are analyzed.

**Figure 1:** The Data Analysis Process



Data analysis is illustrated in Figure 1. At the end of the interviews, the audio recordings were listened to, and the data were converted into text. The qualitative data analysis process is carried out in a three-stage classification process.

The first of these stages is "data reduction." In this stage, the data collected from the field and not yet processed are subjected to the processes of sorting, summarizing, and transforming (Miles & Huberman, 1984). In accordance with this stage, the data collected from 80 preservice teachers was sorted, and irrelevant data was removed, resulting in a content analysis conducted with the data from a total of 40 preservice teachers.

The second step of the data analysis is "data visualisation." This stage aims to weave the data extracted, summarized, and transformed during the data reduction process into a structure designed to draw specific conclusions. Thus, the data set, which does not yet carry a specific meaning, is transformed into a more comprehensible form by interweaving the data (Miles & Huberman, 1984). For this purpose, the obtained data were divided into themes and subthemes and made more understandable. Expert opinions were obtained in the creation of themes and subthemes to increase the credibility and consistency of the research.

The final step of the data analysis process recommended by Miles and Huberman (1984) is "*reaching and confirming the conclusion.*" The reality, which remains vague and somewhat hidden within the data at the beginning of the research process, is determined in the final stage. In this stage, the collected data are explained and interpreted, and a detailed description is provided by presenting the participants' opinions. In presenting the participants' opinions, the teacher candidates were assigned numbers from 1 to 40 (the top 5 candidates for each university were coded as taking environmental courses). Numbers 1 to 10 represent prospective teachers studying at the first university, numbers 11 to 20 represent prospective teachers studying at the second university, numbers 21 to 30 represent prospective teachers studying at the third university, and numbers 31 to 40 represent prospective teachers studying at the fourth university.

## 4. Results and Discussion

### 4.1 Dimension (a)

Dimension (a) of the problem is "Do science prospective teachers' examples of global pollution differ depending on whether they have taken an environmental course?"

The results are shown in Table 2.

**Table 2:** Change in responses to the question "Can you explain global pollution with examples?" based on whether the prospective teachers have taken an environmental course

| Theme                    | Subtopic                    | E.C. Not taking | E.C. Taking/f |
|--------------------------|-----------------------------|-----------------|---------------|
| Environmental Pollution  | Air pollution               | 12              | 15            |
|                          | Water pollution             | 9               | 13            |
|                          | Soil pollution              | 5               | 13            |
|                          | Light pollution             | 1               | 1             |
|                          | Noise pollution             | 2               | 2             |
|                          | Nuclear pollution           | 1               | 1             |
|                          | Radioactive Pollution       | 2               | 0             |
| Humans' Damage to Nature | Industrialization           | 0               | 1             |
|                          | Population Growth           | 0               | 2             |
|                          | Unplanned Urbanization      | 1               | 1             |
|                          | Forest Fire and Destruction | 1               | 2             |
|                          | Erosion                     | 1               | 0             |
|                          | Exhaust Fumes               | 4               | 0             |
|                          | Perfume and Deodorant Use   | 5               | 3             |

|                                 |                                       |           |           |
|---------------------------------|---------------------------------------|-----------|-----------|
|                                 | Lack of Environmental Awareness       | 2         | 4         |
|                                 | Use of Non-Renewable Energy Resources | 2         | 2         |
|                                 | Smoking                               | 1         | 0         |
|                                 | Factory-Ship Waste and Garbage        | 9         | 4         |
| <b>Impact of Natural Events</b> | Ozone Layer Depletion                 | 7         | 3         |
|                                 | Global warming                        | 2         | 5         |
|                                 | Acid Rain                             | 4         | 2         |
|                                 | Climate Change                        | 2         | 4         |
|                                 | Melting of Glaciers                   | 3         | 3         |
|                                 | Changes in Greenhouse Gas Level       | 0         | 1         |
| <b>Total</b>                    |                                       | <b>76</b> | <b>82</b> |

Table 2 shows the frequencies of responses given by science teacher candidates who have and have not taken environmental courses to the question, "Can you explain global pollution with examples?" The teacher candidates' answers to global pollution were grouped under three themes: "environmental pollution," "human harm to nature," and "the impact of natural events." When evaluating the teacher candidates' responses under the environmental pollution theme, it was determined that they responded "air pollution (f=27), water pollution (f=22), and soil pollution (f=18)" more frequently than other subthemes, and accordingly, their awareness of air, water, and soil pollution was higher. On this topic, teacher candidates T1, T12, T25, and T33 stated, *"I consider air, water, and soil pollution a global problem."* Based on these findings, teacher candidates identified global pollution as the most prominent environmental pollution. However, it was found that candidates who took environmental courses had higher frequencies of responses under the specified subthemes, and therefore, their awareness was higher. It was determined that candidates who took environmental courses did not mention "radioactive pollution" at all. Candidates T2 and T4 stated that *"radioactive pollution is a dangerous phenomenon that negatively affects all living things."* These findings were only expressed by candidates who received education at a public university. This may be due to the high number of factories in the area where the teacher candidates live. When the overall results were evaluated on the environmental pollution theme, it was determined that candidates who took environmental courses (f=45) had higher awareness.

When the responses given by the teacher candidates under the theme of human damage to nature were evaluated, it was found that the subtheme "Factory-Ship Waste and Garbage (f=13)" was mentioned more frequently than the other subthemes. Candidates who did not take environmental courses had higher frequencies of responses under the specified subtheme, and therefore, candidates who did not take environmental courses had higher awareness. Regarding this topic, candidates T13 and T28 stated, *"I think that the lack of filters in factories causes air pollution and harms all living things."* Candidate T34 stated, *"I think that the disposal of factory waste into the sea causes water pollution and harms the lives of marine life."* Candidate T15 stated, *"I think that the leakage of oil reserves carried on ships into the sea and the disposal of ship waste into the sea will negatively affect the lives of all living things."* Based on these findings, prospective teachers analyze the pollution events they observe in their environment in depth and can predict their

consequences. It was found that candidates who did not take environmental courses did not mention the subthemes of "industrialization" and "population growth," and their awareness on these issues was lower than those who did. Similarly, candidates who did take environmental courses did not mention the subthemes of "Smoking," "Erosion," and "Exhaust Fumes," and their awareness on these issues was lower than those who did not take environmental courses. When the overall results were evaluated regarding the theme of human damage to nature, it was determined that candidates who had not taken an environmental course (f=26) had a higher level of awareness.

When the responses given by the prospective teachers under the theme of the impact of natural events were evaluated, it was determined that candidates who had taken an environmental course more frequently mentioned the subthemes "global warming (f=5)" and "climate change (f=4)", while those who had not taken an environmental course more frequently mentioned the subthemes "ozone layer depletion (f=7)" and "acid rain (f=4)", indicating a higher level of awareness on these issues. Regarding the topic, candidates T3 and T5 stated, "I think ozone layer depletion and the resulting harmful gases reaching the earth, as well as acid rain, are a global problem." Furthermore, candidates T8 and T17 stated, "I think global warming and climate change are problems affecting the entire world." Additionally, it was determined that candidates who had not taken an environmental course did not mention the subtheme "Changing Greenhouse Gas Rates" at all and that their awareness of these issues was lower than that of those who had taken environmental courses. When the overall results were evaluated regarding the impact of natural events, it can be said that the awareness levels of candidates who had taken an environmental course (f=18) and those who had not (f=18) were similar.

#### 4.2 Dimension (b)

Dimension (b) of the problem is "The examples provided by preservice science teachers regarding global pollution differ according to their gender."

The results are shown in Table 3.

**Table 3:** The variation in responses to the question "Can you explain global pollution with examples?" based on the gender of the preservice science teachers

| Theme                           | Subtopic                    | Woman/f | Man/f |
|---------------------------------|-----------------------------|---------|-------|
| <b>Environmental Pollution</b>  | Air Pollution               | 15      | 11    |
|                                 | Water Pollution             | 13      | 10    |
|                                 | Soil Pollution              | 6       | 10    |
|                                 | Light Pollution             | 2       | 0     |
|                                 | Noise Pollution             | 4       | 0     |
|                                 | Nuclear Pollution           | 0       | 2     |
|                                 | Radioactive Pollution       | 0       | 2     |
| <b>Humans' Damage to Nature</b> | Industrialization           | 1       | 0     |
|                                 | Population Growth           | 1       | 1     |
|                                 | Unplanned Urbanization      | 2       | 0     |
|                                 | Forest Fire and Destruction | 3       | 0     |

|                                 |                                       |            |           |
|---------------------------------|---------------------------------------|------------|-----------|
|                                 | Erosion                               | 0          | 1         |
|                                 | Exhaust Fumes                         | 4          | 0         |
|                                 | Perfume and Deodorant Use             | 8          | 0         |
|                                 | Lack of Environmental Awareness       | 5          | 1         |
|                                 | Use of Non-Renewable Energy Resources | 3          | 1         |
|                                 | Smoking                               | 1          | 0         |
| <b>Impact of Natural Events</b> | Factory-Ship Waste and Garbage        | 10         | 4         |
|                                 | Ozone Layer Depletion                 | 7          | 3         |
|                                 | Global warming                        | 5          | 2         |
|                                 | Acid Rain                             | 2          | 4         |
|                                 | Climate Change                        | 4          | 2         |
|                                 | Melting of Glaciers                   | 4          | 2         |
|                                 | Changing Greenhouse Gas Rates         | 1          | 0         |
| <b>Total</b>                    |                                       | <b>100</b> | <b>56</b> |

Table 3 shows the frequencies of responses given by female and male science teacher candidates to the question, "Can you explain global pollution with examples?" The teacher candidates' answers to global pollution were evaluated under three themes: environmental pollution, human damage to nature, and the impact of natural events.

When the teacher candidates' responses under the environmental pollution theme were evaluated, it was determined that they gave the subthemes "air pollution (f=27), water pollution (f=22), and soil pollution (f=18)" more frequently than the other subthemes, and that their awareness of these issues was at a similar level. Regarding this topic, candidate T12 stated, *"I think air, water, and soil pollution negatively affect all living things, both directly and indirectly."* Teacher candidates are aware of the interrelationships between natural events and living things and can predict their consequences. Female candidates did not mention the subthemes "radioactive pollution" and "nuclear pollution," indicating lower awareness than male candidates on these issues. Male candidates did not mention the subthemes "light pollution" and "noise pollution," indicating lower awareness than female candidates on these issues. When the overall results were evaluated regarding the environmental pollution theme, female candidates were found to have higher awareness.

When the responses given by prospective teachers under the theme "human damage to nature" were evaluated, female prospective teachers responded more frequently to "perfume and deodorant use (f=8)," "exhaust fumes (f=4)," and "lack of environmental awareness (f=5)" than other subthemes, while they did not mention "erosion" at all. Male candidates did not respond to questions such as "Smoking," "Exhaust Fumes," "Perfume and Deodorant Use," "Forest Fires and Destruction," "Unplanned Urbanization," and "Industrialization," and were found to have lower awareness on this issue than female candidates. Female candidates were found to have higher awareness on the subthemes "Factory and Ship Waste and Garbage (f=14)," "Lack of Environmental Awareness (f=6)," and "Use of Non-Renewable Energy Resources (f=4)" under this theme. Regarding this topic, candidates T<sub>14</sub> and T<sub>23</sub> stated, *"I think that the use of perfume, car exhaust fumes, and smoking cause air pollution and affect all living things."*

Teacher candidates generally explained global pollution using the most common events in their immediate environment. When the overall results were evaluated regarding the theme "Human Damage to Nature," it was determined that female candidates (f=38) had higher awareness. When examining the responses of prospective teachers under the theme of the impact of natural events, female candidates were more likely to respond to "global warming (f=5)," "climate change (f=4)," "ozone layer depletion (f=7)," and "glacier melting (f=4)," and, consequently, they were more aware of these issues than male candidates. In the responses under this theme, male candidates were more likely to respond to "acid rain (f=4)" than female candidates, and, consequently, they were more likely to respond to these issues than female candidates. Regarding this topic, prospective teachers T5, T15, T27, and T32 stated that *"the depletion of the ozone layer, the transmission of harmful gases to the earth, and the resulting climate change resulting from global warming are negative natural events that affect all living things."* Pollution is explained by the most frequently discussed natural events. Male candidates did not respond to the question "Changing Greenhouse Gas Rates" at all and were less aware of these issues than female candidates. When the overall results were evaluated regarding the impact of natural events, female candidates (f=23) were found to have higher awareness.

#### 4.3 Dimension (c)

Dimension (c) of the problem is "Does science teacher candidates' awareness of the negative effects of air pollution on humans, animals, and plants vary by whether they have taken an environmental course (dimension a) and by gender (dimension b)?"

The results are presented in Table 4.

**Table 4:** Responses to the question "What are the negative effects of air pollution on humans, animals, and plants?" vary by whether they have taken an environmental course and by gender

| Theme                             | Subtopic               | Live   | E.C. Not Taking (f) | E.C. Taking (f) | Woman (f) | Man (f) |
|-----------------------------------|------------------------|--------|---------------------|-----------------|-----------|---------|
| Occurrence of Biological Problems | Respiratory diseases   | Human  | 23                  | 24              | 33        | 14      |
|                                   | Respiratory diseases   | Animal | 7                   | 5               | 9         | 3       |
|                                   | Decrease in efficiency | Herb   | 5                   | 8               | 10        | 3       |
|                                   | Developmental problems | Herb   | 11                  | 12              | 15        | 8       |

Table 4 shows the frequencies of the most common responses given by science teacher candidates to the question, "Do you think air pollution has negative effects on humans, animals, and plants? What are they?" The most common responses were grouped under the theme "occurrence of biological problems." When the responses given by the teacher candidates under the theme of "occurrence of biological problems" were evaluated, it was determined that the subtheme "Respiratory diseases (f=47)" was given more frequently than other subthemes, and accordingly, their awareness of respiratory diseases was

higher. When evaluated according to whether or not they had taken an environmental course, candidate T6 (who had taken an environmental education course) stated, *"I think that allergic diseases such as asthma and bronchitis are increasing in people as a result of air pollution,"* and T18 (who had not taken an environmental education course) stated, *"I think that air pollution will cause shortness of breath in people and that excessive air pollution can lead to poisoning."* When evaluated by gender, female candidates mentioned the subtheme "Respiratory diseases (f=33)" more frequently than male candidates, and their awareness of this issue was higher than male candidates. Candidate T9 (female) stated, *"I think air pollution will affect people with asthma more."*

When the responses given by teacher candidates under the theme of biological problems occurring, it was determined that they mentioned the subtheme "Respiratory diseases (f=12)" more frequently than other subthemes, and accordingly, their awareness of respiratory diseases was higher. When evaluated by whether they had taken an environmental course, candidates T22 (who received an environmental education course) and T31 (who received an environmental education course) stated, *"I think animals may experience lung diseases and shortness of breath as a result of air pollution."* When evaluated by gender, female candidates mentioned the subtheme "respiratory diseases (f=9)" more frequently, and their awareness of this issue was found to be higher than that of male candidates. Candidates T29 (female) and T37 (female) stated, *"I think air pollution will harm the upper respiratory tract of animals."*

When the responses given by preservice teachers under the theme of biological problems were evaluated, it was determined that the subthemes "Developmental problems (f=23)" and "Reduction in productivity (f=13)" were mentioned more frequently than other subthemes, and accordingly, their awareness of these subthemes was higher. When evaluated by whether or not they had taken an environmental course, candidate T12 (who received an environmental education) stated, *"I think air pollution will cause a decrease in plant productivity, disrupt photosynthesis, and cause the plant to wilt."* Candidate T3 (who received an environmental education) stated, *"I think air pollution will cause problems in plant development."* When the responses were evaluated based on whether they had taken an environmental course on the theme of biological problems, it was determined that the awareness of candidates who had taken an environmental course (f=20) was slightly higher. When evaluated by gender, female candidates were found to have stated the subthemes "Decrease in yield (f=10)" and "Developmental problems (f=15)" more frequently than male candidates, and their awareness of these issues was higher than that of male candidates. Candidate T13 (female) stated, *"I think that air pollution will disrupt photosynthesis in plants, and as a result, the plant will dry out,"* while candidate T3 (male) stated, *"I think air pollution will cause problems in the metabolic processes of plants."* When the overall results were evaluated on the theme of biological problems, it was determined that female candidates (f=25) had higher awareness in the responses.

#### 4.4 Dimension (d)

Dimension (a) of the problem is “Does the awareness of prospective science teachers regarding the negative effects of water pollution on humans, animals, and plants vary depending on whether they have taken an environmental course (dimension a) or not (dimension b)?”

The results are presented in Table 5.

**Table 5:** Responses to the question, "What are the negative effects of water pollution on humans, animals, and plants?" vary depending on whether the prospective science teachers have taken an environmental course and by gender

| Theme                             | Subtheme               | Live   | E.C. Not taking (f) | E.C. Taking (f) | Woman (f) | Man (f) |
|-----------------------------------|------------------------|--------|---------------------|-----------------|-----------|---------|
| Occurrence of Biological Problems | Infectious diseases    | Human  | 10                  | 10              | 11        | 19      |
|                                   | Infectious diseases    | Animal | 5                   | 7               | 8         | 4       |
|                                   | Decrease in efficiency | Herb   | 5                   | 4               | 6         | 3       |
|                                   | Developmental problems | Herb   | 10                  | 7               | 8         | 9       |

Table 5 shows the frequencies of science teacher candidates' responses to the question, "Do you think water pollution has negative effects on humans, animals, and plants? What are they?" The most common responses were gathered under the theme of biological problems.

When the teacher candidates' responses under the theme of biological problems emerged, it was seen that they most frequently mentioned the theme of "Infectious diseases (f=20). When evaluated according to whether they had taken an environmental course, candidates S9 (who have taken an environmental education course) and T26 (who have not taken an environmental education course) stated, "I think water pollution will cause infectious diseases such as amoeba, dysentery, and cholera in humans." T27 (who has not taken an environmental education course) stated, "I think harmful substances ingested through water pollution will cause kidney stones." When evaluated by gender, candidates T7 (male) and T23 (female) stated, "I think water pollution will cause microbial diseases transmitted through drinking water, such as amoeba and dysentery, in humans," while candidate T28 (female) stated, "I think that ingesting polluted water will cause the formation of kidney stones."

When the responses given by prospective teachers under the theme of biological problems were evaluated, it was determined that they mentioned "Infectious diseases (f=12)" more frequently than other subthemes and that they had greater awareness of the aforementioned subtheme. When evaluated by whether they had taken an environmental course, candidates T11 (who had taken an environmental education course) and T37 (who had not taken an environmental education course) stated, "I think animals could be poisoned by wastewater contamination." When evaluated by gender, candidates T13 (female)

and T37 (female) stated, *"I think microbial diseases will occur in animals that drink polluted water."*

When the responses given by the prospective teachers under the theme of the emergence of biological problems were evaluated, it was determined that they mentioned the sub-theme "Developmental problems (f=17)" more frequently than the other sub-themes and that they had a greater awareness of the mentioned sub-theme. When evaluated according to whether they had taken an environmental course, prospective teachers T1 (who took C.D.) and T22 (who took C.D.) stated, *"I think that plants using water polluted by waste materials will experience growth and development problems."* Prospect T17 stated, *"I think that plants that ingest polluted water will experience disruptions in photosynthesis."* When the general results were evaluated under the theme of the emergence of biological problems, it was determined that the awareness levels of prospective teachers who took environmental courses (f=14) and those who did not (f=16) were similar. When evaluated according to gender, candidates T2 (female) and T22 (male) stated, *"I think the metabolic activities of plants that take in polluted water will be damaged."* Candidate T18 (female) stated, *"I think the photosynthesis of plants that use water polluted by waste materials will be disrupted."* When the results were evaluated in general regarding the theme of the emergence of biological problems, it was determined that the awareness of female candidates (f=17) was slightly higher.

This study examined how preservice science teachers define the concept of global pollution in relation to their environmental course attendance and gender. When the definitions of global pollution were analyzed based on whether participants had taken an environmental course, it was found that the subthemes "Air, Water, and Soil Pollution" were most frequently cited as the causes of global pollution. These results indicate that preservice teachers who had taken environmental courses demonstrated higher awareness of global pollution. This may result from the new information they acquired during their courses and their engagement with environmental media.

Similar to the current study, Yilmaz *et al.* (2012) reported that preservice teachers emphasized fundamental environmental issues such as water pollution, global warming, air pollution, and soil pollution. Likewise, Bozkurt (2011) found a significant difference between science teacher candidates who took environmental courses and those who did not regarding their understanding of the greenhouse effect, the ozone layer, acid rain, and biodiversity. Altinel *et al.* (2024) also observed that nearly half of science teacher candidates associated the concept of environmental problems with the words "garbage" and "air pollution." Similarly, Demir *et al.* (2023) identified global warming, water problems, deforestation, air pollution, and climate change as the most significant global environmental issues according to teachers.

When the definitions of global pollution were examined by gender, female teacher candidates gave more responses and demonstrated higher awareness than male candidates. Female participants emphasized subthemes such as "Air and Water Pollution," "Factory-Ship Waste and Garbage," and "Perfume and Deodorant Use," while male participants focused more on "Air and Water Pollution," "Factory-Ship Waste

and Garbage,” and “Acid Rain.” These findings suggest that both male and female teacher candidates show a relatively high sensitivity to environmental issues. In contrast, Ercengiz *et al.* (2014) and Erdogan (2016) reported no significant gender differences in environmental sensitivity or behavior among Social Studies and Psychological Counseling and Guidance preservice teachers. This difference may stem from science teacher candidates’ closer engagement with environmental topics due to the nature of their field.

Yilmaz (2024) found that environmental consciousness levels of teacher candidates varied across grades, with first-year students showing higher scores than those in later years. Additionally, female teacher candidates were more successful in transforming environmental awareness into practical skills than males. In the present study, both groups of science teacher candidates (those with and without environmental course experience) mentioned “Respiratory Diseases” most frequently when describing the negative effects of air pollution on humans. Both groups had similar awareness of air pollution’s effects, although awareness was slightly higher among those who had taken environmental courses. The same trend was observed for the effects of air pollution on animals, while the subtheme “Developmental Problems and Decreased Productivity” was most common for plants. These results indicate that attending environmental courses positively influences awareness of pollution’s biological effects.

Consistent with these results, Bradley *et al.* (1999) reported that students who took an environmental science course showed significant improvements in both knowledge and attitudes. When analyzed by gender, female participants mentioned “Respiratory Diseases” more frequently across all living groups (humans, animals, and plants), indicating higher overall awareness of the negative effects of air pollution. Similar results were obtained by Tikka *et al.* (2000), who found that female students were more environmentally responsible and more willing to engage in nature-related activities. However, Karatas (2013) found no significant gender differences in environmental awareness among preservice science, classroom, and social studies teachers.

Regarding water pollution, both male and female candidates most frequently mentioned “Infectious Diseases” as a negative effect on humans and animals. Those who had taken environmental courses expressed higher awareness levels than those who had not. For plants, “Reduction in Productivity” and “Developmental Problems” were the most common responses, with slightly higher awareness among females. These findings are consistent with Karatas (2013), who emphasized that environmental course attendance increases awareness of water pollution’s effects on living beings, even if gender does not always have a significant impact.

Overall, this study showed that preservice science teachers had higher awareness of the negative effects of global pollution on humans but lower awareness of its effects on plants and animals. This imbalance suggests that the biological dimensions of environmental pollution may not be sufficiently emphasized in current science education curricula.

## 5. Recommendations

- 1) It was determined that pre-service science teachers had higher awareness regarding the biological effects of air, water, and soil pollution on living organisms; however, their awareness of the biological effects of noise and light pollution was lower. It may be recommended that the content of environmental courses included in science teacher education programs at faculties of education be reconsidered in order to increase awareness about noise and light pollution.
- 2) It was found that pre-service teachers had higher awareness regarding the negative effects of global pollution on humans, whereas their awareness regarding its negative effects on plants and animals was lower. It may be recommended that the content of environmental courses in science teacher education programs be revised with a greater emphasis on the biological effects of global pollution on animals and plants.
- 3) It was determined that taking environmental courses positively affected pre-service science teachers' awareness of the biological effects of global pollution. Therefore, it may be recommended to include environmental courses in other undergraduate programs within faculties of education as well as in programs of other faculties, and to update the content of existing courses accordingly.
- 4) It was determined that female pre-service teachers had higher awareness regarding the biological effects of global pollution. In this regard, it may be recommended to increase the awareness of male pre-service teachers by encouraging their active participation in extracurricular environmental activities.
- 5) The biological effects of global pollution are an important issue affecting all people. In-service training programs on these issues may be provided for teachers who will educate future generations.
- 6) Awareness studies regarding the biological effects of global pollution may be conducted in different faculties and departments.

## 6. Conclusion

The findings of this study indicate that preservice science teachers who have taken environmental courses possess a higher level of awareness about global pollution than those who have not. Female preservice teachers were found to be more sensitive and conscious regarding environmental issues compared to males. The participants generally demonstrated stronger awareness of the human-related effects of pollution, especially respiratory and infectious diseases, while showing weaker understanding of the biological and ecological consequences affecting plants and animals.

It is recommended that faculties of education revise the content of environmental courses in science education programs to include more emphasis on the biological and ecological effects of global pollution on plants and animals. Environmental education curricula should integrate practical applications, such as fieldwork and project-based

learning, to help preservice teachers connect theoretical knowledge with real-world environmental challenges. Furthermore, in-service training programs focusing on global pollution and its biological effects should be offered to practicing teachers who will educate future generations.

Raising awareness of the biological effects of global pollution across different faculties and academic disciplines is also essential for developing a holistic understanding of environmental issues. Ultimately, global pollution affects not only humans but also all living organisms and ecosystems. Therefore, developing environmentally literate, responsible, and sensitive science teachers is a critical step toward promoting environmental awareness in future generations.

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### **Ethics Statement**

This research was carried out in full compliance with academic research ethics and legal regulations. Ethics committee approval for the study was granted by the Kahramanmaraş Sutcu Imam University Faculty of Science Ethics Committee with approval code 92405296-17, dated 31/10/2016. The study was approved within the scope of the thesis titled "*An Investigation of the Awareness of Preservice Science Teachers Regarding the Biological Effects of Global Pollution on Living Organisms*".

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### **Data Availability Statement**

The data presented in this study are available upon scholarly request.

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### **Conflict of Interest Statement**

The author declares no conflict of interest regarding the publication of this study.

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### **References**

- Ajiboye, J. O., & Olatundun, S. A. (2010). Impact of some environmental education outdoor activities on Nigerian primary school pupils' environmental knowledge. *Applied Environmental Education & Communication*, 9(3), 149–158. <https://doi.org/10.1080/1533015X.2010.510021>

- Akın, G. (2009). *Ekoloji-Çevrebilim ve çevre sorunları*. Tiydem Yayıncılık. Retrieved from [https://scholar.google.com/citations?view\\_op=view\\_citation&hl=en&user=Jrl1YtwAAAAJ&citation\\_for\\_view=Jrl1YtwAAAAJ:9yKSN-GCB0IC](https://scholar.google.com/citations?view_op=view_citation&hl=en&user=Jrl1YtwAAAAJ&citation_for_view=Jrl1YtwAAAAJ:9yKSN-GCB0IC)
- Altinel, T. Z., Hamalosmanoğlu, M., & Kızılay, E. (2024). Examination of pre-service teachers' cognitive structures regarding environmental issues. *Journal of Individual Differences in Education*, 6(1), 1–19. Retrieved from <https://dergipark.org.tr/tr/download/article-file/3681567>
- Bal, H. (2016). *Nitel araştırma yöntem ve teknikleri*. Sentez Yayıncılık.
- Barbas, T. A., Paraskevopoulos, S., & Stamou, A. G. (2009). The effect of nature documentaries on students' environmental sensitivity: A case study. *Learning, Media and Technology*, 34(1), 61–69. <https://doi.org/10.1080/17439880902759943>
- Başoğlu, M. (2014). *Küresel ısınma ve toprak ananın yıkımı*. Su Yayınları.
- Bozkurt, M. (2011). *Fen ve teknoloji öğretmen adaylarının çevre kavramları ile ilgili algulamalarının değerlendirilmesi ve bu algulamaların çevreye yönelik tutumları ile tutarlılığının incelenmesi* [Yayımlanmamış yüksek lisans tezi]. Çukurova Üniversitesi, Sosyal Bilimler Enstitüsü.
- Bradley, J. C., Waliczek, T. M., & Zajicek, J. M. (1999). Relationship between environmental knowledge and environmental attitudes of high school students. *The Journal of Environmental Education*, 30(3), 17–21. <https://doi.org/10.1080/00958969909601873>
- Büyüköztürk, Ş., Çakmak, E. K., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2008). *Bilimsel araştırma yöntemleri* (15. baskı). Pegem Akademi. <https://doi.org/10.14527/9789944919289>
- Çınar, Ö. (2013). *Çevre kirliliği ve kontrolü*. Nobel Yayıncılık. Retrieved from [https://www.researchgate.net/publication/283082229\\_Cevre\\_kirliligi\\_ve\\_kontrol\\_u](https://www.researchgate.net/publication/283082229_Cevre_kirliligi_ve_kontrol_u)
- Demir, F. B., & Öteleş Ulukaya, Ü. (2023). Öğretmenlerin gözüyle çevre sorunları ve çevre sorunlarına ilişkin çözüm önerileri. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 23(1), 379–396. <https://doi.org/10.17240/aibuefd.2023.-1224985>
- Erdoğan, K. (2016). *Sosyal bilgiler öğretmenlerinin çevre eğitimi konusundaki görüşleri ve yeterlilikleri* [Yüksek lisans tezi]. Gazi Üniversitesi. Retrieved from <https://avesis.gazi.edu.tr/yonetilen-tez/ae5bb793-386c-497c-a587-d9a3624c2ba9/sosyal-bilgiler-ogretmenlerinin-cevre-egitimi-konusundaki-gorusleri-ve-yeterlilikleri>
- Ercengiz, M., Keçeci Kurt, S., & Polat, S. (2014). Öğretmen adaylarının çevre sorunlarına yönelik duyarlılıklarının incelenmesi: Ağrı ili örneği. *Ağrı İbrahim Çeçen Üniversitesi EKEV Akademi Dergisi*, 59, 126–128. Retrieved from <https://dergipark.org.tr/en/download/article-file/2567005>
- Eşme, A., Yağcı, Ç., & Demir, D. (2021). Öğretmen adaylarının çevre sorunları ve yenilenebilir enerjiye yönelik farkındalık düzeylerinin incelenmesi. *Journal of Social and Humanities Sciences Research*, 8(73), 2154–2166. <https://doi.org/10.26450/jshsr.2669>

- Fettahlioğlu, P. (2018). Algılanan çevresel sorunların çevre okuryazarlık düzeyine göre analizi. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 14, 404–425. Retrieved from <https://dergipark.org.tr/tr/pub/mersinefd/article/400607>
- Günay, T. (1995). *Orman, ormansızlaşma, toprak ve erozyon* (3. basım). TEMA Vakfı Yayınları.
- Hansen, P. J. K. (2005). The greenhouse effect and the effects of the ozone layer: Norwegian teacher students' development of knowledge and teaching skills. *European Meteorological Society*, 2, 33–39.
- Karataş, A. (2013). *Çevre bilincinin geliştirilmesinde çevre eğitiminin rolü: Niğde Üniversitesi Eğitim Fakültesi örneği* [Doktora tezi]. Ankara Üniversitesi, Sosyal Bilimler Enstitüsü. Retrieved from <https://avesis.ankara.edu.tr/yonetilen-tez/0d3da183-0706-4508-b32e-9a62f6b11411/cevre-bilincinin-gelistirilmesinde-cevre-egitiminin-rolu-ve-nigde-universitesi-egitim-fakultesi-orneği>
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage Publications. Retrieved from [https://books.google.ro/books?id=2oA9aWlNeooC&printsec=frontcover&redir\\_esc=y#v=onepage&q&f=false](https://books.google.ro/books?id=2oA9aWlNeooC&printsec=frontcover&redir_esc=y#v=onepage&q&f=false)
- Maslin, M. (2011). *Küresel ısınma*. Dost Kitabevi Yayınları. Retrieved from [https://books.google.ro/books/about/K%C3%BCresel\\_Isınma.html?id=W2DTzgeACAAJ&redir\\_esc=y](https://books.google.ro/books/about/K%C3%BCresel_Isınma.html?id=W2DTzgeACAAJ&redir_esc=y)
- McMillan, E. E., Wright, T., & Beazley, K. (2004). Impact of a university-level environmental studies class on students' values. *The Journal of Environmental Education*, 35(3), 19–27. <https://doi.org/10.3200/JOEE.35.3.19-27>
- Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: A sourcebook of new methods*. Sage Publications. Retrieved from [https://books.google.ro/books/about/Qualitative\\_Data\\_Analysis.html?id=5AFHAAAMAAJ&redir\\_esc=y](https://books.google.ro/books/about/Qualitative_Data_Analysis.html?id=5AFHAAAMAAJ&redir_esc=y)
- Tikka, P. M., Kuitunen, M. T., & Tynys, S. M. (2000). Effects of educational background on students' attitudes, activity levels, and knowledge concerning the environment. *Journal of Environmental Education*, 31(3), 12–19. <https://doi.org/10.1080/00958960009598640>
- Tomanbay, M. (2008). *Dünyada su ve küresel ısınma sorunu*. Phoenix Yayınları.
- Türkoğlu, A., & Şahin, Ü. (2013). Öğretmen adaylarının çevre sorunlarının nedenlerine, çözümlerine ve çevre eğitimine ilişkin görüşleri. *Ankara Üniversitesi Eğitim Bilimleri Dergisi*, 46(2), 179–193. Retrieved from <https://dergipark.org.tr/en/pub/auebfd/article/445014>
- Yıldırım, A., & Şimşek, H. (2016). *Nitel araştırma yöntemleri* (10. baskı). Seçkin Yayınları. Retrieved from <https://www.seckin.com.tr/kitap/sosyal-bilimlerde-nitel-arastirma-yontemleri-ali-yildirim-hasan-simsek-s-p-116659534?srsltid=AfmBOoqNM9vEHqEklwyoah4sjdNAIosjwrv-yQWR5TcuPQwiMa0G6g9N>
- Yılmaz, F., & Gültekin, M. (2012). Sınıf öğretmeni adaylarının çevre sorunları bağlamında öğrenim gördükleri programa ilişkin görüşleri. *Dicle Üniversitesi Ziya Gökalp*

- Eđitim Fakóltesi Dergisi*, 18, 120–132. Retrieved from <https://dergipark.org.tr/tr/pub/zgefd/article/606632>
- Yılmaz, S., & Zorlutuna, Ő. (2024). Öğretmen adaylarının çevresel duyarlılık, çevre bilinci ve çevre sorunlarına yönelik davranışlarının incelenmesi. *Sinop Üniversitesi Sosyal Bilimler Dergisi*, 8, 25–49. Retrieved from <https://dergipark.org.tr/en/pub/sinopusd/article/1462960>
- Zak, K. M., & Munson, B. H. (2008). An exploratory study of elementary preservice teachers' understanding of ecology using concept maps. *Journal of Environmental Education*, 39(3), 32–46. <https://doi.org/10.3200/JOEE.39.3.32-46>