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Investigation of the Opinions of Preservice Science Teachers about Chemical Wastes

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Abstract
This research was carried out with the aim of investigating the opinions of preservice science teachers about chemical wastes. The research conducted with the screening model was carried out with the voluntary participation of 54 preservice teachers studying at the Department of Science Education at a state university in the 2019-2020 spring semester in Turkey. An opinion form composed of 6 questions prepared by the researchers was used as a data collection tool. Expert opinions were taken for the validity of the questions in the form. Opinions of preservice teachers were analyzed by making content analysis. As a result of the research, preservice science teachers stated that people exposed to chemicals through breathing, food and contact; that chemical wastes cause environmental problems such as water, air and soil pollution; that chemicals have toxic effects that can cause health problems, respiratory diseases and death; that chemicals have effects on all living creatures and the environment such as diseases and restriction of habitats; that the collection, utilization and disposal of chemical wastes is done by recycling; that there is a connection between chemical wastes and bacteria or virus outbreaks and they can lead to diseases / outbreaks.

Key words: Chemical wastes, Opinions of preservice teachers, Preservice science teachers

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1. Introduction

There are many hazardous products we use to make life easier but they harm the environment. Cleaning, paint, cosmetics etc. products enable us to do our tasks more quickly, easily and effectively. However, these products contain hazardous chemicals and their harmful effects may be observed if they are not used carefully or chemical waste is not disposed (Ministry of Environment and Forestry [MoEF], 2009). Substance or by-product occurring after the application of any chemical process or during any process can be considered as chemical waste. These wastes may pose a risk to the human health and the environment (Mann, 2006).

In addition to the increase in waste types, substantial increase in the amount of waste generated also creates an environmental problem. Duties and responsibilities fall to conscious, sensitive and mindful individuals in reducing waste amount, sorting waste at its source and sending it to recycling (Karatekin, 2013). Waste fluorescent lamps, waste batteries and paints from building products are chemical wastes that affect the ecosystem. For example, whereas thousands of new fluorescent lamps are installed every year, almost the same number of lamps are thrown away. With the recycling of fluorescent lamps, both hazardous wastes are properly disposed and resources such as glass, metal and phosphorus powder are recycled (Akyol, Yeşilnacar, Derin and Turp, 2018).

The release of wastes into coastal waters harms local marine life and poses a serious health hazard to society (Mann, 2006). From this perspective, many industries are associated with environmental

pollution. These industries include leather industries, and organic and inorganic substances used to remove pollutants produce toxic wastewater (Saxena, Chandra and Bharagava, 2016). Although many environmental organizations have listed certain chemicals as hazardous and have prevented them from being used in the leather industry, most of these chemicals are still detected in wastewater. Mixing wastewater with drinking water or pouring it onto the surface may cause major problems on human health (Crosby, Tatu, Varonka, et al., 2018).

The precautions, processes and methods applied for human and environmental health during the production, supply and management of chemicals are provided by eliminating or reducing the negative effects of wastes, and controlled and conscious production of chemicals. When working with chemicals, contaminated waste and packages are used. The disposal of chemical waste, reducing the waste level at its source, reusing them if possible, categorizing the wastes by considering their types and characteristics are of capital importance. The categorized wastes must be collected separately and the collected wastes must be accumulated and stored in the designated temporary storage area. The transportation, recycling / recovery of wastes or disposal according to the type of waste, monitoring, controlling and auditing processes related to the negative effects that may arise from the disposal are among the steps of waste management. In order to manage the waste reduction process properly, chemicals that will produce as little waste as possible should be used, and planning should be made regarding production methods and processes (Arslan Kılınç, 2019).

Chemicals are classified according to their hazard characteristics and in this process, they are labeled using pictograms to guide them. Compatible and incompatible chemicals are separated according to their hazard classes (explosive, toxic, oxidizing, flammable, radiation-containing, corrosive, biohazardous substances, compressed gases). It is checked that the classified chemicals do not interact with each other and do not cause hazardous reactions (Directorate of Occupational Safety and Health Services [DOSHS], 2011).

Although there are some regulations for the management of chemicals in national and international platforms, there are no regulations to meet the needs. Providing safe management of chemicals Inter-Organization Program for The Sound Management of Chemicals (IOMC) among organizations is thought to strengthen cooperation at the international level in the field of chemicals (Tarım, 2017). Accordingly, it is important to treat chemical wastes appropriately. The standard security protocol is considered as an obligation, as the misuse of chemical waste can damage personal security and corporate assets. In this respect, many laboratories have chemical disposal guidelines (Armor, 2003; Stricoff and Walters, 1995).

The wastes generated from the use of the chemicals we prefer to make our daily life easier can harm nature and living creatures. Preservice teachers should be aware of chemical wastes and the sources that cause these wastes, the ways of exposure to chemicals, the effects of chemicals on living creatures and the environment, and the control of wastes (Çelikler, Yenikalaycı and Aksan, 2019). As the teachers of the future who will educate their students about human, other living creatures and environmental health is important to first determine the opinions of the preservice science teachers about chemical wastes. In this study, it was aimed to determine the opinions of preservice science teachers about chemical wastes. In the research, an answer was sought to the question "What are the opinions of preservice science teachers about chemical wastes?" The sub-questions of the research are as follows:

1. What are the opinions of preservice science teachers on the ways of exposure to chemicals?
2. What are the opinions of preservice science teachers on the environmental problems caused by chemical wastes?
3. What are the opinions of preservice science teachers on the toxic effects of chemicals?
4. What are the opinions of preservice science teachers on the effects of chemicals on living things and the environment?
5. What are the opinions of preservice science teachers on how chemical waste is collected, used and disposed?
6. What are the opinions of preservice science teachers regarding whether there is a connection between chemical wastes and bacteria or virus outbreaks?

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2. Method

2.1 Research Model

The screening model provides a quantitative description of the studies carried out with the sample selected from the universe and the features such as tendency, attitude and opinion about the universe (Cresswell, 2017).

2.2 Study Group

The research was carried out in the spring semester of 2019-2020 with the voluntary participation of 54 preservice teachers studying at the Department of Science Education at a state university in Turkey. The study group included preservice teachers studying at the 3rd and 4th grades as they attended at least 1 course (Environmental Sciences / Special Topics in Chemistry) related to chemical wastes.

2.3 Data Collection Tool

An opinion form composed of 6 questions prepared by the researchers was used as a data collection tool. The opinions of 6 experts from science and biology education fields were taken for the validity of the questions in the form. They are asked to explain the ways of exposure to chemicals, the environmental problems caused by chemical wastes, the toxic effects of chemicals, the effects of chemicals on living creatures and environment, the ways chemical wastes are collected, used and disposed and the link between the chemical wastes and bacteria or virus outbreaks.

2.4 Analysis of Data

The data were analyzed through content analysis and codes were created and direct quotations from the statements of preservice teachers (PT_1 - PT_2 - PT_3 …) were included.

3. Findings

The opinions of preservice science teachers on the ways of exposure to chemicals are analyzed and given in Table 1.

Table 1. The ways of exposure to chemicals

Code	f	Code	f
Through inhalation	19	Through food	19
By contact	11	Polluted water	9
Polluted air	9	Cosmetics	8
Factory wastes	6	Cleaning supplies	6
Environmental pollution	5	Wastes / garbage	5
Polluted soil	4	Professions working with chemicals	4
Radiation	4	Oral	4
Acid rains	3	Medicines / medical waste	3
Technological devices	1	Chemical product factories	1
Absorption	1	I do not know	2

When Table 1 is examined, it is seen that preservice teachers express their opinions about the ways of exposure to chemicals mostly through inhalation (f:19), food (f:19) and contact (f:11). Some examples related to the opinions of preservice teachers are given below.

> "Living creatures exposed to factory waste, those working in a laboratory environment and cleaning operatives" (PT_3)
>
> "Foods, beverages... I think they use chemicals in some products such as chickens to speed up the production phase." (PT_{20})

"Perfumes, deodorants, cosmetics, cleaning materials, medical wastes, foods grown with artificial fertilizers, some textile products" (PT_{26})

"We can be exposed to the chemicals in any way, many materials we touch, from the toothpaste to building materials, have chemical content" (PT_{41})

The opinions of preservice science teachers about environmental problems caused by chemical wastes are analyzed and given in Table 2.

Table 2. Environmental problems caused by chemical wastes

Code	f	Code	f
Water pollution	29	Air pollution	25
Soil pollution	21	Environmental pollution	14
Acid rains	7	Ozone layer depletion	7
Death / life-threatening conditions	5	Diseases	4
Global warming	3	Disruption of ecological balance	3
Extinction of species	3	Climate change	3
Drought	2	Radioactive contamination	2
Disruption of the structure of nature	2	Food contamination	1
Decrease in biodiversity	1	Contamination of nature with waste from industrial sites	1
Decrease in forests and agricultural products	1	Erosion	1
Disruptions in the food chain	1	Decrease in the benefits of vegetables and fruits	1
Risk of economic instability	1	Damage, destruction of plant species	1
Negatively affects human life	1	Threatening the natural habitat of the living creatures	1
Destruction	1	Food spoilage	1
Poisoning cases	1		

When Table 2 is examined, it is seen that preservice teachers express their opinions on environmental problems caused by chemical wastes mostly as water pollution (f:29), air pollution (f:25) and soil pollution (f:21). Some examples of preservice teachers' opinions are given below.

"Drought, radiation, water, soil and air pollution" (PT_5)

"Pollution of the ground and underground waters, reduction in forests and agricultural products" (PT_{32})

"Acid rains lead to a decrease in the benefit of vegetables and also cause death. We are in a mutual relationship with our environment. Therefore, as the interaction between us increases, chemical wastes enter our lives more and more. It mixes with air, soil, water and enters the life of all living creatures." (PT_{35})

"The harmful gases coming out of the pipes of the industry and various factories pollute the air, cause acid rains, and pollute the water while disrupting the structure of the nature. It damages and destroys many types of plants; it also damages and corrodes sculptures made of various materials

such as limestone and other structures." (PT_{38})

"The danger of extinction of plants and animals, the change in oxygen ratio in nature and the depletion of the ozone layer" (PT_{53})

The opinions of preservice science teachers on the toxic effects of chemicals are analyzed and given in Table 3.

Table 3. The toxic effects of chemicals

Code	f	Code	f
Disease	18	Respiratory tract diseases	12
Death	12	Health	8
Destruction / irritation	6	Mutation	5
Contacted organs	3	Air pollution	3
Acid rains	2	Products with changed content	2
Permanent damage to organs	2	Disruption of the cycle of the universe	2
Environmental pollution	2	Extinction of species	1
Ozone layer depletion	1	Through food	1
Radiation	1	I do not know	12

When Table 3 is examined, it is seen that preservice teachers expressed their opinions about the toxic effects of chemicals mostly as diseases (f:18), respiratory tract diseases (f:12) and death (f:12). In addition, it was seen that 12 preservice teachers answered that they did not know this subject. Some examples of preservice teachers' opinions are given below.

"It causes poisoning because of the products we eat and drink. For example, mutated babies were born for years after the explosion of Hiroshima and Nagasaki." (PT_{15})

"Uranium and radium can also harm living and non-living things in the environment. Oxidized iron is harmful to human health. Carbon monoxide is lethal and pollutes the air. Methane gas is explosive and pollutes the environment. Sulfuric acid is poisonous and perforating." (PT_{35})

"It can be irritating, corrosive, allergic, and cause various health problems. For example, there is CO in the smoke and when it enters the respiratory tract, it binds faster and easier than oxygen in the blood. This causes blood poisoning and can even be fatal." (PT_{38})

The opinions of preservice science teachers on the effects of chemicals on living creatures and the environment were analyzed and given in Table 4.

Table 4. The effects of chemicals on living creatures and the environment

Code	f	Code	f
Diseases	19	Restriction of living spaces	18
Disruption of ecological balance	11	Environmental pollution	11
Death	10	Poison effect	9
Disruption in the balance of living creature / nature	9	Mutation	6
Soil pollution / decrease in soil fertility	6	The extinction of living things	5
Infertility in species	4	Diversity in species / impact on the population	4
Life quality of living creatures	3	Climate change / greenhouse effect / ozone layer depletion	3
Air pollution	2	Species losses	1
Water pollution	1	I do not know	1

When Table 4 is examined, it is seen that preservice teachers expressed their opinions about the effects of chemicals on living creatures and the environment mostly as it may cause diseases (f:19) and restrict the habitats of the living creatures (f:18). In addition, it was seen that a preservice teacher answered that she / he did not know this subject. Some examples of preservice teachers' opinions are given below.

> "Fatal, damaging, burning, organ loss" (PT_{23})
>
> "Medications given for plants can sometimes have positive effects and sometimes negative effects, so they can bear both good and bad results." (PT_{37})
>
> "Some plants and animals may be in danger of extinction and acid rains may change the structure of some plants. As a result, living creatures may be mutated; critical diseases such as cancer will appear; the structure of the soil will be deteriorated and its fertility will decrease." (PT_{39})
>
> "It has a poisonous effect on living things, it also has irreversible effects on the environment" (PT_{50})
>
> "It may cause food chain breaks, extinction of species and decrease in vegetation" (PT_{53})

The opinions of preservice science teachers about how chemical wastes are collected, utilized and disposed are analyzed and given in Table 5.

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Table 5. Collection, utilization and disposal of chemical wastes

Code	f	Code	f
Recycling	14	Waste collection bins	5
Disposal according to material	5	Waste treatment	4
Recycling of recyclables	4	Organizing campaigns / awareness of people	3
Waste incineration	3	Non-governmental organizations / waste collection institutions / private collection centers	3
Storage	3	Removal without contact with the environment and living creatures	2
Recycle and reuse	2	Accumulation in a place / facility where chemical waste is collected	2
Selection of appropriate method (recycling-disposal)	2	Categorizing items by type	2
Taking precautions	2	Recycling facilities	2
Release to nature	1	Reducing the use of fossil fuels	1
Producing methane gas	1	Waste sorting	1
Waste should be collected with the help of machines	1	Labeling of the relevant process on the chemical	1
Waste sorting centers	1	I do not know	14

When Table 5 is examined, it is seen that preservice teachers expressed their opinions about how to collect, utilize and dispose of chemical wastes as recycling (f:14). In addition, it was observed that 14 preservice teachers answered that they did not know this subject. Some examples of preservice teachers' opinions are given below.

> "The active ingredients are collected separately and disposed by various processes." (PT_{10})
>
> "There are recycling bins where chemical waste can be collected at first. Then the wastes are classified and the recycling process begins." (PT_{26})
>
> "Detailed information on how to combat the chemicals spread to the environment should be written on the chemical. If the chemicals are sensitive to certain conditions such as heat, humidity, etc. during storage, precautions should be taken accordingly and their storage should be done as such." (PT_{48})
>
> "These wastes are collected separately and brought to the related facility. If it is a recyclable waste, it can be recycled. Wastes are rendered harmless by chemical treatment. If this is not applicable, incineration and storage processes are applied." (PT_{49})

In addition, it is understood that a preservice teacher (PT_{15}) mixes domestic wastes and chemical wastes with the expression "Generally, paper, glass and metal are separately collected. In this way, environmental pollution will be less".

The opinions of preservice science teachers about whether there is a link between chemical wastes and bacteria or virus outbreaks are analyzed and given in Table 6.

Table 6. The link between chemical waste and bacteria or virus outbreaks

Code	f	Code	f
It may cause diseases / outbreaks	10	Chemicals can expand the living environment of bacteria or viruses	7
Mutation of bacteria or viruses	5	Bacteria and viruses are everywhere where hygiene conditions are not met	4
Weakening of immune system	3	It may increase the spread rate of bacteria or viruses	2
Mutation in living cells	2	The presence of microorganisms	2
Disruption of natural balance	2	The survival of bacteria depends on the resistance of the bacteria	1
The virus cannot reproduce without a living cell	1	It is transmitted from living organisms	1
Chemical wastes can mutate and act as viruses or bacteria	1	Wastes can enter the human body as viruses.	1
It may cause radiation.	1	Chemicals can form bacteria.	1
Yes	17	Possible	9
I do not know	8	No	4

When Table 6 is examined, it is seen that preservice teachers have expressed their opinions mostly about whether there is a link between chemical wastes and bacteria or virus outbreaks (f:17) and they may lead to diseases / outbreaks (f:10). Some examples of preservice teachers' opinions are given below.

> "In an environment with chemical waste, bacteria can grow or die. It depends on the resistance of bacteria, but the virus has no viability in such environments, they cannot reproduce without a living cell." (PT_3)
>
> "When chemical wastes enter our bodies as poisons, they can mutate and act as viruses or bacteria." (PT_{15})
>
> "As bacteria and particularly viruses are capable of living in extreme conditions, it will be very easy for them to live and reproduce in such environments. It can also cause outbreaks as a result of excessive reproduction." (PT_{30})
>
> "Excessive chemical consumption leads to weakness in the immune system of the human body; for example, hand disinfectant can destroy the natural layer on the skin and make it easier for viruses to enter the skin. Then, the beneficial bacteria in the digestive system disappear due to the chemicals used and may lose the ability to kill germs." (PT_{52})

In addition, the statement of a preservice teacher (PT_{18}) as "In case of air pollution or environmental pollution, DNA may be disrupted and virus or bacteria can turn into a harmful DNA." draws attention in terms of lack of information.

4. Discussion and Conclusion

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As a result of the research, preservice science teachers stated that

- People are exposed to chemicals through inhalation, food, contact; polluted water, air and soil; cosmetics, factory wastes, cleaning materials, wastes / garbage, radiation, professions working with chemicals;
- Chemicals lead to environmental problems such as water, air, soil and environmental pollution, acid rains, depletion of ozone layers;
- Chemicals have toxic effects that can cause air pollution, respiratory tract diseases, destruction / irritation, damage organs that it contacted, mutation, disease and death;
- Chemicals have effects on living creatures and the environment such as diseases, restriction of habitats, environmental pollution, soil pollution / decrease in soil fertility, disruption of the ecological balance, disruption in the balance of living creature / nature, extinction of species, death, poison effect, mutation;
- The collection, utilization and disposal of chemical waste is done by recycling; especially recyclables should be recycled; waste collection bins must be available; waste collection should be carried out by non-governmental organizations, collection institutions and private collection centers; there are treatment, storage, incineration processes; disposal procedures are applied according to the materials; campaigns should be organized to raise awareness of people on this issue;
- There is a link between chemical waste and bacteria or virus outbreaks; it may lead to diseases, outbreaks; chemicals may expand the habitats of bacteria or viruses; bacteria or viruses may mutate; bacteria and viruses are everywhere where hygiene conditions are not met.

Results of the study are consistent with the literature. Çelikler, Yenikalaycı and Aksan (2019) stated that chemical wastes cause harm to living creatures and the environment and lead to environment, water, soil and air pollution; they are harmful to human health, skin and eyes; they have effects such as respiratory distress, irritation, burning and poisoning. Similarly, Yıldız and Aykan (2018) indicated that healthcare professionals and laboratory specialists have infection and chemical-related occupational risks and stated that pictograms related to laboratory safety can be used in this process.

In the research, preservice teachers stated environmental problems caused by chemical wastes as water, air, soil and environmental pollution. As a matter of fact, chemicals should not be left in dirty places or open areas close to water supply inlets, in areas where they can contact the environment (DOSHS, 2011).

In the research, two preservice teachers (PT_2 and PT_8) stated that products with changed contents may have a toxic effect. Similarly, expired chemicals are the main hazardous waste sources (DOSHS, 2011).

In order to emphasize the link between chemical wastes and bacteria or virus outbreaks, the most important result of the research is that it is necessary to remind that chemicals are classified as biohazardous substances. In addition, the fact that preservice teachers didn't mention the use of personal protective equipment (gloves, apron, mask, boots, etc.) while talking about the ways of exposure to chemicals, points out that there may be a lack of information on this subject.

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