ACTA DIDACTICA NAPOCENSIA

Volume 12, Number 1, 2019

THE COMPARISON OF THE KNOWLEDGE OF PRE-SERVICE TEACHER ON THE NIROGEN-PHOSPHORUS CYCLES USING THE WRITING AND DRAWING METHOD

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Abstract: The purpose of this study is to reveal the levels of knowledge held by pre-service science teacher concerning the nitrogen – phosphorus cycle, using the expression and drawing method. Awareness of a cyclical relationship between nitrogen and phosphorus, which are a vital requirement for living creatures, and living beings and their environment, plays an important role in the understanding of material cycles. 60 candidate teachers, whose education in the 3rd year of the Program in Elementary Science Education, in the Faculty of Education, at the Eskisehir Osmangazi University, is continuing, have participated in this study. It was requested that candidate teachers express the nitrogen and phosphorus cycle in nature both in words and pictures. The writings and drawings of candidate teachers on the two cycles have been have been analysed using the descriptive analysis method. The drawings and written explanations have been grouped and interpreted in terms of levels. As a result of the study, the level of knowledge held by candidate teachers in respect of the nitrogen cycle was determined as level 3 in terms of the levels of knowledge of 63.3%, and in terms of the drawing levels of 76.6% of candidate teachers. When the phosphorus cycle was examined, the levels of knowledge of 43.3%, and drawing levels of 45% of candidate teachers were determined to be at level 3.

Key words: drawing, nitrogen cycle, phosphorus cycle, pre-service science teachers, writing

1. Introduction

Nitrogen and phosphorus are at the top of the list of the fundamental elements which are vital for the existence of living creatures. Nitrogen is present within the structures of the amino-acids and proteins which form the building blocks for living creatures; it is also present within the structures of nucleic acids, hormones and vitamins. Phosphorus, on the other hand, is in the structures of nucleic acids, phospholipids, phosphoproteins and cell membranes.

The principal source of nitrogen within nature is the atmosphere and living creatures. The ratio of nitrogen within the atmosphere is 78%, but only some micro-organisms can benefit from the gas in this form. Nitrogen nitrate (NO_3) and ammonium (NH_4), which are used by plants are nitrogen salts. Animals, on the other hand, acquire nitrogen in the form of amino-acids – that is to say by eating plants and other living creatures.

A large part of the nitrogen used by living creatures is made up of its inclusion in the cycle following the biochemical determination of the free nitrogen within the atmosphere. Various bacteria (*Azotobacter, Rhizobium*) and some green algae (*Anabaena*) can transform the free nitrogen in the air into inorganic nitrate. Additionally, the free nitrogen within the atmosphere can also be transformed into nitrate – and be included in the cycle – physically, through atmospheric incidents such as lightning. The salts of nitrogen, which are in the form of inorganic nitrates, and which have been discovered physically and as bio-chemicals in nature, are transformed into organic nitrogen, by being obtained by plants from either the soil or from water (Gökmen, 2007).

Received November 2018.

Cite as: Filik Iscen, C. (2019). The Comparison of the Knowledge of Pre-Service Teacher on the Nitrogen-Phosphorus Cycles Using the Writing and Drawing Method. *Acta Didactica Napocensia*, 12(1), 177-190, DOI: 10.24193/adn.12.1.13.

The phosphorus store in nature is formed by the phosphate containing rocks and water on the earth. This cycle is very different to the nitrogen cycle. That is because phosphorus cannot be found in the atmosphere, and when compared to nitrogen, it is only present in smaller amounts in nature. Its underlying flow is the transport of phosphorus from land to the sea, and from the sea to land.

Some of the phosphorus present in the phosphate containing rocks on land can be dissolved in water by way of corrosion. This inorganic form is acquired by plants in the form of orthophosphate (N_2PO_4), and transformed into phosphate. It passes on to herbivorous and carnivorous animals through the food chain. The daily waste of plants and animals, and their deaths, lead to their decomposition by micro-organisms and transformation back into the inorganic form, in order to be reused by plants. Some of the phosphorus which flows into the water from land, by erosion, is used by plants and transferred to higher levels through the food chain. Some of the phosphate subsides to the bottom on the death of these living creatures. Due to geological movements, which occur over long periods, these phosphates are carried back on to land. It is also possible for these to be carried on to land via the food chain (by humans eating fish and the tissue of fish-eating birds) (Gökmen, 2007).

An effective science and biology education can be possible through meaningful learning at conceptual level instead of the memorising of information. When it is considered that concepts form the basis of subjects, it is clear that mistaken concepts will have a significant impact on the success of the student (Maila and Loubser, 2003; Kara et al, 2009). It has been determined, through numerous studies, and during the teaching of science, that the aspect of the learning of the concepts is much more important than the aspect of solving problems. However, the studies which have been carried out show that students possess many mistaken concepts in relation to scientific subjects, and that they are resistant to the elimination of these mistaken concepts (Hançer, 2007).

When compared to methods which reveal changes in thinking, such as writing and behavioural measurements, as it takes less time for it to be defined, and as it contains large amounts of information, the drawing method is both more effective, and more efficient, as it is easily assimilated (Atasoy, 2007). It is possible to determine the knowledge, mistaken concepts and changes in the concepts held by students, through the use of the drawing method, the use of which has become frequent in recent years (White and Gunstone, 1992; Rennie and Jarvis, 1995; Şahin et al, 2008). The knowledge and beliefs, which have remained hidden within the student, are able to be revealed with this method (Ayas, 2006).

The aim of this study is to determine the knowledge of primary education science teacher candidates of the nitrogen and phosphorus cycles, which possess an important role for a sustainable environment, and which are included in the Environmental Science class, through the drawing method, and to categorise their levels of knowledge.

2. Method

2. 1. Research Questions and Design

Candidate teachers were asked to answer the following questions on the nitrogen and phosphorus cycles:

Carry out a drawing and a written explanation of the nitrogen cycle in nature?

Carry out a drawing and a written explanation of the phosphorus cycle in nature?

2. 2. Study Group

The study was conducted with 60 pre-service science teachers, who were studying the subject of Environmental Science, and who were in the 3rd year of the Program in Elementary Science Education, in the Faculty of Education, at the Eskişehir Osmangazi University, during the 2016-2017 teaching year.

2. 3. Data Collection and Analyses

During the study the 60 candidate teachers were asked to carry out drawings of the nitrogen and phosphorus cycles, and to explain what they know on these subjects in writing. A descriptive analysis was conducted on the drawings and written explanations obtained, and, these were assessed based on the 5 different levels used by Bartoszeck et al (2008), Uzunkavak (2009a), Uzunkavak (2009b) and Hrin et al (2016).

The level categorisation tables created for the evaluation of the knowledge of science teacher candidates concerning the nitrogen and phosphorus cycles, by drawing, have been given in Table 1.

Table 1. *The level categorisations created for the assessment of the expressions and drawings concerning the Knowledge on the Nitrogen Cycle*

Level	**Explanation**	**Expression**	**Drawing**
Level 1	No expressions / drawings	W1	D1
Level 2	Incorrect expressions / drawings	W2	D2
Level 3	Partially correct expressions / drawings	W3	D3
Level 4	Expressions / drawings with some shortcomings	W4	D4
Level 5	Expressions / drawings which are fully correct	W5	D5

3. Results

The information and drawings on nitrogen and phosphorus, which were obtained from the study, were analysed in order to determine the levels of knowledge held by science teacher candidates. The 5 stage assessment levels given in Table 1 were used for the evaluation of the levels of knowledge and drawings on the nitrogen and phosphorus cycle.

The results of the analysis show that none of the candidate teachers were able to perform a fully correct statement on the nitrogen and phosphorus cycles. However, when the drawings were assessed, it was seen that 2 candidate teachers had performed a fully correct drawing on the phosphorus cycle. Despite the fact that there were no problems with the drawings of these students, as some shortcomings had been determined with their written statements, these were evaluated as level 4.

The drawings and expressions, which can be shown as examples related to the nitrogen cycle, have been given in figures 1, 2a, 2b and 3.

A drawing of a candidate teacher - which has been evaluated as being level 4 – on the nitrogen cycle, is presented in Figure 1. The incidences of nitrification and de-nitrification have been shown in the drawing and written expression carried out by the candidate teacher, who has also included the transformation of plant and animal waste into inorganic compounds by decomposers. However, neither the written statement nor the drawing included the fact that the free nitrogen in the air is physically transformed into nitrate by atmospheric incidents, such as lightning.

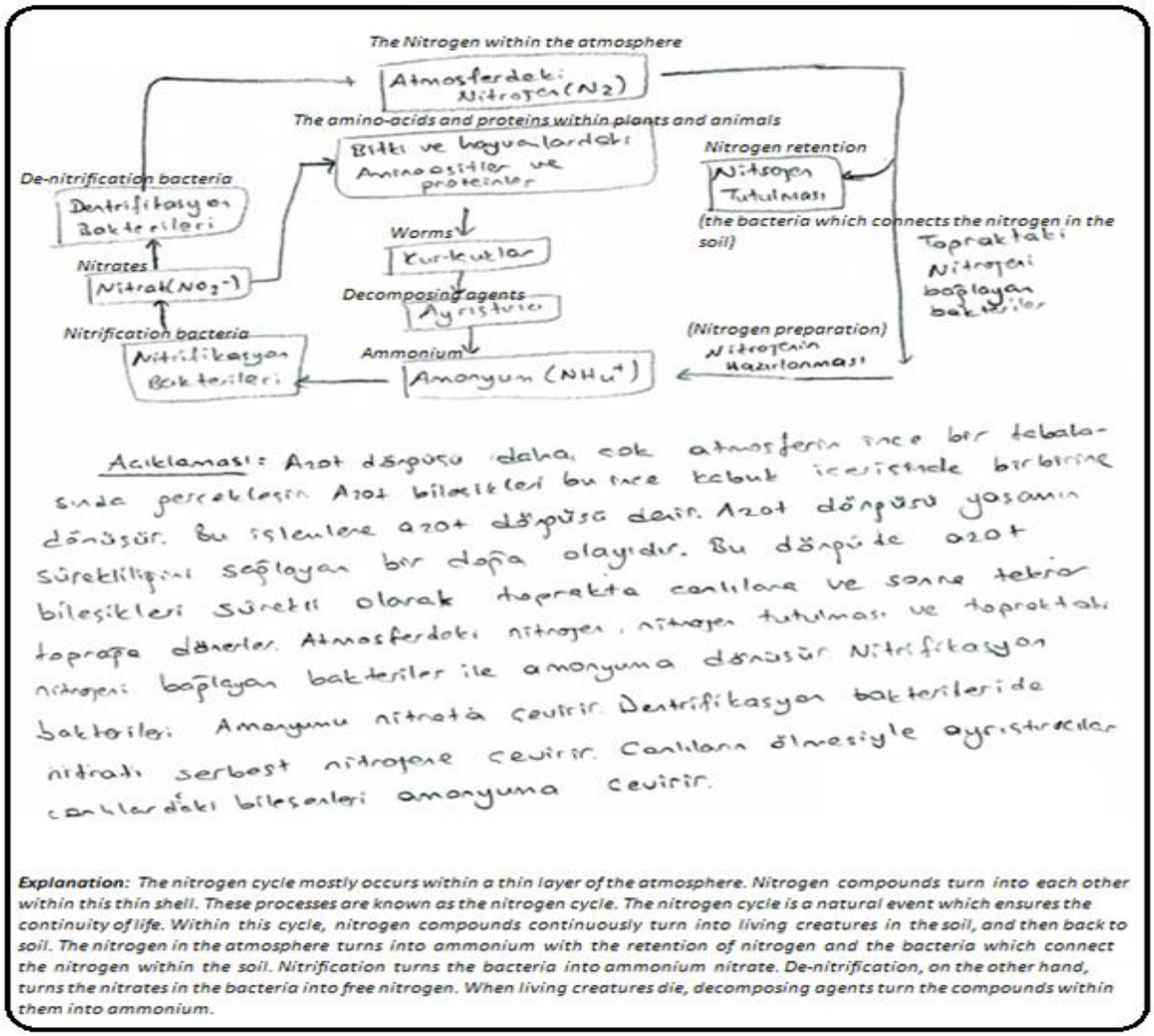

Figure 1. *Example of a Level 4 Nitrogen Cycle Drawing and Statement*

When Figure 2a is examined, it can be seen that the candidate teacher has not provided a full drawing and statement on the nitrogen cycle. The process of the transformation of the nitrogen in the atmosphere to nitrate has been presented in a disjointed manner in the drawing. It can be seen from the drawing and statement that the candidate teacher has not been able to fully perceive the place of the nitrogen linking bacteria within the cycle.

Figure 2b contains the drawing of a second candidate teacher which has been evaluated as being at level 3. The candidate teacher has included the fact that the free nitrogen in the air is transferred to the soil via lightning, but deficiencies can be seen in the transformation of the free nitrogen to nitrate, through a biological change. The candidate teacher has shown the nitrogen in the atmosphere as NO_2, and while attempting to reflect the fact that nitrogen linking bacteria, it can be seen that the candidate teacher possessed a mistaken concept.

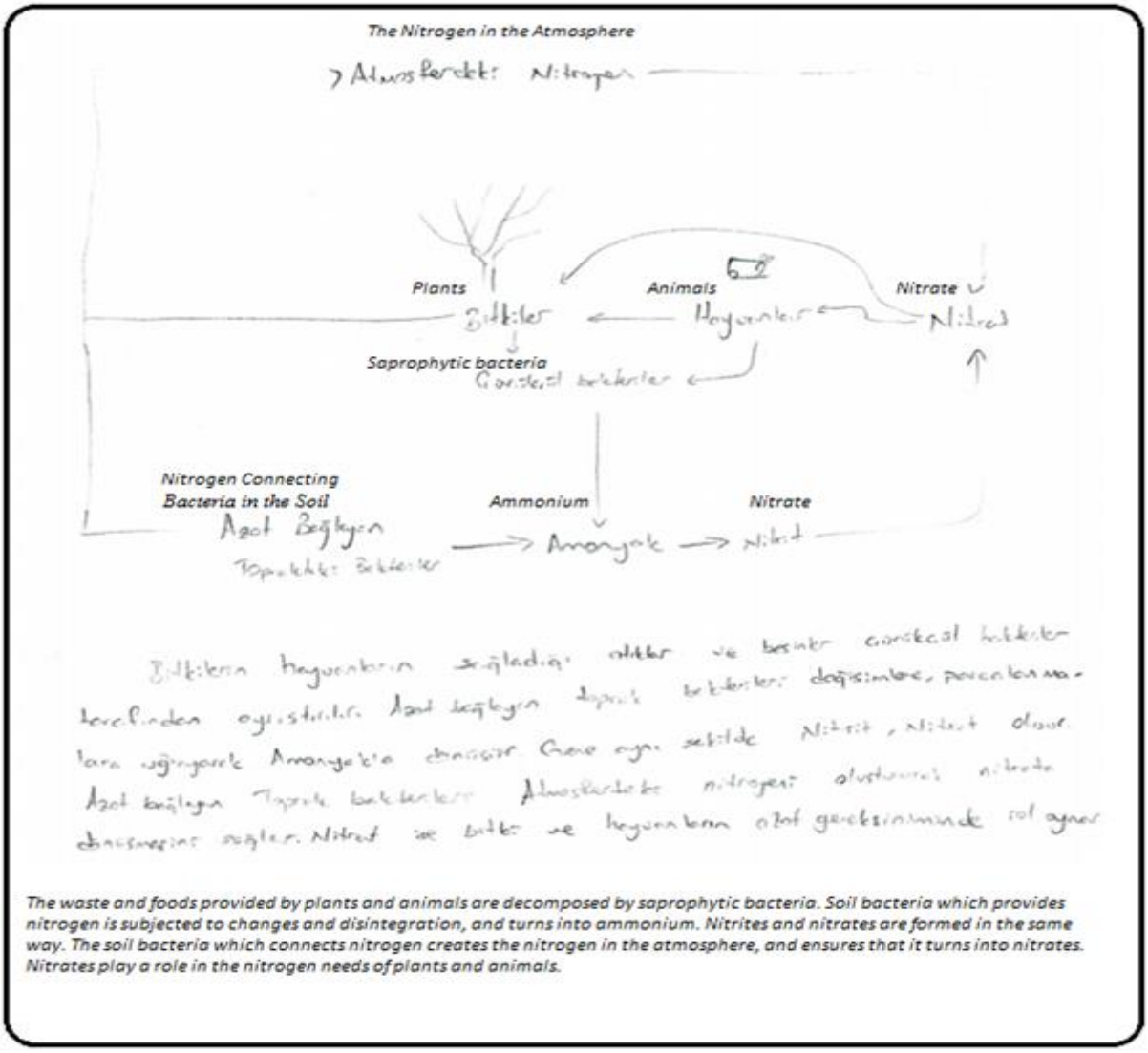

Figure 2a. *Example of a Level 3 Nitrogen Cycle Drawing and Statement*

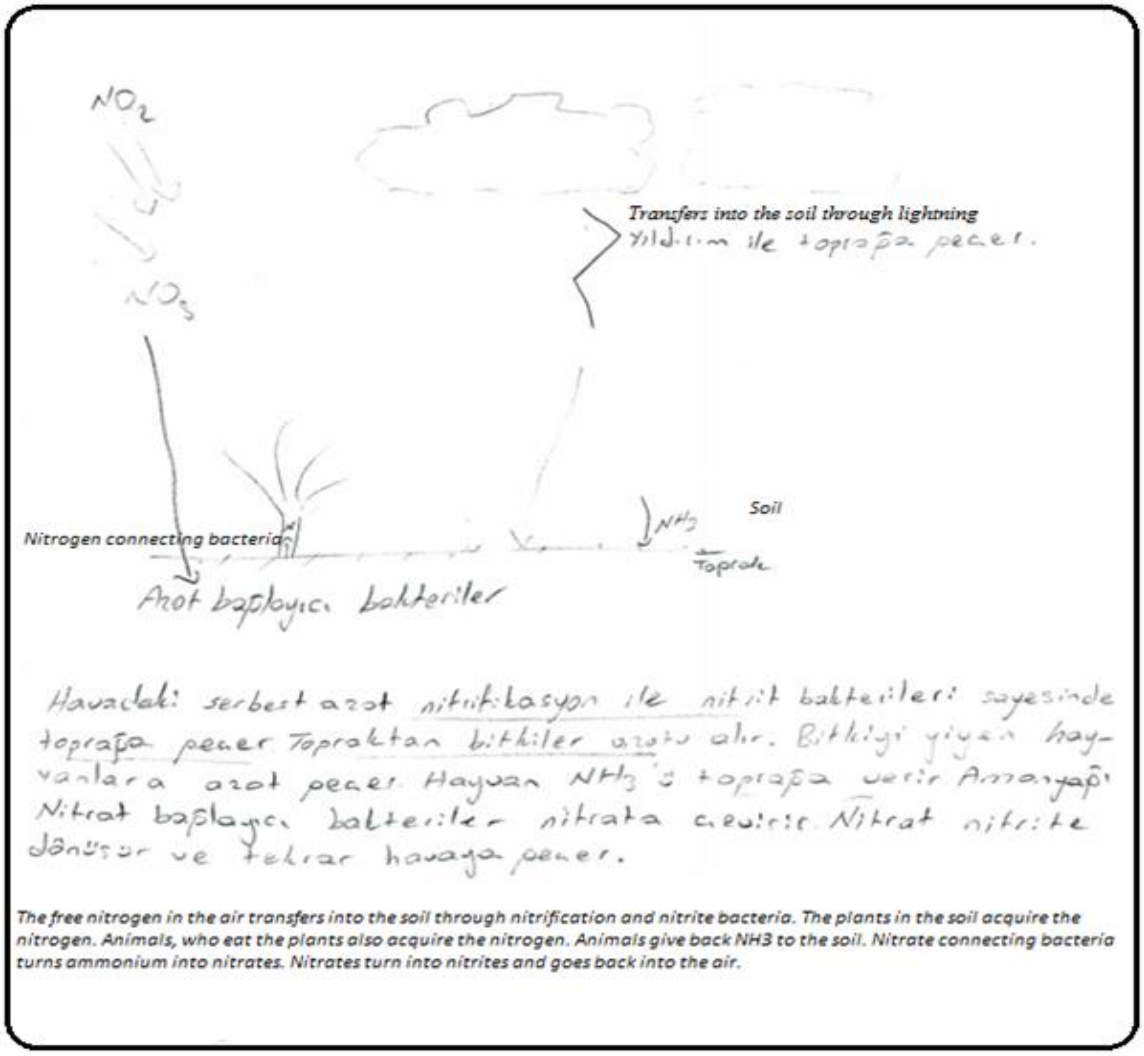

Figure 2b. *Example of a Level 3 Nitrogen Cycle Drawing and Statement*

As can be seen in Figure 3, the candidate teacher has presented an incorrect drawing on the nitrogen cycle. By stating that the 78% nitrogen within the atmosphere is carried into the bodies of living creatures through incidents such as rain and snow, and that the bacteria in the soil become integrated with the nitrogen in the atmosphere, the candidate teacher has completely changed the cycle.

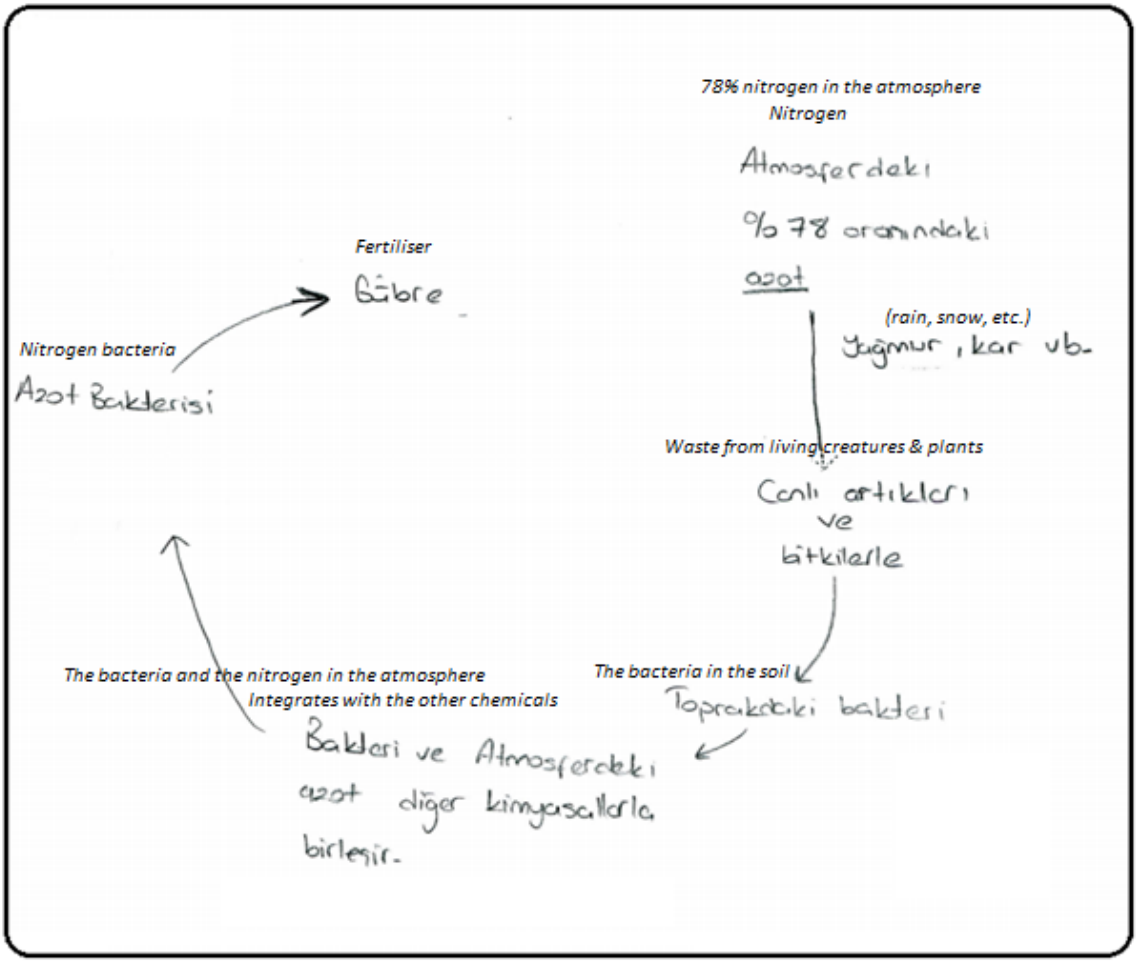

Figure 3. *Example of a Level 2 Nitrogen Cycle Drawing and Statement*

The frequency and percentage distributions of the statement and drawing levels of science teacher candidates concerning the nitrogen cycle, have been given in Table 2.

As can be seen from Table 2, the levels of knowledge of 63.3% , and the drawing levels of 76.6% of candidate teachers have been determined to be at level 3, while the levels of knowledge of 8.3%, and the drawing levels of 13.3% are at level 4. 25% of candidate teachers have not made any explanation concerning the cycle. However, it can be seen that all of them have presented drawings on the nitrogen cycle, but there are no candidate teachers who have provided correct statements and drawings.

The drawings and expressions, which can be shown as examples related to the phosphorus cycle, have been given in figures 4, 5, 6 and 7.

Table 2. *The Results of the Evaluation of the Expressions and Drawings concerning the Nitrogen Cycle*

Level	**Explanation**	**Expression**		**Drawing**	
		f	**%**	**f**	**%**
Level 1	No expressions / drawings	15	25		
Level 2	Incorrect expressions / drawings	2	3.3	6	10
Level 3	Partially correct expressions / drawings	38	63.3	46	76.6
Level 4	Expressions / drawings with some shortcomings	5	8.3	8	13.3
Level 5	Expressions / drawings which are fully correct				

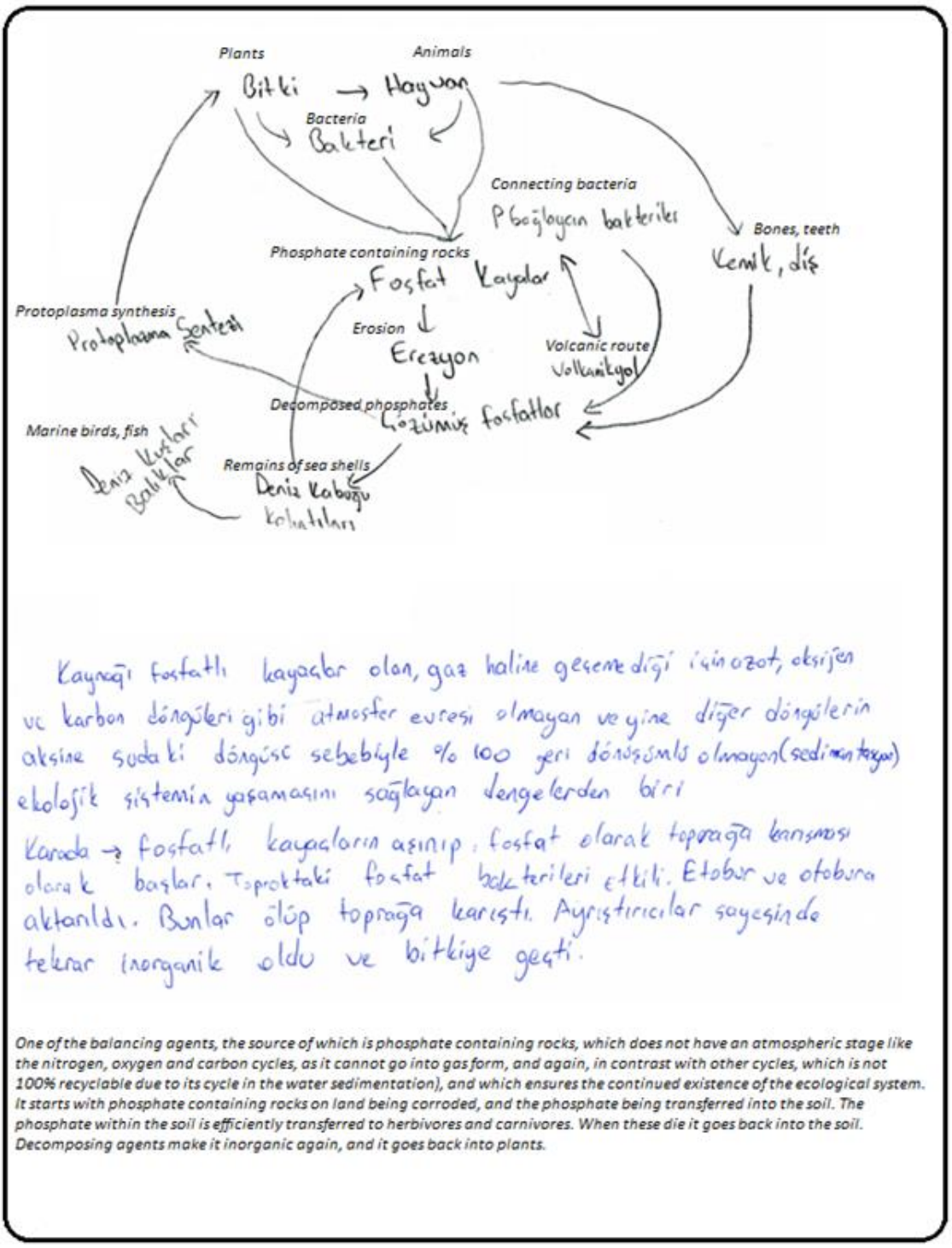

Figure 4. *Example of a Level 5 Phosphorus Cycle Drawing and Statement*

As can be seen from Figure 4, the candidate teacher has provided a fully correct drawing on the phosphorus cycle. When the written statement of the candidate teacher is read, it can be seen that the fact that the source of the phosphorus in nature are phosphate containing rocks, and that the cycle begins from this point, have been included. However, the candidate teacher has not stated the place of the remains of the shells of sea creatures within the cycle, despite having included them in the drawing. Therefore, the statement has been assessed as being at level 4.

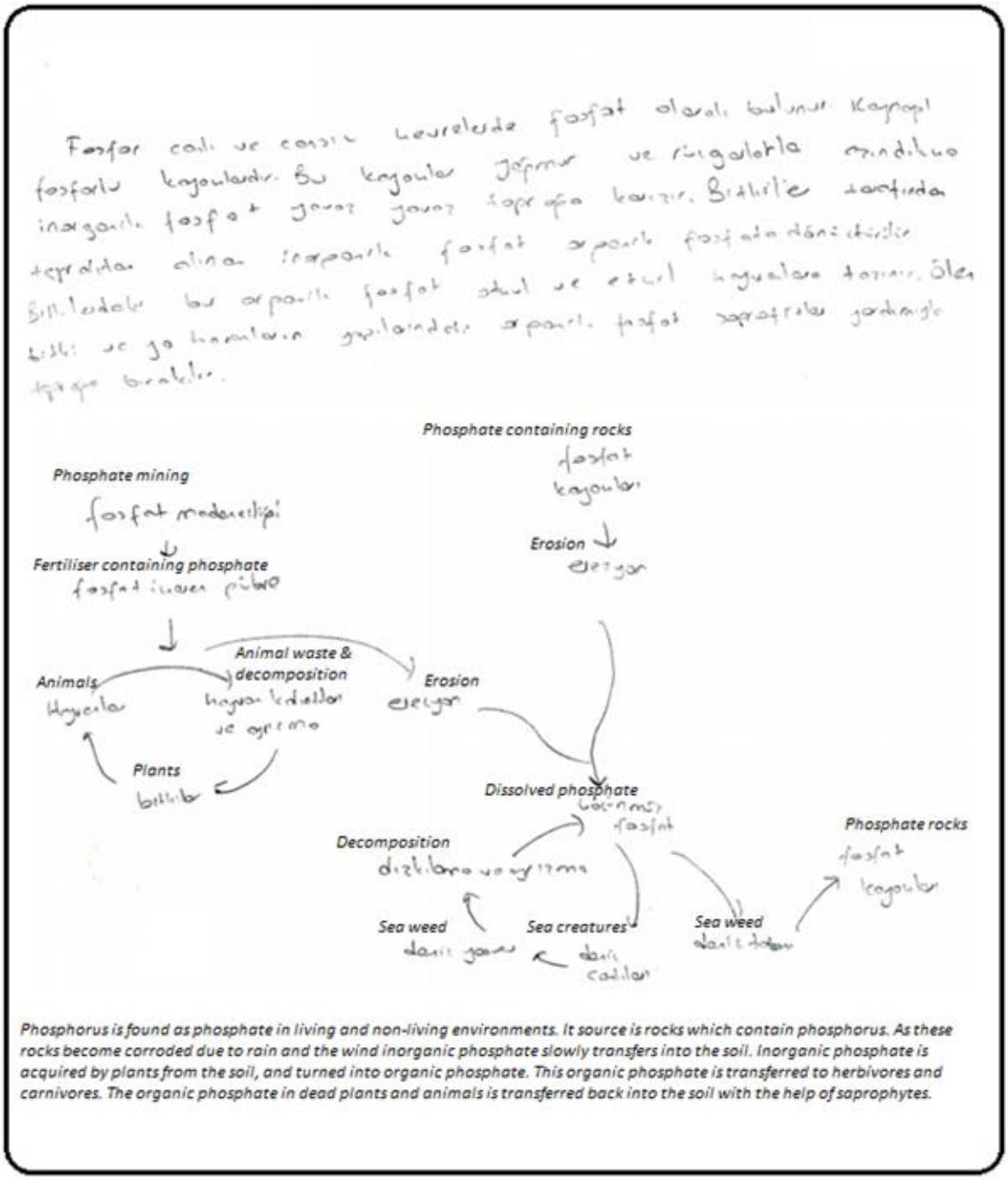

Figure 5. *Example of a Level 4 Phosphorus Cycle Drawing and Statement*

When Figure 5 is examined, it can be seen that the candidate teacher has presented an incomplete drawing related to the phosphorus cycle. The fact that phosphorus dissolves in water following the corrosion of phosphate containing rocks has been included in the drawing, but no description has been given as to how it is transferred into plants and animals. The candidate teacher has also included the fact that humans have an effect on the phosphorus cycle by using man-made fertilisers. None of these details were included in any of the other drawings.

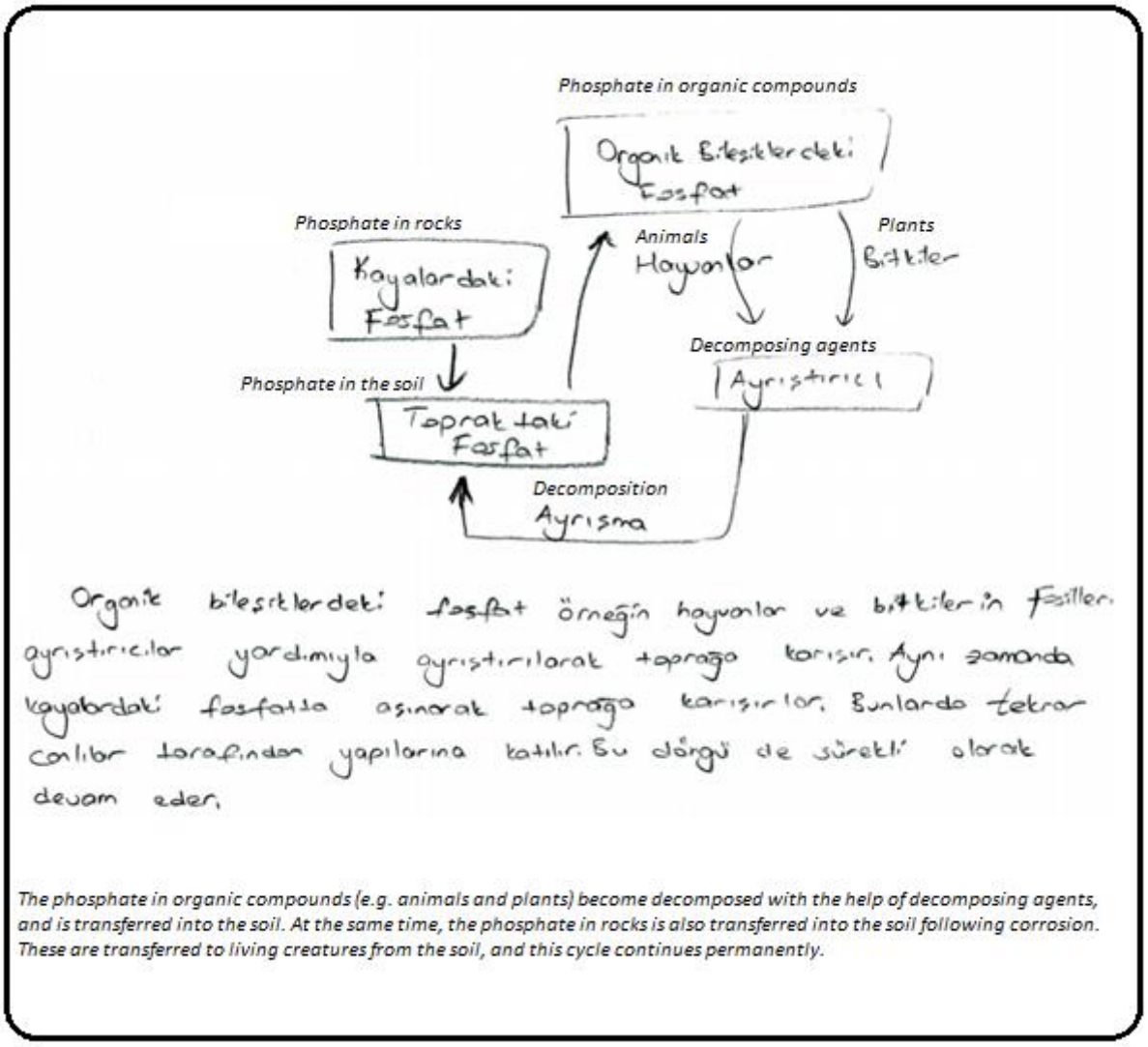

Figure 6. *Example of a Level 3 Phosphorus Cycle Drawing and Statement*

Figure 6 is consistent with level 3, both in terms of the drawing and the written statement. Here, only the land based part of the phosphorus cycle has been referred to, with no mention of the incidents which occur at sea. Therefore, it can be said that the relevant candidate teacher possesses partially correct knowledge on this cycle.

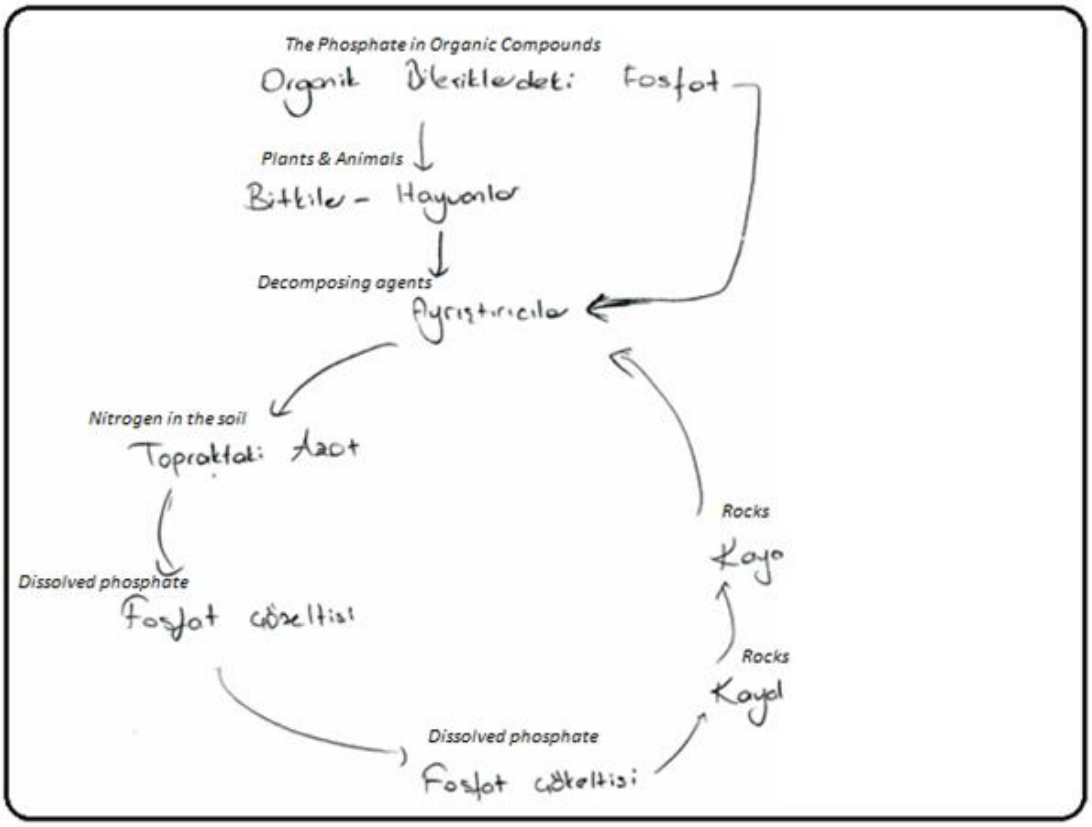

Figure 7. *Example of a Level 2 Phosphorus Cycle Drawing and Statement*

When the drawing in Figure 7 is examined, it can be seen that the candidate teacher has presented an incorrect drawing, and not included any written statement at all. The candidate teacher has stated in the drawing that the cycle begins at the organic structure, that it is converted to an inorganic structure by decomposing agents, and that this becomes mixed with the structure of rocks in the shape of phosphate sediments. The candidate teacher then completes the cycle with decomposing agents. That is to say that, due to inadequate knowledge on the cycle, the candidate teacher was not able to provide a correct drawing and information.

The frequency and percentage distributions of the statement and drawing levels of science teacher candidates concerning the phosphorus cycle, have been given in Table 3.

As can be seen from Table 3, the levels of knowledge of 43.3% , and the drawing levels of 45% of candidate teachers have been determined to be at level 3, while the levels of knowledge of 13.3%, and the drawing levels of 18.3% are at level 4. 40% of candidate teachers have not provided any written statement, and 26.6% have not provided drawings concerning the cycle. The percentage of candidate teachers who have provided a fully correct drawing is 3.3%.

Table 3. *The Results of the Evaluation of the Expressions and Drawings concerning the Phosphorus Cycle*

Level	**Explanation**	**Expression**		**Drawing**	
		f	**%**	**f**	**%**
Level 1	No expressions / drawings	24	40	16	26,6
Level 2	Incorrect expressions / drawings	2	3,3	4	6,6
Level 3	Partially correct expressions / drawings	26	43,3	27	45
Level 4	Expressions / drawings with some shortcomings	8	13,3	11	18,3
Level 5	Expressions / drawings which are fully correct			2	3,3

When compared with the nitrogen cycle, it can be seen that the knowledge of candidate teachers on the phosphorus cycle is less adequate. The number of candidate teachers who have failed to provide any written statement and drawing concerning the phosphorus cycle is considerably higher than the frequency in the nitrogen cycle. The reasons for this can be said to be due to phosphorus being less prevalent in nature than nitrogen, the fact that it is not present in the atmosphere, the fact that the cycle runs from land to sea and then back again from sea to land, and the fact that candidate teachers are not subjected to it in any other subjects during the term of their education. As the underlying source of nitrogen is the atmosphere and living creatures, and as this cycle is also mentioned in other subjects has meant that candidates possess more knowledge on it.

The frequency distribution of the levels of the drawings and written expressions of science teacher candidates on the nitrogen and phosphorus cycles have been presented in figure 8 and 9.

It can be seen from graphs 1 and 2 that, according to the frequency distributions of the candidate teachers related to the nitrogen and phosphorus cycles, the number of drawings and statements which are evaluated as being at level 3 are higher. However, the frequency of candidate teachers who have presented no written statements or drawings on the phosphorus cycle is also seen to be high

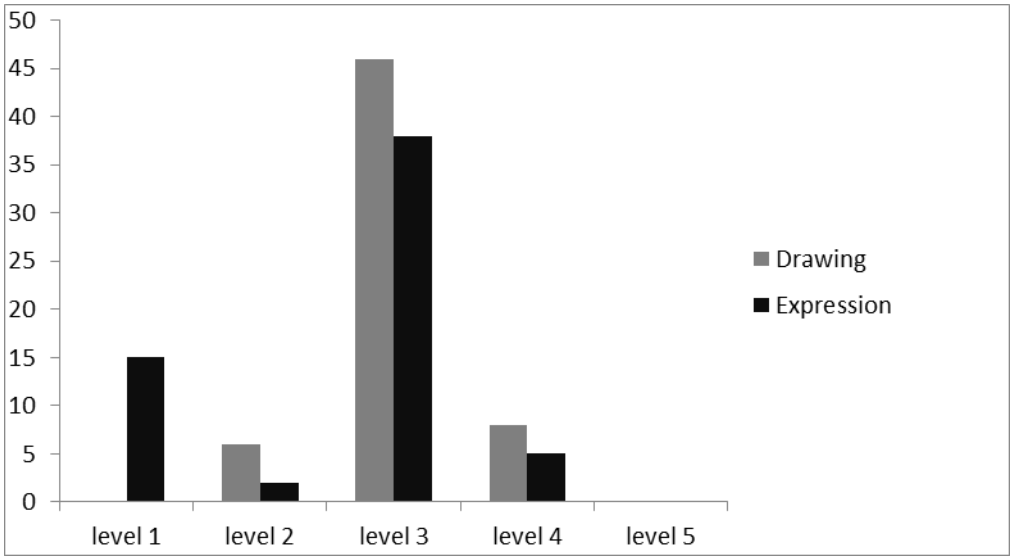

Figure 8. *The frequency distribution of the drawings and written expressions of candidate teachers on the nitrogen cycle*

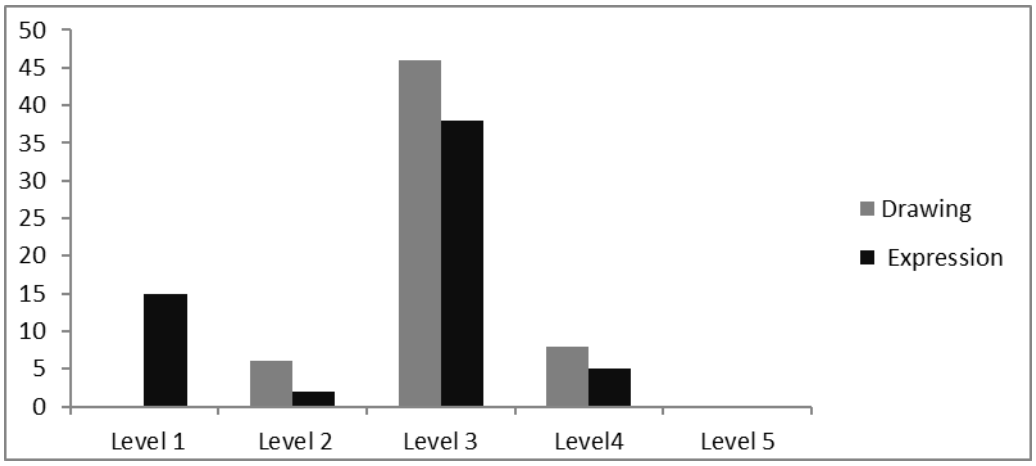

Figure 9. *The frequency distribution of the drawings and written expressions of candidate teachers on the phosphorus cycle*

3. Discussion and Conclusion

Sustainable development is one of the underlying principles of today's societies. The fundamental condition of sustainability is to consume the existing natural resources in a manner which will ensure that they also meet the needs of the future generations, and therefore the continued availability of these resources. A part of the items present in nature are in motion between living creatures and their environment. Living creatures obtain the items necessary for them from their own surroundings and give these back to their surroundings in various ways. Biological, chemical and geological events are effective within this process of give and take. Therefore, the movement of items is known as the biogeochemical cycle. There are two types of biogeochemical cycle. One is the material cycle, in the form of gas, the source of which is the atmosphere. The carbon, nitrogen and oxygen cycles are in this group. The other is the cycle of foodstuffs possessing the characteristics of sediments, the source of which is the lithosphere. Elements such as phosphorus, silisium, sulphur, calcium, magnesium and sodium are included in this group.

In the study, the candidate teachers were asked explain the flow of nitrogen (from among the matters which are in the form of gas) and phosphorus (from among the foodstuffs which possess the characteristics of sediments), in nature, through drawings and written expressions. The primary aim of an effective environmental education is to shape the behaviour of individuals, which is directed towards the environment, in a positive way. If a person is able to understand the cycle of the matters within nature, and its importance, he/she will be able to comment on the negativities brought about by the smallest intervention in the cycle. One of the greatest environmental issues we are faced with today is the fact that the cycles of these matters have become out of the ordinary. We can see this very clearly in the water cycle, and there are studies which exist in this area (Cardak, 2009; Çelikler and Topal, 2011). Among the other most important cycles which have been influenced negatively by human intervention are the nitrogen and phosphorus cycles. An effective science teacher needs to be very sensitive to environmental issues. He/she must know the source of these issues, and teach the generation, whom he/she is to educate, in a manner which directs them towards not creating environmental problems. As is the case today, it is not logical to search for a solution once the problem has surfaced.

Through this study, a determination has been made as to the aspects of drawings and knowledge of the subject by candidate teachers, and their mistaken concepts. 76.6% and 45% of candidate teachers have presented partially correct drawings on the nitrogen and phosphorus cycles, respectively. This shows that they have been able to display their knowledge on the nitrogen cycle by drawing where they were unable to do so in writing. When studies which assess the knowledge of students through drawing are examined, conclusions were reached that the information already held by students became more meaningful, in the studies of Bartoszcek et al (2008) on the organs within the body, Kara et. al (2008) on the concept of light, Köse (2008) on photosynthesis and respiration in plants, Uzunkavak(2009a) on the laws of Newton, Uzunkavak (2009b) on the concept of work, Cardak, (2009) on the water cycle, Çelikler and Topal (2011) on the water and carbon-dioxide cycle, Bartoszcek et al (2011) on organs and systems, Harman (2012) on the division of mitosis, and Çelikler and Kara (2012) on periodic tables.

In conclusion, it should not be forgotten that drawings will be beneficial to candidate teachers in terms of visual retention, and should be used in both the relaying of the subject, and its assessment. Emphasis should be placed on the teachers of the future placing importance on the use of visual materials when relaying subjects.

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