

## The Importance of the Concept of Water in Biology Education

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### ABSTRACT

The purpose of this study is to disclose the units and topics including the concept of water within 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades' biology textbooks that were chosen by the Ministry of National Education (MoNE) Head Council of Education and Morality (HCEM), and provide an overview of the whole content that mentions the concept of water. This qualitative study employed the document review method. The ratio of the number of units including the concept of water in the reviewed biology textbooks/*total number of units-number of topics*/total number of topics are, respectively 3/3-9/9 for 9<sup>th</sup> grade, 2/3-8/11 for 10<sup>th</sup> grade, 3/3-10/12 for 11<sup>th</sup> grade and 4/4-8/9 for 12<sup>th</sup> grade. In general, it has been observed that these units/topics address the structure and characteristics of water; its role on nutrition, respiration, circulation, excretory, reproduction, movement, behaviour, energy flow and metabolic events; its significance on living structure, natural resources, energy resources, living spaces, environmental problems and health; and its relationship with osmotic pressure, enzymes, hormones, professional areas and some structures of living beings. Findings revealed that water has a special place in biology education and biology education is an important tool in conveying the significance of water for the living beings. Further studies may focus on the place of water in teaching various disciplines.

**Keywords:** Water, biology education, textbooks

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### INTRODUCTION

Water is one of the main sources to sustain life. It is very important for preserving life. It is known about the role of water in various forms on earth, in the living structure and biochemical reactions. Water is handed down to future generations, being protected from contamination. The importance of water in the past, present and future highlights the importance of raising individuals who are conscious about these topics, since all that is known about water to be handed down through generations. Education and training in schools in the life sciences, especially biology education, has especially an important role in ensuring the information transfer.



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Textbooks are the main education-training materials, providing great benefit for both teacher and students. Textbooks are keeping their importance despite many changes in the educational system (Yapıcı, Coşkun and Akbayın, 2009). Textbooks are the main documents that guide and teach students in accordance with the goals of the subject, and revealing the topics in the curricula in a planned manner (Ünsal and Güneş, 2004).

Water has a wide range of characteristics that can be discussed in many fields, including physics, chemistry, medicine, health, biology, environment, geography and geology. Thanks to this multifaceted structure of water, it is possible to encounter doctrines on different characteristics of water in various disciplines. In this context, this study is necessary in terms of understanding the importance of water, which is considered as both the existence in any environment and life, for the life science and especially biology education, and determining how much of what is known about water is conveyed through biology education.

There is a wide literature on the way subjects are thought in biology textbooks (Jablon, 1992; Storey, 1992; Myers, 1997; Roth, Bowen and McGinn, 1999; Seçgen and Morgil, 2000; Mülayim and Soran, 2002; Köse, Ayas, Coştu and Karamustafaoğlu, 2004; Uzun and Sağlam, 2003; Özay, 2005; Atıcı, Keskin Samancı, and Özel, 2007; Özay and Hasenekoğlu, 2007; Kete and Acar, 2007; Anılan, Balbağ, Anılan, Görgülü and Çemrek, 2007; Çobanoğlu, Şahin and Karakaya, 2009; Köse, 2009; Dikmenli, Çardak and Öztaş, 2009; Yapıcı et al., 2009; Yürümez, 2010; Coşkun, 2011; Şen, 2011; Türköz, 2011; Üstün, 2011; Akgümüş, 2012; Anagnostopoulou, Hatzinikita and Christidou, 2012; Özbaş and Soran, 2012; Aslan Efe, Efe and Yücel, 2012; Kete, Horasan and Namdar, 2012; Çetin and Çakır, 2013; Arıkan, 2014; Şen and Nakiboğlu, 2014; Chaisri and Thathong, 2014; Adnan 2015; Gündüz, Yılmaz and Çimen, 2016; Ide, Thiel and Fischendler, 2019).

However, there is limited literature, in terms of content and number, on how water subject is included in biology textbooks. Since water has a vital importance for the living beings, it is necessary to teach the concept of water. Biology textbooks are one of the most important tools that are used in the education to convey the young individuals. Thus, the problem status was determined as "the importance of the concept of water in biology education".

The purpose of this study is to disclose the units and topics including the concept of water within 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades' biology textbooks that were chosen by the Ministry of National Education (MoNE) Head Council of Education and Morality (HCEM), and provide an overview of the whole content that mentions the concept of water.

## METHODS

This qualitative study employed the document review method. Document review comprises the analysis of the written materials that include information about the case or cases projected to research about" (Şimşek and Yıldırım, 2016). Document analysis is the process of collecting current records and documentation related to the study to be carried out, code them according to a certain norm or system, and review" (Çepni, 2009).

The universe of the study consists of the secondary education 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades' biology textbooks to be studied during the 2016-2017 school year in Turkey. The sample of the study includes 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades' biology textbooks that were chosen by the MoNE (Appendix 1).

In this study the secondary education 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades' biology textbooks were analysed based on the content and the concept of water in the units and topics. The activities at the end of units within the reviewed books were not included in this analysis. Units and topics that mention the concept of water within the reviewed textbooks were determined during the process of analysis, and numerical data were presented as to how many

units and topics included this concept. In addition, the content that used the concept of water within the textbooks were summarised and reported.

## FINDINGS

According to the findings of this study, the units and topics related to the concept of water in the biology textbooks at each class level are distributed as follows.

**Table 1.** Distribution of units and topics including the concept of water within the 9<sup>th</sup> grade biology textbook

Class	Unit	Subject	Page No
9	1. Biology, the life science	1. The nature of scientific knowledge	18, 20, 21
		2. Common characteristics of living beings	31, 32
		3. Basic components in the structures of living beings	38, 40, 41, 42, 43, 44, 49, 50, 52, 54, 56, 58, 60, 63, 64, 66, 68, 70, 73
	2. The world of living beings	1. Cell and cell theory	80, 90, 91, 92, 94, 98, 100, 101
		2. The variety and classification of living beings	111
		3. The kingdom of living beings	124, 125, 126, 127, 130, 131, 132, 138, 139, 141, 142, 144, 145, 146, 147, 148, 149, 151, 156, 157, 158, 159, 160, 161, 163, 164
	3. Current environmental issues and human	1. Current environmental issues and human	174, 175, 179, 181, 182, 184, 186, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 199, 206, 208, 211
		2. Natural resources	222, 223, 225, 226, 228, 229
		3. Biological diversity.	237, 239, 240, 245

The related units and topics in the 9<sup>th</sup> grade biology textbook are: "Biology, the life science" unit which includes the nature of scientific knowledge, common characteristics of living beings, basic components in the structures of living beings; "the world of living beings" unit which includes cell and cell theory, the variety and classification of living beings, the kingdom of living beings; "current environmental issues and human" unit which includes current environmental issues and human, natural resources, biological diversity. The proportion of the number of units related to the concept of water in 9<sup>th</sup> grade biology textbook to the total number of units is 3/3, while that of the number of topics to the total number of topics is 9/9.

**Table 2.** *Distribution of units and topics including the concept of water within the 10<sup>th</sup> grade biology textbook*

Class	Unit	Subject	Page No
10	1. Reproduction	1. Mitotic and asexual reproduction	11, 13
		2. Meiosis and sexual reproduction	22
	3. Our world	1. The ecology of ecosystem	104, 105, 106
		2. Factors affecting living beings	106, 107, 108
		3. Nutrition types	113
		4. Matter and energy flow	118, 119, 120
		5. The impact of human activities on ecosystem	122, 123, 125
			127, 128, 129, 131,
		6. Biomes	132, 133, 134, 135,
			136, 137

The related units and topics in the 10<sup>th</sup> grade biology textbook are: "reproduction" unit which includes mitotic and asexual reproduction, meiosis and sexual reproduction; "our world" unit which includes the ecology of ecosystem, factors affecting living beings, nutrition types, matter and energy flow, the impact of human activities on ecosystem, biomes. The proportion of the number of units related to the concept of water in 10<sup>th</sup> grade biology textbook to the total number of units is 2/3, while that of the number of topics to the total number of topics is 8/11.

**Table 3.** *Distribution of units and topics including the concept of water within the 11<sup>th</sup> grade biology textbook*

Class	Unit	Subject	Page No
11	1. Energy conversion in living beings	1. Life and energy	5, 6
		2. Photosynthesis,	11, 15, 16, 17, 18,
		3. Chemosynthesis,	24, 26, 27
		4. Respiration	35, 36
	2. Human physiology	4. Respiration	40, 46, 49, 50, 53,
		2. Nerves hormones and homeostasis	56, 57, 58
		4. Digestive system	81, 88, 90, 91, 93
		5. Circulation system	127, 131, 134, 135,
		6. Respiratory system	137, 138, 139
		7. Urinary system	151, 161
			171, 174, 175
3. Behaviour	183, 185, 186, 187,		
	190, 192		
	1. Behaviour	202, 203, 207	

The related units and topics in the 11<sup>th</sup> grade biology textbook are: "energy conversion in living beings" unit which includes life and energy, photosynthesis, chemosynthesis, respiration; "human physiology" unit which includes nerves hormones and homeostasis, digestive system, circulation system, respiratory system, urinary system; "behaviour" unit which includes behaviour. The proportion of the number of units related to the concept of

water in 11<sup>th</sup> grade biology textbook to the total number of units is 3/3, while that of the number of topics to the total number of topics is 10/12.

**Table 4.** Distribution of units and topics including the concept of water within the 12<sup>th</sup> grade biology textbook

Class	Unit	Subject	Page No
12	1. Gene to Protein	2. Genetic Code and Protein Synthesis	43
		1. Structure growth and movement of plants	55, 58, 59, 61, 62, 64, 65, 66, 70, 71, 74, 79, 80, 84, 85, 86, 90, 91
	2. Plant physiology	2. Transfer of matter in plants	100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 111
		3. Sexual reproduction in plants	119, 123, 125
		1. Community ecology	138, 139, 140, 141, 142
	3. Community and population ecology	2. Population ecology	149, 154, 157, 159
		4. Beginning of life and evolution	1. Beginning of life
			2. Evolution

The related units and topics in the 12<sup>th</sup> grade biology textbook are: "gene to protein" unit which includes genetic code and protein synthesis; "plant physiology" unit which includes structure growth and movement of plants, transfer of matter in plants, sexual reproduction in plants; "community and population ecology" unit which includes community ecology, population ecology; "beginning of life and evolution" unit which includes beginning of life, evolution. The proportion of the number of units related to the concept of water in 12<sup>th</sup> grade biology textbook to the total number of units is 4/4, while that of the number of topics to the total number of topics is 8/9.

The content related to the concept of water that is mentioned in these units and topics can be summarised as follows:

*Infiltration of water into living structures:*

- Body of living organism, saliva, blood plasma, urine, bile, mixture in the small intestine, cytoplasm
- Tree, seed, vegetables and fruits

*The importance of water for the living beings:*

- Ensuring continuation of life
- Having structural and functional importance for the living beings
- Protecting both cell structure as well as the shape of the eyeball, saving the body from toxins and wastes, ensuring regular activity of the organs, loss of weight, the beautifying of skin, anti-aging, nourishment, growth
- Having positive effects on human psychology
- Transporting of bacteria, pollens, spores, and some fruits through water

- Being able to recognise the chemical structure of water and return where they were born
- Water is used in different areas of life, such as cleaning, irrigation, water transportation, tourism, dialysis, scientific experimentation and for health purposes.

*Some events where water plays a role in a living body:*

- Diffusion, osmosis, plasmolysis, deplasmolysis, turgor, osmotic pressure, turgor pressure
- Transporting of nutrients and oxygen
- Enzyme activity
- Transpiration, oedema
- Enabling motion in the plant roots, ensuring transport of materials in plants, opening and closure of stoma, germination, capillarity in plants, root pressure, cohesion-tension theory

*Certain prevalent structures in the bodies of living entities in relation to water*

- Contractile vacuole, silk, whip, thread-like structures
- Leaves
- Root, root-like structure, root absorbent hairs, zone of maturation in the root
- Transfer tissue (xylem, trachea, tracheid), epithelium, fungus tissue, cuticles, suberin
- Stoma, hydathode, guard hairs, thorn-like structure
- Parenchyma (Ventilation, transfer, storage)
- Hormones (ADH, aldosterone, gibberellin, ethylene, abscisic acid)
- Gill, fin, swim bladders
- Skin
- Hypothalamus
- Large intestine
- Kidneys (nephrons, glomerulus capillaries, bowman capsule, nephron tubes)
- Lipoproteins in alveoli

*Importance of water for the health:*

- Drinking two litres of water a day, not drinking hard water, consuming plenty of water for an acid accumulating in the body, a well-balanced diet, and diarrhoea, the removal excess water

*Water as a habitat for some living beings:*

- Certain bacteria, certain archaebacteria, algae, phytoplanktons, plankton, euglena, protista, certain plants, aquatic plants, reed maces, bryophytes, yeast, some worms, prawn, aquatic insects, fish, waterfowl, larval stage of amphibians, some mammals (seals, dolphins, otters, penguins)

*Water as a breeding ground for some living beings:*

- Amphibians, mayflies, moss, reptiles

*Water in biochemical reactions:*

- Photosynthesis, chemosynthesis, aerobic respiration, glycolysis, digestion, fat metabolism, hydrolysis, dehydration, ATP break down, transport of carbon dioxide

*Water on the surface:*

- The forms that water takes such as sea, lake, stream, river, brook, creek, watercourse, cloud, rain, dew, humid, water vapour, ocean, glacier, groundwater, thermal waters, wetlands, fresh waters, acid rain, mist, snow, aquatic biomes
- Existence of water in 3/4 of the earth's surface, existence of water in soil and in the atmosphere, non-existence of water on Mars
- Water cycle
- Relation between water vapour and global warming
- Water scarcity and drought
- Water-led erosions, soil loss and non-storability of rain water
- Depletion of water resources and destruction of habitats for various reasons
- Water as the source of oxygen in the atmosphere
- Influence of rainforests on surface waters
- Water as an abiotic factor
- Water wells and water drilling rig
- Competition of living beings for water
- Determining the boundaries of community, and water in the distribution of terrestrial species
- Water in order to sustain the presence of a given population
- Unspoiled natural spring water
- From sulphur and nitrogen, the formation of sulfuric acid and nitric acid, dissolution of limestone in water and carbon dioxide formation, bones and shells in water turning into rocks with high amount of minerals

*Water as an energy source:*

- Hydro-electric power, geothermal power, potential and kinetic energy, water for

*Water pollution:**Causes*

- Infiltration by various ways in water of domestic, industrial, agricultural wastes, contaminants, sewage, petroleum, untreated sewage, radioactive wastes, heavy metals, toxic substances
- Eutrophication
- Oils poured in sink
- Parasites in water
- Ballast water

*Results*

- Transmission of disease as a result of contact with polluted waters and sewage, and the negative impact on human health

*Methods of prevention*

- Reverse osmosis application
- Bio-remediation, cleaning with archaeobacteria, protista, bacteria, fungi, alg, and plants
- Conscious living
- Controlled disposal of industrial and domestic wastes
- Monitoring fertiliser and chemical drug usage in agriculture
- Application of water boiling and domestic treatment systems to avoid parasites in water
- Washing fruits and vegetables with a lot of water to protect from agricultural drugs

- Using water thriftily without polluting the water

*Physical and chemical properties of water:*

- Water is inorganic
- Water is formed by one oxygen and two hydrogen atoms
- Water has Cohesion force
- Water is a solvent
- Water's specific heat is higher than that of many other compounds
- Water transforms into gas when heated; water vapour condensing with cold air in order to form rain
- Water has the highest specific weight at +4 C'
- Different water types have acidic, basic and neutral forms (sea water, fruit juice, pure water, etc.)
- Water becomes hardened depending on the mineral it contains
- Water transmits the energy in lightning quickly

*Fields of occupation related to water:*

- Aquaculture, marine biology, marine biologist, environmental scientists specializing in fresh water and seas

*Other information about water:*

- We show a withdrawal reflex when touching hot water
- Putting chrysalises in hot water for obtaining silk from butterfly pupae
- Efforts to develop drought-tolerant plants are ongoing.
- Mushrooms help plants to extract water from the ground.
- Bacteria cannot survive in 100-degree boiling water however; endospores continue to live.
- Arkebacterists leave a bright blue colour in hot water.
- Water insoluble substances (such as starch, cellulose, phospholipid, fatty acids, cuticula etc.)
- Water that separates acids from bases.
- Water quality

## DISCUSSION

Water is a limited and natural resource that is one of the most significant requirements for life. It has a vital role in maintaining life and no alternative that can substitute it (Pamuk Mengü and Akkuzu, 2008; Çankaya, 2014).

It is important to create social awareness and to raise individuals who are conscious about water in order to protect water resources and ensure water sustainability. This important need can be met through education (Çankaya, 2014).

Biology discipline serves as a source for various information on water. Thus, biology education and the content of the textbooks become crucial in transferring water-related knowledge to future generations.

This study analyzes the concept of water as mentioned in the biology textbooks for 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades, which were accepted by the Ministry of National Education [MoNE] and the Head Council of Education and Morality [HCEM].

The 9<sup>th</sup> grade biology textbook covers three units and nine topics in total. All units and topics include the concept of water. The concept of water was most encountered in the "The

world of living beings" unit and in the "The kingdom of living beings" topic. On the other hand, it was least encountered in the "Biology, the life science" unit and in the "The variety and classification of living beings" topic.

The 10<sup>th</sup> grade biology textbook covers three units and eleven topics in total. Two units and eight topics include the concept of water, while it was most encountered in the "our world" unit and in the "biomes" topic. On the other hand, it was least encountered in the "reproduction" unit and in the "meiosis and sexual reproduction" and "nutrition types" topics. However, the concept of water was not encountered in the "growth and development" topic in the first unit and the "modern genetic practices" and "genetics and biological diversity" topics in the second unit.

The 11<sup>th</sup> grade biology textbook covers three units and twelve topics in total. Three units and ten topics include the concept of water, while it was most encountered in the "human physiology" unit and in the "photosynthesis" and "respiration" topics. On the other hand, it was least encountered in the "behavior" unit and in the "life and energy", "chemosynthesis" and "circulation system" topics. However, the concept of water was not encountered in the "tissues" and "support and motion system" topics in the second unit.

The 12<sup>th</sup> grade biology textbook covers four units and nine topics in total. Four units and eight topics include the concept of water, while it was most encountered in the "plant physiology" unit and in the "structure growth and movement of plants" topic. On the other hand, it was least encountered in the "gene to protein" unit and in the "genetic code and protein synthesis" topic. However, the concept of water was not encountered in the "discovery and importance of nucleic acids" topic in the first unit of this textbook.

While showing that the textbooks increasingly included materials related to water and its importance, unfortunately little emphasis was made on the role of water in chapters related to proteins and nucleic acids even though the importance of water in the nucleic acid and protein structures was highlighted by Chaplin, 2001.

The content in the analyzed textbooks where the concept of water was mentioned can be summarized as follows.

- Water forming a large part of the living body.
- Water's importance for the living beings in terms of structure and functionality.
- Water's role in certain events taking place in the living body, including the operation of enzymes, sweating, and edema.
- Water's relation with some structures in the living body, including with stem, leaves, tissues, organs, hormones, skin, contractile vacuole, cilium, and flagellum.
- Water's importance for health.
- Water as a habitat and breeding ground for some living beings.
- Water's role in biochemical reactions including photosynthesis, chemosynthesis, respiration, hydrolysis, dehydration and the transfer of carbon dioxide.
- Water is on the surface, on earth and in the atmosphere. It takes different forms such as sea, lake, river, and stream. Also, water has a relation with the oxygen resource in the atmosphere such as water cycle, water scarcity, water resources, waterborne erosion, drought etc.
- Water as the hydro-electric power and geothermal power.
- Water pollution caused by eutrophication, domestic, industrial, agricultural, and radioactive wastes that mix in water, heavy metals, and parasites. Unfortunately, water pollution leading to adverse health outcomes. Though water pollution can be prevented by living consciously, bioremediation, controlled disposal of industrial and domestic wastes, treatment, and monitoring agricultural pesticides.

- Composed of one oxygen and two hydrogen atoms, water has an inorganic structure, a certain degree of hardness, specific heat, and the ability of transmutation.
- There are water-related occupational groups, including aquaculture, marine biologist, environmental scientist etc.
- Living beings can show distinct reactions to hot water: some materials are insoluble, water plays a role in the determination of acid or base number, and it has its quality.

One or more of the abovementioned information obtained about water are supported by the studies conducted by Sağlam and Bellitürk (2003); Bayazıt Hayta (2006); Kuşak (2006); Akın and Akın (2007); Boysan and Şengörür (2009); Dedeakayoğulları and Önal (2009); Ilgar (2009); Külekçi (2009); Özsoy (2009); Artun and Coştı (2011); Cappellaro, Ünal Çoban, Akpınar, Yıldız and Ergin (2011); Çakmak and Gökalp (2011); Arsal (2012); Çankaya (2014); Çakmak, Çakmak and Topal (2018); Yılmaz and Özden (2015). Furthermore, results of the studies for various textbooks carried out by Alkış (2005); Alkış (2006); Dikmenli, Çardak and Öztaş (2009); Para and Ayvaz Reis (2009); Gökmenoğlu (2011); Türköz (2011); Akgümüş (2012); Vinisha and Ramadas (2013); Akgün, Tokur and Duruk (2016); Hussein (2018) confirm these findings.

## CONCLUSION and SUGGESTIONS

The purpose of this study was to disclose the role of water in the units and topics within 9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades' biology textbooks that were chosen by the Ministry of National Education (MoNE) Head Council of Education and Morality (HCEM),

In line with this purpose, the findings from the reviewed textbooks have demonstrated that the ratio of the number of units related to the concept of water/total number of units-number of topics/total number of topics are, respectively, 3/3-9/9 for 9<sup>th</sup> grade, 2/3-8/11 for 10<sup>th</sup> grade, 3/3-10/12 for 11<sup>th</sup> grade, and 4/4-8/9 for 12<sup>th</sup> grade.

The units and topics without the concept of water within the reviewed biology textbooks are 10<sup>th</sup> grade Unit 1 Topic 3 (growth and development), Unit 2 all topics (genetics and biological diversity, modern genetic practices), 11<sup>th</sup> grade Unit 2 Topics 1 & 3 (tissues, support and motion system), and 12<sup>th</sup> grade Unit 1 Topic 1 (discovery and importance of nucleic acids).

The following water-related titles of topics were found to be included in the related textbooks:

“water is important for the living beings”; “water is important for health”; “water plays a role in certain events and biochemical reactions that take place in the living body”; “there are living structures related to water”; “water is a habitat and breeding ground for some living beings”; “water is an energy source”; “there are professional fields related to water”; “water is important on the earth's surface and can be found in various forms”; and “water pollution is a serious environmental issue”.

According to the findings, it was concluded that large part of the units and topics in secondary school biology textbooks include the concept of water, and therefore water has a very important place in biology education. In this context, it can be said that biology education is an important tool in conveying the significance of water for the living beings.

Further research can focus on the place of water in teaching other disciplines. It can be researched about the other effective fields of study in conveying the importance of water. Inclusion of water in primary school and secondary school textbooks can also be researched. An in-depth content analysis for the statements regarding water within the textbooks can also be carried out. The content for the concept of water included within the textbooks can be evaluated with a critical approach.

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**APPENDIX-1: Textbooks investigated within the scope of the study**

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