Agriculture, Environment & Society

Journal homepage: www.aes.uoz.ac.ir

A survey on high school students' awareness of environmental issues: A case study of Rudbar County

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ARTICLE INFO

Article history:
Received: 17 September 2025
Accepted: 5 January 2026
Available online: 3 June 2026

Keywords:
Environmental awareness
Environmental protection
High school students
Rudbar

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ABSTRACT

Achieving sustainable development goals requires that community members understand environmental issues well. One of the most effective ways to enhance this understanding is to incorporate environmental education at all levels of schooling. This study evaluated the environmental awareness and behaviors of high school students in Rudbar County across three key areas: ecosystem protection, waste management, and general environmental knowledge. Data were collected using a validated and reliable questionnaire (α=0.870). The results indicated that tenth-grade students' average environmental awareness across all three areas is significantly lower than that of eleventh- and twelfth-grade students. This finding suggests a notable increase in environmental awareness as students progress from tenth grade to higher grades. Conversely, comparisons between eleventh and twelfth grades showed no statistically significant differences. This suggests that students' levels of environmental awareness remain relatively constant after reaching eleventh grade, with no significant increase by twelfth grade. According to the results, the trend of increasing environmental awareness mainly occurs from the tenth to the eleventh grade. Tenth-grade students were identified as having the lowest level of awareness, which suggests a need for environmental education programs to target this educational level. Conversely, the stability of awareness levels between eleventh and twelfth grades may indicate that students have reached a plateau in their knowledge within the current educational framework or that there is a lack of new and effective content in environmental education in the twelfth grade. Integrating a comprehensive curriculum that includes environmental studies into the formal education system can significantly enhance individuals' environmental awareness and performance. Developing practical activities, such as using images, simulation games, board and card games, and puzzle-solving tasks, is an effective way to engage adolescents and young people in understanding environmental issues like water scarcity and pollution. The findings of this study can assist policymakers and planners in creating educational initiatives and promotional programs aimed at increasing environmental awareness.

Highlights

- Environmental awareness was assessed among high school students across three key dimensions.
- Tenth-grade students showed significantly lower environmental awareness than higher-grade students.
- No significant differences were found between eleventh- and twelfth-grade students.
- Targeted environmental education is particularly needed for tenth-grade students.

1. Introduction

Environmental protection is an attitude aimed at preventing harm to the environment and is essential for restoring any damage that has already occurred (Khoiri et al., 2022). In contemporary society, achieving sustainable development goals requires individuals within communities to enhance their environmental knowledge. At the broader environmental scale, achieving

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https://doi.org/10.22034/aes.2026.547718.1113

sustainability also requires a balance between human consumption and the ecological capacity of natural systems. Recent research in northeastern Iran has demonstrated an ecological deficit, indicating that human demands on natural resources exceed the region's biological capacity. These findings highlight the importance of promoting environmental awareness and responsible resource-use practices as essential elements of sustainable development (Galdavi et al., 2025a). A fundamental solution to this challenge is incorporating environmental education at all levels of the education system (Behnood et al., 2021), which is related to Environmental awareness. Environmental awareness is closely tied to sustainability education, which aims to instill values and motivation to act for sustainability at personal, community, and global levels (Elegbede et al., 2023). Also, Education for Sustainable Development (ESD) is becoming a crucial aspect of public education that encompasses three main components: environmental, social, and economic (Purkovic et al., 2023). Its importance has grown in light of ongoing challenges such as climate change and other environmental issues that threaten the sustainability of our planet (Kilag et al., 2023). Experts indicate that environmental problems pose a significant threat to the well-being of individuals, communities, and the planet. These issues arise primarily due to a lack of awareness about the environment. Thus, the need to shift the collective mindset and educate people to foster environmental awareness becomes increasingly evident (Pozo-Muñoz et al., 2023). In response to this challenge, many organizations and governments have taken steps to integrate environmental education into their curricula and syllabuses (Kilag et al., 2023). While environmental education is crucial, its main goal should not merely be the understanding of concepts; rather, it should aim to cultivate individuals' consciences and prompt action through intervention (Stefaniuk, 2021). Therefore, it is essential to take immediate steps to educate and train citizens, helping them first become aware of environmental issues, and then acquire the skills necessary to address these challenges (Pozo-Muñoz et al., 2023). Meanwhile, students, as a generation with a significant influence on the future of the environment, must acquire knowledge and understanding of fundamental environmental issues. This knowledge will promote a change in their attitudes and awareness, impacting how they interact with others and their surrounding environment (Khoiri et al., 2022).

Also, environmental education is viewed as a continuous process that empowers individuals and society to understand sustainable development. Through knowledge, values, skills, and experiences, people become aware of environmental issues and are motivated to take action to address current and future challenges (Seker, 2024). Additionally, human environmental behavior is a crucial factor influencing the environment, attracting considerable attention from sociologists. The excessive use of energy in homes, reliance on personal vehicles, consumption of disposable products, inappropriate waste disposal methods, and failure to collect and separate waste for recycling are all results of harmful human behaviors toward the environment (Zareipour and Asgari, 2023). In addition to individual waste-related behaviors, appropriate waste disposal and management require careful consideration of environmental factors and potential impacts on surrounding ecosystems. Research conducted in Bardaskan, northeastern Iran, demonstrated the importance of environmental criteria, including geological conditions and proximity to drinking-water resources, in selecting suitable sites for sanitary landfills. This highlights the need for both responsible waste-disposal practices at the individual level and environmentally sound waste-management planning at the institutional level (Memarian et al., 2024). Therefore, it is essential to promote environmental literacy through public education, cultural initiatives, and community participation. The importance of environmental awareness is also reflected in the adoption of environmentally responsible practices. For instance, a recent study in the Torshiz area of Iran examined the factors influencing farmers' participation in biological pest control methods and highlighted the relevance of educational, economic, social, and attitudinal factors in the adoption of environmentally friendly agricultural practices (Galdavi et al., 2025b). Such findings emphasize that environmental protection requires not only knowledge but also the development of positive attitudes and active participation in sustainable practices. Environmentally literate individuals are those who are not only sensitive to environmental issues but also act positively from an ecological perspective and possess a strong awareness of environmental matters (Akıllı and Genc, 2015). Since students are the future leaders of society, trying to raise awareness and support sustainable practices, they have a long-term perspective on environmental issues (Mohamed et al., 2025). It is crucial to evaluate their knowledge, perceptions, and practices regarding the environment, as they are particularly vulnerable to the long-term consequences of environmental changes. Their active participation in environmental protection and care is vital. Therefore, this study aims to assess students' understanding of environmental issues and their perceptions related to environmental care.

In this regard, research has been conducted by other researchers, including Pourkhabbaz et al. (2021), who assessed environmental awareness, attitudes, and performance among elementary school students and teachers in Behbahan city using a questionnaire. The study found low awareness of environmental issues in both groups and no significant relationship between their awareness levels. Education level did not impact performance and attitudes, but did affect environmental knowledge. Jadgal et al. (2023) conducted a study on the environmental literacy of students at the Chabahar Nursing School to evaluate their knowledge, attitudes, and behaviors regarding environmental protection. They used questionnaires and analyzed data with ANOVA and Pearson correlation. Results showed 69.8% of students had good environmental knowledge, 66% held positive attitudes, but 50.8% lacked protective behaviors.

Aqanaghad et al. (2023) assessed environmental literacy and ethics among high school students using a four-

part questionnaire. Average scores were: knowledge 87.6, attitude 84.5, performance 50.6, and ethics 82%. Norouzi and Yadollahi (2022) assessed the level of environmental awareness and knowledge among rural communities in the Choghakhor region. They conducted their research using surveys and questionnaires to gather the necessary data. The results revealed that the environmental awareness and knowledge of the villagers were above average. Chen (2020) studied the impact of education on environmental knowledge among Xiamen University students in China. The research assessed the effectiveness of environmental education in higher education over the past two decades, finding that such programs have successfully improved students' environmental knowledge.

Khoiri et al. (2022) examined the environmental awareness of high school students by collecting data through a questionnaire. The results indicated that the students' limited environmental awareness and understanding of their local resources do not contribute to the development of a sustainable environment. But analyzing their attitudes, values, and ethics toward the environment is crucial for understanding their behavior. Pozo-Muñoz et al. (2023) conducted a study to assess the environmental awareness of primary school students in Spain before and after implementing an educational program focused on water management and conservation. The findings revealed a low level of knowledge regarding the complete water cycle among the students. Additionally, the students exhibited a limited sense of responsibility towards water-related issues. These results highlight the need to incorporate water care and conservation topics into the educational curriculum using a multidimensional and interdisciplinary approach to better understand the origins and impacts of water-related problems. Elsharkawy et al. (2024) conducted a study to assess students' knowledge, perceptions, and practices regarding climate change. They also examined the relationships between the levels of knowledge and the reported practices in response to climate change. The results indicated that a majority of students (82.6%) had heard of the term "climate change" and believed it had an impact on their communities. Around 57.8% of students demonstrated a good understanding of the causes and effects of climate change and strongly supported general measures to reduce greenhouse gas emissions. However, their knowledge and practices for reducing emissions were found to be insufficient. The study strongly recommends that climate change education focus on its causes and explain its connection to daily activities, encouraging young people to adopt environmentally friendly practices.

A review of various sources reveals that human ignorance and inattention towards the environment stemming from scientific shortcomings, improper attitudes and behaviors, a lack of responsibility, and overall low levels of environmental knowledge and literacy have significantly contributed to pollution and environmental degradation. Additionally, an examination of studies in the field of environmental knowledge highlights a deficit of rigorous and accurate research. Most studies have focused on individuals aged 20 and older, emphasizing components such as knowledge, attitude, participation, gender, and contextual factors that influence environmental awareness. What sets this study apart from previous ones is its focus on environmental awareness, particularly regarding waste management. This aspect is crucial for implementing practical approaches to prevent various environmental issues.

2. Materials and methods

2.1. Study area

Rudbar County is bordered by Rasht County to the north, Siahkal County to the northeast, Shaft County to the northwest, Qazvin County to the southeast, and Zanjan County to the southwest (Figure 1). It is the southernmost county of Gilan Province and serves as its gateway. Covering an area of 2,517 square kilometers, Rudbar County ranks first among the counties in Gilan Province, and a substantial portion of its territory is situated at altitudes above 100 meters. The county is divided into four districts: Rahmatabad and Blokot, Markazi, Khorgam, and Amarlu. It comprises seven cities, including Rostamabad, Totkabon, Rudbar, Manjil, Lushan, Barehsar, and Jirandeh, with Rudbar serving as the central city (Moghadam et al., 2022). The present study was conducted in high schools in Rostamabad.

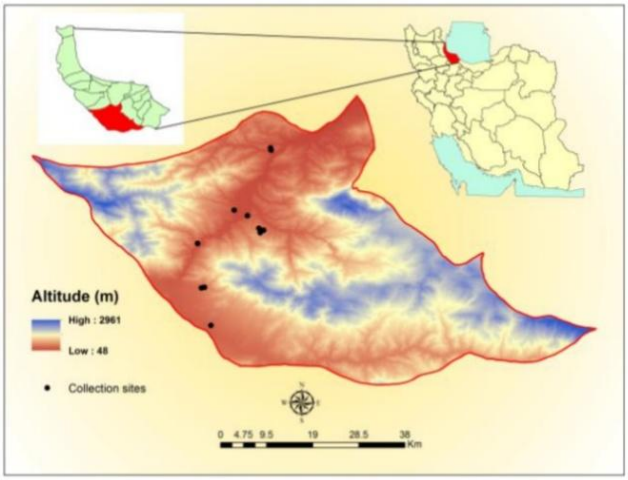


Figure 1. Map of Iran highlighting Guilan Province and its 16 counties, including Rudbar County (Norouzi et al., 2020)

2.2. Research process

The present study was applied and descriptive-analytical in nature, incorporating fieldwork. Initially, information about the region was collected, followed by the preparation of a questionnaire to assess students' awareness levels. So, the authors designed and developed the questionnaire specifically for this study. The research focused on high school students in Rostamabad, located in Rudbar County. Stratified random sampling was employed in this study. This method involved dividing the statistical population into three strata based on educational levels: 10th, 11th, and 12th grades. Within each stratum, samples were selected using simple random sampling to ensure that all educational groups were represented in the sample in proportion to their size. This approach guarantees that the sample accurately represents the target population, thereby enhancing the generalizability of the findings. The questionnaire was divided into two main sections: demographic information (including gender, age, and education) and the primary research questions regarding students' awareness levels.

The questions designed to evaluate the level of awareness were based on a four-point Likert scale, with scores assigned as follows: very low (1), low (2), medium (3), and high (4). A questionnaire consisting of 18 items was developed to assess two key components: ecosystem protection and waste management. So, the questionnaire was analyzed in three sections as follows:

Ecosystem protection component: This variable was derived by calculating the average scores from students' responses to items 1 to 7 of the questionnaire, which included questions about aesthetic values, the protection of forests, oceans, plants, animals, and the role of humans in causing destruction and pollution. This component assesses an individual's overall awareness and attitude toward the environment.

Waste management component: This variable was developed by calculating the average scores of students' responses to items 8 through 18 of the questionnaires. These items include questions about waste recognition, related diseases, the separation and recycling of various materials, composting, drying, and methods for waste reduction. This component evaluates an individual's practical and technical knowledge in the field of waste management.

Environmental awareness (overall): This variable reflects each individual's overall awareness score, calculated by averaging the scores of all 18 items in the questionnaire.

Initially, the validity of the questionnaire was evaluated by experts. To ensure the content validity of the questionnaire, a standard expert evaluation method was employed. The initial version of the research tool was specifically presented to 10 experts in relevant fields, including environmental science, science education, and psychometrics.

The review group consisted of 6 university professors with research experience in environmental education and 4 experienced instructors involved in planning environmental science curricula. Each member received written instructions outlining the evaluation criteria, which included clarity, relevance, comprehensiveness, and understandability, allowing them to document their opinions in a structured manner. In the next stage, we analyzed the collected qualitative and quantitative opinions. Using the expert consensus coefficient (CVI and CVR), we removed or revised any items that were irrelevant or unclear. After incorporating the necessary feedback and making the required revisions, the questionnaire was finalized, and its reliability was confirmed in the subsequent stage. This process significantly enhances the instrument's alignment with the research objectives and its scientific validity. The reliability analysis of the questionnaire was conducted using Cronbach's alpha coefficient on a separate sample of 30 students who did not participate in the main study. This sample was comparable to the study population in terms of demographic characteristics. The results indicated that the alpha coefficient for the entire questionnaire was 0.870, which is considered acceptable. We also evaluated the reliability of the individual components separately.

For the "waste management component," which includes 11 items, the alpha coefficient was 0.867. For the "ecosystem protection component," with 7 items, the alpha coefficient was 0.732. Since all the alpha coefficients exceed the criterion value of 0.7, the research tool demonstrates desirable reliability for measuring the intended variables. This tool was subsequently used in the main study, which included a sample of 197 students. Subsequently, the questionnaires were distributed among school students, who completed them.

In this study, a total of 200 students were invited to participate. Out of these, 197 responded to the questionnaire. Three questionnaires were excluded due to incompleteness. As a result, the response rate was calculated to be 98.5%, indicating a high level of participation among the students. After the completion process, the questionnaires were reviewed, and the data were entered into SPSS software. A descriptive analysis of the collected data was conducted first. Then, to investigate the environmental awareness of the respondents, we examined the components of ecosystem protection and waste management. The score for each item was calculated to determine the level of awareness among the students, and ultimately, their overall awareness was also assessed. Additionally, statistical tests were employed, including One-Way ANOVA, Brown-Forsythe test, Tukey HSD test, and Tamhane's T2 test.

3. Results and discussion

A total of 197 students participated in this study. Table 1 presents descriptive information about the demographic characteristics of the sample, including gender, school, level of education, and field of study.

Table 2 presents descriptive results regarding students' awareness levels for each item in the questionnaire. To further analyze the distribution of responses, the coefficient of variation (CV) was calculated for each of the 18 items. The CV was determined by dividing the standard deviation by the mean and multiplying the result by 100. The items were then ranked from lowest to highest based on their CV.

Table 1. Frequency distribution and percentage of demographic characteristics of the research sample

Variable	Groups	Frequency	Percentage	Mode
Gender	Female	146	74.10%	Female
	male	51	25.90%	
School	Besat Girls' High School	146	74.10%	Besat Girls' High School
	Shariati Boys' High School	51	25.90%	
Educational level	10th grade	71	36.00%	11th grade
	11th grade	90	45.70%	
	12th grade	36	18.30%	
Field of study	Humanities sciences	109	55.30%	Humanities sciences
	Design and sewing	24	12.20%	
	Mathematics, physics	24	12.20%	
	Computer science	22	11.20%	
	Experimental sciences	18	9.10%	

Table 2. Distribution of response percentages to items of the environmental awareness questionnaire

Rank	Factor	Very low	Low	Middle	High	CV (%)
1	Importance of protecting forests and ranges	1.00%	10.20%	33.50%	55.30%	20.85%
2	Aesthetic values of nature	2.50%	8.60%	43.10%	45.70%	22.24%
3	Importance of protecting seas, lakes, and rivers	2.00%	11.70%	33.00%	53.30%	22.81%
4	Human role in destroying nature	5.60%	8.10%	24.90%	61.40%	25.23%
5	Values of plants	7.10%	9.60%	35.00%	48.20%	27.71%
6	Water, soil, and air pollution	9.10%	16.20%	40.10%	34.50%	31.23%
7	Paper recycling and its benefits	7.10%	22.80%	32.50%	37.60%	31.44%
8	Values of wild animals	10.20%	18.80%	29.90%	41.10%	33.27%
9	Recycling	11.70%	17.80%	37.10%	33.50%	33.84%
10	Methods for reducing waste (garbage) at home	10.70%	22.80%	37.10%	29.40%	33.85%
11	Plastic recycling and its benefits	12.70%	19.80%	38.10%	29.40%	34.83%
12	Waste (garbage)	12.70%	24.40%	35.50%	27.40%	35.66%
13	Separation of waste at source	12.70%	31.00%	33.00%	23.40%	36.44%
14	Diseases related to waste (garbage)	14.70%	27.40%	34.50%	23.40%	37.32%
15	Production of dry matter from waste and its benefits	18.30%	24.40%	40.10%	17.30%	38.25%
16	Waste composting and its benefits	16.20%	29.90%	32.50%	21.30%	38.60%
17	Glass recycling and its benefits	20.30%	32.50%	29.90%	17.30%	41.02%
18	Metal recycling and its benefits	22.80%	25.40%	31.00%	20.80%	42.54%

According to Table 2, the descriptive results reveal a clear pattern in students' environmental awareness. Overall, awareness levels are very high in general areas; however, they are significantly lower when it comes to technical and practical issues related to waste management. Specifically, the highest levels of awareness (indicated by high responses) are linked to the role of humans in environmental destruction (61.4%), the importance of forest protection (55.3%), and sea protection (53.3%). These figures demonstrate that students have a good understanding of general environmental issues and the significance of protecting nature. In contrast, the lowest levels of awareness are found in specialized recycling areas, with the highest percentages of low and very low responses associated with glass recycling (52.8%), metal recycling (48.2%), and composting (46.1%).

This knowledge gap suggests that while students recognize the importance of protecting the environment, they require more targeted training in practical and detailed waste management methods.

The results of calculating the coefficient of variation (CV) for each question in the questionnaire provide a clear understanding of the homogeneity or heterogeneity of students' responses regarding environmental concepts. As shown in the table, the questions ranked first to fifth, such as "Importance of Protecting Forests", "Aesthetic Values of Nature", and "Human Role in Destroying Nature, "exhibit the lowest CV values, ranging from 20.85% to 27.71%. This suggests that students generally agree on these issues and share a common understanding of the importance of protecting natural elements and the impact of human activities on the environment.

In contrast, the questions that scored lower, particularly those related to recycling specific materials such as glass, metal, and plastic, as well as composting and dry matter production from waste, exhibited the highest coefficient of variation (CV) values, ranging from 38.25% to 42.54%. This finding indicates that students' knowledge on these topics is highly varied; some students possess relatively good information, while many others have very limited or incorrect understanding. This knowledge gap suggests a deficiency in practical and specialized training in waste management within the formal curriculum. The high percentage of students indicating “very little” and “little” knowledge about glass recycling (52.8%) and metal recycling (48.2%), along with the significant coefficient of variation, highlights not only a lack of sufficient knowledge in these areas but also considerable uncertainty or misunderstanding among them.

Conversely, questions concerning general environmental challenges such as water, soil, and air pollution, as well as waste-related diseases exhibit a relatively high coefficient of variation (around 31–37%). This suggests that while the mean understanding is moderate, students’ grasp of the connection between waste and public health remains inconsistent.

3.1. Questionnaire and analysis dimensions

According to the results presented in Table 3, the overall average environmental awareness score among

students is 2.92, which falls within an average understanding level on a scale of 1 to 4 for the studied population. However, a deeper analysis of the components reveals a significant knowledge gap. The average score for the ecosystem protection component is 3.26, which is notably higher than the average score of 2.71 for the waste management component. This suggests that while students have a good grasp of general concepts and recognize the importance of protecting nature (indicating a level close to high), their practical knowledge regarding waste management methods, recycling, and waste separation remains at a low to medium level. Furthermore, the relatively low standard deviations indicate a narrow range of responses and a degree of homogeneity among students in both components. To assess the normality of the data distribution, skewness and kurtosis indices were calculated. Since the skewness and kurtosis values for all three variables fall within the acceptable range (+2 to -2), we can conclude that the data distribution for the main research variables is normal. This justifies the use of parametric statistical tests, such as analysis of variance (ANOVA) and Pearson correlation, to test future hypotheses.

Table 3. Descriptive indicators of environmental awareness variables and their components

Variable	Number	Mean	Standard Deviation	Skewness	kurtosis
Ecosystem Protection Component	197	3.26	0.53	-1.09	1.82
Waste Management Component	197	2.71	0.65	-0.09	-0.28
Environmental Awareness (General)	197	2.92	0.52	-0.29	0.40

To determine whether there is a significant difference in environmental awareness and its components among students of different educational levels (10th, 11th, and 12th grades), and to analyze the significance of the observed differences in means, a one-way analysis of variance (ANOVA) test was conducted. Additionally, Levene's test assessed the assumption of homogeneity of variances. Descriptive statistics and ANOVA Test Results for Comparing Means by Educational Level are presented in Table 4.

Table 4. Descriptive Indicators and ANOVA Test Results for Comparing Means by Educational Level

Variable	Grade	N	Mean ± SD	Test Statistic	df_1, df_2	Sig.
Ecosystem Protection Component	10th	71	3.12 ± 0.52	F = 4.21	(2, 194)	.016*
	11th	90	3.32 ± 0.50			
	12th	36	3.38 ± 0.57			
Waste Management Component	10th	71	2.41 ± 0.50	Brown-Forsythe = 15.04	(2, 159.03)	<.001**
	11th	90	2.91 ± 0.71			
	12th	36	2.80 ± 0.54			
General Environmental Awareness	10th	71	2.69 ± 0.40	Brown-Forsythe = 13.99	(2, 155.10)	<.001**
	11th	90	3.07 ± 0.58			
	12th	36	3.03 ± 0.45			

Note: Independent samples were analyzed using one-way ANOVA when Levene's test was non-significant ($p > .05$). For variables with unequal variances (Levene's test $p < .05$), the robust Brown-Forsythe test was used. *$p < .05$, ** $p < .01$.

An initial review of the averages in Table 4 shows that tenth-grade students have notably lower mean scores than those in the eleventh and twelfth grades. When the Levene test indicates a violation of the homogeneity of variances assumption (Sig. < 0.05), the Brown–Forsythe statistic is applied as a more robust alternative. Overall, the analysis of variance (ANOVA) results presented in Table 4 reveal statistically significant differences among students at different educational levels across all three studied variables. For the variable in which Levene's test was not significant ($p = 0.639$), the assumption of equal variances was satisfied, and the ANOVA results confirmed a significant difference among the means of the three groups ($F(2, 194) = 4.21$, $p = 0.016$).

For these two variables, Levene's test was significant ($p = 0.014$ and $p = 0.026$, respectively), indicating that the variances are not homogeneous. In such circumstances, the results of alternative and more robust tests, such as Brown-Forsythe, are reported. The results of this test also confirmed that the difference in means for the component of waste management ($F(2, 159.03) = 15.04$, $p < 0.001$) and general environmental awareness ($F(2, 155.10) = 13.99$, $p < 0.001$) is highly significant.

To further explore the significant ANOVA results, follow-up tests were conducted to identify the specific educational levels that showed differences. For the ecosystem protection component, Tukey's HSD test was applied based on the results of Levene's test. In contrast, Tamhane's T2 test was utilized for the waste management and general environmental awareness components, as these did not meet the assumption of homogeneity of variance. The findings from these pairwise comparisons are summarized in Table 5.

The results indicate that the average environmental awareness of tenth-grade students in three areas ecosystem protection, waste management, and general awareness is significantly lower than that of eleventh- and twelfth-grade students, with all significance values being less than 0.05. This finding suggests that there is a notable increase in environmental awareness as students progress from the tenth grade to higher grades. In contrast, none of the comparisons between 11th and 12th grade showed a statistically significant difference, as all significance values were well above 0.05. This indicates that students' levels of environmental awareness remain relatively stable after 11th grade and do not significantly increase by 12th grade.

Table 5. Results of post hoc tests for pairwise comparisons of average educational levels

Variable	Comparison of educational levels (I) vs. (J)	Mean difference	Standard error	Significance level (Sig.)
Ecosystem Protection Component (Tukey test)	10th grade vs. 11th grade	-0.20	0.082	0.040*
	10th grade vs. 12th grade	-0.26	0.106	0.038*
	11th grade vs. 12th grade	-0.06	0.102	0.826
Waste Management Component (Tamhane's T2 test)	10th grade vs. 11th grade	-0.50	0.095	0.000**
	10th grade vs. 12th grade	-0.39	0.107	0.002**
	11th grade vs. 12th grade	0.11	0.117	0.728
General Environmental Awareness (Tamhane's T2 test)	10th grade vs. 11th grade	-0.38	0.077	0.000**
	10th grade vs. 12th grade	-0.34	0.088	0.001**
	11th grade vs. 12th grade	0.04	0.096	0.958

Significant differences at the $p < 0.05$ level are marked with an asterisk (*) and at the $p < 0.001$ level is marked with an asterisk (**). All p-values are reported with three decimal places, and values less than .001 are denoted as <.001.

The findings suggest that there is a significant increase in environmental awareness primarily during the transition from the tenth to the eleventh grade. Tenth-grade students have been identified as having the lowest level of awareness, indicating a need for targeted environmental education programs at this educational stage. Conversely, the consistency of awareness levels between the eleventh and twelfth grades may imply that students have reached a knowledge ceiling within the current educational framework, or that the twelfth grade lacks new and effective content in this area.

Students' environmental awareness was examined based on gender, school, and major. The relevant results are presented below (Tables 6 to 9).

Table 6. Comparison of environmental awareness by gender

Variable	Gender	N	Mean ± SD	T	Sig.
Ecosystem Protection Component	Female	146	3.24 ± 0.53	-0.817	195
	Male	51	3.31 ± 0.53		
Waste Management Component	Female	146	2.68 ± 0.67	-1.182	195
	Male	51	2.80 ± 0.58		
General Environmental Awareness	Female	146	2.90 ± 0.54	-1.215	195
	Male	51	3.00 ± 0.48		

Note: Levene's test indicated equal variances were assumed for all three components (all $p > .05$). An independent samples t-test was used.

The results of the independent samples t-test revealed no statistically significant differences in environmental awareness between male and female students across any of the three measured components (all $p > .05$). Although male students showed slightly higher mean scores in Ecosystem Protection (M = 3.31 vs. 3.24) and General Awareness (M = 3.00 vs. 2.90), these differences were not significant. This suggests that gender does not play a determining role in shaping environmental knowledge among high school students in Rudbar County (Table 6).

Table 7. One-way ANOVA results for environmental awareness by field of study

Variable	Field of Study	N	Mean ± SD	Test Statistic	df_1, df_2	Sig.
Ecosystem Protection Component	Humanities Sciences	109	3.26 ± 0.50	Welch = 1.746	4, 51.821	.154
	Computer Science	22	3.40 ± 0.44			
	Design and Sewing	24	3.00 ± 0.63			
	Mathematics and Physics	18	3.36 ± 0.40			
	Experimental Sciences	24	3.29 ± 0.66			
Waste Management Component	Humanities Sciences	109	2.82 ± 0.68	Brown-Forsythe = 5.506	4, 94.170	.001**
	Computer Science	22	2.42 ± 0.39			
	Design and Sewing	24	2.33 ± 0.55			
	Mathematics and Physics	18	2.84 ± 0.68			
	Experimental Sciences	24	2.78 ± 0.56			
General Environmental Awareness	Humanities Sciences	109	2.99 ± 0.54	Brown-Forsythe = 4.294	4, 98.701	.003**
	Computer Science	22	2.80 ± 0.30			
	Design and Sewing	24	2.59 ± 0.48			
	Mathematics and Physics	18	3.04 ± 0.50			
	Experimental Sciences	24	2.98 ± 0.54			

Note: Levene's test indicated unequal variances for Waste Management ($p = .025$) and General Awareness ($p = .124$), so the robust Brown-Forsythe test was used. For Ecosystem Protection ($p = .043$), both F-test and Welch's test were reported; neither reached significance. *p < .05, ** p < .01.

The results indicate that there are no statistically significant differences in environmental awareness between students from different fields of study across the Ecosystem Protection Component (all $p > .05$). This suggests that knowledge and attitudes toward protecting natural ecosystems are relatively uniform among students, regardless of their academic specialization.

However, significant differences were found for the Waste Management Component (Brown-Forsythe $F = 5.506$, $p = .001$) and General Environmental Awareness (Brown-Forsythe $F = 4.294$, $p = .003$). Post hoc Tamhane's T2 tests revealed that:

- Students in the Humanities Sciences stream scored significantly higher in Waste Management than those in Computer Science (Mean Diff. = 0.40, $p = .004$) and Design and Sewing (Mean Diff. = 0.50, $p = .004$).
- In General Awareness, Humanities Sciences students also scored significantly higher than Design and Sewing students (Mean Diff. = 0.40, $p = .005$).

These findings suggest that while overall environmental awareness is similar across streams, practical knowledge of waste management is more developed in humanities students, possibly due to greater exposure to social and civic issues in their curriculum. The lower scores in technical fields like Computer Science and Design and Sewing may reflect a gap in integrating practical environmental content into these programs. Therefore, curricula in non-humanities fields should incorporate more applied environmental modules to ensure balanced environmental literacy.

Table 8. Independent-samples t-test results for environmental awareness by school

Variable	School	N	Mean ± SD	t	df	Sig.
Ecosystem Protection Component	Besat Girls' High School	146	3.24 ± 0.53	-0.817	195	.415
	Shariati Boys' High School	51	3.31 ± 0.53			
Waste Management Component	Besat Girls' High School	146	2.68 ± 0.67	-1.182	195	.239
	Shariati Boys' High School	51	2.80 ± 0.58			
General Environmental Awareness	Besat Girls' High School	146	2.90 ± 0.54	-1.215	195	.226
	Shariati Boys' High School	51	3.00 ± 0.48			

Note: Levene's test indicated equal variances were assumed for all three components (all $p > .05$). An independent-samples t-test was used.

The results of the independent samples t-test revealed no statistically significant differences in environmental awareness between students from Besat Girls' High School and Shariati Boys' High School across any of the three measured components (all $p > .05$). Although male students (Shariati Boys' High School) showed slightly higher mean scores in Ecosystem Protection (M = 3.31 vs. 3.24) and General Awareness (M = 3.00 vs. 2.90), these differences were not significant. This suggests that gender does not play a determining role in shaping environmental knowledge among high school students in Rudbar County.

Table 9. One-way ANOVA and Brown-Forsythe results for environmental awareness by educational level

Variable	Grade	N	Mean ± SD	Test Statistic	df_1, df_2	Sig.
Ecosystem Protection Component	10th	71	3.12 ± 0.52	F = 4.21	(2, 194)	.016
	11th	90	3.32 ± 0.50			
	12th	36	3.38 ± 0.57			
Waste Management Component	10th	71	2.41 ± 0.50	Brown-Forsythe = 15.04	(2, 159.03)	<.001
	11th	90	2.91 ± 0.71			
	12th	36	2.80 ± 0.54			
General Environmental Awareness	10th	71	2.69 ± 0.40	Brown-Forsythe = 13.99	(2, 155.10)	<.001
	11th	90	3.07 ± 0.58			
	12th	36	3.03 ± 0.45			

Note: Levene's test indicated equal variances for Ecosystem Protection ($p = .639$), so the standard F-test was used. For Waste Management ($p = .014$) and General Awareness ($p = .026$), variances were unequal, so a robust Brown-Forsythe test was reported.*p < .05, ** p < .01.

The results of the one-way ANOVA revealed statistically significant differences in environmental awareness across educational levels for all three components (all $p < 0.05$). This indicates that students' level of environmental knowledge is not uniform across grades.

- Ecosystem Protection Component: Students in 10th grade ($M = 3.12$) had a significantly lower mean score compared to those in 11th grade ($M = 3.32$), with a significant difference confirmed by Tukey's HSD test ($p = .040$). Additionally, students in 12th grade ($M = 3.38$) scored higher than those in 10th grade, and this difference was also statistically significant ($p = .038$). However, no significant difference was found between 11th and 12th graders ($p = .826$). These results indicate that both 11th and 12th graders show stronger ecosystem protection awareness than 10th graders, but their performance does not differ significantly from each other.
- Waste Management Component: A highly significant difference was found ($F = 13.506$, $p < .001$). Post hoc analysis using Tamhane's T2 showed that 10th-grade students ($M = 2.41$) scored significantly lower than both 11th ($M = 2.91$; $p < .001$) and 12th ($M = 2.80$; $p = .002$) graders. No significant difference was observed between 11th and 12th grades ($p = .728$).
- General Environmental Awareness: Similarly, 10th-grade students ($M = 2.69$) demonstrated significantly lower overall awareness compared to 11th ($M = 3.07$; $p < .001$) and 12th ($M = 3.03$; $p = .001$) graders. Again, no significant difference existed between 11th and 12th grades ($p = .958$).

These findings suggest that environmental awareness increases substantially between 10th and 11th grades, after which it stabilizes. This pattern may reflect the cumulative effect of environmental education received in higher grades or increased maturity and exposure to environmental issues. The consistently lower scores among 10th graders highlight a critical gap in environmental literacy at the beginning of high school education, suggesting that targeted interventions are needed to strengthen foundational environmental knowledge early in students' academic journey.

In this context, other researchers have conducted studies that align with the findings of the present study. For example, Pourkhabbaz et al. (2021) assessed the environmental awareness, attitudes, and performance of elementary school students and teachers in Behbahan city using a questionnaire. Their results indicated that while the level of education does not influence environmental performance and attitudes, it does impact environmental knowledge. Jadgal et al. (2023) conducted a study on the

environmental literacy of nursing students in Chabahar city to evaluate their knowledge, attitudes, and practices regarding environmental protection. The findings revealed that while most students demonstrated a good understanding of environmental protection behaviors, their actual performance in protecting the environment was lacking. Aqanaghad et al. (2023) examined the environmental literacy of high school students and its connection to their environmental ethics. Their findings indicated that, while students possess a relatively good level of environmental knowledge, attitudes, and ethics, they exhibit weaknesses in their environmental behavior and performance. Therefore, it is essential to cultivate a culture of environmental ethics starting from preschool and elementary school to enhance students' environmental behavior and performance.

Chen (2020) conducted a study to investigate the impact of environmental education in higher education institutions, specifically colleges and universities, in China over the past two decades. The research focused on how this education affects students' environmental knowledge and awareness at Xiamen University. The results indicated that environmental education programs were effective in enhancing students' understanding of environmental issues over time.

Pozo-Muñoz et al. (2023) conducted a study to investigate the environmental awareness of primary school students in Spain before and after implementing an educational program focused on water management and conservation. The results indicate that students had a low understanding of the complete water cycle and displayed a limited sense of responsibility regarding water-related issues. This study highlights the need to incorporate content on water care and conservation into the educational curriculum, adopting a multidimensional and interdisciplinary approach to better understand the origins and impacts of water problems.

Elsharkawy et al. (2024) conducted a study to assess university students' knowledge, perceptions, and practices regarding climate change.

The research aimed to explore the relationship between students' knowledge levels and their reported practices in response to climate change. The findings revealed that while most students were aware of climate change and strongly supported general measures to reduce greenhouse gas emissions, their actual knowledge and practices for reducing emissions were lacking. The study strongly recommends climate change education that focuses on its causes and its connection to everyday activities, encouraging young people to adopt more climate-friendly practices. Since Non-governmental organizations (NGOs) play a vital role in raising awareness and educating communities about environmental issues (Mercan and Varol Selçuk, 2023). Therefore, it is beneficial to leverage the resources of NGOs to inspire students to appreciate and respect nature. Additionally, effective environmental education strategies should be developed to enhance awareness, involve stakeholders, and promote responsible behaviors toward environmental protection and sustainability (Seddiky et al., 2020).

4. Conclusion

The results indicate that environmental awareness predominantly increases during the transition from tenth to eleventh grade. Tenth-grade students appear to have the lowest level of awareness, suggesting a need to focus environmental education programs specifically at this educational level. In contrast, the level of awareness remains stable between the eleventh and twelfth grades, which may imply that students reach a knowledge ceiling based on the current curriculum or that there is a lack of new and effective content in environmental education during the twelfth grade. Therefore, employing effective methods of environmental education is crucial to enhancing awareness and education in this area within the country. Television and the Internet are two important educational tools that can be utilized to provide environmental education. By enhancing environmental education through workshops and raising awareness about issues such as water shortages, climate change, and pollution, we can encourage community members, especially students, who serve as a bridge between their families and schools, to place greater emphasis on environmental protection. Developing and promoting an environmental culture is essential for environmental protection and resource management, especially in light of the environmental disasters and crises we face in the current century. Furthermore, incorporating environmental education into the formal education system and community-based programs can engage a broader audience and foster sustainable development. Involving key stakeholders, designing programs tailored to the specific needs of target audiences, and continuously evaluating and monitoring these programs are crucial for the success of environmental education initiatives. To achieve this, it is recommended to develop a comprehensive curriculum that integrates environmental studies for primary and secondary schools. Creating practical activities such as using pictures, simulation games, board and card games, and puzzle-solving can effectively educate and engage adolescents and young people in understanding environmental issues like water scarcity and pollution. Additionally, planning field trips or outdoor activities can significantly enhance the understanding of key concepts related to environmental problems. Teaching environmental issues in the classroom is important, but it's not enough on its own. To promote environmental protection more effectively, schools should implement policies like a "No-Litter Practice" and a "Bottle and Personal Garbage Separation Program." Additionally, it is recommended that school officials and teachers extend learning beyond the classroom by organizing activities such as tree planting and community clean-ups.

This study serves as a valuable resource for planners, policymakers, and environmental activists to enhance environmental awareness and understanding, thereby improving the environmental behavior of students as the next generation who will impact the environment.

During this research, we encountered several limitations that should be noted. First, data collection was limited to Rudbar County and took place over a specific time period, which means the results may not be fully

applicable to other regions or times. Additionally, not all schools and students participated, as access was restricted, and some individuals chose not to complete the questionnaire for various reasons. This may have impacted the diversity of our sample. Furthermore, the data were based on students' self-reports, which introduces the potential for bias or inaccuracies in their responses.

Acknowledgments

This research was the result of a research project with contract number GH/779/1404/580 under the financial support of Kashmar Higher Education Institute.

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