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Global warming awareness among the University of Bahrain science students

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Abstract This study was designed to investigate the awareness regarding global warming among the College of Science students at University of Bahrain. A total of 143 science students were examined using a questionnaire that covered three aspects of global warming including causes, impacts, and solutions. The study included 51, 28, 40 and 24 students from the departments of biology, chemistry, mathematics, and physics respectively. The results have shown that $55 \pm 10.18\%$ of all students examined answered the questions correctly of which $51 \pm 10.28\%$ were in the first year, while $60 \pm 7.4\%$ were in their fourth year indicating a direct positive impact of university education. A significant dependence ($p \leq 0.05$) was recorded between first and fourth year students' answers. The results have shown that fourth year biology students were the most knowledgeable, a fact that can be attributed to their academic curriculum. Therefore, the study has recommended integrating environmental concepts into the university curriculum for all students irrespective of their academic specialization in order to increase the environmental awareness.

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1. Introduction

According to the environmental protection agency (EPA), global warming is defined as the recent and ongoing rise in earth surface temperature. The greenhouse gases are the most contributors to climate pattern change. The greenhouse gases (GHGs) include water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). The hazard of global warming is one of the most important and critical problems

of the world (Gul et al., 2009; GCRIO, 2011; Ozbayrak et al., 2011; EPA, 2013a,b).

CO_2 is the most contributed gas to the greenhouse effect accounting for 80% of the impact. CO_2 and other gases arise from combustion of fossil fuels, agricultural activities, industry, energy use and fertilizers (Ozbayrak et al., 2011). It is believed that global warming will affect the world even if we managed to dramatically reduce emissions of GHGs today. Such trends would continue for a long period, could be decades or centuries to come (UNEP, 2003). Therefore, cutting GHGs emissions in order to minimize future climate change as well as responding to the unavoidable impacts that our past emissions will cause must be a top priority. The Emission Gap reports prepared by the United Nations Environment Program (UNEP) advocate that a universal and collaborative effort to reduce carbon footprint is the only way to ease the greenhouse

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effect and reduce the impact of global warming (UNEP, 2013). Contributions such as saving energy around the house, using public transportation and renewable energy can help too (Brown, 2009), but it all starts with raising awareness (UNEP, 2003).

People everywhere need to understand how climate change is going to affect them and what can they do to cope, starting with understanding what is causing global warming and what effects it has in order to find out solutions and implement them (UNEP, 2003). Therefore, educating people and making them aware of this matter by including global warming issues in educational curricula at every level, and by revealing the misconception of students and people about global warming received from the mass media is of great importance. Today, environmental education of global warming from elementary school to the university level is the most effective way to raise the environmental consciousness among nations (Anderson and Wallin, 2000; Skamp et al., 2009; Taber and Taylor, 2009; Kilinc et al., 2011).

As far as we know there are no available studies on the awareness of students about environmental issues in general and global warming specifically, in the kingdom of Bahrain or even in the Cooperation Council for the Arab States of the Gulf (GCC) except for the study of Ambusaidi et al. (2012) which was designed to determine grades 6–12 students' view regarding actions that might help to reduce global warming and their willingness to participate in such actions. However, there is a substantial amount of international studies that have been conducted on school students' perception, ideas and understanding on greenhouse effect, climate change and global warming (Bozdogan, 2009; Liarakou et al., 2011; Hasiloglu et al., 2011; Yazadanparast et al., 2012).

The majority of the literature conducted on this topic focused on school students' perception on global warming as young as kindergarten age to high school age and some focused on the role of teachers and formal Environmental Education in raising awareness (Boyes and Stanisstreet, 2001; Bozdogan, 2009; Yurttas and Sulun, 2010; Cimer et al., 2011; Ozbayrak et al., 2011; Owolabi et al., 2012).

Several international treaties were signed to reduce the GHG concentration in the atmosphere on international levels, but reduction on a national level is also important to attain this universal goal and awareness is one of the first steps to accomplish that (Arslan, 2012).

University students' awareness of environment, global warming, and greenhouse effect, specifically science students, is expected to be one of the highest among students in the formal educational pyramid, and an important indicator to the knowledge of the general population (AbuQamar et al., 2015). Accordingly, the educational awareness regarding biotechnology issues among the undergraduate students at the United Arab Emirates University (UAEU) has shown that students from the college of science and Food and Agriculture were more aware of the use of biotechnology and its environmental impact in comparison to students from other colleges. However, no significant differences were recorded between freshly admitted students and those that are at higher academic levels, suggesting that students have mainly gained their knowledge through the general education rather than the academic achievement at the university level (AbuQamar et al., 2015).

The aim of this study was to determine the level of awareness among University of Bahrain science students regarding global warming and greenhouse effect, to identify gap areas among the students' knowledge in order to suggest solutions for improvements, to compare level of knowledge between the different departments at the College of Science, and investigate possible variations in awareness between first and final year students in order to access the role of school and university education toward this issue.

2. Material and methods

2.1. The Instrument

This study was based on a primary survey using a questionnaire (Table 1) that was based on the Environmental Issue Questionnaire that was developed by Boyes et al. (1993) and Liarakou et al. (2011). A multiple choice and true and false questions were used in this survey. The questionnaire included 30 questions in total, 14 multiple choice, and 16 true and false questions. The questions covered three aspects of the global warming including causes, impacts, and solutions based on the study of Liarakou et al. (2011). Fifteen of the questions were created to test the knowledge of students about the most known causes of global warming and GHG effect, eight questions were dedicated to the impacts on the environment and humans, and seven questions focused on the possible solutions of this global dilemma.

A reliability analysis was carried out in order to examine the internal consistency of its questions. The value of Cronbach's alpha was 0.70 implying that the instrument was consistent and reliable in achieving the study objective.

2.2. The study group

The questionnaire was distributed in November 2013 among the first and fourth year students at the University of Bahrain, College of Science, Department of Biology, Department of Chemistry, Department of Mathematics, Statistics and Operation Research, and Department of Physics (Fig. 1). University of Bahrain is the lone governmental university harboring the largest number of students among all the universities in the Kingdom of Bahrain. The study group included all enrolled students ($N = 143$) in which the majority of them were female (133) with an age range from 18 to 24 years old. The questionnaires were distributed during lectures or laboratory sessions to guarantee that the students have relied solely on their knowledge to answer the survey questions.

2.3. Statistical analysis

The statistical analysis was performed using the Statistical Package for Social Science (SPSS 18.0 for windows, SPSS Inc., Chicago, IL) and statistical package from Excel 2007 (Microsoft Corporation) for comparison of means. Results are presented as percentage of the mean and standard deviation (\pm SD). The values were also statistically analyzed using the chi-square test of independence. Differences with p value ≤ 0.05 were considered statistically significant.

Table 1 Questionnaire statements [C = Cause, I = Impact, S = Solution].

True/false questions $n = 15$	Multiple choice questions (MCQ) $n = 15$
1. During the last years, the average global sea level has been rising (<i>true</i>) [I]	1. At present, the major environmental problem that causes global warming is [C] a. Radioactive waste b. Acid rain c. Water pollution d. Air pollution
2. The use of solar energy accelerate global warming (<i>false</i>) [S]	2. Which of the following energy resources cause the most environmental pollution leading to global warming? [C] a. Coal b. Oil c. Natural gas d. Solar
3. Carbon dioxide is a gas that has contributed to aggravating global warming (<i>true</i>) [C]	3. The BEST definition of global warming is [C] a. The increase of the temperature on earth b. The emission of gases in the atmosphere that causes greenhouse effect c. The study of human impact on the environment d. The excessive emission of gases
4. During the last years, the ice cover of Earth's two polar regions has increased (<i>false</i>) [I]	4. The principle gas that causes the "hole" in the ozone layer is [C] a. Carbon dioxide (CO ₂) b. Methane gas (CH ₄) c. Carbon mono-oxide (CO) d. Chlorofluorocarbons (CFCs)
5. Global warming will not lead to displacement of human population (<i>false</i>) [I]	5. The best known CFC is Freon, a heat transfer agent found in [C] a. Televisions and radios b. Microwaves c. Refrigerators and air conditioners d. ovens
6. With the passage of time, the average global temperature rises (<i>false</i>) [I]	6. The increase emission of gases from fossil fuel burning [C] a. Causes the greenhouse effect b. Causes global warming c. Prevent the sun rays from going out of the atmosphere after reflecting on earth d. All of the above
7. The growing incidence of skin cancer in recent years is due to the ozone layer depletion (<i>true</i>) [I]	9. What do you think we can do individually at home to decrease global warming? [S] a. Decrease electricity consumption b. Use non-recyclable products c. Increase water consumption d. Increase waste products (garbage)
8. Carbon dioxide increases in the atmosphere mainly because of fossil fuel combustion (<i>true</i>) [C]	10. What do you think we can do to decrease global warming as individuals outside? [S] c. Use public transportation or share private transports d. Use sun protection cream
9. In general, the use of public transport instead of private cars can contribute to minimizing global warming (<i>true</i>) [S]	11. Recent climate change is primarily caused by [C] a. Melting of ice cover of Earth's two polar regions b. Human activities c. Rise of the average sea level worldwide d. Displacement of human population
10. The use of solar energy exacerbates (worsen) global warming (<i>false</i>) [S]	12. All of the following human behaviors contribute to global warming except: [C] a. Using hydrogen as energy source b. Wasting non-renewable energy resources c. Destroying forests d. Consuming fossil fuels. Plant trees. Use artificial fertilizers
11. The ozone layer prevent the ultraviolet rays of the sun rays from entering the earth atmosphere (<i>true</i>) [I]	13. Due to global warming, important climatic changes such as all of the followings can occur except: [I] a. excessive heat waves b. Windstorms c. Killer floods and forest fires d. Abnormal diseases
12. Greenhouse gases allow solar radiation to pass through but hinder the escape of infrared rays (heat) back into space (<i>true</i>) [C]	14. Which of the following gases contribute most to the greenhouse effect, accounting for nearly 80% of the impact? [C] a. Helium b. Ozone c. Carbon dioxide d. Nitrous Oxide
13. TV does not consume energy when it is turned off by remote control (<i>false</i>) [S]	
14. The Kyoto Protocol concerns the reduction of the greenhouse gases and thus global warming (<i>true</i>) [S]	

(continued on next page)

Table 1 (continued)

True/false questions $n = 15$	Multiple choice questions (MCQ) $n = 15$
15. Greenhouse gases such as Argon, Neon, Helium, Methane, Hydrogen, Nitrous Oxide, and Ozone also have negative impact on global warming (<i>true</i>) [C]	15. Greenhouse gases [C] a. Absorb infrared radiation, thus warms the earths' surface and increase the atmosphere heat. b. Reflect infrared radiation, thus warms the earths' surface and increase the atmosphere heat. c. Absorb ultraviolet radiation, thus warms the earths' surface and increase the atmosphere heat. d. Reflect ultraviolet radiation, thus warms the earths' surface and increase the atmosphere heat
7. Select the correct association [C] a. Carbon dioxide-Bacterial decomposition b. Nitrous oxide-Fertilizer use and animal wastes c. Methane-Fossil fuel and wood burning d. Chlorofluorocarbons-flooding	
8. In case global warming continues, what do you think we are going to encounter danger? [I] a. Increased ice fields b. Drought and desertification c. Water desalination d. Sea level decline	

Based on the study of Boyes et al. (1993) and Liarakou et al. (2011).

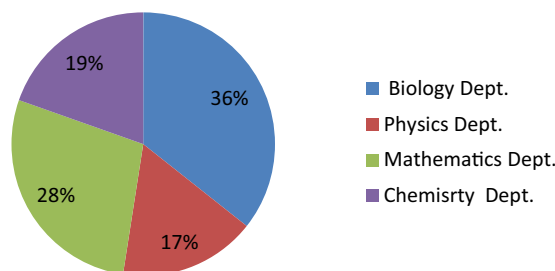


Figure 1a Percentage of the surveyed students according to the departments.

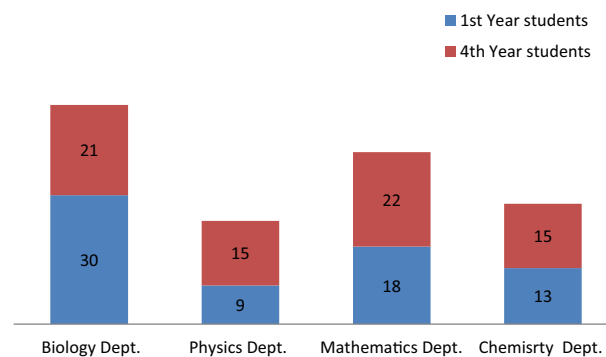


Figure 1b Numbers of the surveyed students according to their study year.

3. Results

Percentage of total correct and incorrect answers according to the study groups have shown that 55% of all students surveyed answered the questions correctly of which $51 \pm 10.28\%$ were in the first year, while $60 \pm 7.4\%$ were in their fourth year. A significant difference ($p \leq 0.05$) was recorded between first and fourth year students' answers.

The results have also shown that fourth year biology students were the most knowledgeable with $69 \pm 0.21\%$ correctly answering the questions, followed by mathematics first year students ($66 \pm 0.24\%$), physics fourth year students ($65 \pm 0.25\%$), physics first year students ($60 \pm 0.31\%$), chemistry fourth year students ($53 \pm 0.24\%$), mathematics fourth year students ($52 \pm 0.22\%$), and chemistry first year students who scored the lowest percentage ($40 \pm 0.21\%$).

Percentage of correct and incorrect answers regarding global warming causes among first and fourth year students of different department are summarized in Table 2. Mathematics first year students were the most knowledgeable with $68 \pm 0.18\%$ correct answers and biology first year students being the least knowledgeable with $40 \pm 0.17\%$ correct answers. Percentage of fourth year biology students' correct answers was 22% higher than those of first year students. Similarly fourth year chemistry students' correct answers were 9% higher than those of first year students. On the contrary, fourth year mathematics students' knowledge was lower (14%) than first year students, while fourth year physics students' knowledge was slightly higher (5%) than first year students.

Table 2 Percentage of correct and incorrect answers regarding global warming causes among first and fourth year students of different departments.

Causes questions <i>n</i> = 15	Biology 1st year <i>n</i> = 30	Biology 4th year <i>n</i> = 21	Physics 1st year <i>n</i> = 9	Physics 4th year <i>n</i> = 15	Mathematics 1st year <i>n</i> = 18	Mathematics 4th year <i>n</i> = 22	Chemistry 1st year <i>n</i> = 13	Chemistry 4th year <i>n</i> = 15
Correct answers	40 ± 0.17	65 ± 0.19	63 ± 0.30	61 ± 0.21	68 ± 0.18	49 ± 0.17	41 ± 0.21	50 ± 0.20
Incorrect answers	60 ± 0.17	35 ± 0.19	37 ± 0.30	39 ± 0.21	32 ± 0.18	51 ± 0.17	59 ± 0.21	50 ± 0.20

The values are expressed as mean ± SD.

Table 3 Percentage of correct and incorrect answers regarding global warming impact among first and fourth year students of different departments.

Impact questions <i>n</i> = 8	Biology 1st year <i>n</i> = 30	Biology 4th year <i>n</i> = 21	Physics 1st year <i>n</i> = 9	Physics 4th year <i>n</i> = 15	Mathematics 1st year <i>n</i> = 18	Mathematics 4th year <i>n</i> = 22	Chemistry 1st year <i>n</i> = 13	Chemistry 4th year <i>n</i> = 15
Correct answers	56 ± 0.18	72 ± 0.28	57 ± 0.43	68 ± 0.36	54 ± 0.36	51 ± 0.28	39 ± 0.25	59 ± 0.37
Incorrect answers	44 ± 0.18	23 ± 0.28	43 ± 0.43	32 ± 0.36	46 ± 0.36	49 ± 0.28	61 ± 0.25	41 ± 0.37

The values are expressed as mean ± SD.

Table 4 Percentage of correct and incorrect answers regarding solutions of global warming among first and fourth year students of different departments.

Solutions Questions <i>n</i> = 7	Biology 1st year <i>n</i> = 30	Biology 4th year <i>n</i> = 21	Physics 1st year <i>n</i> = 9	Physics 4th year <i>n</i> = 15	Mathematics 1st year <i>n</i> = 18	Mathematics 4th year <i>n</i> = 22	Chemistry 1st year <i>n</i> = 13	Chemistry 4th year <i>n</i> = 15
Correct Answers	51 ± 0.19	75 ± 0.14	59 ± 0.20	70 ± 0.20	73 ± 0.17	60 ± 0.23	41 ± 0.19	50 ± 0.12
Incorrect Answers	49 ± 0.19	25 ± 0.14	41 ± 0.20	30 ± 0.20	27 ± 0.17	40 ± 0.23	59 ± 0.19	50 ± 0.12

The values are expressed as mean ± SD.

Table 5 Variation in respondent answers regarding impacts, causes, and solutions questions among different departments.

Questions	Chi-square	<i>p</i> -Value
Impacts questions between four departments	36.5	0.019
Causes questions between four departments	42.6	0.44
solutions questions between four departments	32.3	0.05
Impact questions between first and fourth year students of different departments	17.1	0.017
Causes questions between first and fourth year students of different departments	19.0	0.163
Solutions questions between first and fourth year students of different departments	16.8	0.018

The results of percentage of correct and incorrect answers regarding global warming impact among first and fourth year students of different department are recorded in [Table 3](#). Students' knowledge regarding impacts of global warming was higher among fourth years student of all departments except fourth year mathematics students. Biology fourth year student scored the highest correct answers percentage (72 ± 0.28%), whereas chemistry first year students had the lowest score (39 ± 0.25%).

Similarly, students' knowledge regarding solutions toward global warming was higher among fourth year students of all departments except fourth year mathematics students ([Table 4](#)). Biology fourth year students scored the highest correct answers percentage (75 ± 0.14%), whereas chemistry first year students had the lowest score (41 ± 0.19%).

Chi-square test results ([Table 5](#)) revealed a statistical significant dependence between respondents from all departments regarding impacts, and solutions questions only. A significant

dependence was also registered between first and fourth year students regarding impacts, and solutions questions among different departments. However, no significant dependence was recognized between respondents from all departments as well as first and fourth year students of different departments regarding causes questions.

4. Discussion

Global warming is one of the most important challenges currently facing the world. The adverse impacts of global warming can be catastrophic and a potential threat to the humanity existence. Therefore, it is essential for everyone, especially those in the scientific community to have a full appreciation of the issue as well as the potential solutions to the problem so that they can initiate the necessary changes to the economies, resource utilization, behavior, and general approach to nature (Aydin, 2010). Science education aims to promote students' understanding of science concepts and the application of their understanding to solving real world problems, including global warming issues. However, students themselves need to have a clear understanding of the global warming issues in relation to other factors such as the impact of biotechnology on the environment before they can act as effective changing agents within the larger society (Groves and Pugh, 1999; AbuQamar et al., 2015).

The result of the present study has shown that more than half of all participated students ($55 \pm 10.18\%$) responded correctly to the questions. In general, a significant improvement was registered between fourth year students ($60 \pm 7.4\%$) in comparison to first year students ($51 \pm 10.28\%$) regarding global warming awareness indicating a direct positive impact of university education. The study has observed tangible differences in awareness among the students across different departments. Overall, the majority of the biology fourth year students showed greater awareness of global warming aspects ($69 \pm 0.21\%$) compared to their first year counterparts ($47 \pm 0.18\%$). Similarly, chemistry first year students ($40 \pm 0.21\%$) were less aware of the issue, while a record of good improvements was observed among fourth year students ($53 \pm 0.24\%$). On the other hand, students from the Department of Physics have shown slight improvement ($65 \pm 0.25\%$) compared to their first year counterparts ($60 \pm 0.31\%$), while the level of awareness among fourth year mathematics students ($52 \pm 0.22\%$) was much lower than their first year colleagues ($66 \pm 0.24\%$). The better performance of the biology students can be attributed to the fact that their academic curriculum includes a number of compulsory as well as elective courses that include aspects related to the environment and global warming such as General Biology (BIOLS 102), General Ecology (BIOLS 340), Principles of Environmental Science (BIOLS 341), Marine Biology (BIOLS 380), Oceanography (BIOLS 383), Marine Pollution (BIOLS 385), Environmental Impact Assessment (BIOLS 441), Conservation Biology (BIOLS 442), and Fish and Fisheries (BIOLS 481) (UOB, 2014). Similarly, Department of Chemistry academic curriculum covers some environmental aspects including global warming in some elective courses including Green Chemistry (CHMEY 315), Environmental Chemistry I (CHMEY 412), and Environmental Chemistry II (CHMEY 413). On the contrary, the decline in the level of awareness among fourth year mathematics

students as well as the slight improvement among fourth year physics students can be attributed to the fact that there are no environmental or related subjects taught as part of the mathematics and only one elective course in physics Curricula (Environmental Physics, PHYSC 366) (UOB, 2014), and therefore no academic knowledge was gained during their university study years and their academic knowledge was solely gained during their school years.

A similar trend was observed regarding global warming three tested aspects (causes, impacts, and solutions) in which biology fourth year students were the most knowledgeable regarding all aspects (causes $65 \pm 0.19\%$, impacts $72 \pm 0.28\%$, solutions $75 \pm 0.14\%$), while chemistry fourth year students' level was significantly higher (causes $50 \pm 0.20\%$, impacts $59 \pm 0.37\%$, solutions $50 \pm 0.12\%$), than those in the first year (causes $41 \pm 0.21\%$, impacts $39 \pm 0.25\%$, solutions $41 \pm 0.12\%$), whereas the level of fourth year physics students was higher (causes $61 \pm 0.21\%$, impacts $68 \pm 0.36\%$, solutions $70 \pm 0.20\%$), than first year students (causes $63 \pm 0.30\%$, impacts $57 \pm 0.43\%$, solutions $59 \pm 0.20\%$) in both impacts and solutions but slightly lower in causes aspect; and the fourth year mathematics students level being lower in all aspects (causes $49 \pm 0.17\%$, impacts $51 \pm 0.28\%$, solutions $60 \pm 0.23\%$) compared to first year students (causes $68 \pm 0.18\%$, impacts $54 \pm 0.36\%$, solutions $73 \pm 0.17\%$). This trend can again be attributed to the department different curricula and the amount of knowledge gained through the academic study.

This is the first study in the region testing university students' knowledge and attitudes about global warming. The level of global warming awareness among first year students could most probably be a representative of the knowledge they have gained through their school education. The present study has shown that the general awareness regarding global warming issues among first year students ($51 \pm 10.28\%$) was higher than secondary school students in some regional countries such as Turkey (36%) (Keskin et al., 2013) but less than other international students from China (85%) and US (75%) (Jamelske et al., 2012). In general, limited literature on college student understanding of climate change is available (Artz, 2012; Bostrom et al., 2012; Wachholz et al., 2014; Pawan et al., 2013; Ayeni, 2014; Rideout, 2014); whereas most studies were conducted on different levels of school students (Aydin, 2010; Bozdogan, 2011; Liarakou et al., 2011). Most of those studies have dealt differently with this issue, making each study unique in its approach and conclusion.

In many developed countries around the world, specific Environmental Education (EE) programs have been implemented in their educational systems. EE suggests a structured learning process, in which the issues of climate change and other environmental subjects can be approached in an integrated way through out all educational levels (Liarakou and Flogaitis, 2007). This is not the case in the Kingdom of Bahrain, since there is no formal EE program implemented at any educational level and thus the knowledge that most students acquire does not come from their education but rather from other sources mainly the media including television, radio, newspapers, World Wide Web, social media, etc. Such sources are not always reliable and can deliver misconception (Hassan and Ismail, 2011; Liarakou et al., 2011). In addition, Rickinson (2001) has stated that television is the main source of information for students on environmental issues through

nature programs, news and documentaries with more attention given to the impacts of global warming and greenhouse effect rather than discussing possible solutions and the main causes of these events.

In general, many factors have a strong influence on environmental awareness among students, firstly, the prevailing education system in general and the curriculum in particular. In addition, there are other key factors which normally contribute to students' understanding of environmental issues including the media, and public/government sponsored awareness programs. Therefore, strategic intervention is required to enhance the media coverage on environmental issues and global warming. Government also needs to focus its efforts on programs aimed at educating the public on global warming issues (Aydin, 2010; Liarakou et al., 2011; Tosun, 2013; Rideout, 2014).

At the University of Bahrain level, a number of initiatives can contribute to enhancing the level of awareness of global warming, such as introducing topics and academic projects related to the environment and global warming in the curriculum for all students, actively support and promote commemoration of events such as the World Earth Day (22nd April) and World Environmental Day (5th June) every year by gathering the students, presenting some attractive movies or shows that deliver the necessary information, as well as engaging the students in creating attractive activities related to the concerned events such as planting trees, distribute related brochure, etc. Finally, considerable work needs to be done in the direction of integrating environmental concepts into the university curriculum in order to increase environmental awareness of all students irrespective of their academic study specialization. This would go a long way in creating a new generation who can effectively work toward mitigating the challenges of global warming. Education is the first defense line to spread the awareness and start impacting people's behavior and attitudes toward the environment, and higher education students should lead by example to all other educational levels.

Conflict of interest

There is no conflict of interest.

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