GLOBE Investigation

Gozo College Middle School 2019-2020

Title - Does Plastic Litter Affect Sea Water Temperature and pH?

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Optional Badges: I am a Data Scientist, I make an Impact, I am a STEM professional

Abstract

Litter is found in all the world's oceans and seas, even in remote areas far from human contact and obvious sources of the problem. The continuous growth in the amount of solid waste discarded irresponsibly, and the very slow rate of degradation of most items, are together leading to a gradual increase in marine litter found at sea, on the sea floor and coastal shores. Marine litter is known to have a negative effect to organisms and ecosystems. All sea turtle species, half of marine mammals and 21% of sea bird species are victims of entanglement or ingestion of marine debris. But are there other consequences as a result of all this litter ending up in the oceans and seas? Does plastic affect sea water conditions? The purpose of this study was to investigate the effects of marine litter, especially plastic, on sea water conditions. This study investigated the effects of plastic litter on sea water temperature and sea water pH levels. This was analysed by recording the sea water temperature and sea water pH levels from two different samples: two large glass jars were filled with the same amount of sea water. In one of the jars the students put some plastic litter which they had collected during a clean-up activity from Ħondoq Bay. The glass jars were placed outside exposed to the sun and rain. The students also measured air temperature, humidity and barometric pressure and the GLOBE Observer App and Observation Cloud chart to measure the cloud cover following the steps of the GLOBE Protocols (GLOBE, 2014). The main objective was to find out the temperature and pH differences between these two samples. Results showed that the sea water containing plastic litter had a higher temperature and pH level. Results support the statement that plastic litter affects the temperature and pH of sea water.

Key words: marine litter, plastic, sea water temperature, sea water pH, coastal areas

Research Questions

What are the effects of plastic on the marine environment?

Does plastic litter affect sea water temperature and sea water pH level?

Taking a whole school approach and integrating the investigation with various subjects including geography and science, the students learnt about Marine Litter. Research on marine pollution, the sources of marine litter and the degradation of plastic was carried out. An outdoor classroom activity, in one of Gozo's coastal areas, gave the students the opportunity to collect data themselves. Using a digital microscope, the students also sampled the sand for microplastics. With all the knowledge learnt from their research on marine litter the students could understand better the concept of how marine litter is posing a threat to marine animals, ecosystems and the coastal environment. Students carried out data collection and used it to investigate if marine litter of which plastic affects sea water conditions. Using a digital thermometer and a digital pH reader, the students measured sea water temperature and sea water pH level during the months of December and January. Readings were taken from two samples: one glass jar filled with sea water and another glass jar filled with sea water with plastic litter added to it.

From the study of the weather conditions, cloud cover, and the observation of variations in temperatures and pH levels from their sea water samples, the students discussed and came up with their own conclusions.

Is there a relationship between sea water temperature and the amount of plastic litter?

What is the effect of a change in sea water temperature and pH level to marine animals and ecosystems?

Plastic debris in our seas and oceans is causing an increase in sea water temperature and higher pH levels when compared to sea water free from plastic fragments. Supported with the knowledge obtained by the students during their science and geography lessons together with the research conducted on the marine litter, it was concluded that plastic litter really effects sea water temperature and sea water pH levels.

Introduction

The aim of the study is to find out the extent of the effect of plastic litter on sea water temperature and sea water pH levels. In this study we used the experimental method, where the sea water temperatures and pH levels were measured during December 2019 and January 2020. During this period, the sea water temperatures and pH levels of two different samples were measured. From this study it was found that plastic litter has an effect on the sea water temperature and pH level. This study contributes significantly to the importance of reducing single use plastic, increasing awareness about the effects of marine litter and opting for zero waste societies not only locally but globally.

According to the International Maritime Organization (IMO, 2020), marine litter presents a huge problem in our oceans, with some scientists warning that, by 2050, the quantity of plastics

in the oceans will outweigh fish (Bessa et al., 2018). Plastic materials in all shapes and sizes can be found everywhere, in all our seas and oceans. They break down extremely slowly in the marine environment, taking over 400 years (Reddy et al, 2018). Marine litter originates from many sources and causes a wide range of environmental, economic, safety, health and cultural impacts. For example, marine litter can cause harm to sea life if ingested or even death if a marine mammal becomes entangled in litter (PEW, 2018 - www.pewtrusts.org)

Marine litter has been defined by UN Environment (2018) as "any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores." (OMI, 2020 - www.imo.org)

Research Methods

Study site:

Following an outdoor classroom activity held at Ħondoq Bay (Figure 1), a small sandy beach in the SE of Gozo, the students decided to investigate the effects of plastic litter on sea water temperature and sea water pH levels.

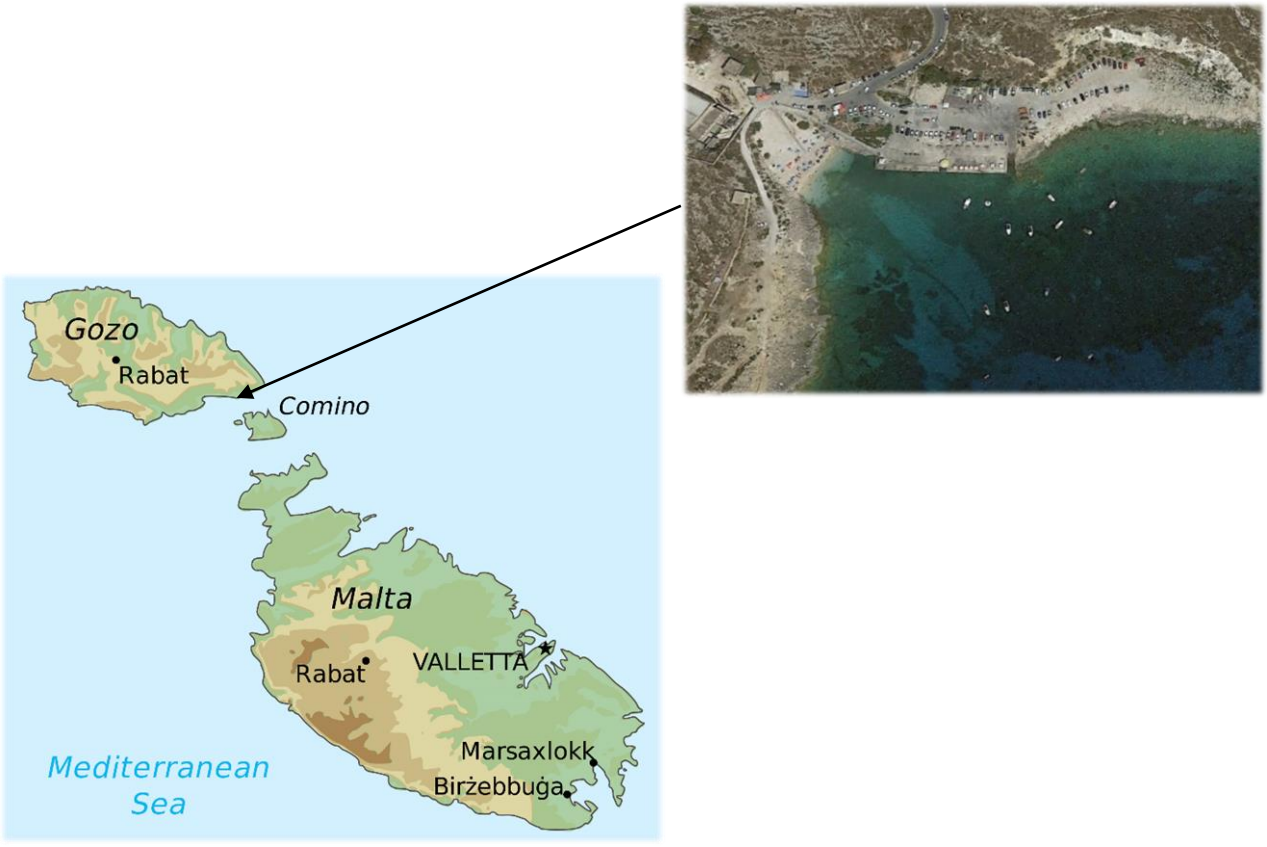

Figure 1 Map of the Maltese Island and study site from where sea water samples were collected

Methodology:

Taking some sea water samples at school, the students filled two large glass jars with the same amount of sea water. In one of the jars the students put some plastic litter (Figure 2) which they had collected during the clean-up activity from Ħondoq Bay. The glass jars were placed outside exposed to the sun and rain.

Figure 2 Glass jars filled with sea water

Apparatus used:

Data logger to measure air temperature, humidity and air pressure

GLOBE Observer App to record cloud type and cover

2 big glass jars

Sea water

Plastic litter

Digital pH reader

Digital thermometer

Every day the students took three readings of the sea water temperature and pH level from both jars (Figure 3) and then the mean of the three samples was calculated. Moreover, the students measured the air temperature, humidity and air pressure, observed cloud cover using the GLOBE Observer App and described the general outlook of the weather following the steps of the GLOBE Protocols (GLOBE, 2014).

Figure 3 Readings of sea water temperature and pH value on 19th December 2019

By the third week it was noticed that the sea water in both jars had evaporated by a third (Figure 4). We decided to continue taking readings without adding any sea water not to affect pH readings. The weather in Malta was particularly dry during this year's winter months with days being warm and sunny.

Figure 4 Sea water in glass jars evaporated by a third

The last day of observation and data collection was January 31st, 2020 (Figure 5). The students decided to stop collecting data for the following reasons:

i. Sea water evaporated even further.
ii. With 23 readings we noticed a consistent pattern.
iii. It was time to analyse our data.

Figure 5 Students collecting daily readings

Data Analysis

All data gathered was analysed through mean values of repetitions (pH and temperature) by jar to the both treatments (with plastics, without plastics). The mean values were plotted along the time to verify the changes between the both treatments. Finally, the mean values were analysed using a paired sample-t test to verify meaningful differences between the means of the treatments to both the pH and the water temperature. The test was performed using the free software Past 4.0 (Hammer, 2001).

Results

The screenshots below show data uploaded on GLOBE website during observation period between December 2019 and January 2020 (Figures 6, 7, 8 and 9). Besides the sea water temperature and sea water pH values, the students collected daily readings of air temperature, barometric pressure, humidity and cloud cover and type together with surface conditions following GLOBE Protocols guide.

Air Temperature

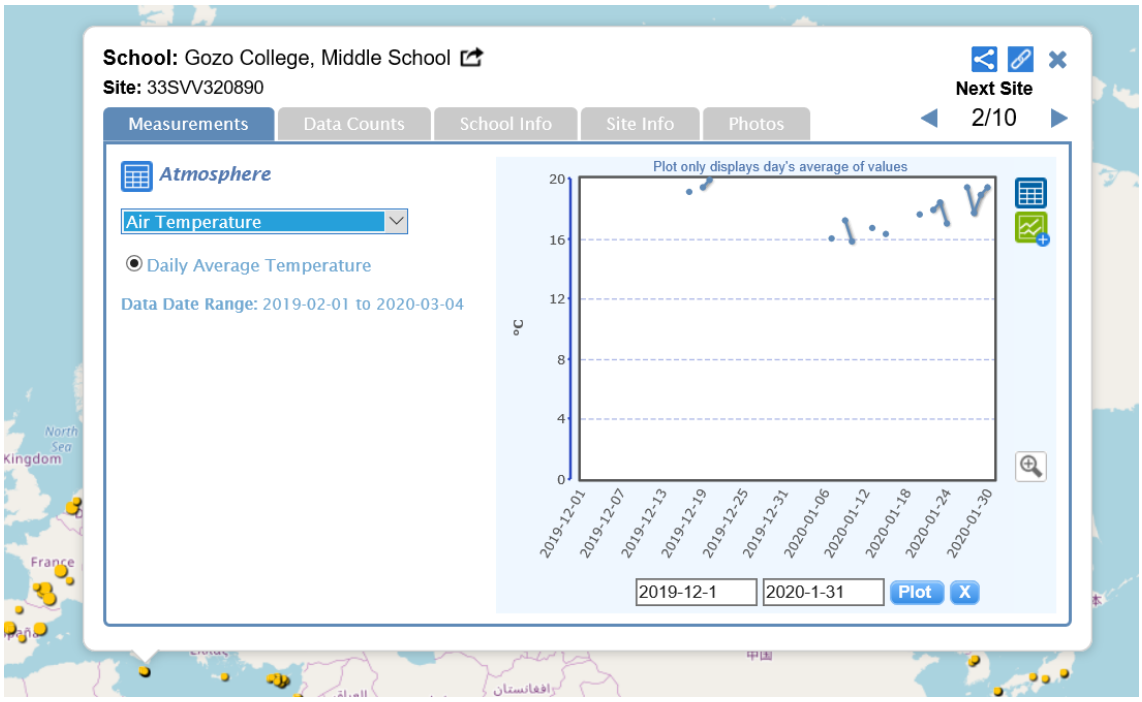

Figure 6 Air temperature plot of VIZ GLOBE

Barometric pressure

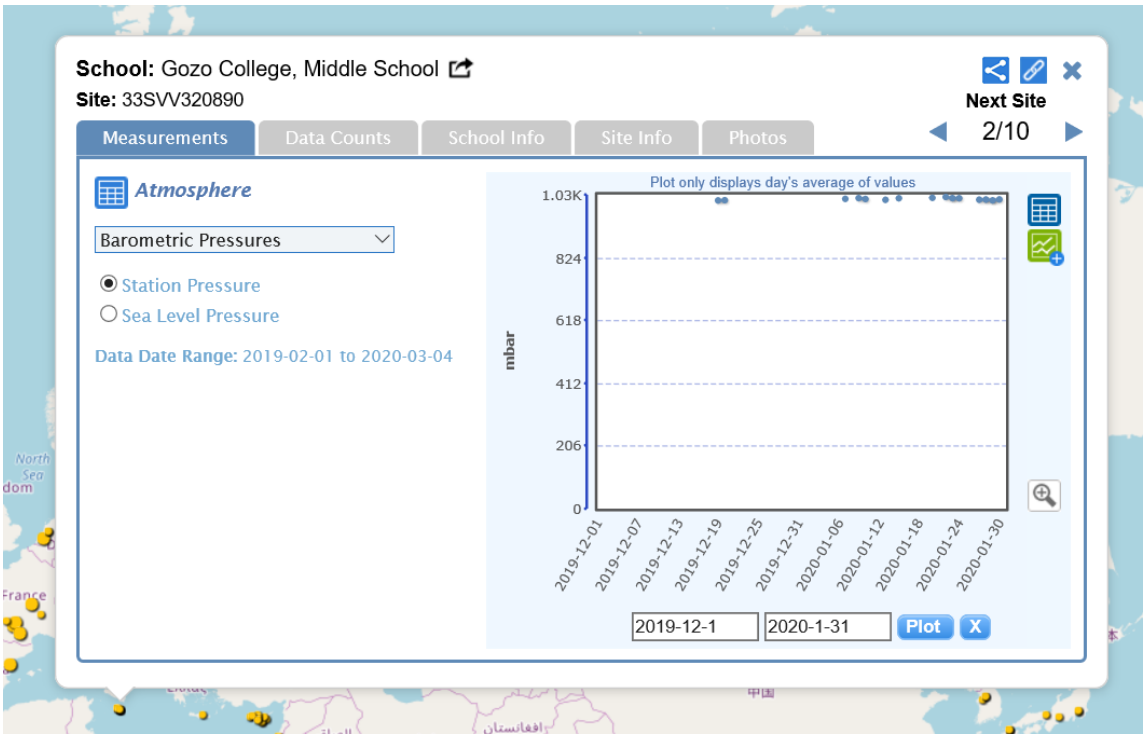

Figure 7 Barometric pressure plot of VIZ GLOBE

Relative humidity

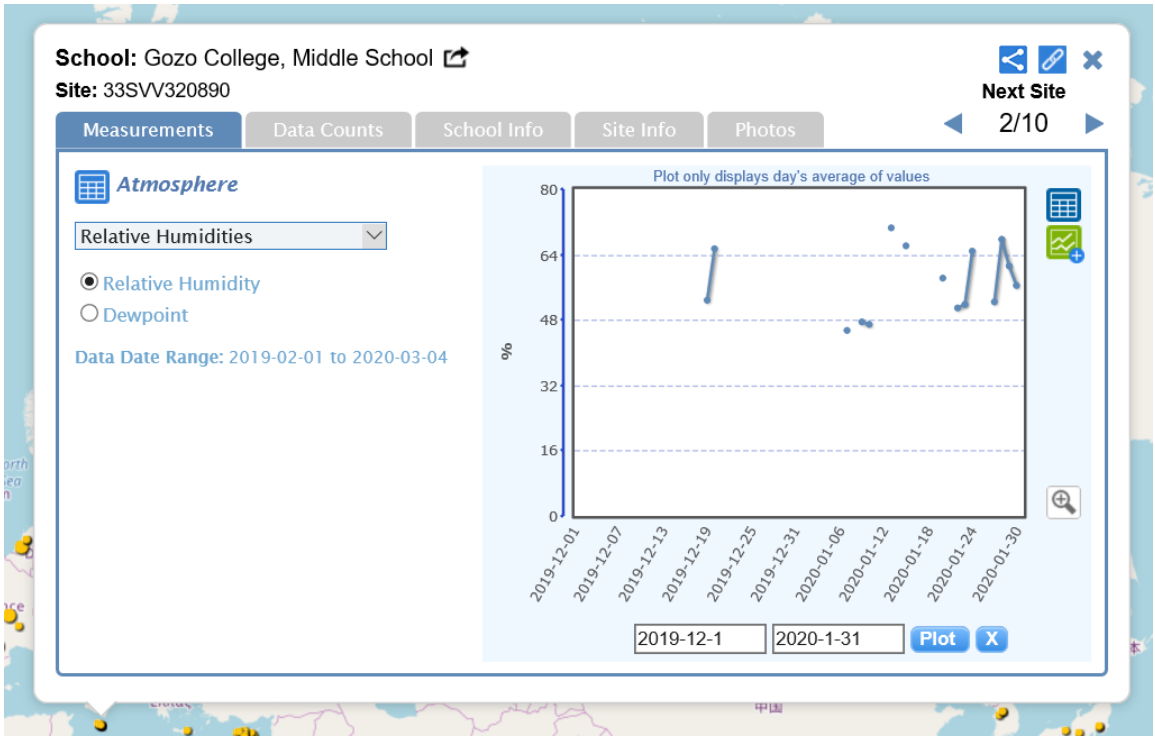

Figure 8 Relative humidity plot of VIZ GLOBE

Clouds

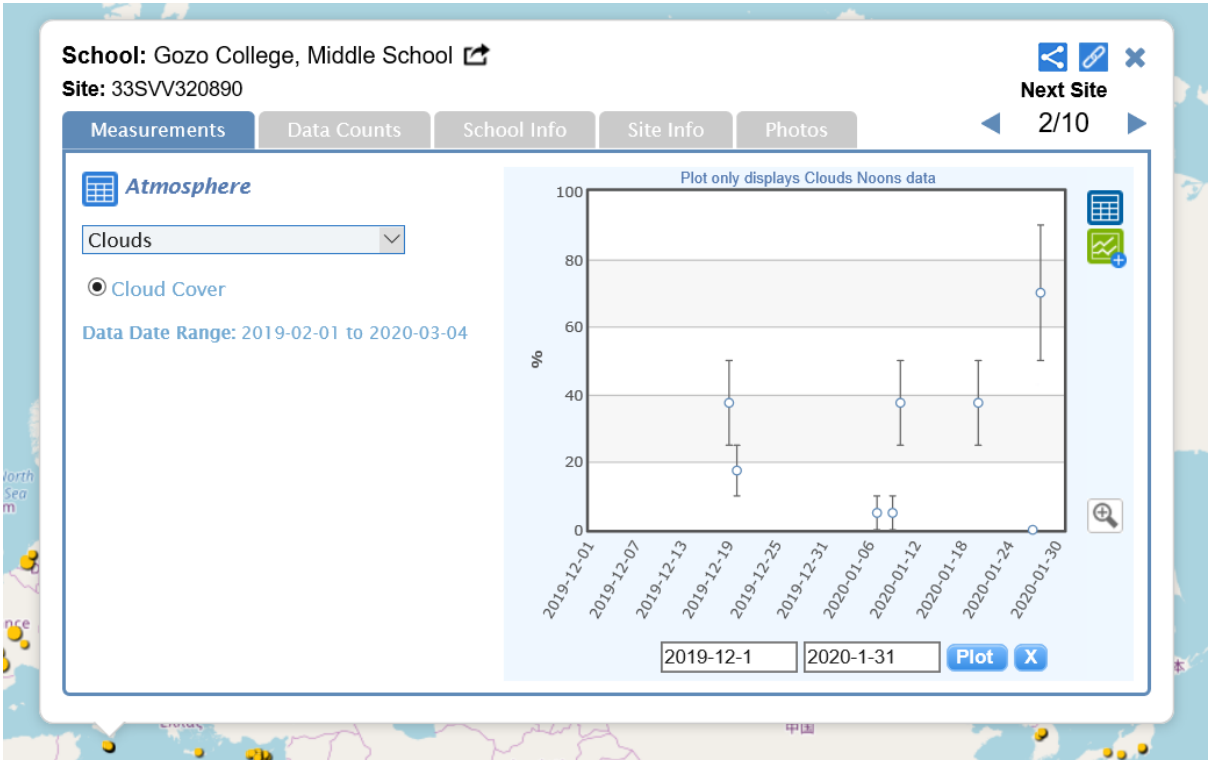

Figure 9 Clouds plot of VIZ GLOBE

Screenshots from observer.globe.gov showing different cloud types and surface conditions for two particular days from the observation period, one in December (Figure 10) and one in January (Figure 11)

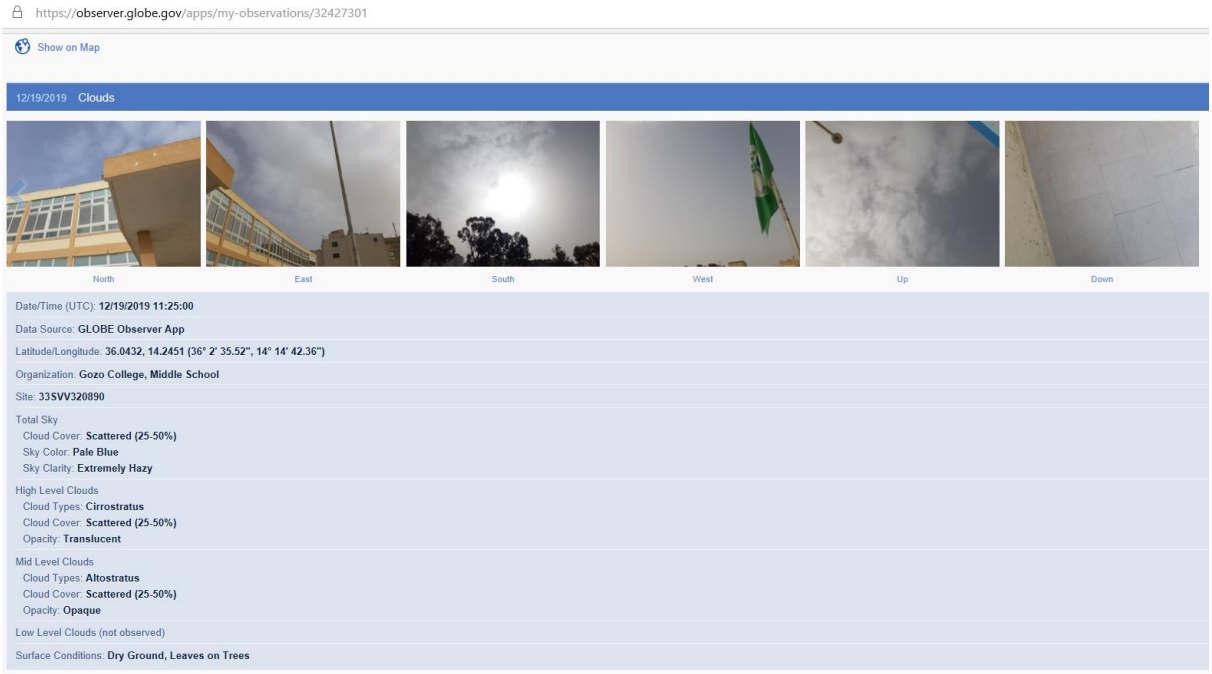

Figure 10 Clouds and surface conditions on 19th December 2019

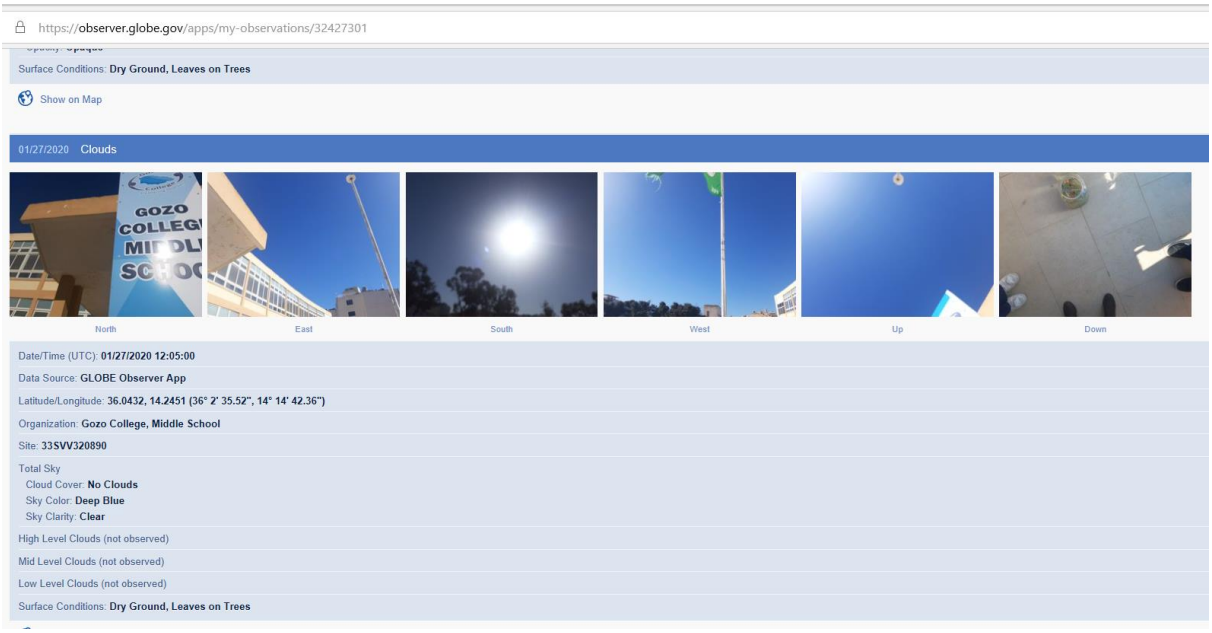

Figure 11 Clouds and surface conditions on 27th January 2020

Table 1: Data Sheet – Sea Water with Plastic Litter

Data	Date	Time	Sea Temperature (°C)				pH reading				Air Temperature (°C)	Air Pressure (mb)	Humidity (%)	Weather General Outlook
			S1	S2	S3	**Mean**	S1	S2	S3	**Mean**				
1	17/12/19	11:00	18.3	18.3	18.3	**18.3**	7.8	7.8	7.8	**7.8**	19.1	1011.3	58	Cloudy
2	18/12/19	12:25	18.8	18.8	18.8	**18.3**	7.8	7.8	7.8	**7.8**	19.4	1010.4	57.3	Cloudy & Windy
3	19/12/19	12:14	18.2	18.2	18.2	**18.2**	7.7	7.8	7.8	**7.8**	19.5	1010.8	52	Cloudy & Hazy
4	20/12/19	12:16	19.4	19.5	19.3	**19.4**	7.8	7.8	7.8	**7.8**	19.9	1011.6	65.5	Sunny
22	07/01/20	12:15	16.3	16.3	16.3	**16.3**	8.4	8.5	8.5	**8.5**	16	1016.0	45.4	Sunny
23	08/01/20	13:25	16.7	16.7	16.7	**16.7**	8.5	8.5	8.5	**8.5**	17.7	1015.2	58.2	Cloudy
24	09/01/20	12:39	16.6	16.6	16.9	**16.7**	8.4	8.4	8.4	**8.4**	17.2	1018.5	47.5	Sunny
25	10/01/20	12:50	16.4	16.3	16.4	**16.4**	8.3	8.4	8.3	**8.3**	15.8	1015.5	46.9	Partly cloudy
28	13/01/20	13:07	12.7	12.4	12.3	**12.5**	8.4	8.4	8.5	**8.5**	15.7	1012.9	70.5	Cloudy & rainy
29	14/01/20	13:06	17.8	17.9	17.9	**17.9**	8.4	8.4	8.4	**8.4**	16.3	1015.3	72.4	Partly cloudy
30	15/01/20	13:14	18.6	18.7	18.7	**18.7**	8.4	8.4	8.4	**8.4**	16.3	1018.0	66.1	Partly cloudy
31	16/01/20	13:07	18.7	18.8	18.7	**18.7**	8.3	8.3	8.4	**8.3**	17.4	1018.4	62.0	Partly cloudy
32	17/01/20	13:01	17.8	17.8	17.8	**17.8**	8.3	8.4	8.4	**8.4**	16.7	1016.9	59.0	Cloudy and windy
35	20/01/20	12:40	17.4	17.3	17.4	**17.4**	8.3	8.4	8.4	**8.4**	17.6	1019.4	58.2	Partly cloudy
36	21/01/20	13:03	17.4	17.5	17.4	**17.5**	8.3	8.3	8.4	**8.3**	17.4	1017.2	54.7	Partly cloudy
37	22/01/20	13:16	18.6	18.6	18.6	**18.6**	8.3	8.3	8.4	**8.3**	17.9	1022.2	50.9	Partly cloudy
38	23/01/20	13:32	18.1	18.2	18.2	**18.2**	8.3	8.3	8.3	**8.3**	18.4	1018.4	51.8	Cloudy
39	24/01/20	13:05	19.1	19.2	19.2	**19.2**	8.3	8.3	8.3	**8.3**	17.0	1018.1	64.8	Cloudy
42	27/01/20	13:00	23.2	23.5	23.5	**23.5**	8.2	8.3	8.3	**8.3**	19.4	1013.3	52.4	Sunny
43	28/01/20	13:11	21.8	21.9	21.9	**21.9**	8.2	8.3	8.3	**8.3**	17.7	1013.8	67.7	Cloudy
44	29/01/20	13:25	22.2	22.2	22.2	**22.2**	8.2	8.2	8.2	**8.2**	18.9	1011.1	61.2	Partly cloudy
45	30/01/20	13:07	21.6	21.6	21.7	**21.7**	8.2	8.2	8.2	**8.2**	19.8	1014.2	56.4	Partly cloudy
46	31/01/20	13:00	19.6	19.7	19.7	**19.7**	8.2	8.2	8.2	**8.2**	18.2	1014.5	71.4	Cloudy

Table 2: Data Sheet - Sea Water without Plastic Litter

Data	Date	Time	Sea Temperature (°C)				pH reading				Air Temperature (°C)	Air Pressure (mb)	Humidity	Weather General Outlook
			S1	S2	S3	**Mean**	S1	S2	S3	**Mean**				
1	17/12/19	11:00	18.3	18.3	18.3	**18.3**	7.8	7.8	7.8	**7.8**	19.1	1011.3	58	Cloudy
2	18/12/19	12:25	19.1	19.1	19.1	**19.1**	7.8	7.8	7.8	**7.8**	19.4	1010.4	57.3	Cloudy & Windy
3	19/12/19	12:14	19.0	18.9	19.0	**19.0**	7.9	7.9	7.9	**7.9**	19.5	1010.8	52	Cloudy & Hazy
4	20/12/19	12:18	20.4	20.5	20.5	**20.5**	7.9	7.9	7.9	**7.9**	19.9	1011.6	65.5	Sunny
22	07/01/20	12:16	16.6	16.6	16.6	**16.6**	8.1	8.1	8.1	**8.1**	16.0	1016.0	45.4	Sunny
23	08/01/20	13:25	15.6	15.6	15.6	**15.6**	8.2	8.2	8.2	**8.2**	17.7	1015.2	58.2	Cloudy
24	09/01/20	12:33	15.9	16.1	15.9	**15.9**	8.1	8.1	8.1	**8.1**	17.2	1018.5	47.5	Sunny
25	10/01/20	12:44	15.2	15.3	15.2	**15.2**	8.1	8.1	8.1	**8.1**	15.8	1015.5	46.9	Partly cloudy
28	13/10/20	13:03	11.8	11.9	11.8	**11.8**	8.2	8.2	8.2	**8.2**	15.7	1012.9	70.5	Cloudy & rainy
29	14/01/20	13:02	17.1	17.2	17.2	**17.2**	8.1	8.2	8.1	**8.1**	16.3	1015.3	72.4	Partly cloudy
30	15/01/20	13:15	18.3	18.2	18.3	**18.3**	8.2	8.2	8.2	**8.2**	16.3	1018.0	66.1	Partly cloudy
31	16/01/20	13:05	18.2	18.1	18.2	**18.2**	8.1	8.1	8.1	**8.1**	17.2	1018.4	62.0	Partly cloudy
32	17/01/20	13:01	17.5	17.4	17.4	**17.4**	8.0	8.2	8.2	**8.1**	16.7	1016.9	59.0	Cloudy and windy
35	20/01/20	12:32	16.6	16.5	16.6	**16.6**	8.1	8.2	8.2	**8.2**	17.6	1019.4	58.2	Partly cloudy
36	21/01/20	13:04	16.2	16.3	16.3	**16.3**	8.1	8.1	8.2	**8.1**	17.4	1017.2	54.7	Partly cloudy
37	22/01/20	13:15	17.9	17.9	17.9	**17.9**	8.1	8.2	8.2	**8.2**	17.9	1022.2	50.9	Partly cloudy
38	23/01/20	13:30	17.2	17.2	17.2	**17.2**	8.1	8.1	8.2	**8.1**	18.4	1018.4	51.8	Cloudy
39	24/01/20	12:59	18.0	18.1	18.1	**18.1**	8.1	8.2	8.2	**8.2**	17.0	1018.1	64.8	Cloudy
42	27/01/20	13:00	22.2	22.2	22.2	**22.2**	8.1	8.1	8.1	**8.1**	19.4	1013.3	52.4	Sunny
43	28/01/20	13:10	20.8	20.9	20.8	**20.8**	8.1	8.1	8.1	**8.1**	17.1	1013.8	67.7	Cloudy
44	29/01/20	13:23	21.2	21.2	21.2	**21.2**	8.1	8.1	8.1	**8.1**	18.9	1011.1	61.2	Partly cloudy
45	30/01/20	13:05	20.2	20.2	20.2	**20.2**	8.1	8.1	8.1	**8.1**	19.8	1014.2	56.4	Partly cloudy
46	31/01/20	13:00	18.8	18.8	18.9	**18.8**	8.1	8.1	8.1	**8.1**	18.2	1014.5	71.4	Cloudy

*School closed for Christmas holidays between 23/1/19 and 6/1/20

Once all data was collected the students presented it in a graph and analyzed it. They considered all data both for the sea water temperature and the pH level it came out that the average sea water temperature was 18.50 degrees Celsius and the pH level of 8.24 for the glass jar filled with sea water and plastic litter. On the other hand, the glass jar containing just sea water showed an average sea water temperature of 17.93 degrees Celsius and a pH level of 7.37. The sudden drop in sea water temperature on day 28, in both jars, could be attributed to the fact that on that day it rained. In fact, that was the only day rain was reported during the whole observation period. Correspondingly the pH level, on that day, increased in both jars. On average air temperatures were around the mean with a slight drop being noted on cloudy days.

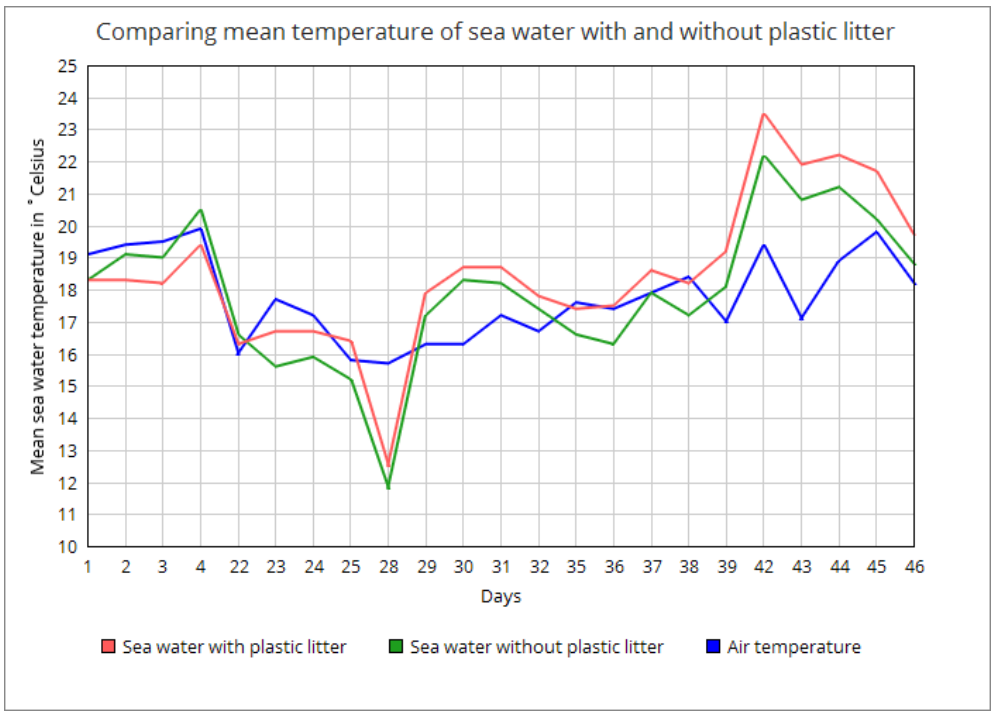

Figure 12 Comparing mean temperature of sea water

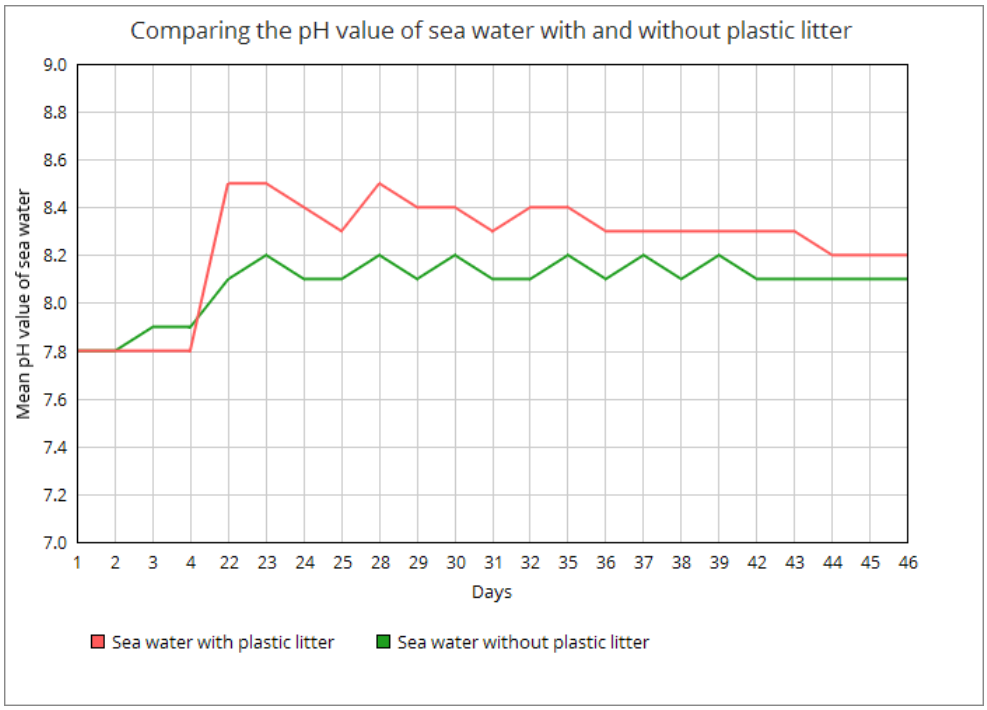

Figure 13 Comparing pH levels

The paired sample t-test applied confirms, with 95% confidence, that there are significant statistical differences between the pH and the temperature of both samples (with and without plastic litter) as shown.

Temperature

Plastic		*No plastic*	
N:	23		
Mean:	18,513	**Mean:**	17,93
Median:	18,3	**Median:**	18,1
t test			
Mean difference:	0,58261	**95% conf.:**	(0,27196 0,89325)
***t*:**	3,8895	***p* (same mean):**	0,00078932
Exact test not executed (N>22)			

pH

Plastic		*No plastic*	
N:	23		
Mean:	8,2478	**Mean:**	8,0826
Median:	8,3	**Median:**	8,1
t test			
Mean difference:	0,16522	**95% conf.:**	(0,10897 0,22146)
***t*:**	6,092	***p* (same mean):**	3,9346E-06
Exact test not executed (N>22)			

Discussion

The data collected helped to determine whether there is an effect on the sea water temperature and sea water pH level as a result of marine litter and that there is a relationship between them. The more plastic litter there is in the sea, the higher is the temperature and pH level.

Temperatures and pH levels recorded were illustrated on a graph and concluded that the relationship between them is a direct relationship. These results correspond to the conclusions obtained following the hypothesis and the data collected was sufficient to answer our research question. The data collected tells us that we were right when setting the hypothesis. Plastic litter does affect sea water temperature and pH level. With 23 readings we noticed a consistent pattern. The sea water in the glass jar containing plastic litter has a higher temperature and a higher pH value when compared to the readings of the glass jar filled with sea water only. Some explanations to the higher temperature in the glass jar with plastic litter could be that plastic litter act as layer, just like the greenhouse effect, maintaining the temperature in the jar and avoiding the entry of fresh air to cool the water. Researchers have found that several greenhouse gases are emitted as common plastics degrade in the environment. Their study reports the unexpected discovery of the universal production of greenhouse gases methane and ethylene by the most common plastics when exposed to sunlight (Royer et al, 2018).

The students did not stop here. Having discovered the effects of plastic on the marine environment, they wanted to bring change as quickly as possible. So besides contacting the local authorities to take action and place more bins in coastal areas, they took the matter in their

hands. After doing research on the effects of marine litter, they organised an open day at school and invited students, teachers and parents from all over the island of Gozo. They set up an exhibition to explain the effects of marine litter, presented their investigation and gave ideas on how to go zero waste. They also gave a bamboo toothbrush to all attendees as a first step towards a plastic free lifestyle.

Conclusion

Through the data collected it was concluded that the hypothesis can be accepted. Plastic litter does have an effect on sea water temperature and sea water pH level. This study contributes significantly to the importance of disposing of plastic in the correct way and reducing single use plastic. In coastal areas there is the need to increase the number of bins, put up slogans and posters to create awareness of the dangers plastic is imposing on marine ecosystems and educate the general public on how to reduce plastic use.

This is actually the reason why the students took the initiative and went a step further. They wanted to set the example and be part of the change. Through the Open Day the wider community got a better understanding of what's happening in our seas and oceans. The students explained their investigation and findings and suggested ways on how plastic can be eliminated. The bamboo toothbrush given to all visitors was an action to combat plastic from our lifestyle and participants were able to view an exhibition in the school grounds, which highlighted Marine Litter and ways to become more eco-friendly and take action to get closer to reach the Sustainable Development Goals mainly SDG 14 (Life below water) and SDG 12 (Responsible Consumption and production) and SDG 11 (Sustainable cities and communities).

Recommendations:

i. The findings and context have an important impact on science because our research can lead to other investigations. Other similar but more detailed studies of sea water temperatures and sea water pH levels can be conducted involving more samples, during different months/seasons, to be able to find out how higher sea temperatures and higher pH levels are affecting marine organisms and ecosystems.
ii. Raise awareness amongst the local community and authorities as regards better waste management and reduction of single-use plastics.

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Badge Descriptions/Justifications:

I am a Data Scientist

Students analysed their own data (from their measurements). They were able to analyse line graphs to interpret the data. They also became aware of the limitations of the data and could only draw conclusions from the samples studied. From the data analysis, the students answered their research questions and made suggestions for future research.

I make an Impact

Marine litter is causing a detrimental effect on our environment and is also a terrible waste of resources. The research helped students and the community recognize the effect of marine litter. In addition to taking measurements at school, students also disseminated their knowledge among family and friends. Finally, students made recommendations for future research in other periods of time and in the same period to better understand the effect of plastic litter on marine wildlife and ecosystems.

I make a STEM Professional

This research was developed with some suggestions and feedback of the biologist Ms Claudia Caro, from Peru. She suggested some questions and sent us some information to improve the discussion of our results. Moreover, she helped us with a sample t-paired test to compare the meaningful differences between the two samples (the glass jars with the same amount of sea water, one with some plastic litter).