COMPARISON OF THE TOTAL BACTERIAL COUNTS BETWEEN THE BATHING SEASON AND OFF-SEASON IN A NUMBER OF BEACHES IN THE MALTESE ISLANDS

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Abstract
A number of Blue Flag beaches around the Maltese Islands were sampled over a 13-month period in order to study the total bacterial counts during the bathing season (from the third week of May until the third week of October) and in the off-season. A non-Blue Flag beach was also considered for comparison purposes. Relatively low bacterial counts were observed during the bathing season when compared with the winter months. The most prominent variations in terms of total bacterial counts occurred in September, a few weeks before the end of the bathing season. The results also showed variation within the same study areas.

Keywords: Beach, Coastal waters, Bacteria, Monitoring, Mediterranean Sea

Introduction
Over the past years environmental awareness in society has run parallel along with development and implementation of environmental management systems in tourist destinations. Schemes such as the Blue Flag are significant as they address the potential hazards of bathing water and emphasise the importance of public awareness of coastal management, thus attracting more safety-conscious, as well as environmentally-conscious beachgoers [1].

According to the Bathing Water Directive (2006/7/EC), all EU member states are required to monitor the water quality in the designated coastal and inland bathing waters throughout the bathing season. This study compares the total bacterial counts between the bathing season (from the third week of May until the third week of October) and the off-season in a number of beaches that have been awarded the Blue Flag (hereafter referred to as BF Beaches) and one beach which is still popular with bathers but does not have the Blue Flag award (hereafter referred to as a NBF Beach). The study also allows for the comparison of natural and non-natural beaches in terms of total bacterial counts.

Material and Methods
Water samples from three natural beaches (Mellieha Bay [BF], Golden Bay [BF] and Ghajn Tuffieha [BF]) and two non-natural beaches (St George's Bay [BF] and Pretty Bay [NBF]) were taken over the course of 13 months between March 2016 and March 2017. Two to three sampling points were considered from each study area with two replicates at each point. pH and temperature were also recorded at each sampling point through *in-situ* analysis.

After sample preparation and incubation [2] the total bacterial counts were taken after 24 hours and 48 hours. Square root transformation was applied to the raw data and statistical analyses were carried out using SPSS v24 (IBM Corp.).

Results and Discussion
In terms of total bacterial counts, the most prominent variations occur around September (Fig. 1). Low bacterial counts were observed during the bathing season when compared with the off-season. September coincides with the beginning of the wet season, which could explain the high levels of bacterial counts recorded during this month. Precipitation could lead to surface run-off ending up directly in the coastal waters. This occurs more frequently when the rain falls on impervious surfaces rather than if it falls on permeable substrata. The high bacterial counts found at St George's Bay could be attributed to the beach being an artificial one composed of granite particles. Sand can be considered a diffusive nonpoint source of pollution and also a habitat for bacteria [3]. Subsequently when intense rainfall occurs there will be a higher infiltration rate resulting in the coastal water becoming saturated with contaminants. There could be other sources of contamination not considered in this study. These could include, but are not limted to the wide array of anthropogenic activities and the different land uses found within and around the study area.

The relatively high standard deviations clearly imply that there is a lot of variation within the same study area. A possible reason for such variation could be the extent of wave action on the beach sand. Implications of wave action vary on the direction, shape and angle of exposure of the shore and, depending on the actual sampling point, this can contribute to significant variations within the same study area.

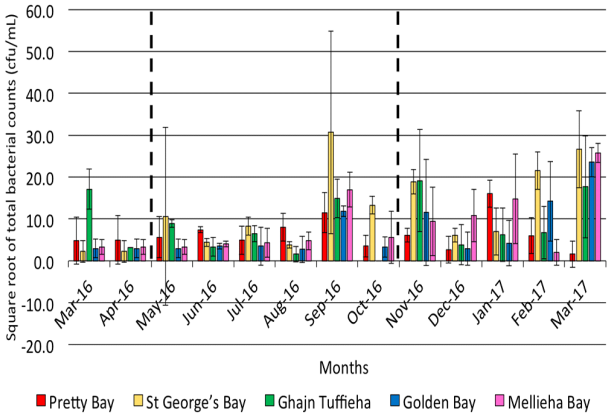

Fig. 1. The square root of the total bacterial counts in cfu/mL after 48 hours incubation. The months shown between the dotted lines represent the bathing season.

Strong variations can be observed when comparing March 2016 with March 2017, with the latter showing an excessive increase in bacterial counts (with the exception of Pretty Bay). This could imply that an increase in the sampling frequency could evaluate the differences in bacterial contamination that might exist among the different beaches and across the different seasons better.

All the beaches considered in this study have their own characteristics which can eventually determine the water quality; some of the beaches are urban while others have rural characteristics. Due to these characteristics, the natural features and the anthropogenic activity would subsequently influence the water quality. Thus, by considering the land-uses in the surrounding vicinity of the beaches, as well as the wide variety of anthropogenic activities found at each beach, a better idea of potential sources of bacterial contamination can be obtained.

References
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