BACTERIAL LOAD AND BEACH SEDIMENTS CHARACTERISTICS IN 10 TOURISTIC BEACHES OF W. GREECE

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Abstract
Over a six-month period, a beach sediment sampling survey, from 10 touristic beaches of Achaia prefecture, W. Greece, was undertaken. The abundance of bacteria (Total coliforms, *E. coli* and *Enterococcus spp.*) in sediments together with grain size parameters were measured in order to define the bacterial load of the beaches and to figure out the correlation between microbial and physical characteristics of the coastal sediments.

Keywords: Bacteria, Sediments, Beach, Mediterranean Sea

Introduction
Beach sediments are a well-recognized reservoir for enteric microorganisms, whose increase depends on a variety of physical processes as much as of the human activity. Exposure poses a risk to swimmers in recreational waters [1]. In order to reduce the risk of exposure, sediment quality at recreational beaches is assessed by regulatory agencies using indicator microbes, such as *E. coli, Enterococcus spp.* and Total coliforms [2].

Field work and methods
The beaches were selected taking into account the touristic activity and the presence of potential pollutant sources (hotels, restaurants, cafeterias, etc.). All beaches chosen for this study are characterized by different sediment grain size characteristics (sand, pebbles, cobbles) and experience a large tourist influx during warmer weather, with the highest usage occurring in July and August, while beach usage declines during the winter months. Ten beaches in Achaia Prefecture were surveyed; one (Kalogria, A1) at the Ionian Sea, three (Niforeika, A2, Rogitika, A3, Paralia, A4) at the southern coast of Patras Gulf, two (Plage, A5, Bozaitika, A6) at the proximity of the Patras city, two (Rion, A7, Dimorigopoulos, A8) at the vicinity of Rion-Antirion Straits and two (Ag. Vasilios, A9, Alykes, A10) at the Gulf of Corinth (Fig. 1).
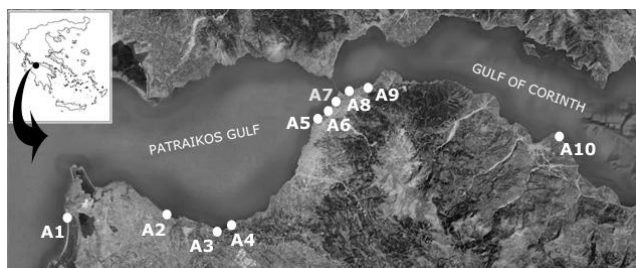

Fig. 1. Map showing the sampling locations at ten touristic beaches of Achaia Prefecture.

Sampling process was being performed once a month, from February to August on the 10 touristic beaches. The main environmental parameters (i.e., air and sediment temperature, humidity, and weather conditions) were also recorded. All the sediment samples were analyzed according ISO standard methods for the detection of Total coliforms (ISO 9308-1:2000), *E. coli* (ISO 9308-1:2000), and *Enterococcus spp.* (ISO 7899-02:2000). On the condition that samples had high bacterial load, was preceded the Successive Dilution Method. In order to extract microbes from sediment grains, a part of each sample (10 g) was aseptically transferred into a sterile bottle containing 100 mL of sterile distilled water and stirred vigorously at least 50 times [2]. After allowing the sediment to settle (2 min), eluents were filtered [3]. Counts were expressed as colony forming units (CFU) per gr of dry sediments. Grain size analysis of sediments was conducted utilizing the dry sieve method [4]. The calculation of grain size statistical parameters (i.e., mean size, standard deviation, sorting skewness and kurtosis) was achieved by the moment method. Furthermore, sphericity and roundness of the sediment grains were determined with the use of a stereoscope and a canvas (20x20 cm) that was manufactured in laboratory.

Results
Total coliform loads range from 0 to 1200 CFU/gr and *E. coli* loads from 0 to 580 CFU/gr, with an average of 486 CFU/gr and 17 CFU/gr, respectively. *Enterococcus spp.* loads run from 0 to 1040 CFU/gr, with an average of mean 69 CFU/gr. The existence of bacteria depended on the season as well as the human crowding on beaches. Mean values of bacteria range greatly between the winter/spring and summer seasons. Total coliform as well as *Enterococcus spp.* mean values increase impressively during warm months, while *E. coli* mean values decrease in the summer. Specifically, Total coliforms and *Enterococcus spp.* increase from 63.9 and 49.2 CFU/gr to 1034.7 and 69 CFU/gr, respectively. *E. coli* mean shows a clear decline from 23 to 9.7 CFU/gr. Sediments with increased Total coliform loads were recorded during the warmer months, in six (Kalogria, Rogitika, Paralia, Bozaitika, Plage, Dimorigopoulos) out of ten beaches. Enhanced *E. coli* load was observed in Bozaitika during the summer and high *Enterococcus spp.* values were measured in Rogitika, Bozaitika and Plage also in the summer. Four beaches out of ten were observed with bacterial load higher than the maximum acceptable limits. Specifically, during winter/spring season, Rogitika and Bozaitika beaches were found to have higher *Enterococcus spp.* load than the maximum acceptable limit. Additionally, total coliform load was above the maximum acceptable limit at Dimorigopoulos and Bozaitika beaches during the summer. Similarly, Bozaitika, Rogitika and Plage showed higher *Enterococcus spp.* load compared to maximum acceptable limit in summer season. It should be mentioned that the highest bacteria loads were noticed at beaches which are located near hotels, beach houses and recreation nuclei, for instance Bozaitika and Dimorigopoulos beaches. The Spearman correlation coefficient between bacteria load and the grain size characteristics of the sediments did not show any significant correlation. However, Total coliforms and *E. coli* showed a weak correlation (r=0.3-0.4) with mean grain size and sphericity of the grains of the beach sediments.

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