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RELIABLE SEAWATER RESOURCES: A FACTOR FOR DEVELOPMENT OF THE GROWING VARNA REGION

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Abstract

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In terms of water resources, important concern and one of the challenging issues will continue to be reliable seawater for a growing population, development of coastal infrastructure, and associated social and environmental activities. As the Varna Bay and the Black Sea coastal area near to Cape Galata contribute greatly to the well-being of a large number of people, in 2013, in response to social and environmental concerns, hydrological and hydrochemical research was fulfilled. This investigation promotes protection and development of the Varna Black Sea region for years to come and to be met various demands. Varna region's seawater protection has to encompass also effective policies and management practices so that the impacts of rapid urbanization can be managed better and sustainable development for all to be achieved.

Key words: seawater; Varna Bay; Cape Galata; Black Sea; water environment
Abbreviations: SSS – Sea surface salinity; SST – Sea surface temperature; $O_{2,}$ % – Oxygen saturation; COD-Mn – Chemical oxygen demand–Mn; St. – Station

Introduction

In terms of water resources, important concern and one of the challenging issues will continue to be reliable seawater for a growing population, development of coastal infrastructure, and associated social and environmental activities. As the Varna Bay and the Black Sea coastal area near to Cape Galata contribute greatly to the well-being of a large number of people, in 2013, in response to social and environmental concerns, hydrological and hydrochemical research was fulfilled. Understanding the dynamics of key seawater parameters in the Varna region promotes development of long term strategies and reducing risks, improving public and environmental health. The investigation conduces to protection and sustainable development of the Varna Black Sea region for years to come and to be met various demands. This research can be used by local authorities over policy making and planning, by environmental officers to support regulatory function, and by utility and service providers for improved service provision.

Materials and Methods

Hydrological and hydrochemical study was fulfilled in the Varna Bay and in the Black Sea coastal area near to Cape Galata in June 2013, with sampling at waters offshore of Cape Galata (Figure 1C) at 1 mile (St. G1), 3 miles (St. G3), 5 miles (St. G5) and in the Varna Bay (Figure 1B; Dineva, 2011) at St. B3, St. B4, St. B5 and St. B8. St. B3 is located in the southern Varna Bay zone which is under influence of Varna Lake stream. St. B4 is situated in the north area of the Varna Bay, St. B5 – in the middle, and St. B8 – in the open central zone. Regular study at First jetty in the north area of the Varna Bay (Figure 1A) was carried out during 2013, as well. Samples were taken from the surface water. Measurements of temperature, salinity, oxygen, oxygen sat-

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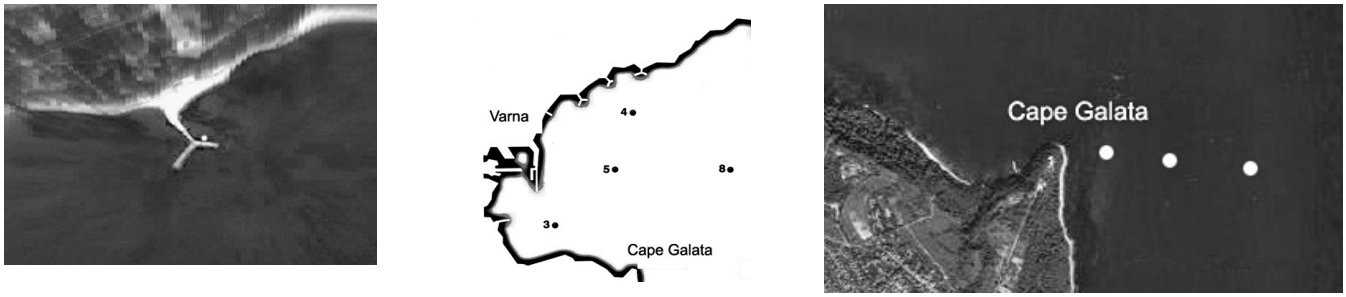

A ***B*** ***C***

Fig. 1. Maps of the sampling stations: *A* – First jetty in the north area of the Varna Bay. Source: Google Earth, 2013. Data SIO, NOAA, U.S. Navy, NGA. *B* – Varna Bay. *C* – Galata Transect. Source: Google Earth, 2013. Data SIO, NOAA, U.S. Navy, NGA

uration and pH were done by Multi-meter (Oakton, 2010). Processing of samples for nutrients was performed by unified methods for marine waters (Gashina, 1993; UNESKO, 1994). Concentrations of nitrite nitrogen, nitrate nitrogen and phosphate phosphorus were established by Spectrophotometer HITACHI-U 2001 UV/Vis (1995).

Results and Discussion

Temperature, salinity, and dissolved oxygen are essential parameters of the seawater (Keondzhyan and Terekhin, 1990; Rjabinin et al., 1991; Sapozhnikov, 1992; Dineva, 2005; Dineva, 2007). Seawater has an excellent buffering system with the interaction of carbon dioxide and water so that it is generally always at a pH of 7.5 to 8.5 (Dineva, 2013a). If seawater is out of normal range (7.5–8.5) then something would be wrong. pH is important to the productivity of the ecosystems. pH could be lowest in the most productive regions where upwelling occurs or under anthropogenic loads, and at phytoplankton „blooms" could approach 10. Increase in CO_2 in the seawater, for example at oxidation of organic matter, leads to drop in pH (Alekin, Lyahin, 1979).

Monthly dynamics of temperature in the north area of the Varna Bay in 2013 is presented in Figure 2. An open winter was observed, with SST minimum of 6.0°C in February. Sharp warm of the seawater has come from April to May: from 10.1°C to 17.4°C. Sea surface temperature maximum of 27.6°C has come in August. By November, seawater cooling has reached 13.7ºC.

Sea surface salinity provides key information on the variability of precipitation, evaporation, and currents.

As a result mainly of increased Danube's discharge, and rains and slight seawind as well (Dineva, 2013 b; Dineva, 2013c), SSS year's monthly minimum of 14.28 psu was ascertained in May (Figure 3). The absolute SSS minimum was 12.00 psu (18th May). Sea surface salinity was highest in March and August – 18.18 psu and 17.95 psu respectively.

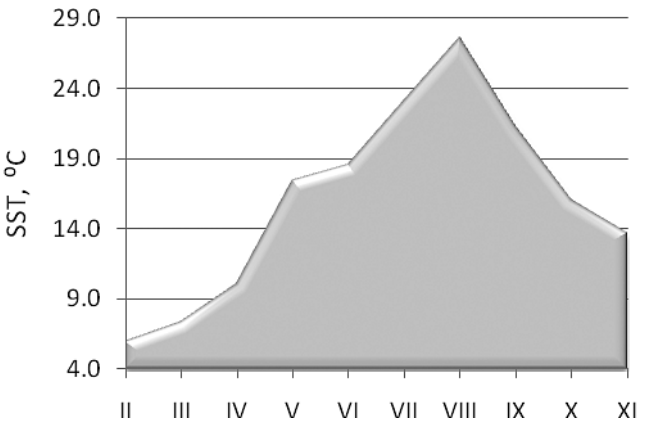

Fig. 2. SST (°C) in the north area of the Varna Bay in 2013

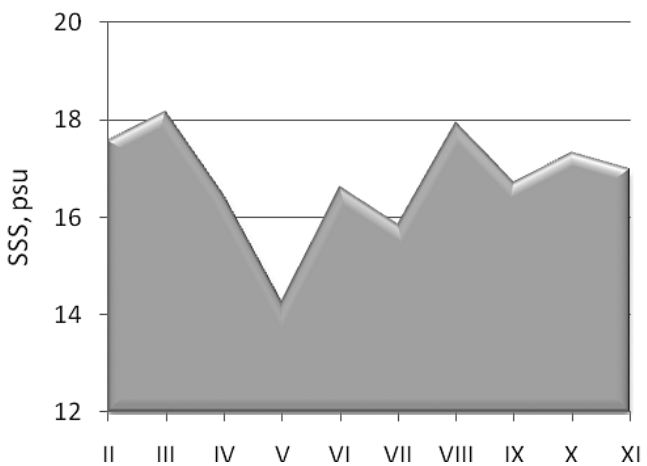

Fig. 3. SSS (psu) in the north area of the Varna Bay in 2013

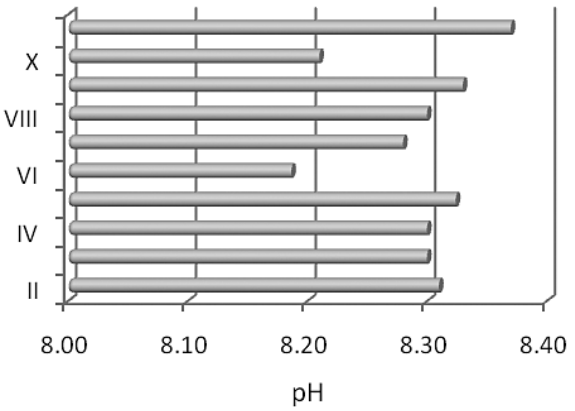

Fig. 4. pH of the surface water in the north area of the Varna Bay in 2013

pH in normal range of 8.19 to 8.37 (Figure 4) was observed over the year as the minimum occurred in June and the maximum – in November.

Dissolved oxygen maximum of 8.90 ml.l^{-1} has come in March due to low temperature of water and increased influence of photosynthesis. Dissolved oxygen minimum of 4.80 ml.l^{-1} occurred in August owing to the highest temperature of water, high salinity, and increased consumption of O_2. Oxygen saturation of water has varied between 83.75% and 116.87% (Figure 5).

Moderate concentrations of nutrients were mainly ascertained over the year. Due to increased consumation, annual minimum has come in August as nitrite nitrogen has reached 0.004 μM, nitrate nitrogen – 0.73 μM and phosphate phosphorus – 0.86 μM.

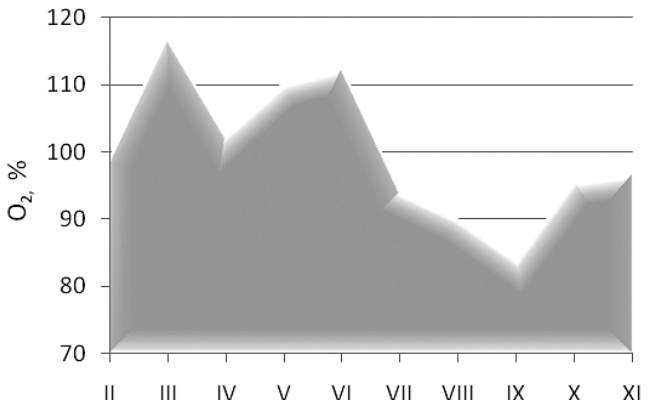

Fig. 5. Oxygen saturation (%) of the surface water in the north area of the Varna Bay in 2013

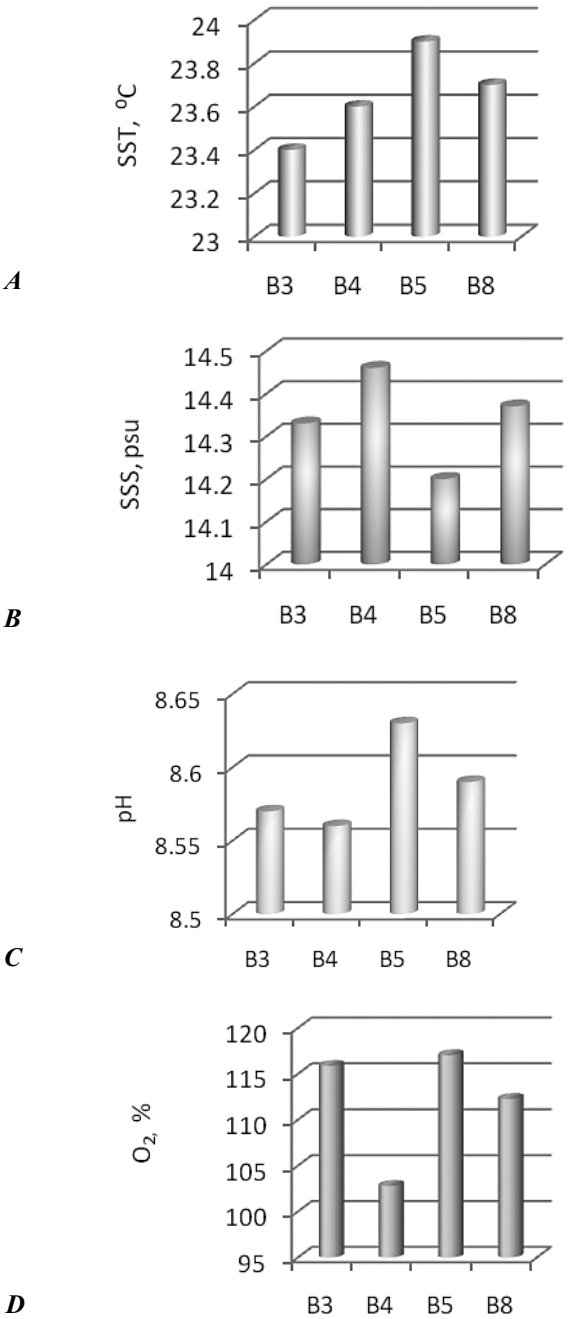

Fig. 6. Dynamics of parameters in the surface water of the Varna Bay in June 2013: *A* – Temperature (°C). *B* – Salinity (psu). *C* – pH. *D* – Oxygen saturation (%)

In June, increase in SST was up to 23.7ºC in the Varna Bay (Figure 6A), with 1ºC higher than in the 5-mile zone in front of Cape Galata. A low SSS of 14.34 psu was ascertained (Figure 6B). For comparison, pH of 8.59 in the Varna

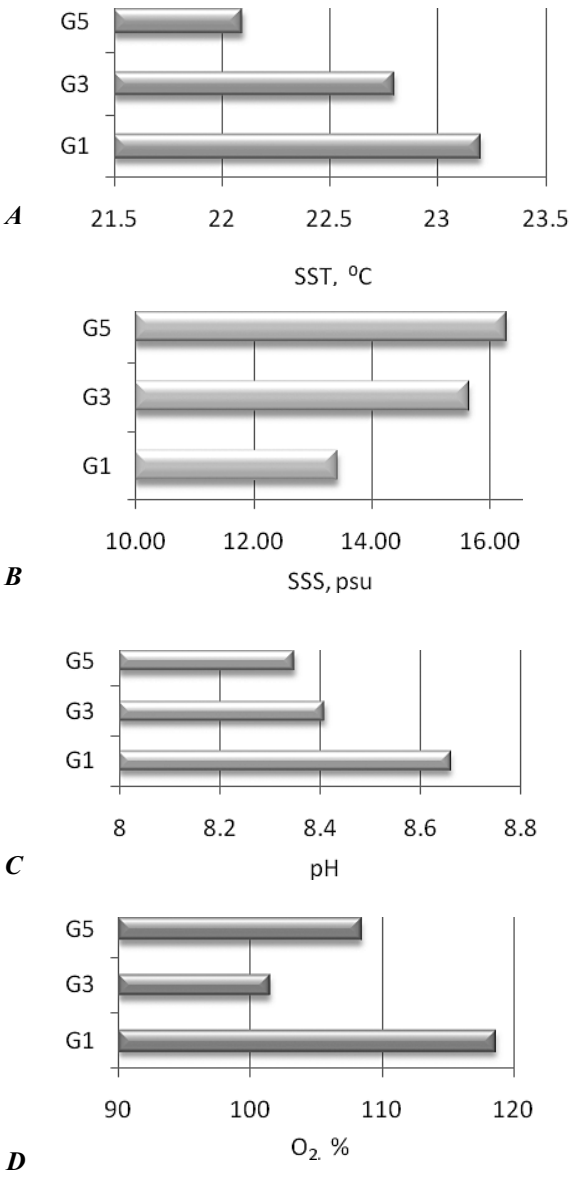

Fig. 7. Dynamics of parameters in the surface water at 1, 3, and 5 miles offshore of Cape Galata in June 2013: *A* – Temperature (°C). *B* – Salinity (psu). *C* – pH. *D* – Oxygen saturation (%)

Bay (Figure 6C) was higher than in the 5-mile zone in front of Cape Galata – 8.47. Surface water was oxygen super-saturated (Figure 6D) – 112%. Concentrations of nutrients were accordingly: nitrite nitrogen – 0.04 μM, nitrate nitrogen – 2.58 μM, and phosphate phosphorus – 1.31 μM. Under influence of Varna Lake stream, highest were the concentrations in the southern area of the Varna Bay.

In the 5-mile zone in front of Cape Galata, SST was 22.7ºC in June, with stronger warming up closer to the coast (Figure 7A). Under influence of the Danube transformed waters, passing along the Bulgarian coast, SSS was 13.40 psu at 1 mile offshore (Figure 7B) – lower than in the Varna Bay, and with an increase towards 5 miles up to 16.25 psu. A pH of 8.66 was highest at 1 mile offshore – in the core of Danube's current, with drop in east to normal value of 8.35 at 5 miles offshore (Figure 7C). As in the Varna Bay, surface water was oxygen super-saturated (Figure 7D), up to 118.69 % at 1 mile offshore. In the 5-mile zone, nitrite nitrogen concentration was as in the Varna Bay – 0.04 μM, nitrate nitrogen concentration and phosphate phosphorus concentration were accordingly 1.95 μM and 1.05 μM, with decrease from 1 mile to 5 miles offshore.

Conclusions

Improved protection is essential for achieving betterment both in environmental health and in resort conditions, and to cope with seawater-related challenging issues of the socio-economic development. Varna region's seawater protection has to encompass effective policies and management practices, so that the impacts of rapid urbanization can be managed better and sustainable development for all to be achieved. By helping restore completely and sustainable manage Varna Black Sea region, improved health, ecological, economic and social outcomes will be achieved.

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