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SEAWATER-RELATED SURVEY IN THE VARNA REGION

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Abstract: *Of all natural resources, water underpins sustainable development perhaps more than any other. Great environmental awareness will place more emphasis on maintaining healthy ecosystems for people as well as nature. Seawater-related survey in Varna region over 2014 provides key information and discusses the parameters which are to be considered as more important in relation to main available practices for management. Key challenges about the Varna Black Sea region include setting realistic targets, making the right development choices, and promoting sustainable water resources development in a way that values healthy ecosystems. But the sectors can't be viewed in isolation, they are interconnected and must be managed in an integrated way. Water cuts across many of the Sustainable Development Goals, so there is much need to reflect on the interactions and identify locally appropriate solutions to managing seawater resources.*

Keywords: *seawater; water environment; Black Sea; Cape Galata; Varna Bay; Varna Lake*

Introduction

Of all natural resources, water underpins sustainable development perhaps more than any other.

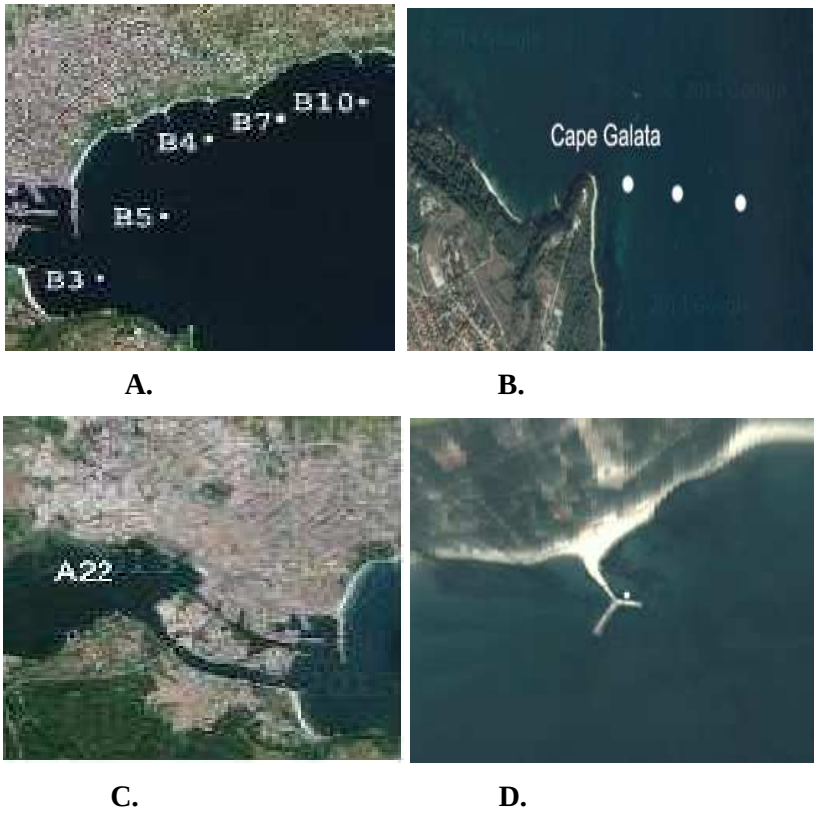
Seawater-related survey fulfilled in Varna Black Sea region over 2014 aims to provide key information and to discuss parameters which are to be considered as more important in relation to main available practices for management. This research is important to the understanding and predicting seasonal to decadal shifts in water environment and for studying the dynamical processes in the coupled system, and for considerations such as population growth, economic growth, energy efficiency and a host of other factors.

The study is a continuation of similar water-related investigations in Varna region [2]; [4]; [7], updated with new information.

Key challenges about the Varna Black Sea region include setting realistic targets, making the right development choices, and promoting sustainable water resources development in a way that values healthy ecosystems. But the sectors can't be viewed in isolation, they are interconnected and must be managed in an integrated way.

Material and Methods

In 2014, hydrological and hydrochemical survey was fulfilled in the Varna Bay and in the Black Sea coastal area near to Cape Galata in September and November, with sampling at waters offshore of Cape Galata (Figure 1 B) at 1 mile (Station G1), 3 miles (Station G3), 5 miles (Station G5) and in the Varna Bay (Figure 1 A) at a set of Stations (St.): St.B3, St. B4, St. B5, St. B7 and St. B10 [3]. St. A22 in the Varna Lake (Figure 1 C) was assumed as Control Station where sampling was done in September and November. Regular study at First jetty in the north area of the Varna Bay (Figure 1 D) was carried out during 2014, as well. Samples were taken mostly from the surface water. Measurements of temperature, salinity, oxygen, oxygen saturation and pH were done by Multi-meter [12]. Processing of samples for nutrients was performed by unified methods for marine waters [9]; [15]. Concentrations of nitrite nitrogen, nitrate nitrogen and phosphate phosphorus were established by HITACHI-U 2001, UV / Vis Spectrophotometer [11].



A. **B.**

C. **D.**

Figure 1. Maps of sampling stations: (A) Varna Bay. (B) Galata transect. (C) Station A22 in the Varna Lake. (D) First jetty in the north area of the Varna Bay. Source: [10]

Results and Discussion

Sea surface temperature (SST) variability in the north area of the Varna Bay (First jetty) during 2014 is produced monthly in Figure 2. An open winter, with SST minimum of 6.0 ˚C in February, has indicated relationship to climatic events. Seawater was warmed significantly, up to 22.7ºC, in May. Due to heavy rains, June was relatively cool. SST maximum of 28.6 ˚C in August 2014 was 1 ºC higher than in 2013 [7], 2.2 ºC higher than in 2012, also 4.25ºC higher than 1992-2000 mean [5].

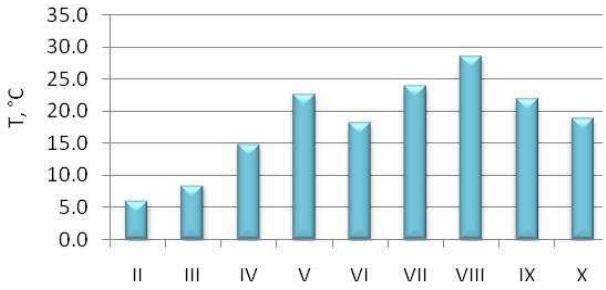


Figure 2. SST (˚C) in the north area of the Varna Bay in 2014

In February, sea surface salinity (SSS) was high - 17.69 psu. As in the previous years [6]; [7], SSS minimum of 14.35 psu has come in May. Because of heavy rains which led to devastating flooding in June and subsequent vastly increased runoff, salinity has kept low in the next months.

Generally, there were no big differences in oxygen saturation of the water compared to the long-term mean.

Concentrations of nutrients were accordingly: nitrite nitrogen - 0.05 µM, nitrate nitrogen - 2.00 µM, and phosphate phosphorus - 0.94 µM in February-May period. As a result of the runoff, caused by the heavy rains in June, concentrations have increased to annual peaks: 0.06 µM nitrite nitrogen, 3.16 µM nitrate nitrogen, and 1.56 µM phosphate phosphorus.

Chemical oxygen demand (COD)-Mn in neutral medium (Figure 3) has ranged from 1.53 mg.l^{-1} to 1.60 mg.l^{-1} during February-April period. A small increase up to 1.97 mg.l^{-1} was established in May. Annual peak of 5.32 mg.l^{-1} has confirmed by the extreme conditions in June.

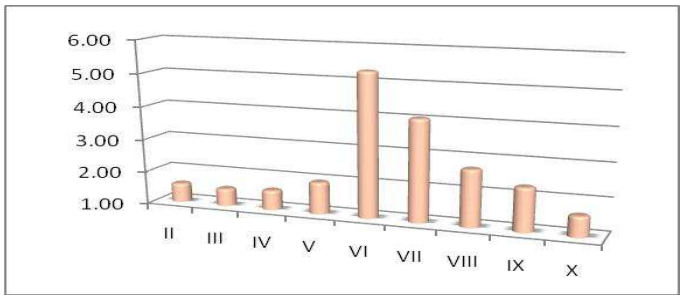


Figure 3. COD-Mn in neutral medium (mg.l^{-1}) in the surface water of the north area of the Varna Bay in 2014

Water mass forming of the Varna Lake is mainly by seawater [13]; [8].

In September, temperature of the surface water was 24.7 ˚C at St. A22 in the Varna Lake. Salinity was 15.24 psu in the 4-m layer. pH has ranged from 8.02 at the surface down to 7.97 on the vertical. Organic matter in water, that can be assessed by COD-Mn [1]; [14]; [13]; [5], was at highest level compared to other areas of the Varna region. Nitrite nitrogen concentration was 0.22 µM, nitrate nitrogen concentration - 2.78 µM, and phosphate phosphorus concentration - 1.48 µM

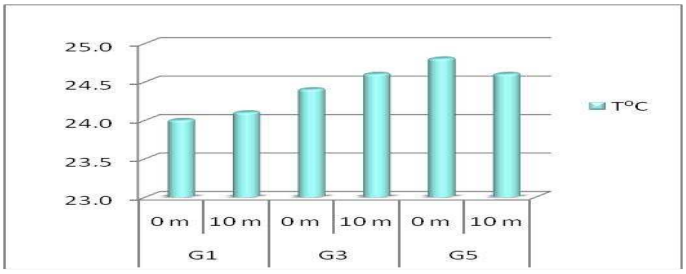


Figure 4. Temperature of the water (˚C) at 1, 3, and 5 miles offshore of Cape Galata in September 2014

Seawater offshore of Cape Galata was kept warm in September (Figure 4), with temperature range 24.0 - 24.8 ˚C.

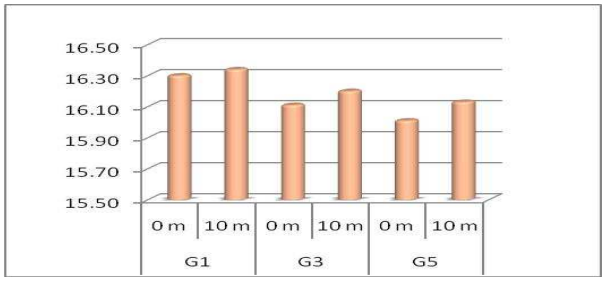


Figure 5. Salinity of the water (psu) at 1, 3, and 5 miles offshore of Cape Galata in September 2014

Under influence of the Danube's transformed waters, salinity in 10-m layer in front of Cape Galata was lowest at 5 miles and has increased towards the coast (Figure 5), ranging at the surface from 16.01 psu (St. G5) to 16.30 psu (St. G1) and on 10 m depth - from 16.13 psu (St.G5) to 16.34 psu (St.G1).

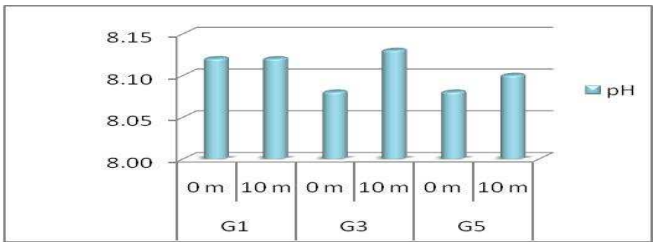


Figure 6. pH of the water at 1, 3, and 5 miles offshore of Cape Galata in September 2014

Like salinity, pH variability (Figure 6) has indicated an increase from 5 miles offshore of Cape Galata towards the coast: at the surface from 8.08 to 8.12 and in the bottom layer - from 8.10 to 8.13 at St.G3 and to 8.12 at St. G1.

Nitrite nitrogen concentration range was 0.09 - 0.15 µM, nitrate nitrogen concentration has varied from 1.85 µM to 1.96 µM and phosphate phosphorus concentration - from 0.72 µM to 0.80 µM in the 10-m layer of the 5-mile zone in front of Cape Galata.

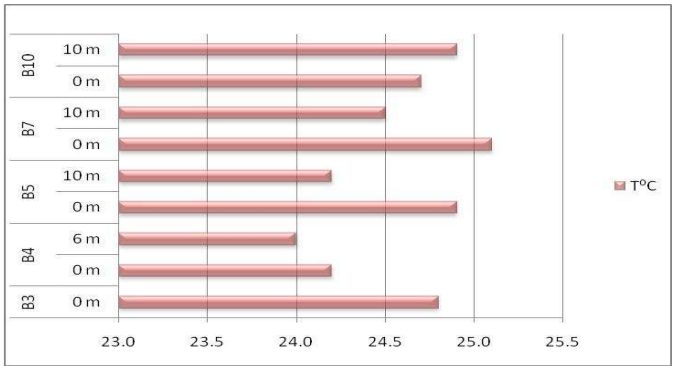


Figure 7. Temperature of the water (˚C) in the Varna Bay in September 2014

Temperature of the water in the Varna Bay (Figure 7) was almost the same compared to 5-mile zone in front of Cape Galata, varying from 24.0 ˚C (St. B4, 6 m) to 25.1 ˚C (St. B7, 0 m) in September.

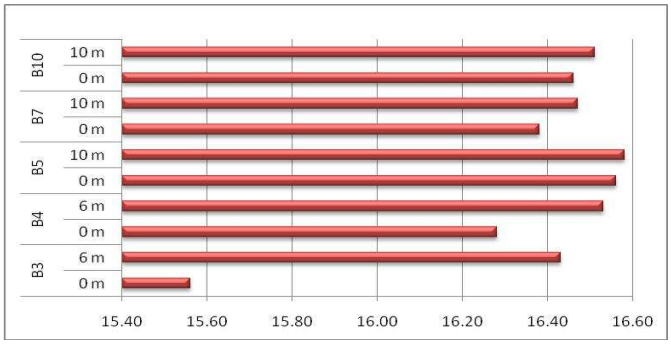


Figure 8. Salinity of the water (psu) in the Varna Bay in September 2014

Under influence of the lake current, salinity (Figure 8) was lowest at the surface of St. B3 - 15.56 psu.

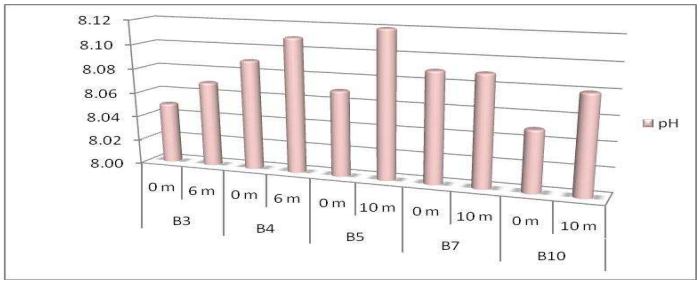


Figure 9. pH of the water in the Varna Bay in September 2014

Lowest pH was ascertained in the surface water of St. B3 and St. B10 - 8.05 and highest at St. B5, 10 m - 8.12 (Figure 9).

Nutrient concentrations have varied in the surface-bottom layer as follows: nitrite nitrogen -from 0.02 µM to 0.11 µM, nitrate nitrogen - from 1.48 µM to 235 µM, and phosphate phosphorus - from 0.69 µM to 1.19 µM as under influence of the Varna Lake current, highest concentrations were established at St. B3.

Comparatively good oxygen regime was established in Varna region in September.

In November, SST was almost the same in the 5-mile zone in front of Cape Galata: 14.4 - 14.5 ˚C.

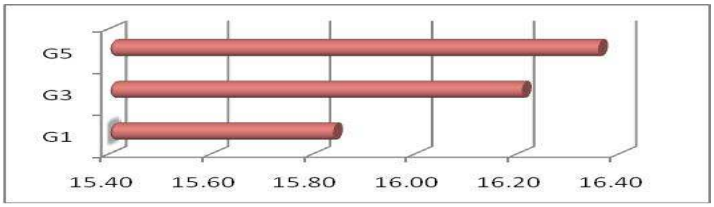


Figure 10. SSS (psu) at 1, 3, and 5 miles offshore of Cape Galata in November 2014

Sea surface salinity has increased from 15.84 psu at 1mile in front of Cape Galata to 16.36 psu at 5 miles on the transect (Figure 10). Oxygen saturation was close to the norm. Moderate nutrient concentrations were ascertained. Drop in organic matter quantity compared to September was ascertained.

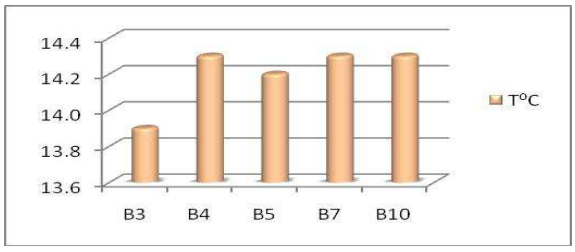


Figure 11. SST (˚C) in the Varna Bay in November 2014

Sea surface temperature was in the range 13.9 - 14.3 ˚C in the Varna Bay in November (Figure 11).

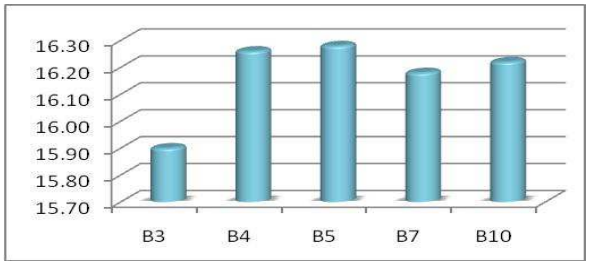


Figure 12. SSS (psu) in the Varna Bay in November 2014

Under influence of the Varna Lake current, SSS at St. B3 was 0.3 psu lower than the rest area of the Varna Bay (Figure 12). Like the coastal water in front of Cape Galata, oxygen saturation was close to the norm. Nutrient concentrations were highest at St. B3. COD-Mn in the Varna Bay was 1.37 $mg.l^{-1}$.

In November, surface temperature was 13.9 ˚C, salinity - 15.48 psu, and oxygen saturation – normal at St. A22 in the Varna Lake. Organic matter and nutrients were higher than in the Varna Bay.

Conclusions

In 2014, SST variability in the north area of the Varna Bay (First jetty) has produced an open winter, with relationship to climatic events. Due to heavy rains, June was relatively cool. In August 2014, SST annual maximum was 1 ºC higher than in 2013, 2.2 ºC higher than in 2012, also 4.25ºC higher than 1992-2000 mean. Winter and summer temperatures in recent decades appear to be the highest since at least about temperature estimates. Global temperature increase will integrate widely varying regional responses, mostly in the winter and summer seasons in the Varna Black Sea region. SSS annual minimum of 14.35 psu has come in May. When precipitation crucially increases, there is evidence of increases in the heavy and extreme precipitation events. Because of heavy rains which led to devastating flooding in June and subsequent vastly increased runoff, salinity has kept low in the next months. As a result of strengthened runoff because of extreme precipitation events in June, nutrient concentrations have increased to annual peaks. COD-Mn annual maximum has occurred in June, according to organic matter increase.

Temperature of the water was yet high in the 5-mile zone in front of Cape Galata, in the Varna Bay, and in the Varna Lake in September. Alike salinity was recorded down on the vertical in the east area of the Varna Lake. Under influence of the Danube's transformed waters, salinity in the 10-m layer was lowest at 5 miles in front of Cape Galata and has increased towards the coast. Under lake impact, salinity was lowest in the south Varna Bay area. COD-Mn has increased in the direction of coastal waters-Varna Bay-Varna Lake. Nutrient concentrations were highest in the lake water. pH of normal range was ascertained.

In November, surface temperature has ranged slightly in the Varna region. Small differences in SSS were established in the 5-mile zone in front of Cape Galata and in the Varna Bay. Increase in salinity has occurred from 1 mile towards 5 miles on Galata transect. Salinity was lowest again in the south Varna Bay area. Nutrient concentrations and organic matter have increased in coastal waters-Varna Bay-Varna Lake direction.

In 2014, comparatively good oxygen regime was ascertained in the seawater of the Varna region.

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