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Abstract

In the paper there are presented the impact of the climate change on Adriatic Sea hydrology. The study is based on the results of inversion of 6 thermologs data for the ground surface temperature history in Albania, and climate change according to the meteorological data from different regions of Albania. The wells and the meteorological stations are located at the field region in the west of Central Albania and in the mountainous region of the northeast Albania. Ground Surface Temperature history presents a gradual cooling before a middle of the nineteenth century, followed by 0.6 K warming. This warming mainly after the second half of the twentieth century is presented also by meteorological data. The warming has caused its impact on country climate, inland and coastal water systems and ecosystems of the Albania, and to the Adriatic Sea hydrology.

Keywords

Ground temperature • Climate changes • Hydrology • Hydrographic system • Adriatic sea • Environmental impact

72.1 Introduction

Water discharge from the Albanian Hydrographic System into Adriatic Sea is one of the main factors, which determined processes of the forming and circulation of the Adriatic Sea water mass. Analyze of the factors that conditioned water discharge and their impact on Adriatic Sea Hydrology are presented in the paper.

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In the first part of the paper is presented detailed analyzes of the climate in Albania, the ground surface history (GSH) and paleoclimate change according to the temperature measurements in the different wells in Albania. Climate changes during the last half of the twentieth century has been analyzed also based on the meteorological data. In paper is estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed.

According to the complicated nature of the Albanian Hydrographic System, in the second part of the paper, is presented the analytical methodic for estimation of the total continental water flow in this system.

72.2 Materials and Methods

Climate change are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The

ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole (Frashëri 1995; Frashëri and Pano 2002; Frashëri et al. 2008). Six thermoplots were used for inversion of the ground surface temperature history. Wells are located at the plane region in the west of Central Albania, and in the mountainous region of the northeast of the Albania.

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations. These stations are located in different plane regions (Shkodra, Tirana, Kugova and Fier) and in mountainous region of Albania (Kukes), where the investigated wells are situated (Albanian Climate 1978; Boriçi and Demiraj 1990; Gjoka 1990; Mici et al. 1975, the data for 1985–2000 after Mustaqi V).

Water potential of the Albanian Rivers System have been evaluated by a specific way, because this System is very complicated (Pano 1974, 1984, 2008). Albanian River System represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. Part of Albanian Hydrographic Network are lake system, Prespa-Ohri, and Scutary. A karstic phenomenon is very intensive in the limestone formation, which is extended in great surface of the country. The monitoring network has more than 22 meteorological and hydrometric stations, during the observed period 20–100 years.

Estimation of run-off discharge (Q_i) are performed for two categories of river basins, with different hydrographical and hydraulical natural conditions:

1. Water system: Scutary Lake-Drini River-Buna River, where the run-off discharge Q_i is computed by $Q_i = F(H_i, Q_1)$, where Q_1 represent the discharge of the lateral source.
2. Drini, Mati, Ishmi, Semani, Vjosa River systems, etc., where the run-off discharge Q_i is computed by $Q_i = f(H_i)$, where H_i - level in the river $Q_i = f(H_i)$, where H_i is altitude of the water level river (i) section.

The hydrographical complex Scutary Lake-Drini River-Buna River is very complicated and unique for its hydraulic regime, this particularity has made necessity of the estimation of the water flow of Buna River, based on hydraulic conditions:

The discharge of the Buna River, when it flows away from the Scutary Lake Q_2 depends not only from the level of the water H_2 , but also on the level H_2 and the Drini River discharge into the Buna River Q_4 . So, the only possibility to calculate the discharge of the Buna River Q_2 is to find the connection $Q_2 = f(H_2, Q_4)$. The $Q_2 = f(H_2, Q_4)$ correspond to the results obtained through the hydraulic calculations the dependence $Q_3 = f(H_3)$, topomorphometric

data, and the hydraulic parameters of the rivers discharge are the basic dependence of this calculation. Giving standard values to the discharge Q_4 equal to 50, 100, 300, 1500 m^3/s and solving the dependence of Q_2 as an explicit function from the Scutary Lake level H_2 and the Drini discharge Q_4 , it was made possible to form a single family of the countable curves of the Buna discharge in the Scutary Lake.

The phenomenon of dry and wet years has always had a significant role and great interest. All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydro-graphic System.

Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions “Saranda 1963”, “Patosi 1964” for the wet years (Pano 1974), and Italian—Albanian Expeditions “Italica I and II, 2000 and 2001” for dry years (Pano 2008).

72.3 Results and Discussion

The ground surface temperature (GST) history, yielded by tighter inversion of Ko-10, at coastal plane region of western Albania, presents a gradual cooling of 0.6 K, before a middle of the nineteenth century (Fig. 72.1). Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2–3 centuries. GST history of boreholes, which are located in the mountainous regions of Northeast Albania, presents some changes, which are observed in these regions as to the cooling of 0.2 K during the nineteenth century. Later, was observed the warming trend of 0.6 K during the twentieth century, by a gradient 6.7 mK/year. Warming gradient increasing at

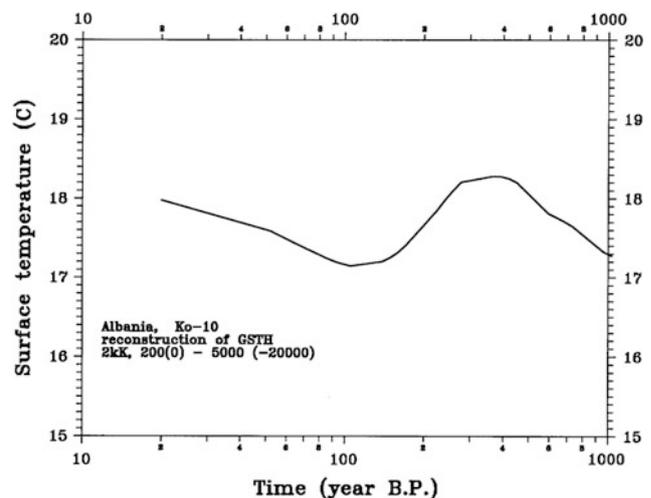
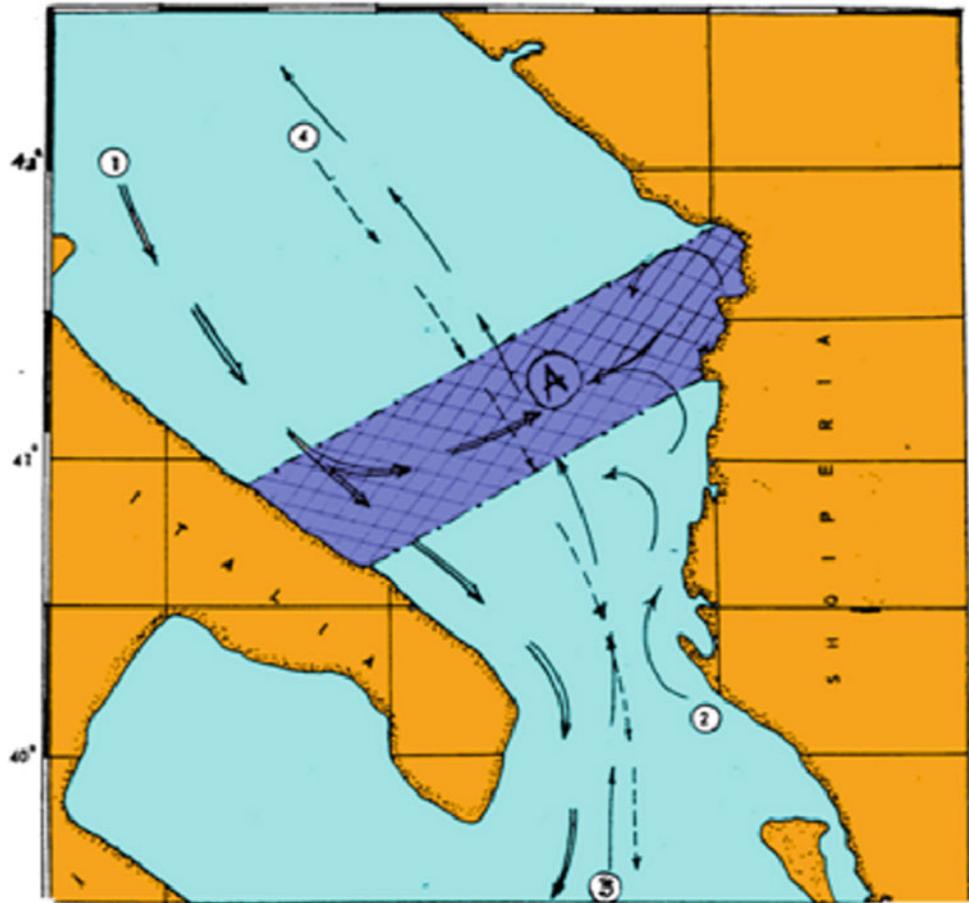


Fig. 72.1 Ground surface temperature history according to thermoplot of Ko-10 and Arza-31 wells

Fig. 72.2 “The Bridge” of continental water in the Adriatic Sea. 1. Adriatic deep water mass, 2. Eastern adriatic superficial water mass, 3. Intermediate levantine water mass, 4. Northern adriatic water mass



mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of twentieth century.

Climate changes in Albania are observed also by the meteorological studies. Thirty quarter of twentieth century is characterized by a cooling of 0.6 °C, and later, up to present a warming of 1.2 °C. The warming trend is not a monotone one, in short intervals are observed cooling and warming (Boriçi and Demiraj 1990; Demiraj et al. 1996). Warming trend of maximum 1.2 °C, in particular after 70 years, is observed in all Albanian territory. Warming of the soil is more intensive than air warming.

The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200–400 mm. In the dependence of the geographical location of the areas changes the cross correlation of the rainfall quantity: Tirana area with Shkodra area $C_c = 0.62$, with Korga $C_c = 0.81$, Kugova $C_c = 0.66$, Kukesi $C_c = 0.88$, Gjirokaster $C_c = 0.88$, Vlora $C_c = 0.53$, during the period of 1930–1970. The warming have accompanied with decreasing of the wind speed about 1.5 m/s and 5 % increasing of the wetness, during the period of 1950–1994.

This warming is part of the global Earth warming during the second half of twentieth century. Its impact has been observed also on water systems and water resources. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea. These processes, in the particularly intensity of the penetration of the Levantine hot and saline waters in the Adriatic Sea through Otranto Strait, for long time period have been explained by the external phenomena from this sea. Has been supposed that Adriatic Sea doesn't participate in this penetration.

Based on two Albanian Oceanographic Expeditions have been collected data related to the mechanism of the forming and circulation of the Adriatic Sea water (Pano 1974, 2008).

The water potentials of Albanian rivers system is $W_o = 41.249 \cdot 10^9 \text{ m}^3$ that correspond to a mean annual discharge of $Q_o = 1306 \text{ m}^3/\text{s}$. So, Albania is one of high specific water potential in Mediterranean. The multi annual data have arguments that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas varies in very wide limits. Minimal discharge is 700–800 m^3/s for the hydrological dry years of low precipitation, up to maximal values 1900–2200 m^3/s for the hydrological wet years of high precipitation. Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with

Po River in Italy, are determinant in the water balance of the Adriatic Sea.

The oceanographically situation of the wet years 1963–1964 has been characterized by formation of “The Bridge” with continental water in the Adriatic sea (Fig. 72.2). “The Bridge” is closely linked with the intensity of the river flow (Pano 1974). The eastern water mass are formed in SE Adriatic Sea area by the discharge of the Albanian rivers, and the Adriatic North water masses are formed by the discharge of Po River, Italy. This “Bridge”, includes not only the surface layer, but also the Levant Intermediate Water (LIW) up to 600 m. depth. Low salt content and density of the seawaters are observed over “the bridge”. This phenomenon has a complex and an important influence on many dynamics aspects of the formation Adriatic Deep Water (ADW), the deportation Levant Intermediate Water (LIW), and the monitoring mechanism of water into Otranto Street.

72.4 Conclusions

1. The climate at coastal plane region of Western of Albania was cooled of .6 K before of middle of nineteenth century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day. In northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during twentieth century.
2. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
3. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes.
4. The oceanographically situation in the Adriatic Sea is characterized from the formation of “The bridge” with continental water in the Adriatic Sea. “The bridge” is closely linked with the intensity of the river flow.

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Outlook on Seawaters Dynamics Factors for the Albanian Adriatic Coastline Developments

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Abstract

Results of integrated offshore and onshore hydrographical studies in Albanian Adriatic Littoral are presented in this paper. According to the geophysical and geological marine and onshore surveys, geodesic and bathy metric mapping has study different geomorphology and setting of Albanian Adriatic Shelf and coastline. Accumulative coastlines are extended at plain areas. Beautiful sandy beaches and dunes are main elements of these areas. Marine Quaternary deposits from plain sea floor up to some kilometres in the land have a thickness from some to hundred meters. Narta, Karavasta and Kune-Vaini Lagoons are located in plain area of the littoral. These lagoons are formed in some sea bays, which are closed by solid sediments transported by rivers to the sea. Erosive coastlines are extended in the hilly base of some capes. Sandstone banc are extended in the sea floor. Neotectonics development at the present has caused submergence of two sectors to the accumulative areas.

73.1 Introduction

The Albanian coastal area has its environmental individuality, and a perfect ecological balance. River mouths and deltas, lagoons system, abandoned riverbeds, inland, marsh labyrinths, sandy beaches, dunes covered with vegetation, dense forests represent an important and particular natural area of great international values.

Albanian littoral represent continuation of coastlines of two major paleogeographic zones: Erosion Coastline of Ionian tectonic zone in the southwestern part of Albania, and Adriatic Coastline of Peri-Adriatic Depression in the

central and northwestern part of Albania. There are three different segments: Accumulative segments, erosive segments, and submerged areas, where is observed marine transgression toward the mainland.

The Adriatic coastline geomorphology and dynamics are conditioned by geological setting of the western side of Albanides, the neotectonic developments. Very important role has the dynamics of the seawaters and solid material solid discharge from Albanian River network to the Adriatic Sea, and their deposition along the coastal zone.

73.2 Material and Methods

Albanian Adriatic Coastline developments study is based on integrated marine and onshore surveys results.

73.2.1 Hydrological and Hydro-Geomorphological

Studies represent the interpretation of the information of Albanian hydrometric network during the observed period of 20–100 years.

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73.2.1.1 Hydrological Studies

Temperatures, water levels and discharge into the Adriatic Sea, suspended material discharge; alluvial granulometric composition, chemical composition etc. were observed in main Albanian rivers. Estimation of run-off discharge (Q_i) are performed for river basins with different hydrographical and hydraulic natural conditions.

73.2.1.2 Hydrogeomorphological Studies

Hydrogeomorphological studies were performed to evaluate the geomorphologic characteristics, evolution and migration of Albanian Adriatic coastline, The geomorphological regime of the Adriatic. Limnological observation on the Albanian lagoon system were performed in hydrometric stations in Butrinti, Karavasta, and Narta lagoons, by peridical expeditions.

73.2.1.3 Oceanographic Studies

Oceanographic studies have been carried out in 59 hydrometric stations. Oceanographic expedition were organized in the Southern Adriatic and Northern Ionian.

73.2.1.4 The Integrated Geological-Geophysical

Marine geological mapping and integrated offshore geophysical surveys have been performed using reflection seismic, electrical soundings and profiling, magnetic radiometric surveys.

73.2.1.5 Climate Change

Climate change was analyzed by ground surface temperature history, using the temperature record in the wells, and by the meteorological observations data.

plain areas. Flattened accumulative coast is general characteristic of this coastline. There are also some marine caps with cliffed coast. The caps are located in the sectors where the Neogene molassic structures are abrupt by coastline and continues in the Adriatic Sea.

73.3.2 Outlook on Albanian Littoral Hydrology

The water flow of the hydrographic network of the Albanian rivers to the sea varies in wide limits. The discharge of the Albanian rivers into the Mediterranean Basin varies in very wide limits, from $Q_o = 700\text{--}850\text{ m}^3/\text{s}$ for the hydrological years of a lower precipitation up to $Q_o = 1850, 2150\text{ m}^3/\text{s}$ for the years of a higher precipitation. The volume of suspended material, which is transported through river network, is $65,7 \times 10^6$ ton/year, while the turbidity $Q_o = 1,260\text{ gr}/\text{m}^3$. The flow module of the suspended matter on the catchment surface of the Albanian rivers is $R = 1,260\text{ ton}/\text{km year}$. (Pano 1984). The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making river's mouths very active. The period with the wave height of $H_1 = (0,1\text{--}0,2)\text{m}$ represents about 80 % of the general cases, while the height of $H = (0,2\text{--}4,5)\text{m}$ about 20 % of them for the average multi annual year. The highest waves have a direction from Northwest to West and a maximum wave height about $h = 3,5\text{--}4,5\text{ m}$ near shore. Sea level has an average daily amplitude 0,30–0,40 meters and a multi annual maximal amplitude $h = 1,14\text{--}1,53\text{ m}$. Intensive winds with their maximal speed of 40–45 m/s. The average annual temperature of the water varies from $t = 17,7\text{--}19,2^\circ\text{C}$.

73.3 Regional Hydrographic Outlook on the Albanian Littoral

The Albanian coastal area lies on the east side of the Southern Adriatic Sea, from Shengjini to Vlora bays and Northern Ionian Sea, from Vlora to Saranda bays at the south (Fig. 73.1). The coastal line length is 447 km. The water basin of this network is $43,305\text{ km}^2$, from which $28,550\text{ km}^2$ is inside of the Albanian state territory. Albanian River System represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. The hydric resources of Albania are $41,249 \times 10^9\text{ m}^3$ water, which correspond to a module of 30 liter/s.1 km^2 .

73.3.1 Adriatic Coastline

Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits, in western

73.4 Analyze and Results

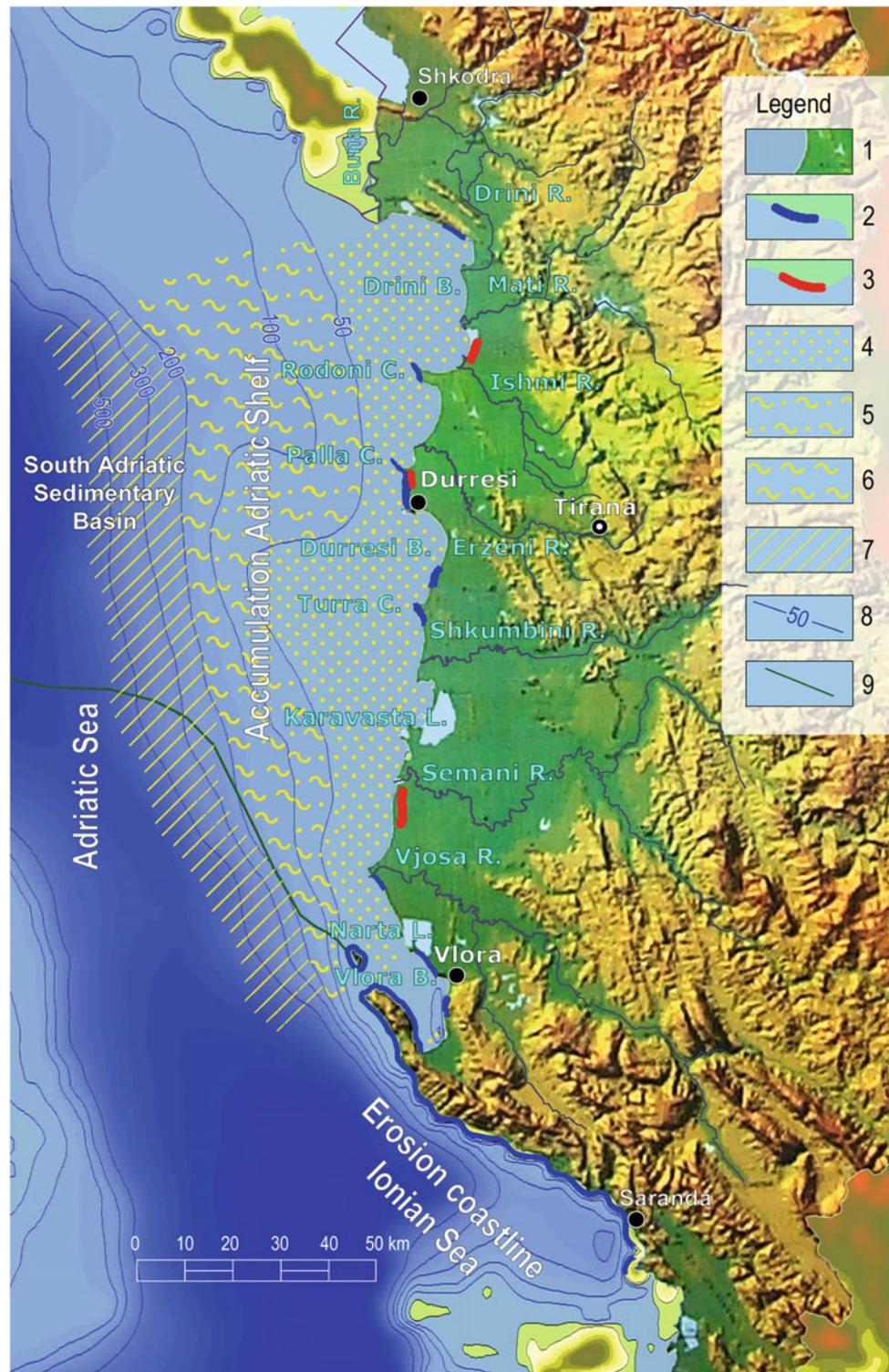
73.4.1 Albanian Adriatic Coastal Areas

Adriatic coastal line has the marine accumulation flattened coast, the marine erosion coast, and the submerged areas.

73.4.1.1 Accumulative Areas Represents Main Part of the Coastline

Accumulative areas represents main part of the coastline are extended over the edge of western Albanian plains. This littoral is characterized by presence of the different genetic types Quaternary (Q) (Frasheri et al 1996, 1994; Thereska 1981). Sandy littoral belt along the accumulative littoral have a width up to 5 km. Sand dunes are situated along this belt. Sand dunes belts have a length of 25 km and an average width more of 50–100 m. Generally, the granulometry of quartzite sand deposits represented by fine sand. Very beautiful sandy beaches are extended in accumulative

Fig. 73.1 Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline. (Digital Terrain Model, National Geophysical Data Center (NGDC), Geodas database, 2005. 1 Accumulative coastline; 2 Erosion coastline; 3 Submerged littoral zone; 4 Shoal shelf area with sand deposits; 5 Flat shelf area with sandy-silt deposits; 6 Inclined shelf area with muddy silt and deposits; 7 Continental slope with argillaceous sediments; 8 Isobaths; 9 Western flank of the South Adriatic Sedimentary Basin. 1



coastal areas. In the accumulation coast the flat shelf sinks gradually up to the depth 100 m. Over there, the majority of deposits represents by sand and silt.

73.4.1.2 Erosive Zones

Erosive zones were developed in accumulation littoral of Adriatic shoal. In the erosion coast, usually, the sea bottom is sandy. Durrësi–Kepi Pallës area is one most typical erosive segment. Durrës-Kepi Pallës coastline is extended along the western flank of the Neogene molasses anticline. Western fold flank are lies under the Adriatic Sea waters. (Aliaj 1989; Frashëri et al. 1996). Zvërneci hilly zone is located at northwestern direction of Vlora Bay. The Tortonian molasse Zvërneci hills chain from the isle separated Narta lagoon from the Adriatic Sea.

73.4.1.3 Submerged Areas, Where is Observed Marine Transgression Toward the Mainland

Semani beach at western Albanian region and Patoku beach in the southern side of the Shwngjini Bay represent submerged areas within accumulative coastline. Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression (Aliaj 1989). In Semani beach coastal water line has a ingression of 305 m toward the mainland, with a gradient 9.4–8.1 m/year.

Second submerged area is observed at the Patoku beach, between Ishmi River Mouth at the south and Mati River Mouth at the north. During the period 1972–2012 coastal water line has a ingression of 175 m toward the mainland.

73.4.1.4 Lagoon Area

Lagoon area has a total surface of about 150 km², while the volume over 350-million m³ water. The most important lagoons are those of Karavasta, Narta, Butrinti, Viluni etc. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom. The lagoons represent the new lakes. Its creation started during Pliocene Period, some 4–5 million years ago, and its creation lasted during the Quaternary Era till our days.

73.4.2 Impact of the Climate Change on Adriatic Sea Hydrology

Ground Surface Temperature history according to the geothermal studies presents a climate change influence. Generally, during the first half of twentieth century, the climate warming for about 1°C is observed. Thirty quart of this century has been characterized by a cooling for 0.6 °C. Later, up to present a warming for 1.2 °C is observed (Frashëri et al. 2004; Pano et al. 2001). Climate changes in Albania are observed also by the hydrometeorological studies (Albanian

Climate 1978; Demiraj et al. 1996). The warming period in Albania is accompanied with changes of the rainfall regime., wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200–400 mm. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea (Pano 2008).

Based on two Albanian Oceanographic Expeditions has been proposed a mechanism of the forming and circulation of the Adriatic Sea water (Pano 1975, 1984, 2008). The multi annual data have arguments that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas varies in very wide limits. Minimal discharge is 700–800 m³/s for the hydrological dry years of low precipitation, up to maximal values 1900–2200 m³/s for the hydrological wet years of high precipitation. Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with Po River in Italy, are determinant in the water balance of the Adriatic Sea.

73.5 Conclusions

- Albanian Adriatic coastline has an intensive change and continuously modifying its shape.
- Submerged process, caused by neotectonic activity, is observed in some sectors within accumulative Adriatic coastline.
- The climate at coastal plain region of Western of Albania has a warming of 0.6 K occurred, from last quarter of nineteenth until present-day. These climate changes have their impact on country water system, on and water resources, on the erosion processes, and on the hydrographic regime of the Adriatic Sea.

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Abstract

In the paper are analyzed impact of climate change, and hydrologic characteristic of the river and sea: Buna River runoff discharge, water mass circulation in Drini bay, wave refraction, sea level and incursion of the high tide waves, coastal accumulation and erosion processes et al that are conditioned hydro-geomorphologic development of the delta of Buna River. The morphology and hydro-geomorphologic development dynamics of the Buna River Delta are conditioned by hydrological regime of the river, thalassographic regime of the Adriatic Sea, and climate change impact.

Keywords

Delta • Ground temperature • Climate changes • Hydrographic system • Adriatic sea

74.1 Introduction

Albania is a subtropical zone. To the east, in the mountain areas, the climate is Mediterranean mountainous. The climate in Albania varies from a region to the other. The climate change studies are based on geothermal inversion results and meteorological observation data. There is analyzed the ground surface history (GSH) and paleoclimate

change according to the temperature recorded in the different wells in Albania. Climate changes during the last half of the twentieth century has been analyzed also based on the meteorological data. There are estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed. In the second part of the paper, is presented the analysis of climate change impact on Buna River Delta in Adriatic Sea.

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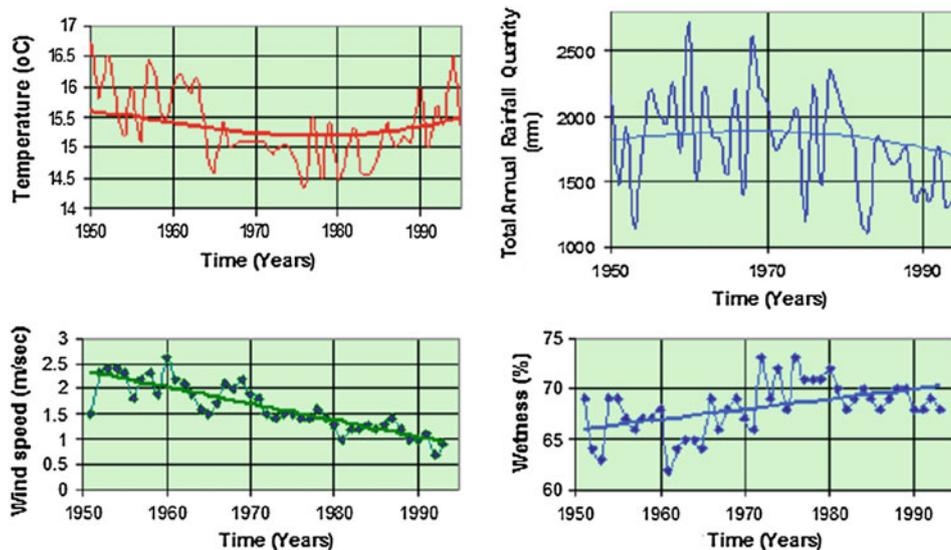
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74.2 Materials and Methods

Climate changes are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in six boreholes, which are located at the plain and mountain regions. The study of geothermal field of Albania has been carried out based on the temperature logging in the wells and boreholes (Cermak et al. 1996;

Fig. 74.1 Air average annual temperature, total year rainfall quantity, wind speed and wetness variations, at Shkodra meteorological stations (Period 1950–1994)



Frasheri et al. 1995, 2004). Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations (Fig. 74.1) (Albanian Climate 1978; Borifi and Demiraj 1990; Gjoka 1990; Mici et al. 1975, the data for 1985–2000 after Mustaqi V.).

Water potential of the Albanian Rivers System have been evaluated by a specific way (Pano 1967, 1995, 1998), based on the multi annual archival data (Hydrometeorological Institute of the Academy of Sciences of Albania) have calculated the annual runoff discharge of the Scutary Lake-Buna River-Drini River System, according to the corresponded types of the water supply, structure of the annual discharge distribution. All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydrographic System. Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions “Saranda in 1963”, “Patosi in 1964” (Pano 1967), and Italian-Albanian Expeditions “Italica I and II, 2000 and 2001” (Pano 2008).

74.3 Results and Discussion

Buna River is important part of the hydrographic complex “Scutary Lake-Buna River-Drini River”. Delta of the Buna Rives is located in Drin Bay at Adriatic Sea. This delta presents one of more active and interesting area of the Mediterranean Sea.

The ground surface temperature reconstructions of the thermoplots of Kolonja-10 deep wells, which are located at coastal plain region of western Albania presents a gradual

cooling of 0.6 K, before a middle of the nineteenth century. Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2–3 centuries. GST history shows that warming gradient increasing is observed also at mountainous regions.

Climate changes in Albania are observed also by the hydrometeorological studies. Figure 74.1 present graphics of yearly average temperature of the air in Shkodra Meteorological Stations, for the period from 1931 to 2004. In general, the end of first observes half twentieth century, a warming of climate, about 10 °C (Borifi and Demiraj 1990).

Thirty quarter of twentieth century is characterized by a cooling of 0.6 °C, and later, up to present a warming of 1.2 °C. The same climate changes are observed also at Shkodra City. The cross correlation coefficient is $C_c = 0.78$ between variation curves of the average annual temperatures of both of these stations. Warming trend of maximum 1.2 °C, in particular after 70 years, is observed in all Albanian territory. The warming have accompanied with decreasing of the wind speed about 1.5 m/s and 5 % increasing of the wetness, during the period of 1950–1994.

This warming is part of the global Earth warming during the second half of twentieth century. Its impact has been observed on water systems and water resources. Inland water resources change has its impact also on the hydrographic regime of the Adriatic Sea (Pano 1984, 1994, 2008). There are great impacts of the specific natural conditions of the Albanian Hydrographic System catchment in particular of the Scutary Lake-Buna River-Drini River System.

Buna River maximal flow (respectively discharge (QM p%) and volume (WMp%) for different probabilities ($p = 0,01; 0,1; 1; 2; 5; 10, 20$ %) is presented in Fig. 74.2. Maximal flow with a probability $p = 1$ % (one in

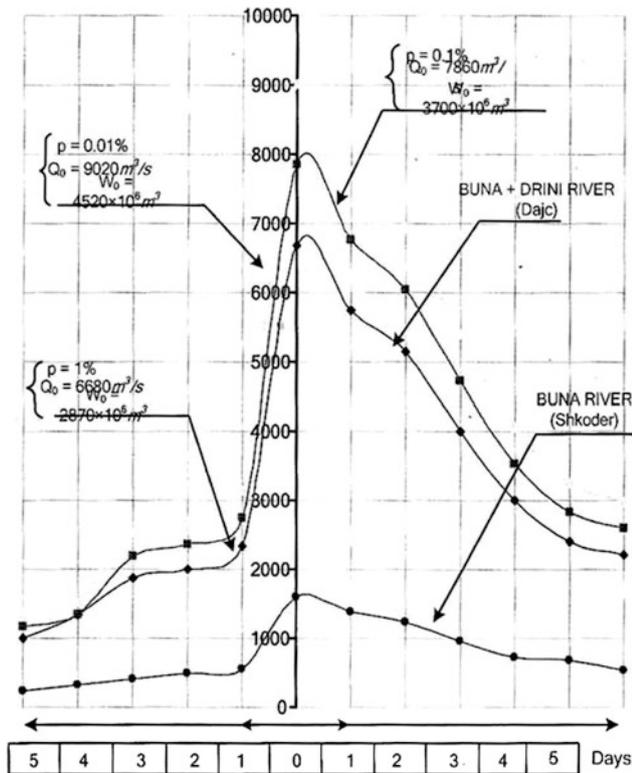


Fig. 74.2 Maximal flow, Buna + Drini River-Dajc

100 years) has the discharge $Q_{Mp} = 1\% = 6680 \text{ m}^3/\text{s}$ and a volume $W_{Mp} = 1\% = 2870.106 \text{ m}^3$.

The average annual sea level is $H = 0,12 \text{ m}$ on the 0" absolute level. In the multi annual period the maximal level with the probability of $p = 1\%$ on the Albanian offshore is $H_{max} = 1,2 \text{ m}$ on the 0" absolute level, while the minimal level is $H_{min} = -0,5 \text{ m}$ Abs. as the results the maximal amplitude of the sea level during the multiannual period is $AH = (H_{max} - H_{min}) = 1,62 \text{ m}$. The most eventual waves observed during the year in the Drini Bay are $h = 0,6-1 \text{ m}$ (33 % of the cases). Same important ones are also the following: $h = 1,6-3,1 \text{ m}$ (20 % of the cases). The one of the $h = 3,5 \text{ m}$ have are not observed very often, about 0,3 %. Their principal directions are S, SW, NW, and S. The maximal waves in marine shelf: height $h = 5,10 \text{ m}$, length $L = 80,6 \text{ m}$, velocity $C = \text{m/s}$ and period $T = 7,2 \text{ s}$. Minimal discharge is $700-800 \text{ m}^3/\text{s}$ for the hydrological dry years of low precipitation, up to maximal values $1900-2200 \text{ m}^3/\text{s}$ for the hydrological wet years of high precipitation.

Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with Po River in Italy, is determinant in the water balance of the Adriatic Sea.

Climate change and variation of the discharges have its impact on the marine water mass flows and solid material transport in the time, velocity and locations, and also on the

wave regime. Consequently, in the Buna delta during the short period for about 37 years (1972–2009) are developed intensive erosion, and in the both side of the coastline an accumulation process. In the Buna River Delta actually is formed a marine spit.

Ecosystems, and biodiversity, in the particularly in the water's flora and fauna have an important influence from climate change. Temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon as Kune-Vaini in Lezha region etc. thermal stress has its impact, first of all on the biodiversity. This stress is extended also in the shallow coastal waters; consequently there are observed diminution of the fish quantity.

74.4 Conclusions

1. The climate at coastal plain region of Western of Albania was cooled of 6 K before of middle of nineteenth century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day. Temperature records in northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during twentieth century. Warming, mainly during the last quarter of the twentieth century, is demonstrated also by meteorological data.
2. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. Impact it is observed first of all on the biodiversity.
3. The rainfall regime changes have their consequences in the fresh water re-sources of the country, of surface's and underground waters.
4. In the Buna delta during the short period for about 37 years (1972–2009) are developed intensive erosion and in the both side of the coastline an accumulation process.
4. Geomorphologic change of the coastline it is necessary to evaluate during the urban planning of the coastline.

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