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- References must be indicated in the text, between brackets and they must include the author's name and the date of the publication (Popescu, 2000). When three or more authors are referred, they will appear in the text as follows: (Popescu et al., 1997). References must be listed in alphabetical order at the end of the text.

The following style sheet is recommended:

- for journals:

Miletić, R., Lukić, V., & Miljanović, D. (2011). Deindustrialization and structural changes in commuting flows in Serbia. *Forum geografic*, X(2), 244-254. doi:10.5775/fg.2067-4635.2011.009.d

- for books:

Bran, F., Marin, D., & Simion, T. (1997). Turismul rural. Modelul european, Editura Economică, București

- for papers from conference proceedings:

Deci, E. L., Ryan, R. M., (1991), A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), *Nebraska Symposium on Motivation: Vol. 38. Perspectives on motivations* (pp. 237-288). Lincoln: University of Nebraska Press.

Review process

All the manuscripts received by the editors undergo an anonymous peer review process, necessary for assessing the quality of scientific information, the relevance to the field, the appropriateness of scientific writing style, the compliance with the style and technical requirements of our journal, etc. The referees are selected from the national and international members of the editorial and scientific board, as well as from other scholarly or professional experts in the field. The referees assess the article drafts, commenting and making recommendations. This process leads either to acceptance, recommendation for revision, or rejection of the assessed article. Editors reserve the right to make minor editorial changes to the submitted articles, including changes to grammar, punctuation and spelling, as well as article format, but no major alterations will be carried out without the author's approval. Before being published, the author is sent the proof of the manuscript adjusted by editors. If major revisions are necessary, articles are returned to the author so that he should make the proper changes. Authors are notified by email about the status of the submitted.

In Memoriam Professor Vasile Pleniceanu – life and activity

Oana MITITELU-IONUȘ^{1,*}, Liliana POPESCU¹

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"Un Om ales și de ispravă
cum alții nu-s în rostul lor.
S-a dus pandurul, fără zarvă,
spre vadul fără vis și dor.

Acolo unde Jiul plânge
cu lacrimă de rouă lină
alura lui se va răsfărânge
precum o jerbă de lumină".

(Prof. univ. dr. Pompei Cocean, Aprilie 2020)



Vasile Pleniceanu was born on January, 2nd, 1942 in Cetate village, Dolj county. During the 1953-1956, he attended Cetate Gymnasium and in 1960 he graduated from Cetate Theoretical Highschool. Between 1960 and 1965 he was a student at the University of Bucharest, Faculty of Geology-Geography, specializing in Geography-Biology. In the following decades, he also enrolled in post-tertiary education focusing on hydrology, hydro-geology, water quality and environment protection, two of them abroad:

- Moscow, in the former USSR, *Lomonosov University*, in May-July 1971 – post-university training within the *International course of high hydrology studies*, focusing on underground waters, organized by UNESCO, having as advisers Prof.dr. B.I. Vartazarov, Moscow, USSR and Dr. G. Castani, from Paris, France.
- Madrid, Spain, January – June 1979 – *International course of general and applied hydrology*, also held under UNESCO auspices, scientific coordinator Prof.dr R.H. Rodrigues, Spain.

In 1985, he presented his PhD thesis titled *The Oltenia Plain between the Ji and the Danube – hydrologic study, focusing on underground waters*, PhD. Coordinator Prof.dr Ioan Pișota, from the University of Bucharest, Faculty of Geology-Geography.

Vasile Pleniceanu s-a născut la 02 ianuarie 1942 în Comuna Cetate, județul Dolj. În perioada 1953-1956 a fost elev la *Școala generală Cetate*, iar în anul 1960 a absolvit *Liceul Teoretic Cetate, Secția Reală*. Începând cu 1960 și până în 1965 a fost student al *Universității din București, Facultatea de Geologie-Geografie, Specializarea Geografie-Biologie*. A urmat apoi specializări postuniversitare în domeniul hidrologiei, hidrogeologiei, protecției calității apelor și mediului înconjurător, dintre care doua în străinătate:

- Moscova, Universitatea "V.I. LOMONOSOV", 1971, Mai – Iulie, stagiul de specializare postuniversitară în cadrul "Cursului internațional de înalte studii hidrologice", specializarea ape subterane, sub egida U.N.E.S.C.O.. Îndrumători științifici: prof. univ. dr. doc. B.I. Vartazarov, Moscova, U.R.S.S. și G. Castani – dr. în științe, Paris, Franța.
- Madrid, Spania, 1979, Ianuarie – Iunie, stagiul de specializare postuniversitară "Cursul internațional de hidrologie generală și aplicată", desfășurat sub egida U.N.E.S.C.O. Îndrumător științific: prof. univ. dr. R. H. Rodrigues – Spania.

Formarea profesională a culminat în iunie 1985 prin teza de doctorat cu titlul "Câmpia Olteniei dintre Dunăre și Jiu – Studiu hidrologic, cu privire specială asupra apelor subterane", sub coordonarea științifică a Prof.dr. Ioan Pișota, Universitatea din București, Facultatea de Geologie – Geografie.

Later on, his PhD thesis was published under the title *Waters within the Oltenia Plain* (1999) at Universitaria Publishing House, Craiova.

He began his career in 1965 teaching at Cetate Theoretic Highschool, which he attended as a pupil, until 1968. He later transferred to the National Institute of Meteorology and Hydrology Bucharest, where he was named Chief of Underground Water Department for Oltenia Branch (1969-1975).

Later, between 1976 and 1988, Vasile Pleniceanu was the manager of Dolj Water Management Directory, part of the National Council of Waters, Bucharest.

Beginning with 1990, until 1998, he was Chief inspector of the Agency of Environment Protection Craiova, which was part of the Ministry of Waters, Forests and Environment Protection.

For the last two decades of his professional career, Vasile Pleniceanu taught at the University of Craiova, being Assistant Professor at the Department of Geography, Faculty of History-Philosophy-Geography, and, beginning with 1998 until he retired Head of Geography Department. While at the University of Craiova, he was also Editor-in-chief of the two scientific journals edited by the Department of Geography: *Annals of the University of Craiova*, Series Geography, beginning with 1999, and *Forum Geografic*, since 2001.

During his more than 40 years long career, he had the opportunity to work in various scientific fields, also carrying on a pioneer activity to some extent for a geographer.

Thus, in the domain of underground waters in Romania, Vasile Pleniceanu was the first to insist on the need for hydro-geological drills for the phreatic and underground water structures in order to gather more detailed information about underground hydrology, the regime and chemical composition of underground waters in Oltenia.

When working for the Qualitative and Quantitative Management of Waters, he promoted and supported various programmes for the protection of water quality, waste-water treatment, as well as planning works for protection against floods.

In the domain of Environment protection, his main target was to bring solutions for diminishing and limiting the negative effects of pollution sources spread throughout the entire Dolj county.

Apart from great organisational skills, he was a very prolific researcher, publishing 6 books, 112 scientific papers in national and international journals with referees and attending numerous conferences. He published the following books (in Romanian):

1. Pleniceanu, V., (1999), *Waters within Oltenia Plain*, Universitaria, Craiova;

Teza de doctorat a fost publicată ulterior (1999), sub titlul *Apele din Câmpia Olteniei* la Editura Universitaria, Craiova.

Experiența profesională a început în anul 1965 în cadrul *Liceului Teoretic Cetate* unde Pleniceanu Vasile a fost profesor titular până în 1968. În perioada 1969-1975 a deținut funcția de Șef serviciu ape subterane – Oltenia, Sectorul Teritorial de Meteorologie și Hidrologie – Filiala Craiova a Institutului Național de Meteorologie și Hidrologie București.

Ulterior, 1976 – 1988, Vasile Pleniceanu a fost directorul Oficiului de Gospodărire a Apelor Dolj – Consiliului Național al Apelor București.

Începând cu anul 1990 și până în 1997, a deținut funcția de inspector-șef al Agenției de Protecție a Mediului Craiova, din structura organizatorică a Ministerului Apelor, Pădurilor și Protecției Mediului.

Începând cu anul 1999 și până la ieșirea la pensie în 2010, Pleniceanu Vasile a fost cadru didactic la Universitatea din Craiova, fiind conferențiar universitar la Facultatea de Istorie, Filosofie, Geografie, Specializarea Geografie și Șeful Departamentului de Geografie din 1998 până în 2010. În toată această perioadă, a fost Redactor șef al Revistei „Analele Universității din Craiova” – Seria Geografie (din 1999) și Redactor șef al Revistei de specialitate „Forum Geografic”, ce apare sub egida Universității din Craiova din anul 2001.

În activitatea sa științifică și cariera profesională desfășurată de-a lungul a peste 40 ani, Pleniceanu Vasile a avut șansa să lucreze în domenii de activitate în care pentru un geograf au fost ca un pionierat.

În *domeniul apelor subterane*, Pleniceanu Vasile a promovat, pentru prima dată, realizarea de foraje hidrogeologice pentru structurile acvifere freatice și de adâncime în scopul cunoașterii caracteristice hidrologiei subterane, a regimului și chimismului apelor din Oltenia.

În *domeniul Gospodăririi Calitative și Cantitative a Apelor* a promovat și susținut programe privind protecția calității apelor, epurarea apelor uzate, precum și realizarea de lucrări pentru apărarea împotriva inundațiilor.

În *domeniul protecției mediului*, preocuparea primordială a fost aceea a modului de soluționare, în sensul diminuării și limitării efectelor negative ale surselor de poluare „distribuite” în județul Dolj.

Concomitent cu activitatea de pregătire profesională și de cercetare științifică Pleniceanu Vasile publicat 6 carti, 112 articole în reviste de specialitate naționale și internaționale recunoscute CNCSIS și a susținut numeroase comunicări la manifestări științifice naționale și internaționale.

Cărți:

1. Pleniceanu, V., (1999), *Apele din Câmpia Olteniei*, Editura Universitaria, Craiova;

2. Pleniceanu, V., (2000), Hydrology, (Vol. I), SITECH, Craiova;

3. Pleniceanu, V. (2003), Lakes and wet lands,

4. Pleniceanu, V., Ionuș, O., (2007), Geography of continental waters, Universitaria, Craiova;

5. Pleniceanu, V., Ionuș, Oana, Marinescu, Ioan, (2008), Geography of water resources on the Earth, Universitaria, Craiova;

6. Pleniceanu, V., Ionuș, Oana, (2009), Course of General Hydrology, Universitaria, Craiova.

He also wrote more than 100 papers, published in peer-reviewed journal, some of the most important of them being:

1. Maria Pleniceanu, Pleniceanu, V., (2000), *Radioactivity of environment factors within the southern part of Oltenia. Radio-protection measures*, Annals of the University of Craiova, Biology Series, TPPA., vol. IV (XL)/1999;
2. Pleniceanu, V., (2000), *Information about underground water discharge within Oltenia Plain*, Annals of the University of Craiova, Biology Series, TPPA., vol. IV (XL), 316-321;
3. Pleniceanu, V., Petrișor, I., (2001), *Integrated monitoring system for establishing the state and the evolution of the air quality in the area of Craiova city*, Volume „IV Yugoslav Symposium – Chemistry and Environment, pag. 133-135, Zrenjanin, Serbia;
4. Pleniceanu, V., (2001), *New perspectives on the ecological education in Romania*, Journal of Environmental Protection and Ecology, Balkan Environmental Association (B.EN.A.), vol. 2, nr. 3, pag 643-652;
5. Pleniceanu, V., S. Boengiu, (2002), *Impact of human activities on the evolution of the Jiu water quality, in Global environment changes*, A.S.E;
6. Pleniceanu, V., S., Boengiu, (2003), *RWater resources and their quality within Oltenia Plain*, Annals of Valahia University, Series Geography, III
7. Pleniceanu, V., (2004), *New perspective on the ecological education in Romania*, Journal of Environmental protection and ecology, Vol. 2, No 3, 643-651;
8. Pleniceanu, V., (2006) *Modifications of the atmospheric natural quality within the industrial area of Ișalnița – Craiova*, Journal of Environmental Protection and Ecology, Vol. 2;
9. Pleniceanu, V.– co-author (2006), *The Rehabilitation of the Danube Floodplain on Rast - Corabia Sector*, Annals of the University of Craiova, Geography Series, Vol. IX, Universitaria Publishing House, Craiova, 43 – 52;
10. Pleniceanu V., Ionuș O., Licurici M. (2008), *Extreme hydrological phenomena in the hydrographical basin of the Danube. The floods from the spring of 2006 along the Oltenian sector of the river*, Annals of the University of Craiova, series Geography, XI: 37-47.

3. Pleniceanu, V., (2003), Lacuri și zone umede, Editura Universitaria, Craiova;

4. Pleniceanu, V., Ionuș, Oana, (2007), Geografia apelor continentale, Universitaria, Craiova;

5. Pleniceanu, V., Ionuș, Oana, Marinescu, Ioan, (2008), Geografia resurselor de apă ale Terrei, Editura Universitaria, Craiova;

6. Pleniceanu, V., Ionuș, Oana, (2009), Hidrologie generală – curs universitar, Editura Universitaria, Craiova.

Dintre lucrările reprezentative, publicate în reviste cotate CNCSIS, amintim:

1. Maria Pleniceanu, Pleniceanu, V., (2000), *Starea radioactivității factorilor de mediu în zona de sud a Olteniei. Măsurile de radioprotecție*, Analele Universității din Craiova, Seria Biologie, Horticultură, TPPA., vol. IV (XL)/1999, 310-315;
2. Pleniceanu, V., (2000), *Contribuții la cunoașterea scurgerii apelor subterane în Câmpia Olteniei. Implicații asupra culturilor agricole*, Analele Universității din Craiova, Seria Biologie,
3. Pleniceanu, V., I. Petrișor, (2001), *Integrated monitoring system for establishing the state and the evolution of the air quality in the area of Craiova city*, IV Yugoslav Symposium – Chemistry and Environment, pag. 133-135, Zrenjanin, Serbia;
4. Pleniceanu, V., (2001), *New perspectives on the ecological education in Romania*, Journal of Environmental Protection and Ecology, Balkan Environmental Association (B.EN.A.), vol. 2, nr. 3, pag 643-652, Bulgaria;
5. Pleniceanu, V., S. Boengiu, (2002), *Impactul activităților antropice în evoluția calității apelor Jiului, „Modificări globale ale mediului”*. Contribuții științifice românești. Editura A.S.E, pag. 153-161;
6. Pleniceanu, V., S., Boengiu, (2003), *Resursele de apă și calitatea acestora în Câmpia Olteniei*, Analele Universității Valahia –Târgoviște, Seria Geografie, Tomul III/2003, 134-138;
7. Pleniceanu, V., (2004), *New perspectives on the ecological education in Romania*, Journal of Environmental protection and ecology, Vol. 2
8. Pleniceanu, V., (2006) *Modifications of the atmospheric natural quality within the industrial area of Ișalnița – Craiova*, Journal of Environmental Protection and Ecology, Vol. 2
9. Pleniceanu, V.– co-author (2006), *The Rehabilitation of the Danube Floodplain on Rast - Corabia Sector*, Annals of the University of Craiova, Geography Series, Vol. IX, 43 – 52;
10. Pleniceanu V., Ionuș O., Licurici M. (2008), *Extreme hydrological phenomena in the hydrographical basin of the Danube. The floods from the spring of 2006 along the Oltenian sector of the river*, Analele Universității din Craiova, Seria Geografie, XI:37 – 47.

Vasile Pleniceanu was part of twelve research grants, either as manager or researcher, involving young researchers, such as:

- Monitoring pollution along the rivers from southern Romania. Monitoring water quality along the Jiu river – international grant, cooperation between the University of Craiova and Luton University, England (1997-2001).
- Strategy of environment protection în Dolj county on short, medium and long term (2000-2010);
- Health Environment status within Oltenia South-Western Development Region (Dolj, Gorj, Olt, Mehedinți, Vâlcea counties) (2000-2002);
- Waste Management în Craiova city. Administration and elimination of waste, especially toxic and dangerous waste – a collaboration between the University of Craiova and the Balkan Environmental Association (2001-2002).
- Strategy for sustainable development of Craiova, phase 1.

Pleniceanu Vasile kept connections to various colleagues not only from other institutions în Craiova – colleagues from „Romanian Waters” National Administration and Environment Management System; but also throughout the country – "Spiru Haret" University, Romanian Academy Geography Institute, universities of Bucharest, Cluj-Napoca, Timișoara, Târgoviște and Iași, acting as co-chair during numerous conferences.

His prodigious activity was recognised at national and international level, being a member of important scientific and professional societies, such as:

- The Romanian Committee for the International Hydrological Decade, Bucharest;
- Romanian Geographical Society;
- Association of Geomorphologists from Romania;
- National Society of Hydro-Geology;
- Balkan Environmental Association, Bulgaria;
- National Geographic Society, Washington DC;
- International Association for Danube research.

He was also the:

- Founding member of the NGO *Romanian Ecological Action*, Craiova;
- Vicepresident of the International Office of the Environmental Education Association, University of Craiova;
- Director of the Centre for Environment Research and Sustainable capitalization of resources.

Pleniceanu Vasile a fost membru sau chiar a coordonat echipe de tineri geografi în cadrul a 12 contracte/granturi de cercetare, dintre care:

- Grant/Contract Internațional (Universitatea din Craiova în colaborare cu Universitatea LUTON, Anglia), „Monitorizarea poluării apelor râurilor din Sudul României. Monitorizarea calității apelor râului Jiu” (1997-2001).
- Proiect de Cercetare - Dezvoltare - „Strategia de Protecție a Mediului în Județul Dolj, Pe Termen Scurt, Mediuși Lung” (2000-2010);
- Grant/Contract „Starea Mediului în Regiunea de Dezvoltare Sud-Vest Oltenia (Jud. Dolj, Gorj, Olt, Mehedinți și Vâlcea)” (2000-2002);
- „Waste Management în Craiova City. Administration and elimination of wastes Especially Of The Toxic And Dangerous ones - Balkan Environmental Association (B.EN.A) și Universitatea din Craiova (2001-2002);
- Strategia de dezvoltare a municipiului Craiova, etapa I.

Pleniceanu Vasile a păstrat mereu legătura cu colegi de la diverse institutii din Craiova – colegii de la Administrația Națională Apele Române și Adminsitrația apelor bazinale Jiu, Agenția de protecție a mediului, dar și din Romania – Institutul de Geografie al Academiei Române, Universitățile din București, Iași, Cluj-Napoca, Târgoviște, și Universitatea Spiru Haret.

Activitatea la nivel național și internațional a fost recunoscută și prin apartenența la societăți științifice și profesionale, precum:

- Comitetul Român Pentru Deceniul Hidrologic Internațional, București;
- Societatea de Geografie din România;
- Asociația Geomorfologilor din România;
- Societatea Națională de Hidrogeologie;
- Membru Fondator al Organizației Nonguvernamentale „Acțiunea Ecologică Română”, Craiova;
- Membru Al „Balkan Environmental Association” (B.En.A.) Sofia, Bulgaria;
- Membru al „National Geographic Society” Washington D.C.;
- Vicepreședinte al “International Office Of Environmental Education” – Of The Balkan Environmental Association, Universitatea din Craiova;
- Membru al “International Association For Danube Research”;
- Director Al Centrului De Cercetare A Mediului Și Valorificare Durabilă A Resurselor (CCMVDR).

Recunoasterea activitatii profesorului Pleniceanu

Vasile s-a confirmat prin:

- Diploma de Merit în Domeniul Gospodăririi Apelor, Consiliul Național Al Apelor, București, 1986;
-

His fellow peers recognized his important contribution to the geographical research in Romania, granting him several honorific titles and diplomas:

- Certificate of Merit for Water Management, National Council of Waters, Bucharest 1986;
- Diploma and votive medal, celebrating 75 years since the establishment of Natural Museum of Craiova and 70 years of existence as part of the Oltenia Museum (1998);
- Diploma and votive medal, celebrating *A century of geographic education at the University of Bucharest* (1900-2000), Bucharest, 2000;
- Diploma and votive medal, celebrating *125 years since the establishment of Romanian Society of Geography* (1875-2000), Bucharest, 2001.

Vasile Pleniceanu was and will be one of the pillars of Craiova school of Geography, as under its direct supervision and unconditional support, a young, strong and passionate team was formed, all of our first career steps being taken due to his advice and constructive criticism (Teodorescu Camelia, Curcan Gheorghe, Boengiu Sandu, Marinescu Emil, Marinescu Ioan, Vlăduț Alina, Popescu Liliana, Ionuș Oana). Professor Pleniceanu left his mark on numerous generations of students and young fellows, always letting us on his personal and professional experience, with great patience and especially humour, while teaching us to pursue our career with passion and devotion and offer unconditional support to our peers.

On April, 11th, 2020, Professor Pleniceanu passed away. All the persons that met, respected and loved him owe him not only to have high expectations from ourselves, but also to be kind and supportive with our fellows.

- Director Al Centrului De Cercetare A Mediului Și Valorificare Durabilă A Resurselor (CCMVDR).

Recunoasterea activității profesorului Pleniceanu Vasile s-a confirmat prin:

- Diploma de Merit în Domeniul Gospodăririi Apelor, Consiliul Național Al Apelor, București, 1986;
- Diploma și Medalia Jubiliară cu prilejul împlinirii a 75 ani de la înființarea Muzeului de Istorie Naturală al Craiovei și a 70 de ani de la funcționarea sa ca Secție a Muzeului Olteniei, Craiova, 1998;
- Diploma de Onoare și Medalia Jubiliară "Un Secol de Învățământ Geografic la Universitatea din București (1900-2000)", București 2000;
- Diploma de onoare și Medalia Jubiliară "125 de Ani de la Înființarea Societății de Geografie din România (1875-2000)", București 2001.

Vasile Pleniceanu a fost și va rămâne unul din pilonii reprezentativi ai geografiei craiovene, căci sub coordonarea și sprijinul său necondiționat s-a creat un colectiv tânăr, puternic și unit, care a făcut primii pași în cariera universitară și în cercetarea științifică avându-l drept critic și sfătuitor (Teodorescu Camelia, Curcan Gheorghe, Boengiu Sandu, Marinescu Emil, Marinescu Ioan, Vlăduț Alina, Popescu Liliana, Ionuș Oana).

Profesorul Pleniceanu și-a lăsat amprenta asupra multor generații de studenți și tineri colegi, cărora le-a împărtășit cu răbdare, și întotdeauna cu umor, din experiența profesională și personală, învățându-ne, în același timp, să dăm dovadă de dăruire și devotement în cariera didactică și de sprijin necondiționat față de colegi.

În data de 11 Aprilie 2020, mult îndrăgitul profesor Pleniceanu Vasile a trecut în lumea celor drepti. Noi toți care l-am cunoscut, respectat și iubit, suntem datori cu înalte năzuințe profesionale și întoarcerea către semeni a cel puțin o faptă bună.

Climate aridity in southern Bulgaria for the period 1961-2015

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Abstract

The climate change on a global, regional and local scale is one of the largest problems indicated by the 21st century studies. Some of the major climate changes on the Balkan Peninsula, and in particular in Bulgaria, are related to rising temperatures and decreasing precipitation, which leads to drought and climate aridity. The present study focuses on the investigation of the climate aridity in the non-mountainous part of Southern Bulgaria in order to assess the aridity condition in temporal and spatial scale. The main investigated period is 1961-2015 and the reference periods are 1961-1990 and 1986-2015. The aridity is analysed on the basis of monthly data for air temperatures and precipitation from eight meteorological stations by calculation of De Martonne aridity index and Emberger Index. The survey shows that in all the analysed meteorological stations in Southern Bulgaria there are periods which display characteristics of the semiarid or arid climate. The aridity is well-expressed in the southwest part of Bulgaria (station Sandanski) and the western part of the Thracian lowland (station Plovdiv). Despite the aridity conditions established in the investigated region the tendencies in multiannual variability of De Martonne and Emberger indices show decreasing of aridity during the last 30 years (1986-2015) of the investigated period.

Keywords: *aridity, climate change, Southern Bulgaria, De Martonne Aridity Index, Emberger Index*

Rezumat. Ariditatea climatică în sudul Bulgariei în perioada 1961-2015

Schimbările climatice la scară globală, regională și locală sunt una dintre cele mai mari probleme indicate de studiile secolului XXI. Unele dintre schimbările climatice majore din Peninsula Balcanică, în special în Bulgaria, sunt legate de creșterea temperaturilor și scăderea precipitațiilor, ceea ce duce la secetă și ariditate climatică. Studiul de față se concentrează pe investigarea aridității climatice din partea non-muntoasă a sudului Bulgariei pentru a evalua starea de ariditate la scară temporală și spațială. Principala perioadă investigată este 1961-2015, iar perioadele de referință sunt 1961-1990 și 1986-2015. Ariditatea este analizată pe baza datelor lunare de temperatură a aerului și de precipitații la opt stații meteorologice prin calculul indicelui de ariditate De Martonne și al indicelui Emberger. Studiul arată că la toate stațiile meteorologice analizate din sudul Bulgariei există perioade care sunt caracteristice climatului semiarid sau arid. Ariditatea este bine exprimată în partea de sud-vest a Bulgariei (stația Sandanski) și în partea de vest a podișului tracic (stația Plovdiv). În ciuda condițiilor de ariditate stabilite în regiunea investigată, tendințele variabilității multianuale ale indicilor De Martonne și Emberger arată scăderea aridității în ultimii 30 de ani (1986-2015) din perioada investigată.

Cuvinte-cheie: *ariditate, schimbare climatică, Bulgaria de Sud, indicele de ariditate De Martonne, indicele Emberger*

Introduction

The study of the climate aridity could give important information about the condition for natural vegetation and agricultural plants. Aridity and drought are not equal concepts. Aridity, in contrast to drought, is a constant feature of the climate in a given area with low rainfall, resulting in a number of problems such as water scarcity. The aridity is a result of large-scale sustainable atmospheric and oceanic circulations or regional geographic features of the topography (Maliva and Missimer, 2012). The study of the aridity is based in large periods (at least 30 years), while the study of the drought is performed in small periods, which is a consequence of its occasional character. According to Maliva and Missimer (2012) there are four basic reasons for the existence of the arid climate: constant anticyclones with a combination of trade winds; continental air masses with low humidity; orographic shadow and cold ocean currents.

The existing publications show that the aridity has been investigated by various complex climatic indices. One of the most common indices for aridity research is the Thornthwaite climate index (moisture index). According to this index, aridity is shown in several tropical and subtropical areas of the world, being represented in Europe only in small parts of the south and southeast of the Iberian Peninsula (Feddem, 2005). In the last years, many studies revealed the existence of aridity and water scarcity in many areas of the Mediterranean and the Balkan Peninsula: Nastos et al. (2013), Rego and Rocha (2014), Andrade and Corte-Real (2016), Chendeş (2010), Vlăduț et al. (2017). According to Topliiskiy (2006) the aridity is characteristic for almost 2/3 of the plains of Bulgaria and can be observed well in the period June - October. Nikolova and Mochurova (2012) point out the tendency to arid climate during late summer and beginning of autumn in many region of Bulgaria. The De Martonne and Thornthwaite indices are used by Mitkov and

Topliiski (2018) who have determined the tendencies to arid or semi-humid climate in Bulgaria.

The aim of present paper is to analyse spatial and temporal variability of aridity condition in South Bulgaria. In order to achieve this aim two climatic indices (De Martonne aridity index and Emberger index) are calculated and the years with the extreme values of the indices are determined. The tendency in temporal variability in both indices is reveal.

Studied area, data and methods

In order to assess the aridity condition in temporal and spatial scale the present study focuses on the investigation of the climate aridity in non-mountainous part of Southern Bulgaria (Fig. 1) which

is one of the main agricultural areas in the country. The main investigated period is 1961-2015 and the reference periods are 1961-1990 and 1986-2015. The aridity is analysed on the basis of monthly data for air temperatures and precipitation from eight meteorological stations (Table 1) by calculation of the De Martonne aridity index and Emberger Index.

The selection of the stations and the duration of the investigated period are determined by the availability of monthly precipitation data. The sources of monthly data are the Meteorological yearbooks (National Institute of Meteorology and Hydrology, Bulgaria) and the Statistical yearbooks (National Statistical Institute, Bulgaria).

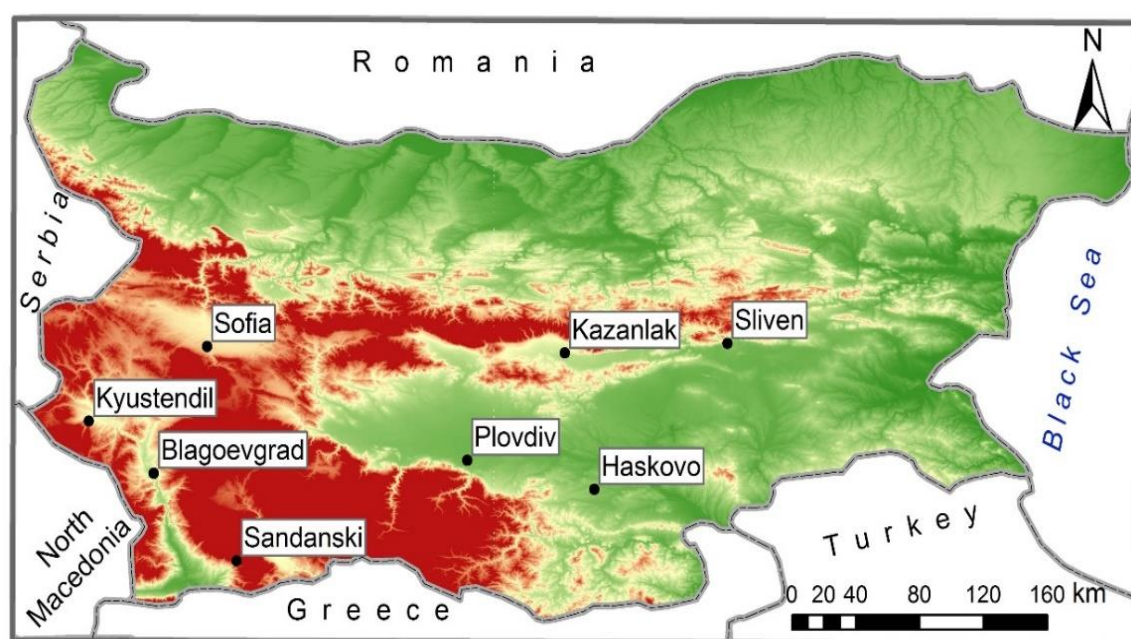


Fig. 1: Location of the studied meteorological stations (Base map SRTM digital elevation model, NASA JPL, 2013)

Table 1 List of meteorological stations used in the survey

Meteorological station	Latitude	Longitude	Altitude /m/
Sandanski	41°33'	23°16'	296
Blagoevgrad	42°00'	23°05'	410
Kyustendil	42°16'	22°43'	560
Sofia	42°39'	23°23'	500
Kazanlak	42°37'	25°24'	407
Plovdiv	42°04'	24°51'	164
Haskovo	41°55'	25°34'	203
Sliven	42°40'	26°19'	243

The analyses have been made using empirical and statistical methods. The De Martonne aridity index is one of the first indices used to assess aridity. The index was created by the French geographer Emmanuel de Martonne in 1926. In recent years there are many publications, based on

De Martonne's aridity index in Greece (Mavrakis and Papavasileiou, 2013), Bulgaria (Mitkov and Topliiski, 2018), Romania (Vlăduț et al., 2017), Turkey (Chendeş, 2010), etc.

The annual values of the De Martonne index (Ia) are calculated using the following formula:

$$I_a = \frac{P}{T + 10}$$

where:

P - the annual precipitation totals

T - the average annual air temperature

10 - coefficient used to acquire positive values

The acquired results can be related to the following climate types, according to the De Martonne index (Table 2).

Table 2 Climate types according to DeMartonne aridity index

Climate types	De Martonne index values
Arid	< 10
Semi-arid	10 – 20
Mediterranean	20 – 24
Semi-humid	24 – 28
Humid	28 – 35
Very humid a	35 – 55
Very humid b	> 55

Source: Baltas (2007), Nikolova (2018)

The Emberger index is based on data from rainfall sums and average monthly air temperatures of the coldest month and warmest month (Emberger, 1930). Emberger used this index to classify phytoclimatic regions. That is why some scientists investigate the dissemination of vegetation according to the Emberger index (Gavilán, 2005 in Spain; Savo et al., 2012 in Italy). The Emberger Index (IE) is calculated using the following formula:

$$IE = \frac{100 \cdot P}{M^2 - m^2}$$

where:

P - the annual sum of rainfall

M - the monthly average temperature of the warmest month

m - the average monthly air temperature of the coldest month

The climate types according to the Emberger index are the following (Table 3):

Table 3 Climate types according to Emberger index

Climate areas	Emberger index values
Arid	< 30
Semi-arid	30 – 50
Semi-humid	51 – 90
Humid	> 90

Source: Nikolova (2018)

The temporal variability of aridity is analysed by application of linear regression model ($y=b_0+b_1 \cdot x$) of the time-series of both investigated indices (De Martonne aridity index and Emberger index). The statistical significance of the trend is determined by T-test using AnClim software (Štěpánek, 2008). Also, to obtain more information about the aridity in Southern Bulgaria and in particular about the causes of this climate characteristic, a correlation was made between the data for the De Martonne and Emberger indices and the North Atlantic Oscillation (NAO) and the Western Mediterranean oscillation (WeMOI).

The impact of NAO and MOI on the climate of Europe, including Bulgaria, are active throughout the year, but are best expressed in the cold half of the year (Hurrell, 2000; Martin-Vide and Lopez-Bustins, 2006). The NAO represents the difference in sea level atmospheric pressure between Iceland and the Azores. When NAOI is positive western winds are stronger and the winter in southern Europe are a colder and drier. The negative NAOI determine wet and warmer winters in southern Europe. The WeMOI is determined as an air pressure difference between Padua and Cadiz. The positive WeMOI is related to the anticyclone over the Azores and low-pressures in the Liguria Gulf. The negative phase coincides with the anticyclone located over the central Europe (Martin-Vide and Lopez-Bustins, 2006). The NAOI are taken from Hurrell Station-Based dataset¹ and WeMOI are from Climate Research Unit².

Results and discussion

Aridity indices – average and extreme values

The present study of aridity in South Bulgaria is based on calculations of the De Martonne aridity index and Emberger Index. According to the De Martonne index the average values for three investigated periods 1961-2015, 1961-1990 and 1986-2015 show humid and semi-humid climate while for the meteorological stations in Sandanski and Plovdiv the indices are constantly associated with the Mediterranean climate (Table 4). This fact can be also interpreted as a geographical expansion to the north of the Mediterranean climate. In most of the investigated stations the average values of the Emberger index show humid climate (Table 5) while De Martonne index indicates semi-humid climate. The difference between the two types of indices is biggest for stations Sandanski where the De Martonne index shows Mediterranean climate and according the Emberger index the climate is

¹ <https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-station-based>

² <https://crudata.uea.ac.uk/cru/data/moi/>

semi-arid. The second station with different results is Plovdiv–De Martonne index indicates Mediterranean climate while Emberger index shows humid and semi-humid climate. Despite different 30-

years periods Nikolova and Voisilova (2013) have found similar results for De Martonne aridity index in South Bulgaria, which indicate slight changes in the multi-annual course of the indices.

Table 4 Climate types during various periods based on the De Martonne aridity index

Meteorological station	1961-2015	1961-1990	1986-2015	Lowest values	Year of lowest values
Sofia	29,00	27,7	29,02	12,47	1990
				14,14	2000
Kazanlak	26,98	26,58	26,18	14,77	2000
Sliven	27,44	25,46	28,25	16,90	2008
Kyustendil	27,58	27,93	26,90	14,3	2000
Blagoevgrad	24,08	24,79	23,12	9,79	2000
Plovdiv	23,67	23,28	22,92	11,00	2001
				9,52	2000
Sandanski	20,67	20,33	20,45	9,59	1993
Haskovo	29,25	29,62	27,99	16,03	2008
Climate types					
	Arid	Semi-arid	Mediterranean	Semi-humid	Humid

The average values of the De Martonne index indicate mainly semi-humid and Mediterranean climate during different periods (Table 4). Semi-humid climate is established also by Vlăduț et al. (2017) for the period 1961-2015 in the lowlands and plains in the north part of Bulgaria and south of Romania. On the other side, annual values of the index show that in some of the stations located in south-west part of the study area the aridity conditions have been observed in 22 to 45 % of the investigated years. These are stations which show a Mediterranean type climate according to the 30-years average values: Blagoevgrad (22% of the years with arid or semi-arid conditions), Plovdiv (35

%) and Sandanski (45 %). Based on potential evapotranspiration Nastos et al. (2013) show the tendency to sub-humid and semi-arid climate in many areas, mainly in eastern Greece.

The index values for the 90^{es} and the beginning of the 21st century are the lowest and in some cases are equivalent to arid climate (Blagoevgrad and Sandanski according to the De Martonne index; Sandanski, Blagoevgrad, Plovdiv and Kyustendil according to the Emberger index), Tables 4 and 5. The peculiarity of the results is that both indices (De Martonne index and the Emberger index) indicate as the most arid year the year 2000 for which the lowest values of the indices are obtained (Tables 4 and 5).

Table 5 Climate types during various periods based on Emberger index

Meteorological station	1961-2015	1961-1990	1986-2015	Lowest values	Year of lowest values
Sofia	124,65	126,56	118,52	39,67	2000
Kazanlak	115,45	120,93	105,21	42,08	2000
Sliven	105,9	110,38	102,92	59,22	2013
Kyustendil	117,8	124,69	107,77	26,72	2000
Blagoevgrad	95,87	104,29	85,52	22,57	2000
Plovdiv	90,89	94,12	83,11	22,36	2001
				28,03	2000
Sandanski	69,89	74,71	64,51	28,23	1993
Haskovo	111,84	119,67	108,44	48,24	2000
Climate types					
	Arid	Semi-arid	Semi-humid	Humid	